Detailed Remediation and Enabling Works Strategy
Former Manox Works

Reference: 13-887-R6-4
Date: February 2023

REMEDIATION AND ENABLING WORKS STRATEGY

Former Manox Works
Coleshill Street
Miles Platting
Manchester

Prepared for:
Landcare (East Manchester)

Report Ref: 13-887-R6-4
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EXECUTIVE SUMMARY

Site Address	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE
National Grid Reference	N 386202, E 399393
Site Area	• Manox Zone (approximately 3.0 ha) • Zone 5W (approximately 1.3 ha) • Zone 7 (approximately 2.0 ha)
Background	E3P has been instructed by Landcare (East Manchester) to develop a detailed remediation and enabling works strategy for the proposed residential development at the site located at the former Manox site and surrounding zones. The E3P Remediation and Enabling Earthworks Strategy has been produced in due consideration of the geoenvironmental site investigation and contaminated land assessments previously undertaken by E3P and others previously on behalf of the landowner. This report includes a 'Remediation Options Appraisal' developed in accordance with the EA Land Contamination Risk Management (LCRM) framework (2021). The primary purpose of the Site Characterisation and LCRM Remediation Options Appraisal is to ensure a robust understanding of the risk, pollutant linkages and viability of a suitable remediation approach that will ensure no unacceptable degree of risk to the critical receptor within the context of the developed Conceptual Site Model (CSM). E3P Ltd has been previously commissioned by Landcare (East Manchester) to undertake a Contaminated Land Site Characterisation Assessment at land north of Coleshill Road, Miles Platting. Specifically, this report relates to the northern sector of the wider development area known as the 'Manox' site. This sector of the site has been the subject of prolonged industrial use associated with chemical manufacture and is considered to represent a significantly increased risk in terms of contaminated land liability. Several phases of site investigation have occurred at the site previously with the first reports prepared for the former site operator (Degussa) in 2004 while the facility was still operational, with subsequent intrusive investigations completed as part of the closure in 2004 and 2006. E3P has also reviewed a more recent and detailed ground investigation from 2019 completed by RSK / Westlakes.

CONTAMINATED LAND RISK ASSESSMENT

Human Health Risk Assessment	The Tier I Human Health Risk Assessment has identified the presence of elevated concentrations of inorganic heavy metals including cyanide, PAH compounds and trace asbestos fibres within Made Ground deposits. VOCs were also recorded above the limit of detection including Dichloromethane up to 10mg/kg in TP601 at 0.80 m bgl and Carbon Disulphide at WS603A, TP601, TP606, TP607, TP608, TP610, TP612, TP616, TP620, CP604, and CP605. The shallow Made Ground is therefore not suitable for use within proposed "soft" areas, where a direct exposure pathway exists. The primary contaminants of concern that cannot be addressed by what is considered 'normal' or standard remediation solutions for a brownfield development site are identified as: • Inorganic heavy metals (Arsenic & Lead) • Cyanide Salts

	• Coal tar derived organic aromatic semi volatile compounds • Coal Tar derived Benzene based compounds The remediation approach will require the removal of primary sources which include discolouration in soils (metals and cyanide salts), separate phase coal tar (former channel and impact) and remediation of site wide soils. The remediation phasing plan, produced by McAuliffe, is available in Appendix VIII. The remediation will need to ensure encapsulation to remove the possibility of future mobility of any compounds and the egress of perched groundwater. The development will likely require specialist membranes in all dwellings to impede the ingress of aromatic hydrocarbon vapour into the dwellings. Membranes will need to be constructed in strict accordance with CIRIA 735 and 748 to be installed by a certified installer, integrity tested by air and each dwelling to be inspected by a qualified person. A vapour risk assessment will be completed post-remediation in order to determine this requirement. All areas of 'soft standing' will need to be constructed with a minimum of 700 mm of clean cover with a proprietary break layer to ensure no future disturbance of the remediated soil and perched groundwater. The design and construction of infrastructure, particularly deep drainage, will require special consideration to ensure no unacceptable risk to construction workers. Asbestos fibres were identified within the Made Ground across the site. This material will require careful management and subsequent placement in an area of no future sensitivity in accordance with the E3P Developed Conceptual Site Model (CSM). Localised, as yet unidentified, contaminant impact cannot be discounted; therefore, the site remediation and enabling works will be completed under the supervision of an independent geoenvironmental engineer. In the event of any as yet unidentified/unexpected source impact being observed, samples will be subject to laboratory testing to inform robust risk assessment and, where necessary, remediation action.

Controlled Waters Risk Assessment	E3P has completed an updated Tier 1 controlled waters risk assessment; this highlighted the prevalence of cyanide throughout the Made Ground in the Manox site at significant concentrations within the soil matrices that are considered to represent an ongoing and persistent source of pollution. Arsenic and lead are locally impacted in discreet locations; however, these metals do not appear to represent a site wide source of widescale impact in the dissolved phase. Significant concentrations of SVOCs associated with the refinement of coal tar are identified within the solid and aqueous phase within all phases of historical ground investigation works. It should be noted that the contaminant load within both solid and perched water are dramatically reduced within all forms of sampling in Zone 7 and 5 to the south, indicating a lack of mobility and migration which is to be anticipated when looking at the fate and transport of these compounds. The deeper groundwater monitoring wells installed by RSK indicate an absence of significant or gross contamination impact within the underlying superficial drift deposits, which when considering the light non aqueous characteristics and relatively reduced solubility is to be anticipated. The results of the historical data review, Tier 1 qualitative and preliminary Tier 2 quantitative risk assessment have allowed E3P to draw the following conclusions with respect to the risk to controlled waters: • There have been extensive and multiple phases of historical ground investigation, this has enabled a detailed assessment of the site and reasonable characterisation of the pollution risk and potential to impact the critical receptor; • The primary receptors are identified as the Canal to the north and culverted Shooters Brook to the south; • The Canal is 'cut' into the glacial till clay aquitard, however when considering the detailed hydrological model, it would appear that the canal loses water to the site and is contributing to the perched water flow across the low permeability clay to the south towards Shooters Brook. • It is probable that impact on the canal will occur through migration of perched water in conduits such as relict drainage infrastructure as opposed to an actual dissolved phase plume and groundwater migration; • Confined perched waters at a higher elevation that egress via conduits from the canal will be removed during the remediation works to negate this identified pollution pathway; • Shooters Brook is at least 150m south, monitoring of installations immediately adjacent to the primary source area suggests that there is significantly reduced contaminant load immediately adjacent to the site boundary. When considering the operational period of the Manox facility (>100yrs) the absence of gross contamination at the boundary substantiates the suggestion that lateral (down hydraulic gradient) migration is reduced. • The underlying aquifer is not considered a high-risk receptor, given the significant depth of glacial clay. In addition, it is noted that four mines are present directly beneath the site. Therefore the groundwater will be of poor quality, and, • The primary area of concern is the Manox site; numerous primary sources of pollution remain in the form of tar channels, chemical waste, tanks, drainage infrastructure and significantly impacted soils. A complete pollutant linkage exists which requires remedial action in line with the site CSM.

Ground Gas	The presence of deep Made Ground and historical underground mining at the site infers a potential ground gas risk at the site for carbon dioxide and methane. A preliminary ground gas monitoring regime was completed by RSK to target the potential sources of ground gas at the site. Six monitoring rounds were completed at the site in the monitoring wells installed. The gas monitoring regime results are presented in the RSK report and conclude that gas protection for methane is not required at this site. However, a preliminary classification as CS2/Amber 1 is given, due to the presence of carbon dioxide, therefore gas protective measures are required in new buildings. Post-remediation ground gas monitoring will be required to provide a fully updated classification for the site. Vapour membranes may be required in the construction of new residential dwellings, to break the vapour release to the indoor air pathway to residential end users, from the potential site wide VOC impact. The use of vapour membranes will be determined in the post-enabling works VOC vapour risk assessment. Should a risk be perceived within a phase of the development, where the time weighted concentrations exceed the derived SSSV or reference concentrations, a chemically resistant membrane designed in accordance with BS8485 / CIRIA 748 will be required for proposed dwellings within that phase of the development.
Coal Mining and Historical Workings	The site is considered to be at risk from mining-related issues, due to the presence of a former mine entry on the site within Zone 7 and several coal outcrops at the site, E3P has prepared a Desk Top Mining Risk Assessment (Ref: 13-887-R2, dated January 2020) for the site and should be read in conjunction with this report. The report confirms it will be necessary to locate the shaft by a process of probe drilling to confirm its exact position, diameter and depth. The shaft will then be pressure grouted in accordance with a suitably designed specification in accordance with industry best practise CIRIA 758 and a Coal Authority Permit. Furthermore, due to the presence of shallow workings beneath the site, the majority of the site will require probe drill and grout by a specialist contractor.
Invasive Plants	Invasive plant species require identification and eradication by a specialist contractor.
Potable Water Supply	The site investigation and contaminant risk assessment identified elevated concentrations of potentially volatile hydrocarbon compounds, which could permeate into the potable supply infrastructure. It will therefore be necessary to undertake appropriate remediation works with robust validation tests.

GEOTECHNICAL ASSESSMENT

Relict Sub-Structures	Extensive relict substructures, infrastructure and materials deemed geotechnically deleterious are identified. All such materials will require removal from beneath proposed structures and infrastructure to the depths and extents as defined within this specification.
Adverse Ground Conditions	All potentially infilled ponds and historical features where deleterious/putrescible material is identified should be located and subject to the necessary remediation works.

Foundation Considerations	The overarching aim of the remediation and enabling earthworks will be the construction of a development platform by the remediation contractor in direct accordance with the E3P geotechnical specification and utilising the current layout to set out the proposed plots. Where deep Made Ground is present (>1.50m), the stratum should be prepared in a manner that will facilitate re-engineering using a vibro stone column (VSC) however the final foundation solution will be confirmed by the future housebuilder. Where shallow stratum is identified which is suitable of supporting a shallow spread foundation, care should be taken to protect and minimise the disturbance of natural drift deposits. Existing trees are present within the site and on the boundaries which will require consideration during the foundation assessment to ensure that for plots located within the influence of trees, the stratum should be prepared to mitigate the potential risk associated with volumetric instability in cohesive soils.
Highways and Infrastructure	All proposed adopted roads will be constructed in accordance with the geotechnical engineering requirements as defined within the MCHW Series 600. Specific engineering and compaction of materials will be completed in strict accordance with the geotechnical specification contained within this report. All materials outside of structural/infrastructure development will be engineered and compacted to ensure consolidation associated with self-weight settlement is limited to < 50 mm in accordance with the E3P specification. The loading for such will be determined by the structural engineer.

REMEDIATION AND ENABLING WORKS

Objectives	The remediation and enabling works will be delivered to seek to implement specialist remediation work to identify, treat, stabilise and solidify the primary groups of potential contaminants of concern and install physical barriers by way of engineering solutions to ensure all perceived pollutant linkages are mitigated. The stated objective of the site remediation will be the delivery of the landholding in a manner that poses no unacceptable degree of risk to either chronic human health to all identified receptors, controlled waters and the wider environs.
Remediation and Enabling Works – Zones 5 and 7	Within the areas identified as 'Zone 5 & 7, ' active remediation works to treat impacted soils and groundwaters are not currently identified as a key requirement. Works in these sectors are classified as 'Site Enabling' to prepare the development platform in a manner that is compliant with all pertinent environmental legislation and controls and the subsequent incorporation of engineering measures in the construction of dwellings to mitigate the residual pollutant risks. The enabling works strategy provides a comprehensive specification for the regeneration of the land in Phases 5 & 7 to negate identified pollutant linkages and construct a development platform that will be geotechnically suitable for the proposed end use. The salient features of the remediation and enabling works strategy are summarised as follows: • Implementing all works in strict accordance with UK Environmental Permitting and local planning authority requirements. • Controlled removal of all non-retained trees and vegetation. • Removal and treatment of all invasive plant species (as required) in accordance with a specialist contractor method statement, validation and independent certification. • Delineation and removal of PCB-impacted soil, validation testing of material that remains and removal of all unsuitable soils.

	• Segregation of organic topsoil deemed unsuitable for use within a residential garden and placement in an area of no sensitivity or removal from site in accordance with UK waste management legislation. • Decommission of all interceptors, tanks and active drainage infrastructure in accordance with the contractor method statement and ensuring no environmental impact. • Management of all anthropogenic material impacted by trace asbestos fibre in a controlled and legislatively compliant manner. • Identification, delineation and removal of organic materials within any shallow infilled ponds. • Removal of all structures, relict foundations and buried features in their entirety. • Completion of a watching brief by a supervising geo-environmental specialist fully conversant with the potential for pollution emanating from the adjacent Manox site; • Where any as yet unidentified source of potential impact is identified, this will be delineated. If material is considered to represent a risk associated with leachate or dissolve phase migration to a surface water receptor, it will be extracted and added to the 'Manox' remediation treatment train; • Removal of all materials considered geotechnically deleterious. • Excavation and processing of Made Ground in a controlled manner with the sorting, processing and segregation of identified deleterious materials to geotechnical specification. • Validation sampling and leachate testing to confirm that material retained on site poses no unacceptable risk to the residential end users, controlled waters or wider environ. • Importation of suitable material (if required) to achieve the required development levels. • Replacement of material in accordance with the E3P enabling specification and engineering requirements.
Remediation and Enabling Works – Manox Zone	The northern sector of the subject site, referred to as the Manox Area, will be the subject of highly specialised, site-specific remediation works that will seek to identify the extent of gross pollution considered to be primary and secondary sources and the subsequent implementation of the 'remediation train' which will facilitate treatment of materials in accordance with the detailed methodologies, protocols and site-specific assessment criteria to be agreed with Manchester City Council and the Environment Agency. Remediation works within the Manox sector will be the subject of an Environmental Permit (EP). The deployment of the appropriate permit will be the responsibility of the approved specialist contractor. This report includes a detailed Remediation Options Appraisal prepared in accordance with LC:RM (2021) that assesses the viable and suitable technologies and protocols for the requisite remediation works and implementation objectives. The E3P Remediation Options Appraisal, which informs this Remediation Strategy is as follows: • Report the findings of the McAuliffe pilot study/treatment trial to determine the appropriate methodology and chemical composition of suitable methods for the solidification and stabilisation of the primary contaminants of concern; • Agree and deploy the appropriate Environmental Permit for the treatment of soil and groundwater using mobile plant; • Removal and disposal of fly tipped waste.

	• Establish site 'Remediation Treatment Train'; this will be the mobile plant and accompanying site protocols that will accept and treat differing material types and subsequent validation testing to facilitate safe and sustainable re-use of material; • Identify, decommission and remove all conduits, such as drainage infrastructure, considered to provide a preferential contamination migration pathway; • Identify and remove all areas of 'primary' contamination impact defined as: ○ Separate phase liquid coal tar within the historic structure; ○ Visible chemical (Cyanide, Arsenic & Lead) impact within Made Ground; ○ Identify localised areas of separate phase liquid coal tar impact (surface spillage); • Control and removal of impacted perched waters confined by historical structures and variable Made Ground during demolition and removal of relict structures; • Extract material from the northern boundary (adjacent to the canal) proven to represent an off-site migration risk and add to the remediation treatment train; • Install a low permeability sheet piled barrier to the entirety of the northern boundary in accordance with the design to be agreed upon by all stakeholders; • Undertake extensive excavation works to remove 'secondary' cyanide (ion salt) and metalloid impact within the Made Ground across the Manox sector. Material to enter the 'Treatment Train' to ensure solidification and stabilisation as required to ensure compliance with site remediation criteria; • Lift sort and process all anthropogenic material (Made Ground) across the entirety of the Manox sector; • Treatment and control of any impacted perched waters during the excavation process; and, • Replacement of materials that have been subject to treatment and demonstrated compliance with the remediation criteria in accordance with the geotechnical design specification and developed site CSM.

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1. INTRODUCTION

1.1. BACKGROUND

E3P has been instructed by Landcare (East Manchester) to develop a detailed remediation strategy and enabling works strategy for the proposed residential development at the site known as the former Manox works in Miles Platting, Manchester.

This report has been prepared to address Conditions 54, 57 and 58 within the Manchester City Council Planning Approval (ref: 131895/JO/2021); items specifically pertaining to the phasing plan (Condition 54), the risk assessment (Condition 57) and a detailed Remediation Strategy (Condition 58).

A previous Outline Remediation and Enabling Works Strategy has been produced by E3P (Ref: 13-887-R5, dated June 2022), which has satisfied Condition 56 alone, on the pretext that certain items are included within this Detailed Remediation Strategy.

This Detailed Remediation and Enabling Works Strategy has been completed with full input by McAuliffe, who are the chosen remediation contractor. Where items have been included by McAuliffe, pertaining directly to their works, this will be made clear within the report text.

The phasing plan and treatment trial studies produced by the appointed contractor, McAuliffe, should also be read as a precursor to this document as the pertinent information from these is utilised in developing this strategy.

This report includes a 'Remediation Options Appraisal' developed in accordance with the EA Land Contamination Risk Management (LCRM) framework (2021). The primary purpose of the Site Characterisation and LCRM Remediation Options Appraisal is to ensure a robust understanding of the risk, pollutant linkages and viability of a suitable remediation approach that will ensure no unacceptable degree of risk to the critical receptor within the context of the developed Conceptual Site Model (CSM).

1.2. REPORT OBJECTIVES

The objectives of this report are to:

- Prepare an overview of contaminated land remediation requirements;
- Evaluate feasible remedial technologies;
- Assess the most appropriate earthworks solution to ensure the delivery of the optimum development platform;
- Define validation criteria to demonstrate the successful implementation of a site remediation and enabling works plan;
- Undertake a detailed controlled waters risk assessment to generate site specific remediation targets;
- Provide full detail of specific protocols and mitigation that will be undertaken by McAuliffe during the course of the remediation and enabling works;
- Specify geotechnical engineering performance requirements; and,
- Ensure the safe, cost effective and regulatory compliant redevelopment of the site.

1.3. SCOPE OF WORKS

The development of the detailed remediation strategy for the subject site includes the following tasks:

- Identification of the relevant pollutant linkages;
- Review of site characteristics;
- Identification of geotechnical constraints;
- Development of remedial objectives;
- Selection of appropriate remedial technology; and
- Development of remedial strategy.

1.4. PREVIOUS WORKS

The following phases of geoenvironmental investigations have previously been carried out at the site:

- **URS** – Contaminated Land Site Audit July 2004
- **URS** – *Phase II Site Investigation*, dated September 2004
- **URS** – Phase III Site Assessment Investigation, dated October 2006
- **URS** – Synopsis of URS soil and Groundwater Investigation, dated November 2006
- **Environmental Resources Management Limited (ERM)** – *Northern Boundary Area Assessment Report*, Former Manox Factory, dated 23rd June 2009. Ref 0098997.
- **RSK**–*Factual Ground Investigation Report*, Former Manox Dye Works dated November 2019. Ref: 11432-04.
- **E3P** – *Geo-Environmental Site Characterisation Assessment*. Ref: 13-887-R3, dated August 2020, Prepared for Landcare.
- **E3P** – *Outline Remediation and Enabling Works Strategy*. Ref: 13-887-R5, dated June 2022, Prepared for Landcare.
- **McAuliffe** – *Stabilisation / Solidification Treatability Report.* Ref: MC2906 Manox S/S Treatability, dated July 2022. Prepared for Engie.
- **McAuliffe** – *Phasing Plan.* Dated August 2022

To inform the assessment of the potential risk to contaminated land within the context of the proposed residential development and to inform the preparation of the remediation strategy, the pertinent points from the above report are summarised in Section 2.

For the avoidance of any doubt, the E3P Geo-Environmental Site Characterisation Report should be read both as a precursor to and in conjunction with this document.

1.5. REDEVELOPMENT PLAN

It is intended to construct a low-rise residential development comprising 409 low-rise residential dwellings with associated gardens, public open space, estate roads and infrastructure. Drawing 13-887-002 (Appendix III) identifies the proposed development layout, and Figure 1.1 provides a snapshot.

The subject site is designated for housing delivery: In the Manchester Core Strategy 2012 – 2027, Miles Platting and the Manox site are allocated as one of Manchester's strategic housing locations. According to the core strategy, the Manox site has the potential to accommodate regeneration objectives and create sustainable communities by delivering increased housing numbers to underpin local services and facilities. The Manox site plays a key role in the regeneration aspirations for the wider Miles Platting area, accordingly, the site is already designated for 'higher density residential including family housing' in MCC's Eastland's Regeneration Planning Framework.

FIGURE 1.1 SNAPSHOT OF PROPOSED DEVELOPMENT



1.6. SUMMARY OF PARTIES INVOLVED

Function/interest	Name of Party
Local Planning Authority	Manchester City Council
Developer	Landcare (East Manchester)
Geoenvironmental Consultant	E3P
Main Contractor	TBC
Remediation/Enabling Works Contractor	McAuliffe Environmental / Geo-Stream
Human Health Regulator	Manchester City Council
Controlled Waters and Waste Regulator	Environment Agency
Highways Adoption Authority	Manchester City Council

1.7. REGULATORY CORRESPONDENCE

Landcare (East Manchester) are in the process of submitting a detailed planning application to the local planning authority for the proposed redevelopment of the site for low-rise residential housing with associated adopted estate roads and infrastructure.

Both Manchester City Council and the Environment Agency are in full correspondence with E3P and McAuliffe during the preparation of the documents pertaining to the planning conditions.

The Coal Authority has also been contacted with regards the mine workings and any documents prepared in this regard will be issued to the Coal Authority for comment.

1.8. SITE DETAILS

Site Address	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE
National Grid Reference	N 386202, E 399393
Site Area	• Manox Zone (approximately 3.0 ha) • Zone 5W (approximately 1.3 ha) • Zone 7 (approximately 2.0 ha)

All acronyms used within this report are defined in the glossary presented in Appendix II.

A site location plan is presented in Appendix III as Drawing 13-887-001.

1.9. SITE SUMMARY

TABLE 1.1 SITE DESCRIPTION AND SETTING

Occupancy/Use	Previously the site was subdivided into three discrete parcels to represent the differing prior land uses. The parcels are referred to as Manox Zone, Zone 5 and Zone 7. **Manox Site:** The site comprises an elongated vacant parcel of land and all structures have now been demolished. The site is primarily surfaced by concrete hard standing. Dense scrubland is present throughout the southwestern and eastern parts of the site. The site is surfaced by several stockpiles comprising demolition rubble and fly tipped material. **Zone 5W:** The site is a rectangular shaped parcel of land which is currently vacant and has no structures present. The centre and western sector of the site are surfaced by hard standing, overgrown vegetation and trees. The east of the site is predominantly surfaced by long grasses. Trees border the periphery of the site. **Zone 7:** The site is a roughly rectangular shaped parcel of land. The east of the site is currently used as a recreational area by the public and is surfaced by grassland. The west of the site is surfaced by gravel and is used by Stobart Rail as a storage compound. Trees border the periphery of the site.	
Environmental Setting	**Drift Geology**	Glacial Till (Devensian)
	Bedrock Geology	Lower Pennine Coal Measures
	Hydrogeology	Secondary undifferentiated (drift) over secondary A aquifer (bedrock).
	Hydrology	There are two surface water features located within 50m of the site, the nearest of which is the Rochdale Canal, situated immediately adjacent to the northern boundary of the subject site. Shooters Brook is allegedly historically culverted beneath adjacent housing to the site circa 150 m southeast. The exact location has not been confirmed.
	Flood Risk	The site is not located within a fluvial flood risk zone.

	Subsidence Hazard	No hazard identified in data searches.
Site History – Zone 5	From 1848, historical mapping shows a road and tracks crossing the site leading to an off-site coal pit in the current Zone 7, otherwise, the site is undeveloped. There may have been localised clay workings on site as these are shown in nearby areas. Between 1891 and 1908, three separate buildings are present, likely residential housing. From 1908 the site contains a school building and surrounding open spaces, presumably used as play areas. In the 1990s, the open area to the northeast of the site contains open earthworks or pit, which may have been used as a skate park, BMX track or similar. The site continues to be used in association with education until around 1992, after which all former buildings have been removed and the site is open vacant land.	
Site History – Zone 7	A coal pit was present in 1848, which may have included spoil heaps. A pit or pond is shown in this area in 1893, which may have been associated with shallow clay extraction. From 1908 onwards, the Zone 7 site has probably been used as a public open space and is shown as a recreation ground from 1922 on the historic mapping records.	
Site History – Manox	The site has historically been utilised as the Ducie Mills, a chemical works, a floor cloth manufacturer, residential housing, brass foundry, cabinet works and a substation. Chemical production commenced in circa 1864 at the site, early processes are believed to have been associated with the refinement of coal tars for inorganic and organic chemical products, most notably dyes and pigments. Historical information suggests that the primary raw materials were derived from coal gas production, sourced from a local gas works (Bradford Road). The Manox site was then said to use the waste spent oxide from the gas works to extract iron and cyanide compounds for the reuse within pigments, produced at the site from circa 1920 until the late 1960's when the manufacture of 'town gas' from coal refinement ceased. The previous audit and GI reports identify a former tar channel on site, known to be used to transport tar from the offsite gas works to the distillation works, located north of the canal. In 1960, Britain saw coal gas start to be imported from the North Sea, so no further gas works waste could be utilised at the works, but the site was still operational and continued to produce pigments.	

Site History – Manox continued…	The URS report confirms that the liquid tar was transported from the distillation works to the north of the Rochdale canal by a pipe over the footbridge, into the Manox site. It is believed the pipe was underground in the central sector of the Manox site prior to discharging into a brick lined 'tar pit' in the central / central west sector (see E3P drawings). It is suggested that coal tar was used in the production of dyes on-site until the cessation of this operation in the 1920's. The primary operations within the Manox site between circa 1920 and 1970 was associated with the manufacture of pigment (inert dyes largely insoluble in water) comprising predominantly inorganic chemicals / salts (cyanide and acids). Cyanide is obtained by the passing of the refined coal gas through filter beds; it is therefore assumed that this operation was completed off site with the cyanide imported for subsequent use in the manufacture of pigments. URS note that tar was incinerated on-site to dispose of waste materials, it is unclear if the tar was used as a heating source in the chemical process. It is suggested that coal tar was used in the production of dyes on-site until the cessation of this operation in the 1920's. The primary operations prior to 1970 were associated with the use of spent oxide, iron and cyanide to manufacture pigments. The land immediately north of the Rochdale Canal formed part of the wider chemical works where coal tar was refined to manufacture carbon disulphide and other organic and inorganic chemicals. There is no evidence to suggest carbon disulphide was either manufactured or stored within the Manox area. Prior to the site acquisition by Degussa, it is reported that all Asbestos Containing Materials were removed by Rhone Poulenc from site. The primary operation on site from 1970 to the cessation of chemical production in 2005 was associated with cyanide related chemical manufacture. In 2003, the main product manufactured on site was Sodium hexacyanoferrate, Yellow Prussiate of Soda or YPS, the process was completed in the central / east sector (see E3P drawing). The chemical process involved the mixing of sodium cyanide with iron chloride in a reaction vessel with spent hydrochloric acid. Other smaller processes being undertaken on-site in 2003 included the manufacture of a blue iron-cyanide pigment. This process (completed in the west) required the mixing of YPS with ammoniacal sulphate, spent acid and sodium chlorate to manufacture Prussian Blue Pigment. Prussian blue is produced by oxidation of ferrous ferrocyanide salts. The iron in this material is all ferrous, hence the absence of deep colour associated with the mixed product. Oxidation of this white solid with hydrogen peroxide or sodium chlorate produces ferricyanide and affords Prussian blue. Prussian blue is utilised in the manufacture of inks, paints, makeup and as a colourant in fungicides amongst other applications requiring a pigment.

Site History – Manox continued…	In 2003, it was reported that 7000T of sodium cyanide was utilised in the YPS and Prussian Blue plants at the Manox facility annually. The sodium cyanide was reported imported to site and stored in tanks prior to use in the process. The blue stores and outside vats were located to the south-west of the main blues plant on the canal boundary. A second blues plant or processing plant (blue mill) was located close to the main effluent treatment plant. The main cyanide storage was at the north-eastern end of the main blues making area and spent acid bulk storage plus other inorganics towards the north-eastern end of the site.
Landfill Sites and Ground Gases	No landfill sites have been identified within 250 m. Bradford Road Works is the closest registered landfill and lies circa 260m south-east of the site.
Radon	Unaffected – no special precautions required.

1.10. SUMMARY OF REPORTED GROUND CONDITIONS

E3P has prepared a detailed Site Characterisation Report (Ref: 13-887-R4, dated September 2020) and an updated site investigation letter report (13-887-L8, dated July 2022) which included more recent supplementary investigation. The summary of reported ground conditions for the Manox site is given in Table 1.2.

TABLE 1.2 SUMMARY OF GROUND CONDITIONS - MANOX

MADE GROUND	**Made Ground – 0.00 m bgl to 2.90 m bgl** A review of the URS 2004-2006 logs confirms Made Ground was encountered within all locations to a maximum proven depth of 2.70 m (BH205), consisting of granular fill with clinker, ash, coal and brick. The ERM investigation logs from 2009 confirm Made Ground was encountered at each of the exploratory locations, with trial pits often terminating at the base of the Made Ground. The thickness of Made Ground was proven to a maximum depth of 3.00 m bgl in TP415, however the thickness was typically 2.00 m. The Made Ground encountered was variable in composition and consistency, but generally comprised gravels of brick and concrete rubble with wood fragments, and areas of reworked clay. In several trial pits (TP401, TP402, TP405, TP406, TP407, TP408, TP419 and TP421), a second concrete or brick obstruction was encountered, potentially from a former below-ground structure or former foundation, suggesting there are remaining constraints at the site, below which have not been investigated. The Westlakes 2019 logs confirm that Made Ground was found across the site from surface level to an average depth of 2.20 m bgl and maximum proven depth of 3.20 m (WS606). Most of the site was covered with hardstanding, except areas located mainly in the far northeast and southwest of the site which contained granular hardcore with some silty made ground at surface level. Made ground was encountered in all exploratory positions across the site from surface level to an average depth of 2.20 m bgl. These deepest areas are in the central eastern part of the site, however generally there is no spatial pattern to the distribution of made ground, which is relatively deep across the site. Groundwater monitoring found perched groundwater in the made ground between 0.40 m and 1.70 m bgl.

	Ash was noted in some locations. Gravel content varied and usually comprised a mix of man-made materials such as concrete and brick although clinker, bitumen, mudstone, sandstone, limestone, slate and coal were also encountered. Cobbles of brick and concrete were mainly encountered within the made ground along with limestone and sandstone and lesser amounts of slate, mudstone, slag, macadam and clinker. Boulders of brick and concrete were also encountered and lesser amounts of macadam. Fragments of wood, glass and ceramic were also found. From the 2021 E3P site investigation logs, Made Ground was identified within all locations advanced to a maximum proven depth of 2.90m bgl (TP806). In general, this was in line with previous findings whereby concrete or asphalt surface covering was underlain by sub-base gravels and reworked gravels. Reworked clays were encountered in TP807, TP810, TP813, TP815. Significant blue staining was noted within soils at TP802-TP804, TP810-TP813, TP816, TT801-TT803. Oily sheens and black staining were noted within soils at TP806, TP807, TP813, TP814, TP815 and TT804. Hydrocarbon odours were noted at TP801, TP802, TP806, TP807, TP811, TP813, TP814 and TT803. Hydrocarbon impact in the form of sheens or odours was noted in the water at TP806, TP811, TP814 and TT804. A depth of made ground plan is presented as drawing 13-877-006 in appendix III.
Drift	**DRIFT – 1.5 m bgl to 9.8 m bgl** Drift deposits were encountered within the majority of the URS 2004-2006 boreholes, the exceptions of which were BH104, BH107, BH201 and BH209, where the full extent of the Made Ground could not be proven due to brick and concrete obstructions in these areas. Drift deposits comprised stiff, dark brown CLAY with cobbles and silt veins to a maximum proven depth of 4.40 m bgl (BH202A). The natural strata encountered within the ERM 2009 works comprised soft to stiff brown to grey CLAY with silt / sand lenses to a maximum proven depth of 3.10 m bgl (TP415). The base of the CLAY was not proven in this site investigation. Westlakes concluded that beneath the Made Ground, Glacial Till was encountered, generally as cohesive Glacial Till comprising firm or stiff silty and slightly gravelly CLAY to a maximum proven depth of 10.00 m bgl in cable percussive boreholes. During the 2021 E3P investigation, drift deposits were encountered within the majority of the locations with the exception of TP806-TP810, TP812-TP815 and TT802. Drift deposits were in line with previous investigations and were proven to 3.00m (TP803) and generally comprised firm to stiff brownish grey mottled sandy clay.
Bedrock	**SOLID – 9.8 m bgl to 25 m bgl** The bedrock geology was encountered at 6.30 m (BH107) during the URS 2004-2006 works, but it is noted elsewhere in the report that bedrock lies circa 13.00 m bgl when reviewing available BGS data. The E3P 2021 investigation did not encounter bedrock. A review of online borehole records held by the BGS confirms the absence of bedrock up to 31.00 m bgl (SJ89NE673).

Groundwater	**GROUNDWATER –** URS identified groundwater strikes between 0.40 m bgl to 2.70 m bgl during investigation works. ERM identified groundwater strikes between 0.30 m bgl to 1.00 m bgl within Made Ground during the investigation works. Westlakes (for RSK) identified groundwater strikes at 0.20 m to 2.50 m bgl within Made Ground. E3P identified groundwater strikes between 0.40 m and 2.50 m bgl. Hydrocarbon impact in the form of oily sheens or odours were noted in the water at TP806, TP811, TP814 and TT804. Groundwater monitoring by Westlakes 2019 found perched groundwater in the Made Ground between 0.40 m and 1.70 m bgl. E3P found groundwater between 0.50 m and 7.50 m bgl.

RSK and Westlakes prepared a Phase 2 Interpretative Ground Investigation Report (Ref: 1493-001-002, dated November 2019) The summary of reported ground conditions for Zone 5 and 7 are given in Table 1.3.

TABLE 1.3 SUMMARY OF GROUND CONDITIONS – ZONE 5 AND 7

MADE GROUND	**Zone 5** Hardstanding was encountered across areas in the west of zone 5. Reinforced concrete was encountered from the surface to between 0.10 m and 0.20 m depth in TP501, TP502 and WS501. Asphalt was encountered at the surface in WS505 and was 0.05 m thick. Vegetation/grass was found to overlie the remaining surface areas. Made Ground was encountered in all exploratory positions across the site from surface level to an average depth of 2.00 m bgl. The minimum proven depth of made ground encountered was 1.10 m. In three areas, the Made Ground was much deeper and extended to 2.90 m (TP506), 3.40 m (WS501) and 4.20 m (CP503) bgl. TP506 and CP503 are both located around the centre of the southeast site boundary near iron street. WS501 is located towards the west corner of the site near Danson street. Granular Made Ground was generally encountered across the site comprising brown sand and/or gravel which included some silt and clay particles. Gravel sized components of brick, concrete and natural stones were generally present as well as cobbles of brick and concrete. Gravel sized fragments of pottery, glass, wood, asphalt, slag, clinker and coal were also occasionally encountered. Ash was noted in some locations. **Zone 7** In the east of the site, turf was underlain by imported topsoil over made ground. The topsoil was usually encountered as a 0.20 m thick layer, although it was found to be slightly thicker in three areas (0.30 m thick in CP703 and WS707A, respectively located in the far southwest of the recreation area and the far northeast of the site, and in CP702, located towards the central east of the site, where the topsoil was recorded as a 0.60 m thick layer).

	In the west of the site (TP701, TP702, TP705, TP708, TP709, WS701 and WS703) was found to have Made Ground from surface level as gravel hardcore of limestone and brick, which was typically 0.20 m thick and underlain by further Made Ground. Made Ground was encountered in all exploratory positions to an average depth of 2.10 m bgl. The minimum depth of Made Ground was 1.00 m (TP703 in the central northeast of the site and TP708 in the far southwest of the site). The maximum recorded depth of Made Ground was 3.00 m which was recorded in two areas (TP706 and TP707) both located towards the central areas of the recreation ground. Historical maps showed that the recreation ground formerly included a coal pit and also clay extraction may have occurred. Consequently, subsequent infill of these areas with made ground is considered likely. Granular Made Ground was generally encountered across the site comprising brown sand and/or gravel which may be silty. Gravel sized components of brick, concrete and natural stones were generally present as well as a low to medium cobble content of brick, concrete and pottery. Glass bottles are noted within the made ground. Gravel sized fragments of pottery, glass, wood, asphalt, clinker and coal were also occasionally encountered. Ash was noted in some locations. WS706, WS706a, WS707, WS707b were all attempted in the far northeast of the site and encountered an obstruction at 0.70 m bgl, preventing further investigation. The obstruction at 0.70 m bgl is assumed to be the buried abandoned former carriageway of Coleshill street.
Drift	**Zone 5** Glacial Till deposits were encountered beneath the Made Ground across the whole site. The Glacial Till was encountered initially as cohesive deposits, however, with depth granular Glacial Till becomes more dominant. Beneath the Made Ground, firm to stiff or stiff cohesive clay, which was slightly sand/gravelly and occasionally silty was encountered. Cobbles and boulders were generally not found within the Glacial Till. The cohesive Glacial Till is typically high strength, firm to stiff or stiff. The Atterberg results indicate that the cohesive Glacial Till is of low to intermediate plasticity. The Modified Plasticity Index ranges between 8% to 26% and therefore the clays are calculated to have low to medium volume change potential. Areas of granular Glacial Till were encountered in 2019 as orangish to yellowish-brown to brown slightly gravelly sometimes clayey fine to coarse sand bands. The sand bands were encountered towards the base of three of the four cable percussive boreholes which extended to a maximum depth of 10 m bgl. Locations encountering the granular Glacial Till typically failed to reach the full SPT penetration depth and encountered very dense sand. **Zone 7**

	Beneath the Made Ground, firm to stiff cohesive clay, which was slightly sandy and slightly gravelly was generally encountered. However soft to firm clay was initially encountered in three of the GI locations (WS707A between 1.40 m to 2.20 m, TP703 between 1.00 m to 1.20 m and TP704 between 1.40 m and 2.00 m), which were generally positioned towards the more eastern areas of the site. The clay in these areas became firm or firm to stiff from 1.20 m, 2.00 m and 2.20 m bgl. Cobbles and boulders were not found within the Glacial Till. The cohesive Glacial Till appears to increase in strength with depth and varies from firm (medium strength) to very stiff (very high strength) clay. The Atterberg results from 2007 and 2019 are broadly comparable. The results indicate that the cohesive Glacial Till is of low to intermediate plasticity. The Modified Plasticity Index ranges between 13% and 25% and therefore the clays are calculated to have low to medium volume change potential. Granular Glacial Till is considered likely to underlie the cohesive deposits across the site. Dense sand was encountered in one 2019 GI position (CP703) from 11.50 m bgl to 12.45 m bgl, where the hole was terminated.
Bedrock	**Zone 5** The maximum depth of the 2019 Ground Investigation was 10 m bgl and did not prove the base of the superficial Glacial Till. However, the rotary borehole (RBH2) drilled in 2007 extended to 50 m depth and recorded the base of the Glacial Till at 26.50 m bgl where the Pennine Upper Coal Measures Formation was encountered. Bedrock was found to comprise strong grey mudstone with siltstone bands from 26.50 m bgl to 50 m bgl where the location was terminated. No coal seams or workings were encountered. **Zone 7** The maximum depth of the 2019 Ground Investigation was 12.45 m bgl and did not prove the base of the superficial Glacial Till. However, the rotary borehole (RBH3) drilled in 2007 extended to 50 m depth and recorded the base of the Glacial Till at 31.00 m bgl where the Pennine Upper Coal Measures Formation was encountered. Bedrock was found to comprise strong grey siltstone with mudstone bands from 31.00 m bgl to 50 m bgl where the hole was terminated. No coal seams or workings were encountered.
Groundwater	**Zone 5** Groundwater was encountered as perched and as small seepages within five exploratory locations between 0.50 m and 2.80 m bgl. During the groundwater monitoring programme, perched groundwater was encountered in some locations in the Made Ground. Groundwater was also recorded in the Glacial Till at depths between 2.97 m and 9.94 m bgl. Perched water may be encountered in the Glacial Till although the true groundwater table may be located at greater depth. **Zone 7** Groundwater was encountered as perched and as small seepages within five exploratory locations between 1.60 m and 2.40 m bgl and within Glacial Till at 3.00 m bgl within WS702 and WS705.

During the groundwater monitoring programme, perched groundwater was encountered in some locations in the Made Ground. Groundwater was also recorded in the Glacial Till. High groundwater levels, between 0.19 m and 0.86 m bgl, were recorded in CP701 and CP702, which had response zones within the cohesive Glacial Till. However, in CP703, which extended into the granular Glacial Till, the groundwater level was towards the base of the well at 11.60 m bgl. This may indicate that perched water may be encountered in the Glacial Till, although the true groundwater table may be located at greater depth.

Visual and Olfactory Contamination

ZONE 5

LOCATION	DEPTH (M)	COMMENTS
TP501	1.00-2.00	organic/solvent odour
TP502	1.00-2.10	hydrocarbon odour, possibly diesel odour, PID detection
TP503	0.00-0.10	organic odour
TP504	0.00-0.20	organic odour
TP505	0.00-0.70	organic odour
TP506	0.00-0.20	organic odour
TP506	1.00-2.90	possible petrochemical/sewage odour
WS501	0.20-1.00	moderate tar odour, PID detection
WS501	1.80-2.75	slight hydrocarbon odour
WS502	0.80-1.10	slight hydrocarbon odour
CP503	0.00-4.20	slight hydrocarbon odour, PID detection

ZONE 7

LOCATION	DEPTH (M)	COMMENTS
CP701	0.90-1.60	ash/clinker, hydrocarbon odour
CP702	0.00-2.30	ash/clinker, slight solvent odour
CP703	0.00-0.30	ash/clinker, organic odour
CP703	0.30-2.20	hydrocarbon odour, PID detection
TP702	0.20-0.70	slight petrochemical odour
TP702	0.70-2.00	sulphurous odour in rare yellow blocks
TP704	0.00-0.20	organic odour
TP705	1.00-2.10	organic/solvent odour
TP706	0.50-3.00	organic/petrochemical odour
TP707	0.00-0.20	organic odour
TP710	1.20-2.10	organic/petrochemical odour
WS703	1.40-1.60	organic odour
WS701	0.50	PID detection, ash/clinker

2. E3P CONTAMINATION RISK ASSESSMENT

2.1. BACKGROUND

E3P has completed a Tier 1 Qualitative Contaminated Land Risk Assessment to determine the potential risk to human health, controlled waters and the wider environ. This assessment is documented in full within the E3P Site Characterisation Assessment report and Supplementary Site Investigation report (13-887-L8, dated July 2022) and, for clarity, is summarised in the following sections of this document.

2.2. HUMAN HEALTH RISK SUMMARY - MANOX

The E3P Tier 1 Qualitative Human Health Risk Assessment identified concentrations of the following determinants at or above the screening criteria for assessing no unacceptable degree of risk to human health. The maximum concentrations recorded are included below in bold:

- Lead (6690 mg/kg)
- Arsenic (**4810 mg/kg**)
- Cadmium
- Copper (42000 mg/kg)
- Chromium (VI)
- Cyanide (Free – 219 mg/kg)
- Mercury
- Iron
- Naphthalene (**2900 mg/kg**)
- Acenaphthene (**810 mg/kg**)
- Fluorene (**520 mg/kg**)
- Fluoranthene (**690 mg/kg**)
- Benzo(a)anthracene (**130 mg/kg**)
- Chrysene (**93 mg/kg**)
- Benzo (a)pyrene (**23 mg/kg**)
- Benzo(b)fluoranthene (**39 mg/kg**)
- Dibenz(a,h)anthracene (**4.2 mg/kg**)
- Phenanthrene (**1300 mg/kg**)
- TPH Aromatic C5-C6 (**79 mg/kg**)
- TPH Aromatic C6-C8 (**130 mg/kg**)
- TPH Aromatic C8-C10 (**300 mg/kg**)
- TPH Aromatic C10-C12 (**48,000 mg/kg**)
- TPH Aromatic C12-C16 (**14,300 mg/kg**)
- TPH Aromatic C16-C21 (**4,400 mg/kg**)
- TPH Aromatic C21-C35 (**2400 mg/kg**)
- Benzene (**1.65 mg/kg**)
- Chrysotile
- Amosite

VOCs were also recorded above the limit of detection, including Dichloromethane up to 10 mg/kg in TP601 at 0.80 m bgl, Carbon Disulphide at WS603A, TP601, TP606, TP607, TP608, TP610, TP612, TP616, TP620, CP604, and CP605, 1,2,4-trimethylbenzene (**8.3 mg/kg**), 1,3,5-trimethylbenzene (**1.7 mg/kg**) and p-isopropyltoluene (**0.46 mg/kg**) are noted above the Atkins ATRISK thresholds in TP814.

2.2.1. HEAVY METALS

With respect to the identified heavy metals, the viable exposure pathway is associated with direct contact, ingestion of particulates, consumption of homegrown vegetables and ingestion of soil. The most significant concentrations of inorganic heavy metal impact are associated with Arsenic (**4,810 mg/kg**), copper (**42,000 mg/kg**) and lead (**6,690 mg/kg**).



Based on the significance of these elevated levels and the fact that these are not related to contamination hotspots but more so a widespread impact, the installation of a simple cover system in this instance would not be deemed sufficient to mitigate what is perceived to be a potentially significant risk due to future disturbance and potential exposure.

It is, therefore, necessary to look at the toxicological data for these contaminants and the wider picture of the remediation as a whole which will set to prepare the site for residential development and ensure the protection of human health, controlled waters and the wider environ.

Whilst varying levels of heavy metals can be associated with natural sources, historical industrial activities have led to the presence of heavy metal contamination on many sites. In the case of arsenic and lead, these are common in chemicals used extensively in the manufacture of pigments. Therefore it is highly probable that the identified impact (also likely to be associated with areas of green and blue discolouration in the soils) is indicative of a primary source of impact within localised areas of the site.

Generally, with respect to arsenic, lead and copper found in soil, they are relatively immobile. However, under reducing conditions, it is possible for these inorganic metalloids to be released from the solid phase, resulting in soluble and mobile forms of heavy metal contamination, which can then cause a leaching risk to groundwater.

Further detail will be provided in the latter stages of this report, however, the remediation of the site will seek to ensure the protection of human health and controlled waters receptors by the solidification and stabilisation of the soils. Whilst it is likely that site-specific threshold values for the protection of controlled waters will be more conservative than the remediation targets solely for human health, basing a remediation on the driving factor of the protection of controlled waters will also ensure the protection of human health by default.

Alongside the remediation by stabilisation/solidification, the installation of a 700mm cover system will also seek to ensure the potential risk of future disturbance is kept to a minimum by the future developers and be undisturbed by the future end users. The future developer will be required to consider the presence of remediated materials (by solidification and stabilisation) which will be retained on site to ensure the appropriate mitigation measures are implemented during construction.

Other site-wide inorganic metalloid impact is identified; however, this is generally consistent with concentrations of a site with a former historical legacy and can be safely mitigated by the construction of a clean cover system upon completion of the main remediation works and construction.

2.2.2. CYANIDE

Free cyanide (hydrogen cyanide or cyanide ion) is not identified at significant concentrations within the soil matrices, however, total cyanide was recorded as very high and distinct blue discolouration is recorded at numerous locations where the soil phase was not subject to laboratory analysis. It is therefore considered that cyanide is possibly present at higher concentrations than that currently reported as a primary contamination source.

The presence of cyanide in the soils is associated with the chemical industrial usage of the site historically. Toxicological data for cyanide suggests the primary exposure to cyanide is from ingestion and to a lesser extent, consumption of contaminated drinking water, however, dermal absorption is not considered to be a significant exposure route.

Cyanide salts are highly soluble; it is evident that in this instance the cyanide has dissolved within the shallow perched groundwater across the subject site as would be expected given the elapsed period of time and quantities of cyanide in-use on site over a prolonged period.



Whilst the presence of cyanide in the soils in its current concentrations presents a significant risk to the human health receptors, cyanide in the soils, due to the high solubility, is considered to be a greater impact to the controlled water receptors. Therefore, the primary driving factor for the remediation of the cyanide impact will be for the protection of controlled waters. Impacted soils will undergo remediation by stabilisation/solidification (more details in the latter stages of the report), which will also seek to ensure the protection of the human health receptors.

Subsequently, the installation of a 700mm chemically suitable cover system will help to address the risk of ingestion to the future residential end users.

2.2.3. ASBESTOS

Asbestos, in the form of chrysotile and amosite, has also been identified within localised areas in shallow Made Ground deposits. No visual signs of asbestos-containing material (ACM) were encountered during the ground investigation; therefore, it is likely that only trace fibres are present within these localised soils and provision of a cover system or placement of impacted soils at depth beneath proposed plots may be undertaken to ensure they pose no unacceptable risk to future site users.

The risk of asbestos being present is reduced, given that all Asbestos Containing Materials (ACM) were reportedly removed before the site acquisition by Degussa in 1990. The removal of ACM from the building fabric has reduced the potential for fibres to be present within the demolition materials. However, given that sub-structure demolition has yet to occur, the potential for ACM within buried pipes and structures needs to be considered within the remediation contractors' plan of work.

2.2.4. CARBON DISULPHIDE

The detailed historical site analysis and assessment of former chemical processes have not identified any lines of evidence to suggest either the manufacture of carbon disulphide on-site or its use in the chemical manufacturing process.

The URS site audit of the operational Degussa facility reported that the primary solvent used in the small on-site laboratory was Toluene and not Carbon Disulphide as is used in some laboratory environments.

No primary source of Carbon Disulphide has been identified within the Manox site.

Carbon disulphide (CS_2) is a toxic, dense non-aqueous phase liquid (DNAPL) that is both highly volatile and highly flammable (Kalin et al., 2005). It is present in the environment due to anaerobic activity in sediments (Moret et al., 2000, Lovelock, 1974). Anthropogenic sources are considered to provide the primary source of CS_2 in the environment (Watts, 2000). Due to its high volatility and the fact that it can ignite or explode when exposed to air (Kalin et al., 2005), remediation of CS2-contaminated sites is difficult and hazardous. Therefore, developing a remediation approach that removes CS_2 contamination from soil and groundwater without exposure to air is essential.

Carbon disulphide has historically been identified within the Rochdale Canal north of the subject site. The developed hydrological model suggests that the canal likely contributes to the perched water flow and down-hydraulic gradient to the south. It is therefore considered plausible that the residual (low-level) carbon disulphide impact within the Manox site, is a residue within a dissolved phase groundwater plume that originated within the chemical works to the north, where a significant primary source was located. It is understood that this primary source has been the subject of remediation.

The risk of a primary carbon disulphide source within the Manox site is considered to be low (considering the lines of evidence approach); however, details of the protocol that will be put in place by McAuliffe during the course of the remediation works in the event of CS_2 discovery have been included within the latter stages of this report.

2.2.5. NAPHTHALENE

Significantly elevated Naphthalene (**919mg/kg**) is identified within the RSK / Westlakes intrusive investigation works and in the E3P supplementary investigation in 2021 (**2900 mg/kg**). This is to be anticipated given the known presence of a significant coal tar primary source (tar channel) and separate phase impact identified by URS (up-hydraulic gradient) of the tar channel. It should be noted that the exact position of the tar channel is as yet to be discovered as extensive intrusive investigation undertaken to date has not identified the location.

All phases of ground investigation within the Manox site describe discolouration and staining of the Made Ground across the Manox site, which represents a hydrocarbon impact (coal tar derived) for the complete site.

The presence of semi-volatile PAH (Naphthalene) is, therefore to be anticipated and expected site-wide.

Naphthalene is part of the Aromatic Hydrocarbon C10-C12 range and is commonly found on sites affected by coal tar, also commonly in association with 1-methylnaphthalene and 2-methlynaphthalene. Naphthalene has a strong, mothball odour and acute exposure to humans by inhalation, ingestion and dermal contact can be associated with hemolytic anaemia, liver damage and neurological damage and has also been classed as a possible human carcinogen.

The primary source of the naphthalene impact has been identified as the tar channel which is yet to be fully delineated. As part of the remediation works, all separate phase impact will be identified and removed. In the first instance, this will be the identification and removal of the tar channel and interconnecting pipework, and the areas of separate phase proven by URS and ERM. Separate phase coal tar will be removed from the site in its entirety to a suitable waste transfer facility; it is anticipated this will be circa 1,000m3.

Furthermore, any unidentified areas of separate phase hydrocarbon (coal tar deviation) are anticipated as localised spillages and leakages from both filler pipework and drainage networks. The remediation solution will include the complete and full-depth excavation of all Made Ground with a visual inspection; therefore, upon completion of the remediation works, there is reduced potential for any as yet unidentified source to remain within the curtilage of the residential development area.

2.2.6. BETANAPHTHYLAMINE

The potential presence of the dye precursor betanaphthylamine has been raised as a possible issue by MCC and is documented in the Smith Grant report. E3P has reviewed the later revision to the RSK / Westlakes report, which confirmed that this particular compound is not present at concentrations above the Limit of Detection for the analytical technique and therefore can be discounted as a pollution source.

2.2.7. PAHS

The presence of concentrations of several PAHs have been identified across the Manox sector, namely, acenaphthene, fluorene, fluoranthene, benzo(a)anthracene, chrysene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene and phenanthrene.

Each of these contaminants has a primary exposure pathway related to dermal contact and ingestion, consumption of homegrown vegetables and soil ingestion. Based on the fact that there are no significant levels of these compounds which would require any greater degree of remediation, the provision of a 700mm chemically suitable cover system will ensure the mitigation of exposure to future residential end users.

2.2.8. SVOCS

A number of coal tar-derived SVOCs including 1-Methylnaphthalene, 2-Methylnaphthalene, 3- & 4-Methylphenol, Carbazole, Dibenzofuran, Bis(2-Chloroisopropyl)ether, Bis(2-Ethylhexyl)phthalate, Biphenyl, Perylene, 2 4 Dimethylphenol, Trimethylbenzene and Bis(2-Ethylhexyl)phthalate, 1,2,4-trimethylbenzene 1,3,5-trimethylbenzene p-isopropyltoluene have been identified above the limit of detection.

Several of these coal tar-related compounds have been focused on below, for the purposes of the assessment to human health risk.

2-METHYLNAPHTHALENE

2-methylnaphthalene is a white crystalline **solid** compound. This determinand is classified as a non-threshold substance, therefore even the smallest amount of exposure is considered to pose a theoretical risk to the critical receptor within the context of the developed CSM.

This compound is detected at a maximum concentration of 252mg/kg.

The vapour pressure of 2-methylnaphthalene is (0.055 mm Hg @ 25°C) is slightly lower than that of naphthalene ((0.085 mm Hg @ 25°C), it is therefore determined that the compound is less volatile than naphthalene. This data is obtained from Pub Chem.

The Tier 1 CIEH / LQM S4UL for naphthalene is 2.3mg/kg for a residential with plant uptake scenario, however this assessment assumes dermal contact, inhalation of particulate and other direct exposure pathways. The developed CSM for the subject site incorporates clean cover systems to ensure no direct exposure pathways.

There is no justifiable or peer reviewed toxicological data for an inhalation pathway for 2-methylnaphthalene, therefore is it not possible to develop a robust site-specific risk assessment model given the absence of suitable input parameters.

In light of the above, we must consider the lines of evidence to hand and given that the compound is a non-threshold substance with no peer reviewed, robust or justifiable toxicological data, we need to ensure focus with regards remediation is on those similar compounds where toxicological information exists and for which appropriate remedial measures can be taken and validation of such utilising a series of site specific screening values.

Based on the chemical formula of 2-methylnaphthalene as a aromatic compound, with a carbon chain of 11, it would be appropriate in this instance to utilise a screening value for C10-C12, which which naphthalene is also associated with. As there are a number of differing contaminants present on the site in various capacities, most of which primarily pose a greater risk to leaching to controlled waters than to human health, the driving factor for the remediation, and thus the more sensitive, is for the protection of controlled waters. A more detailed assessment will be included in the latter stages of this report, which will provide narrative for the assessment of TPH aromatic C10-C12 and naphthalene as an individual entity.

Additionally, it should be noted that as this is deemed to be related to the coal tar having been identified at the site and the associated tar channel, which during the remediation and enabling works will be identified, delineated and removed in its entirety with subsequent chemical validation, the primary source of the 2-methylnaphthalene will be removed.



The US EPA has a residential screening value of 24mg/kg for this compound, while this value cannot be utilised for a SSRT, it must be noted that the risk-based approach assumes significant dermal uptake. Whilst there will be a focus on the remediation of the site to ensure the protection of controlled water receptors based on site derived screening values which is likely to provide conservative validation criteria also for the protection of human health, it is worth consideration of this residential screening value when we are reviewing the remediated soils.

DIBENZOFURAN

This is a white solid compound generally derived from coal tar. There is little or no toxicological data for dibenzofuran. Therefore, it is not possible to generate a site-specific risk-based assessment criterion to determine at what concentration the compound would pose no unacceptable level of risk when considering a vapour exposure pathway in isolation.

This compound is detected at a maximum concentration of 237mg/kg.

As with 2-methylnaphthalene, in the absence of any viable peer reviewed toxicological data, we need to focus on the chemical make up of dibenzofuran, which is similarly an aromatic hydrocarbon compound with a carbon chain of 12 and thus will be addressed as such during the more detailed controlled waters risk assessment where site specific remediation values will be generated.

By way of some form of toxicological information however, the US national library for medicine confirms:

Volatilisation from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's Law constant of 2.1X10-4 atm-cu m/mole. However, adsorption to soil is expected to attenuate volatilisation.

Dibenzofuran is not expected to volatilise from dry soil surfaces (SRC) based upon its vapor pressure

The US EPA has a residential screening value of 7.3mg/kg for this compound, while this value cannot be utilised for a SSRT, it must be noted that the risk-based approach assumes significant dermal uptake. Whilst there will be a focus on the remediation of the site to ensure the protection of controlled water receptors based on site derived screening values which is likely to provide conservative validation criteria also for the protection of human health, it is worth consideration of this residential screening value when we are reviewing the remediated soils.

CARBAZOLE

Carbazole is a non-threshold substance. Carbazole is a white, crystalline solid. It has a characteristic odour. It is a product of incomplete combustion of organic matter and occurs in petroleum, coal, peat, crude oil and coal tar.

There is no toxicological data available to inform the preparation of a robust site-specific risk-based assessment criteria that would model the potential for ingress of vapour to indoor air.

The US national library for medicine confirms:

Carbazole released to air will also be in or on particles that eventually fall to the ground. It is expected to be broken down by sunlight, depending on environmental conditions. It will not move into air from moist soil and water surfaces.

If released to soil, carbazole can have high to no mobility based upon a Koc range of 114-4980, with most values suggesting low mobility to immobility. Volatilisation from moist soil surfaces is not expected to be an important fate process based upon a Henry's Law constant of 1.16X10-7 atm-cu m/mole. Carbazole is not expected to volatilise from dry soil surfaces based upon its vapor pressure.

It is accepted that carbazole is a non-threshold substance, however it will be encapsulated in soils with a temperature in the region of 10oC, furthermore given that it is highly unlikely to move into the ambient air via a vapour phase migratory pathway from a soil or water there cannot be a complete pollutant linkage in this instance.

The recorded concentrations are present to a maximum of 19.8mg/kg.

DISCUSSION

The lines of evidence approach as set out above clearly demonstrates that while there is an absence of peer reviewed and justifiable toxicological data for 2-Methylnaphthalene, Dibenzofuran and Carbazole, these compounds are at the lower limits of the volatile range which is further and significantly inhibited by their encapsulation in soils with a mean temperature in the region of ~10oC.

The US National Library for Medicine confirms that for all three determinands discussed, the vapour pressure and estimated Henrys Law constant suggest that volatilisation is not a theoretical possibility for these compounds.

The dwellings with be constructed with passively ventilated sub-floor voids that allow a complete volume change potential within a 24hr period.

That being said, these compounds may still be considered to pose a risk to controlled waters and due to the more sensitive driving factor of the remediation of the site being for the protection of controlled waters, during the generation of site specific remedial targets, this will also encapsulate the remediation of these specific individual contaminants.

2.3. HUMAN HEALTH RISK SUMMARY – ZONE 5 AND 7

The RSK / Westlakes 2019 Tier 1 risk assessment of soils compared against thresholds for residential housing with gardens, identified the following chemical exceedances (greatest exceedance in bold):

Zone 5

- Arsenic (**129 mg/kg**)
- Lead (848 mg/kg)
- Benzo(a)anthracene (**78.8 mg/kg**)
- Benzo(a)pyrene (**41.9 mg/kg**)
- Benzo(b)fluoranthene (**54.1 mg/kg**)
- Chrysene (**85 mg/kg**)
- Dibenz(a,h)anthracene (**6.88 mg/kg**)
- Aromatic C16-C21 (**1830 mg/kg**)
- Aromatic C21-C35 (**4560 mg/kg**)

Zone 7

- Arsenic (**646 mg/kg**)
- Lead (2500 mg/kg)
- Free Cyanide (**40 mg/kg**)
- Complex Cyanide (**4750 mg/kg**)
- Benzo(a)anthracene (**52.4 mg/kg**)
- Benzo(a)pyrene (**38.2 mg/kg**)
- Chrysene (**53.1 mg/kg**)
- Dibenz(a,h)anthracene (**4.06 mg/kg**)
- Naphthalene (**20.6 mg/kg**)
- Aromatic C16-C21 (**1240 mg/kg**)
- Aromatic C21-C35 (**3240 mg/kg**)

SVOC TICs were noted in three samples (TP502 at 1.50 - 1.60 m, CP702 at 1.50 - 1.60 m and TP705 at 1.50 - 1.60m). Relatively low concentrations of other PAH species were also detected within the SVOC suite above LOD on samples of Made Ground. However, no residential with plant uptake human health GAC are available.

These species include dimethyl phthalate, butylbenzyl phthalate, dibenzofuran, carbazole, bis(2-ethylhexyl)phthalate, 3+4-methylphenol, 2-methylphenol, 2,4- methylphenol 2-methylnaphthalene, perylene. No VOC TICs were identified. VOC detections above LOD were noted for 1,2,4-trimethylbenzene.

Carbon disulphide was detected above the LOD in 2 samples (TP506 at 1.50 - 1.60 m, TP705 at 1.5-1.6m) of Made Ground at concentrations of **9 µg/kg** and **3 µg/kg**. There is considered to be no significant risk at the reported levels. However, should higher levels be identified during remedial works, the contractor should seek to remove these sources if deemed a risk to ensure no risk remains to the end user.

Based on the fact that Zones 5 and 7 are not considered to be impacted by the same widespread contamination as is seen on the Manox sector, it is deemed appropriate to address the various above-stated elevated contaminant concentrations by a 'hotspot' removal exercise which seeks to identify the affected soils, delineate and chemically validate the remaining soils with the excavated soils also validated and placed in an area of lesser sensitivity.

In the case of heavy metals, non-volatile PAH and heavy-end TPH compounds, the viable exposure pathway is associated with direct contact, consumption of homegrown vegetables and ingestion of soil. The proposed development of the site will include a hard cover and the importation of certified subsoil and topsoil in areas of private gardens and landscaping to a minimum 700mm of clean cover, (inclusive of granular break layer), thus removing this pathway.

Drawing 13-887-035 (Appendix III) denotes human health soil exceedances.

2.4. CONTROLLED WATERS CONTAMINATION RISK SUMMARY (ENTIRE SITE)

The E3P review of the factual ground investigation data and subsequent assessment of the identified contamination impact associated with the prolonged and significant industrial land use has confirmed extensive contamination impact within the area of the former Manox facility in particular.

Impact with Zone 7 and 5, associated with contaminants within the solid phase, is considered a secondary source and is notably reduced in terms of the contaminant load. This is represented by reduced dissolved phase impact, especially within the deeper groundwater monitoring wells. The monitoring wells in Zone 7 and 5 are considered to be generally down-gradient of the primary source (Manox) and clearly demonstrate significant reduction, which is indicative of the low mobility of the identified compounds of concern.

The two development parcels Zones 7 and 5, to the south of Manox, have not been subject to the same historical industrial land use, however, waste materials appear to have been deposited within former clay pits, which is contributing to some impact to controlled waters.

The Environment Agency (EA) website (accessed October 2013) shows the superficial deposits underlying the Site (Glacial Till) to be classified as unproductive strata. These generally relate to deposits with low permeability which are likely to reduce or prevent vertical migration, however it should still be noted that this is a groundwater body that is likely to flow with topography. With this in mind, it should still remain a consideration that a possibility exists of influence and impact from the adjacent main Manox site once remediation of this parcel commences and the current possible flow-pathway to the Rochdale canal is removed or reduced by the installation of the sheet pile wall.

Bedrock underlying the site (Upper Coal Measures strata) is classified as a Secondary A aquifer (aquifers formerly classified as minor aquifers). Secondary A aquifers are described as permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers. The Environment Agency indicates that the site is not located within a Groundwater Source Protection Zone for a public water supply abstraction.

The underlying coal measures aquifer is determined to be of reduced sensitivity due to elevated suspended soils and iron concentrations that are a direct result of prolonged coal mining.

The former mine entry in Zone 7 is identified as a conduit/preferential pathway to the aquifer; this feature will be subject to pressure grouting to remove the identified exposure pathway.

The Environment Agency has classified the current (2009) and predicted (2015) quantitative (yield) groundwater status as required under the Water Framework and Groundwater Directives 1 as poor. The Environment Agency has classified the current (2009) and predicted (2015) qualitative (chemical) groundwater status as deteriorating (poor) and poor, respectively.

During the historical ERM investigations (2009) only perched water within Made Ground deposits was encountered; this was largely confirmed by the 2019 RSK ground investigations. It is therefore considered that a perched water table is present, however its lateral and vertical migration is impeded by the clay aquitard which is proven to underlie the site to depths of circa 13.00 m bgl. No groundwater monitoring installations are installed within the granular horizons; however, this is not considered a viable aquifer, furthermore, no deep monitoring wells are installed within the coal measures.

Given the presence of low permeability clay deposits beneath the Made Ground, it is considered extremely unlikely that the shallow perched water encountered, will be in hydraulic continuity with the coal measures aquifer.

When considering the initial CSM and chemical structure of the key metalloids, inorganic salts (primarily cyanide), PAH and TPH compounds have reduced mobility when compared to other compounds that are known to have a greater potential for vertical and lateral migration.

The ground investigation data to date identify aromatic solvents, however, no chlorinated or halogenated compounds are identified; again, this corresponds with the site conceptual site model.

The primary contaminant groups are associated with aromatic hydrocarbons derived from the processing and refinement of coal tars and the resulting residues and inorganic and organic compounds (salts) either used in the refinement process or as a result of the chemical production.

During the historical site investigation works undertaken, the most common observations of impacts within the soil arisings included blue/green staining of fill materials and associated perched water; and dark brown/black staining of fill materials and the upper clay units, sometimes associated with oil/tarry odours. Again, these visual observations generally match the known contaminant grouping and chemical test data.

Anecdotal information suggests historical service clearance works reported drains as being blocked with a blue / black silty clay material and some of the water observed in the channels was blue in colour. Several chambers were also observed to have rubble and general waste in them, and the service clearance contractor noted during the works that the main chamber prior to off-site discharge was damaged.

Field observations and historical information confirm the presence of tar materials on-site, which comprise mainly TPH and PAH compounds. These tar materials appear to be in the mapped former tar channel beneath the site, albeit the exact location of the tar channel has not yet been identified. Previous investigations concluded the channel has been backfilled with granular fill, which was observed to be impacted with thick, black, glossy DNAPL with a tarry odour.

ERM reported that in 2008/2009 Manchester City Council report the egress of a potassium-like substance from the northern site boundary with the canal. Works were reportedly completed to ensure the area was made safe and no viable exposure of direct contact was possible. This anecdotal evidence confirms the presence of chemical waste materials that must be considered a primary source of contamination impact.

E3P has completed an updated Tier 1 controlled waters risk assessment; this highlighted the prevalence of cyanide throughout the Made Ground in the Manox site at significant concentrations within the soil matrices that represent an ongoing and persistent source of pollution.

Arsenic and lead are locally impacted in discreet locations and considering their widespread presence in the soils and the potential for leaching, these compounds have also been considered from a controlled waters perspective.

Significant concentrations of SVOCs associated with the refinement of coal tar are identified within the solid and aqueous phases within all phases of historical ground investigation works. It should be noted that the contaminant load within both solid and perched water are dramatically reduced within all forms of sampling in Zone 7 and 5 to the south, indicating a lack of mobility and migration, which is to be anticipated when looking at the fate and transport of these compounds.

The deeper groundwater monitoring wells installed by RSK indicate an absence of significant or gross contamination impact within the underlying superficial drift deposits, which when considering the light non aqueous characteristics and relatively reduced solubility is to be anticipated.

The results of the historical data review and Tier 1 qualitative risk assessment has allowed E3P to draw the following conclusions in respect to the risk to controlled waters:

- There have been extensive multiple phases of historical ground investigation; this has enabled a detailed assessment of the site and reasonable characterisation of the pollution risk and potential to impact the critical receptor;
- The primary receptors are identified as the Canal to the north and culverted Shooters Brook to the south;
- The Canal is ‘cut’ into the glacial till clay aquitard, however when considering the detailed hydrological model, it would appear that the canal also loses water to the site and is contributing to the perched water flow across the low permeability clay to the south towards Shooters Brook;
- It is probable that impact to the canal will occur through migration of perched water in conduits such as relict drainage infrastructure as opposed to an actual dissolved phase plume and groundwater migration;
- Confined perched waters at a higher elevation that egress via conduits from the canal will be removed during the remediation works to negate this identified pollution pathway;
- Shooters Brook is at least 150m south; monitoring of installations immediately adjacent to the primary source area suggests that there is a significantly reduced contaminant load immediately adjacent to the site boundary. When considering the operational period of the Manox facility (>100yrs), the absence of gross contamination at the boundary substantiates the suggestion that lateral (down hydraulic gradient) migration is reduced;
- The underlying aquifer is not considered a high-risk receptor given the significant depth of glacial clay. In addition, it is noted that four mines are present directly beneath the site, therefore the groundwater will be of poor quality; and,
- The primary area of concern is the Manox site; numerous primary sources of pollution remain in the form of tar channels, chemical waste, tanks, drainage infrastructure and significantly impacted soils.

Based on the Tier 1 controlled waters risk assessment, there exists a theoretical risk to controlled waters and remediation of the impacted soils is required to ensure there is no residual risk to the controlled water receptors following the completion of the remedial works. It is considered that the most appropriate form of validation with respect to controlled waters for the contaminants of concern would be to generate site specific screening levels using the EA P20 RTM. This Tier 2 detailed controlled waters risk assessment is included in Section 3.0.

2.5. GROUND GAS

Ground gas has not been assessed by E3P as part of the E3P Site Characterisation Assessment.

As such, post-remediation ground gas monitoring is recommended to update the initial classification given by RSK / Westlakes in 2019 of CS2 / Amber 1. The presence of semi-volatile compounds in the soils suggests the possible requirement for a vapour analysis at the site, with subsequent gas sample analysis.

Vapour membranes may be required within the construction of new residential dwellings, to break the vapour release to indoor air pathway to residential end users, from the site-wide VOC impact. The use of vapour membranes will be determined in the post-enabling works VOC vapour risk assessment.

The assessment should be completed in accordance with the methodology outlined within the CIRIA publication C665, utilising the results of the ground gas monitoring surveys to calculate a tentative gas screening value (GSV

The GSV should be compared to the criteria outlined with CIRIA C665 to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

Ground gas monitoring and assessment to date suggest that the site can be predominantly classified as CS2, and in these areas, it is considered that gas protection measures will be required. However, the final classification will be confirmed following a phase of post-remediation gas monitoring.

2.6. POTABLE WATER SUPPLY INFRASTRUCTURE

A contaminant risk assessment completed in accordance with the UKWIR assessment framework identified elevated concentrations of potentially volatile/soluble hydrocarbon compounds and it will be necessary to delineate the impacted soils where present at locations that could potentially impact the potable water infrastructure should be suitable to remediation with robust validation testing.

If unacceptable concentrations remain post-remediation, then potable water infrastructure should be constructed in accordance with a suitably robust risk assessment and design compliant with UKWIR.



3. DETAILED CONTROLLED WATERS RISK ASSESSMENT

The hydrocarbon impact within the Made Ground in the location of the tar channel on the Manox site is considered to pose a potential long-term risk to the identified receptors (Rochdale Canal and Shooters Brook) associated with the leaching and mobilisation of potentially soluble compounds, which could eventually generate a complete pollutant linkage.

Subject to the removal of all significantly impacted soils, the disposal off-site of the separate phase coal tar and removal of a small quantity of perched groundwater (if present) with subsequent validation to demonstrate compliance with a set of Site Specific Remediation Targets (SSRTs) for the protection of controlled waters, the site can be delivered and remediated in a manner that would ensure the land poses no significant risk to controlled waters or the wider environ.

In light of the potential for the creation of a complete pollutant linkage, E3P has developed SSRTs to facilitate a further informed understanding to which the site poses a serious risk to controlled waters and the wider environ.

This Tier 2 Quantitative Risk Assessment has been completed to provide a series of site derived validation criteria which may be utilised to validate soils which have undergone remediation.

The Tier 1 controlled waters risk assessment alongside the human health risk assessment, has determined the following compounds of potentially soluble/mobile hydrocarbon compounds could present a theoretical risk to the identified receptors:

CONTAMINANT EXCEEDANCE	
Arsenic	TPH Aromatic C8-C10
Lead	TPH Aromatic C10-C12
Copper	TPH Aromatic C12-C16
Cyanide	TPH Aromatic C16-C21
Benzene	TPH Aromatic C21-C35
2-methylnaphthalene	TPH Aliphatic C8-C10
Dibenzofuran	TPH Aliphatic C10-C12
Carbazole	TPH Aliphatic C12-C16
Naphthalene	TPH Aliphatic C16-C21
	TPH Aliphatic C21-C35

The DQRA has been undertaken using the soil and groundwater data obtained over the various phases of works in order to calculate RTM values for the shallow soils and groundwater to model the theoretical migration of the identified contaminants through the drift deposits and into the Rochdale Canal, Shooters Brooke or to the underlying Secondary A Aquifer.

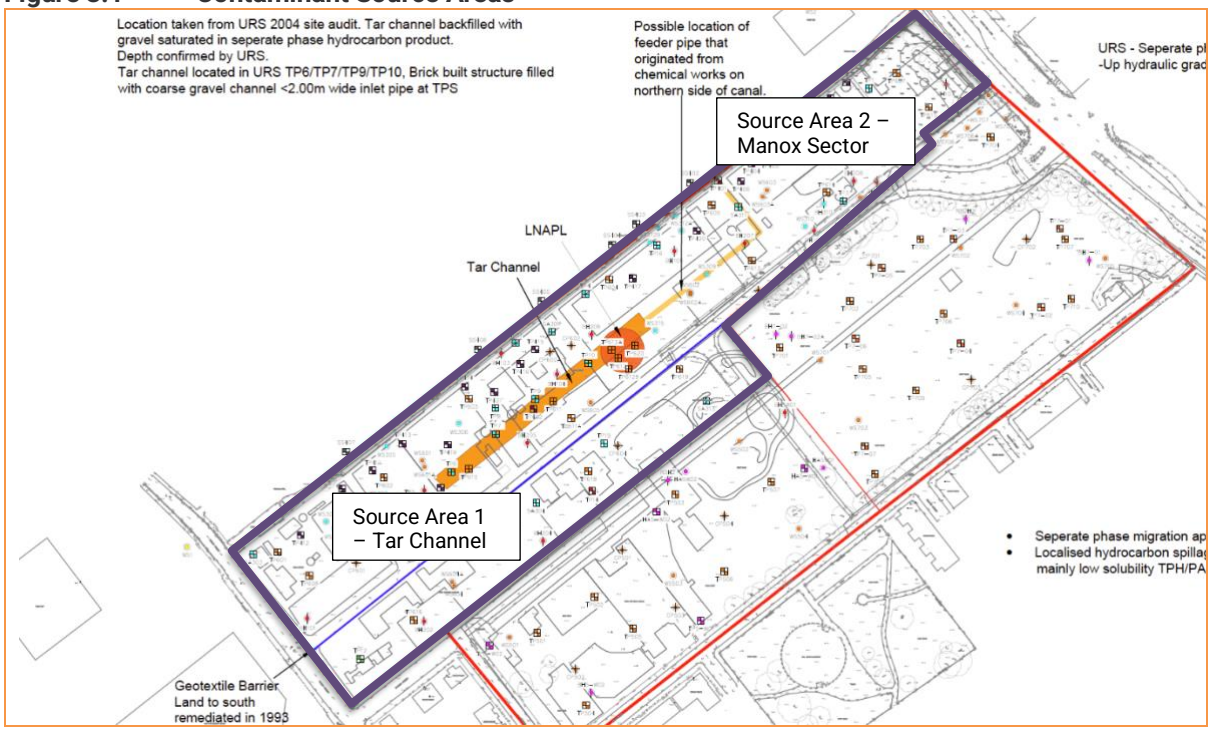
Two separate contaminant sources have been identified as follows:

- **Source Area 1 – Tar Channel:** The tar channel, present in the Manox sector of the site, is mapped as being 10m wide and 100m in length. This is the location where the elevated TPHs and coal tar derived substances have been identified. Whilst the exact location of the tar channel has yet to be identified, this may still be modelled to generate appropriate site-specific screening values to allow the remediation of this locality and remove the current risk to controlled waters. The modelling of this source area will look at the aliphatic and aromatic hydrocarbon fractions, naphthalene, benzene, 2-methylnaphthalene, dibenzofuran, carbazole and naphthalene.

- **Source Area 2 – Manox Sector:** This source area is more widespread than Source Area 1, due to the identified presence of inorganic metalloid contamination across this sector that will require addressing as part of the remediation of the site. The modelling of this source area will look at only arsenic, lead, copper and cyanide.

Figure 3.1 identifies the two source areas which will be modelled. Source Area 1 is denoted by the orange channel and Source Area 2, the purple border surrounding the Manox sector.

Figure 3.1 Contaminant Source Areas



3.1. DISCUSSION OF PHYSICAL PARAMETERS

Detailed groundwater modelling has been undertaken during the previous ground investigations.

Groundwater strikes were encountered within a number of exploratory holes at the base of the Made Ground, perched on the cohesive drift deposits. Groundwater is considered to flow to the south east (away from Rochdale Canal), therefore the compliance point of **30m** from the contaminant source to Rochdale Canal is considered to be conservative.

Deep groundwater was not encountered in the glacial till during previous investigations. The glacial till is considered to inhibit migration to the controlled water receptors.

The hydraulic gradient at the site has been calculated using levelling data to be 0.01. E3P has also utilised soil analysis data for SOM within the Made Ground as obtained within the previous ground investigations. SOM was measured at a range of 2.2% to 25.9%, used to obtain a Fraction Organic Carbon (FOC), returning a value of **0.0812**.

Additionally, E3P has reviewed the annual rainfall data on the Met office for the area and taking into account evapotranspiration and the proposed development containing a large volume of hardstanding and residential buildings, a 1% infiltration figure has been calculated as **0.0000147**.

Further details regarding the various physical and chemical inputs required for the DQRA are included within Table 3.1 and 3.2.

Table 3.1 DQRA Physical Input Parameters

Parameter	Value	Source	Justification
Method of calculating partition co-efficient	Non-polar Organic Chemicals		
Analytical Solution	Ogata Banks		
Degradation Conditions (aerobic / anaerobic)	Assumed anaerobic conditions to remain conservative		
Level Three - Groundwater			
Pathway Aquifer	N/A	N/A	Migration is assumed to be via the clay loam to the Rochdale Canal or Secondary A Aquifer
Saturated aquifer thickness (m)	1.30	Estimate from borehole data	Approximation based on ground conditions encountered on site within boreholes.
Bulk density of aquifer materials (g/cm^3)	1.14	SR3	Taken from the value for clay loam within the Updated Technical Background CLEA-SR3
Air filled porosity (cm^3/cm^3)	0.14	SR3	Taken from the value for clay loam within the Updated Technical Background CLEA-SR3
Water filled porosity (cm^3/cm^3)	0.42	SR3	Taken from the value for clay loam within the Updated Technical Background CLEA-SR3
Effective porosity of the aquifer (cm^3/cm^3)	0.56	SR3	Taken from the value for clay loam within the Updated Technical Background CLEA-SR3
Hydraulic gradient	0.01	Site Data	Calculated using site levelling data
Hydraulic conductivity of the aquifer (m/d)	1.3	SR3	Taken from the value for clay loam within the Updated Technical Background CLEA-SR3
Distance to compliance point (m)	30	Site Compliance Point	The compliance point is believed to be the distance to Rochdale Canal from the source area
Assumed groundwater flow direction	SE	Site Data	Based on site data and groundwater modelling
Fraction Organic Carbon in aquifer (FOC)	0.0812	Site Data	Based on site soil samples.
Source Area 1 – Tar Channel			
Width of plume in aquifer at source (m)	10	Site Data	Based on site data and observations.
Length of plume in aquifer at source (m)	100	Site Data	Based on site data and observations.
Source Area 2 – Manox Sector			
Width of plume in aquifer at source (m)	86	Site Data	Based on site data and observations.
Length of plume in aquifer at source (m)	412	Site Data	Based on site data and observations.
Plume thickness at source (m)	1.3	Calculated within RTM	This value is calculated from the mixing thickness within the Level 2 soils in the RTM model

Table 3.2 General DQRA Chemical Input Parameters

Contaminant	Koc (l/kg)	Kd	Source	Anaerobic Deg. Half-life (d)	Aerobic Deg. Half-life (d)	Source	Henry's Law	Source
TPH Aliphatic C8-C10	30199.5172	-	LQM-CIEH	228	10	Conservative Estimate	41.5	LQM-CIEH
TPH Aliphatic C10-C12	239883.29	-	LQM-CIEH	112	28	Conservative Estimate	64.4	LQM-CIEH
TPH Aliphatic C12-C16	5370317.964	-	LQM-CIEH	3650	3650	Conservative Estimate	171	LQM-CIEH
TPH Aliphatic C16-C21	5754399373	-	LQM-CIEH	8560	8560	Conservative Estimate	1070	LQM-CIEH
TPH Aliphatic C21-C35	5754399373	-	LQM-CIEH	8560	8560	Conservative Estimate	1070	LQM-CIEH
TPH Aromatic C8-C10	1584.8932	-	LQM-CIEH	228	10	Howard et al-Ethylbenzene	0.253	LQM-CIEH
TPH Aromatic C10-C12	2511.8864	-	LQM-CIEH	258	258	Howard et al-Xylene (m)	0.0722	LQM-CIEH
TPH Aromatic C12-C16	5011.872	-	LQM-CIEH	1840	920	Conservative Estimate	0.00126	LQM-CIEH
TPH Aromatic C16-C21	14125.375	-	LQM-CIEH	7300	1898	Conservative Estimate	0.000695	LQM-CIEH
TPH Aromatic C21-C35	125892.541	-	LQM-CIEH	2117	530	Conservative Estimate	0.0000248	LQM-CIEH



Contaminant	Koc (l/kg)	Kd	Source	Anaerobic Deg. Half-life (d)	Aerobic Deg. Half-life (d)	Source	Henry's Law	Source
Benzene	67.6083	-	LQM-CIEH	730	16	Howard et al Benzene	0.116	LQM-CIEH
2-methylnaphthalene	2450	-	LQM-CIEH	360	28	Howard et al – 2-methylnaphthalene	0.0722	LQM-CIEH
Carbazole	5011.872	-	LQM-CIEH	28	7	Howard et al – Carbazole	0.00126	LQM-CIEH
Dibenzofuran	5011.872	-	LQM-CIEH	28	7	Howard et al - dibenzofuran	0.00126	LQM-CIEH
Naphthalene	645.65	-	LQM-CIEH	258	20	Howard et al Naphthalene	0.00662	LQM-CIEH
Arsenic	-	500	LQM-CIEH	9.99E+99	9.99E+99	EA	0	EA
Cyanide	-	100	LQM-CIEH	9.99E+99	9.99E+99	EA	0	EA
Copper	-	100	LQM-CIEH	9.99E+99	9.99E+99	EA	0	EA
Lead	-	500	Estimate	9.99E+99	9.99E+99	EA	0	EA

Existing concentrations in the soil and groundwater have been selected from the worst contaminated areas in the Manox sector.

With respect to the organic contamination in **Source Area 1** (Tar Channel), soil and groundwater concentrations have been selected from historical site investigation laboratory results from the locality of the tar channel, with the maximum concentrations taken for each contaminant of concern. The source area has been taken as the mapped area of the tar channel (10m x 100m).

With respect to the inorganic contamination in **Source Area 2** (Manox sector), input concentrations have been taken from the maximum soil concentrations in historic site investigation data with the model also run using leachate concentrations that have been utilised as worst-case scenario concentrations for the treatability trials undertaken by McAuliffe (detailed in the latter stages of this report). In relation to the leachate results taken from the treatability studies, these have been taken from the 'mix 5' concentrations as this mix is representative of the vast majority (90%) of the manox area soils in general, and removes the cyanide concentrations in soils which will not be suitable for stabilisation/solidification and will require removal off-site.

The source area is considered to be widespread across the Manox sector. It is important that with a remediation of this nature, a balance is achieved between successful validation and viability, to ensure the site may be remediated successfully, validated and delivered for residential development with the full protection to human health, controlled waters and the wider environs . With this in mind, with regards the inorganic metalloid contamination known to be present across the Manox sector, two sets of remedial target values are to be calculated:

- Entire Manox area (86m x 412m) – this will enable a set of values to be calculated that will be directly attributable to the entire sector as a whole, with values on a lower margin however in the vast majority of soils, will be largely achievable.

- A modelled 10m x 10m square – this will enable a set of values to be produced which are calculated utilising representative ground conditions and soil/leachate results to ensure a true representation of the contaminant makeup of the soils present in the Manox sector, but that are of a higher margin. Therefore for those soils which may be more contaminated with inorganic metalloids and which may not be able to be remediated to meet the remedial targets generated from the entire site area, to enable the successful remediation and validation in a cost effective manner but still ensuring the protection of controlled waters (and human health/wider environ), these set of remedial targets may be utilised.

Table 3.3 Maximum Site Concentrations in Soil

Contaminant	Max Conc in Soil (mg/kg)	Site Source
Source Area 1 – Tar Channel		
TPH Aromatic C8-C10	300	TP606
TPH Aromatic C10-C12	48000	TP606
TPH Aromatic C12-C16	14300	TP606
TPH Aromatic C16-C21	4400	TP606
TPH Aromatic C21-C35	2400	WS503
TPH Aliphatic C8-C10	20	WS603A
TPH Aliphatic C10-C12	425	TP606
TPH Aliphatic C12-C16	504	TP606
TPH Aliphatic C16-C21	1170	TP420
TPH Aliphatic C21-C35	7560	TP420
2-methylnaphthalene	252	TP606
Dibenzofuran	237	WS603A
Carbazole	19.8	WS603A
Naphthalene	819	WS603A
Source Area 2 – Manox Sector		
Arsenic	4810	TP611
Cyanide	8270	WS603A

Copper	42000	WS606
Lead	6690	TP607

Table 3.4 Maximum Site Concentrations in Groundwater/Leachate

Contaminant	Max Conc in Groundwater (mg/l)	Site Source
Source Area 1 – Tar Channel		
TPH Aromatic C8-C10	4.306	WS603
TPH Aromatic C10-C12	1.761	WS603A
TPH Aromatic C12-C16	5.706	WS603
TPH Aromatic C16-C35	0.815	WS603
TPH Aromatic C21-C35	0.815	WS603
TPH Aliphatic C8-C10	0.005	TP406
TPH Aliphatic C10-C12	0.037	TP406
TPH Aliphatic C12-C16	0.108	TP406
TPH Aliphatic C16-C21	0.087	TP406
TPH Aliphatic C21-C35	0.94	TP406
2-methylnaphthalene	0.059	WS603A
Carbazole	0.021	WS603A
Dibenzofuran	0.048	WS603A
Naphthalene	0.0081	WS603A
Source Area 2 – Manox Sector		
Arsenic	0.0085 (Leachate)	TP816 (mix 5 treatment trials)
Cyanide	0.34 (Leachate)	TP816 (mix 5 treatment trials)
Copper	0.0071 (Leachate)	TP816 (mix 5 treatment trials)
Lead	0.01 (Leachate)	TP816 (mix 5 treatment trials)

3.2. RESULTS

The results of the risk assessment are summarised in Table 3.5.

The results provide remediation target concentrations for the soils and groundwater which may be used for validation purposes following the remediation of the impacted Made Ground.

Table 3.5 Results

Contaminant	Source Concentration used in RTM Model		Level 3 Remedial Target Concentration		
	Soils (mg/kg)	Waters/Leachate (mg/l)	Soils (mg/kg)	Waters/Leachate (mg/l)	Waters/Leachate (ug/l)
Source Area 1 – Tar Channel					
TPH Aromatic C8-C10	277	4.306	1060	**0.854**	854
TPH Aromatic C10-C12	48100	1.761	**1920**	**0.959**	959
TPH Aromatic C12-C16	14300	5.706	**30.8**	**0.0102**	10.2
TPH Aromatic C16-C21	4440	0.815	**717**	**0.164**	164
TPH Aromatic C21-C35	4560	0.815	18300	**0.456**	456
TPH Aliphatic C8-C10	20	0.005	304000	12.8	12800
TPH Aliphatic C10-C12	425	0.037	1.99 E+07	119	119000
TPH Aliphatic C12-C16	504	0.108	4.01E+06	0.796	796
TPH Aliphatic C16-C21	1170	0.087	3.79 E+09	0.695	695
TPH Aliphatic C21-C35	7560	0.94	3.79 E+09	0.695	695
2-methylnaphthalene	252	0.059	3340	164000	164000000
Carbazole	19.8	0.021	2.89E+8	6.84E+12	6.84E+15
Dibenzofuran	237	0.048	2.89E+8	6.84E+12	6.84E+15
Naphthalene	819	0.0081	1660	3.91E+6	3.91E+9

Contaminant	Source Concentration used in RTM Model		Level 3 Remedial Target Concentration		
	Soils (mg/kg)	Waters/Leachate (mg/l)	Soils (mg/kg)	Waters/Leachate (mg/l)	Waters/Leachate (ug/l)
Source Area 2 – Manox Sector (10m x 10m grid)					
Arsenic	4810	0.0085	**1090**	2.18	2180
Cyanide	8270	0.34	**2190**	2.18	2180
Copper	933	0.0071	**21.9**	0.218	218
Lead	6690	0.01	**1090**	2.18	2180
Source Area 2 – Manox Sector (entire sector)					
Arsenic	4810	0.0085	**28.4**	0.0568	56.8
Cyanide	8270	0.34	**5.7**	**0.0568**	56.8
Copper	933	0.0071	**0.57**	**0.00568**	5.68
Lead	6690	0.01	**28.4**	**0.0568**	56.8

Remediation Target Concentrations have been produced from the RTM model, which may be used to compare validation samples of the soil and groundwater following remediation of the impacted soils to confirm there will be no long-term risk to the controlled water receptors.

Source Area 1 – Tar Channel

The results of the P20 modelled for Source Area 1 (Tar Channel) indicate that for TPH Aromatic C8-C35 fractions, based on existing conditions in the tar channel, the concentrations on site exceed the site-specific remedial targets, therefore a significant risk to controlled waters exists from the site in its current condition.

The site is to undergo a widespread phase of remediation and enabling works, during which the tar channel will be identified, delineated, excavated in its entirety and chemically validated with any separate phase coal tar being disposed of off site. Any materials to remain on site will be chemically validated to ensure they do not exceed the site derived target values.

With this in mind, the current exceeding values for the Aromatic TPHs will no longer pose a risk to controlled waters and it is considered the tar channel area can be suitably remediated.

Source Area 2 – Manox Sector

The results of the modelling for the Manox sector have generated two sets of site specific screening values; one utilising a modelled 10x10m grid and a second set using the actual measured area of the Manox sector, in order to ensure a suitable and deliverable remediation and validation programme.

The model has been completed utilising the worst inorganic metalloid contamination identified within monitoring results in the soils to generate soil remedial targets, along with leachate concentrations from the treatment trials mix 5, which represent the vast majority of the soils across the Manox sector (circa 90%).

The results from the modelling indicate that for the soils, currently the concentrations present exceed the remedial target values and thus pose a risk to the controlled water receptors and remediation works are required. For the water/leachate results however, using the model for the entire Manox sector, cyanide, copper and lead currently exceeds for leachate, however only marginally, and for arsenic, the remedial target is below the current concentrations. Furthermore, when looking at the model using the 10m x 10m square, none of the current leachate concentrations exceed the leachate remedial targets.

Looking also at the treatment trials that have been completed by McAuliffe and specifically, at the ‘mix 5’ trials which represents the vast majority of the soils present within this sector, looking across the 64 day leachate tank test, no breakthrough is noted that exceeds the calculated remedial target concentrations, confirming that these inorganic metalloid impacted soils may be successfully remediated to ensure the full protection of controlled waters.

Whilst there may be more contaminated soils present at the site, during the course of the remediation and enabling works, which will involve the stabilisation and solidification of contaminated soils across the Manox sector, soils which are not able to be stabilised suitably to remove the leaching risk and thus may still pose an unacceptable risk to controlled waters, will be disposed of off-site.

It should be noted however that the calculated remedial targets have also been compared to the treatment trial tank test for 'mix 14' which represents the worst contaminated materials (circa 10% of the contaminated materials) and, with the exception of the cyanide concentrations, the remedial targets calculated for the 10m x 10m square indicate that these materials may be successfully stabilised and solidified. Cyanide concentrations are significant in these soils however and limited treatment trials to date of this significantly contaminated material indicate that they may not achieve the remedial targets, and in this case, further stabilisation trials will be undertaken on these soils to determine an alternative solution, to ensure any remaining soils pose no unacceptable risk to controlled waters.

The treatment trials as referenced above are explained in further detail in the latter stages of the report and the full report is available in Appendix VIII.

4. REMEDIATION OPTIONS APPRAISAL

A remediation options appraisal has been completed in accordance with the principles as set out within the Environment Agency publication Land Contamination: Risk Management (LC:RM) (updated 2021).

The LC:RM requires that the following tiered assessments are followed to ensure a sufficiently detailed and robust appraisal of remediation options to inform the selection of the preferred approach and utilisation of the correct technologies to promote safe and sustainable land remediation:

- Identification of feasible remediation technologies;
- Detailed evaluation of viable options; and,
- Selection of appropriate remediation options.

4.1. DETERMINATION OF SUFFICIENCY OF INFORMATION

Before the commencement of the tiered assessment of remediation options, it is a requirement to assess the sufficiency of available information and the validity of the risk-based assessment on which the remediation options appraisal is based.

Intrusive ground investigation works completed to date are considered sufficient to fully understand the risks to future end users, controlled waters and the wider environ.

4.2. IDENTIFICATION OF FEASIBLE REMEDIATION OPTIONS

4.2.1. OBJECTIVES

The remediation works must be completed safe and sustainably, ensuring that the site's post-remediation condition poses no unacceptable risk to controlled waters or the wider environs. The developed Conceptual Site Model must provide no complete pollutant linkage to ensure successful implementation.

The remediation works must be completed to promote the sustainable re-use of material in a manner that minimises waste and maximises retention of material on-site.

The works should be designed and implemented to ensure no unacceptable risk to an identified receptor during the works in terms of odour, air quality or noise impact.

Works should be designed, planned and implemented to ensure full compliance with all pertinent waste management and environmental permit legislation.

4.2.2. AVAILABLE TECHNOLOGIES

Potential remedial technologies that can be applied to remediate the identified contaminants of concern are summarised in Table 4.1. The remedial techniques would potentially break any source-pathway-receptor linkages, thereby reducing the risk to human health from vapour inhalation to acceptable levels.

TABLE 4.1 SOIL REMEDIATION TECHNOLOGIES

REMEDIAL TECHNOLOGY	CLASSIFICATION	APPLICATION	MEDIUM	LINKAGE ELEMENT AFFECTED
Capping	Containment	In situ	Soil	Pathway interruption
Electro-remediation	Physical	In situ / ex situ	Soil	Removes source
Soil washing	Physical	Ex situ	Soil	Source management
Soil vapour extraction	Physical	In situ	Soil	Removes source
Ex-situ bioremediation	Biological	Ex situ	Soil	Removes source
Thermal desorption	Thermal	Ex situ	Soil	Removes source
Vitrification	Thermal	In situ	Soil	Removes source / breaks pathway
Stabilisation / Solidification	Chemical	In situ / ex Situ	Soil	Pathway Interruption
Excavation and offsite disposal	Civil Engineering	Ex situ	Soil / groundwater	Removes source
Enhanced Bioremediation	Chemical / Biological / Natural attenuation	In situ	Soil / groundwater	Removes source / breaks pathway
Monitored Natural Attenuation	Natural attenuation	In situ	Soil / groundwater	Pathway interruption / eventual removal of source
Vacuum Enhanced Recovery	Physical / Chemical	In situ	Soil / groundwater	Removes source / breaks pathway
Air sparging / Biosparging	Physical / Biological	In situ	Soil / groundwater	Removes source / Pathway interruption
In situ oxidation	Chemical	In situ	Soil / groundwater	Removes source / Pathway interruption

4.2.3. SELECTION OF TECHNOLOGY OPTIONS

Several remedial technologies have been considered in addressing the contaminant linkages of concern identified at the site, as summarised in Table 3.2.

To assess which of these technologies are most viable for this project, each technology has been reviewed based on applicability, permissibility, cost, timescale and acceptability (including sustainability).

A combination of remediation solutions and technologies will be required to address and treat the numerous contamination issues identified on this site.

Aspects of sustainable remediation are also included within the review element of applicability.

Sustainable remediation is 'the practice of demonstrating, in terms of environmental, economic and social indicators, that the benefit of undertaking remediation is greater than its impact and that the optimum remediation solution is selected through the use of a balanced decision-making process', (as defined within 'A Framework for Assessing the Sustainability of Soils and Groundwater Remediation', produced by Sustainable Remediation Forum UK, dated March 2010).

TABLE 3.2 ASSESSMENT OF REMEDIATION TECHNOLOGIES APPLICABILITY

REMEDIAL TECHNOLOGY	APPLICABILITY	REGULATORY APPROVAL / PERMITRY	COST	TIME-FRAME	SCORE	SUITABILITY COMMENT
Capping	5	5	5	5	20	Essential remediation solution to remove direct exposure pathways.
Electro-remediation	1	1	1	1	4	Technique unlikely to treat identified contaminants of concern in an efficient manner.
Soil washing	1	1	1	1	4	Technique unlikely to treat identified contaminants of concern in an efficient manner.
Soil vapour extraction	1	1	1	1	4	Soils to be remediated by excavation for geotechnical purposes meaning such a solution is limited in terms of viability.
Ex-situ bioremediation	4	4	3	3	14	Considered viable to treat soils to ensure residual concentrations pose reduced risk in terms of vapour inhalation and migration in dissolved phase to controlled waters.
Thermal desorption	1	2	2	2	7	Limited application due to nature and depth of material and ability to achieve required results.
Vitrification	1	1	1	1	4	Technique unlikely to treat identified contaminants of concern in an efficient manner.
Stabilisation / Solidification	4	4	4	4	16	The addition of stabilisation and binding agents will limit volatilisation and impede migration. Considered viable.
Excavation and offsite disposal	5	5	1	5	16	Limited by being cost prohibitive. Small quantities of material that cannot be treated or achieve the remediation parameters will be removed. Likely to form one aspect of the remediation approach.
Enhanced Bioremediation	4	4	1	3	12	Considered viable to treat soils to ensure residual concentrations pose reduced risk in terms of vapour inhalation and migration in dissolved phase to controlled waters.

REMEDIAL TECHNOLOGY	APPLICABILITY	REGULATORY APPROVAL / PERMITRY	COST	TIME-FRAME	SCORE	SUITABILITY COMMENT
Monitored Natural Attenuation	4	3	5	1	13	Likely to form one aspect of the remediation solution. Long term monitoring to demonstrate residual impact poses no significant and ongoing risk.
Vacuum Enhanced Recovery	1	1	1	1	4	Technique unlikely to treat identified contaminants of concern in an efficient manner.
Air sparging / Biosparging	1	1	1	1	4	Technique unlikely to treat identified contaminants of concern in an efficient manner.
In situ oxidation	3	3	3	3	12	Likely to form one aspect of the remediation solution. Limited ability to treat significant impact, however where isolated areas of notable organic impact present, this may provide a viable solution to treat aromatic, aliphatic and chlorinated impact to waters.

4.3. SUMMARY OF PREFERRED REMEDIATION OPTIONS

Based on the options appraisal, it is considered that the following combination of remediation technologies provides the most sustainable, viable and economic solutions that will ultimately result in the successful remediation for the site:

- Construction of low permeability **capping system** to limit infiltration of precipitation to reduce mobility of soluble phase impact and ensure no direct exposure pathway to future receptors.
- Construction of dwellings with **specialist membranes** and mitigation measures to ensure no ingress of volatile phase hazardous compounds into a dwelling;
- **Ex-situ bio-remediation** of materials excavated from the Manox sector and treatment on-site in accordance with a Mobile Treatment License (MTL) by a specialist contractor;
- **Solidification and stabilisation** to bind compounds within the soil matrix to reduce volatilisation and migration into the dissolved phase. Works to be completed by a specialist contractor in accordance with a MTL / EP;
- **Off-site removal** of hazardous materials (coal tar etc) which cannot be treated will be required; this operation needs to be limited to materials that cannot be treated on-site to promote sustainability and ensure viable regeneration.

4.4. REQUIREMENT FOR REGULATORY CONTROL

The LC:RM requires that due consideration be given to the following key issues, which will impact the appropriate selection of suitable remediation options.

- Requirement for regulatory permits;
- Noise restrictions;
- Odour control;
- Baseline ambient air quality; and,
- Weather conditions.

The proposed remediation works will require a detailed framework in terms of the Environmental Permit that will be used to recover and treat the waste materials from within the site to enable the remediation process. A standard rules permit with agreed enhanced monitoring will be implemented for the remediation works.

For Zones 5 and 7, the works are relatively straightforward. While they may still be covered by a specific Environmental Permit, it is considered that the processes outlined below will be applicable to the project.

The processing of recycled aggregates will be completed using a LAPC Part B licensed plant with the appropriate deployment notification to the local authority before commencement of works. All materials that are recovered as a recycled aggregate will be compliant with the requirements of the WRAP protocol and the E3P validation testing requirements and as such, would not be deemed to be waste material.

Where necessary, operations, as outlined within the remediation enabling works rationale summarised in this report, may be subject to regulation using the appropriate environmental permit, standard rules exemption and materials management plan, to be created under version 2 of the CL:AIRE *Definition of Waste: Code of Practice (DoW CoP)*.

It is noted that if the material is to be imported utilising the CL:AIRE DoW CoP from an alternative development site, then only chemically certified, clean, naturally occurring material can be transferred.



The Materials Management Plan (MMP) will be created with due consideration of all proposed remediation and enabling works operations prescribed within this document. It will be undertaken by a qualified person with a signed declaration submitted to the EA before re-use of materials on the site.

The importation of material for use within the proposed construction of a development platform will be subject to compliance with the E3P protocol for the importation of materials as set out within the specification for material import included in Appendix IV of this report.

It is considered that a suitable environmental permit can be obtained for the recovery, processing and re-use of material that is no longer considered a waste, therefore this is not a limiting factor in the selection of the remediation option.

4.4.1. NOISE RESTRICTIONS

Numerous sensitive receptors are identified in the form of residential dwellings to the periphery of the area that will be subject to remediation works. The Environmental Permit will seek to limit noise impact on the identified receptors.

The contractor's environmental plan of work will include boundary noise monitoring stations to assess the noise impact, daily monitoring and mitigation measures to ensure no unacceptable degree of impact to the identified receptors. Given that noise impact can be controlled, this is not considered a limiting factor in selecting the correct remediation option.

4.4.2. BASELINE AIR QUALITY AND ODOUR CONTROL

The remediation works to treat and recover the waste will be subject to an environmental permit; this will include detailed protocols for the mitigation of pollution emissions that could adversely impact the background air quality.

However, for the avoidance of doubt, the following protocol has been produced and will be followed by McAuliffe throughout the duration of the remediation works.

It has been recognised that the site is positioned in close proximity to residential properties and a primary school, therefore all odour control protocols have been produced with these sensitive receptors in mind.

Training will be provided to all relevant site personnel to ensure they are competent in completing olfactory assessment forms, which will ensure sufficient monitoring and reporting of odours can be undertaken.

Qualitative monitoring will be undertaken daily as a minimum. This information will be captured along with other emissions data, such as dust and noise levels, at six boundary monitoring points located around the site, in addition to four monitoring points in and around the treatment area. Odour levels will also be gauged at the work face during phases of excavation. The prevailing wind direction will also be monitored.

Olfactory testing will be routinely carried out by competent staff. The assessor should not:

- Smoke or consume strongly flavoured food or drink for at least 30 minutes before the assessment.
- Consume confectionary or soft drinks immediately before the assessment.
- Apply scented toiletries, such as perfume or aftershave immediately before an assessment.
- The starting point of this assessment should be down-wind of the site, progressing towards the site boundary and then away from the site in an upwind direction. The person completing the assessment should walk slowly and breathe as normal.



4.4.3. WEATHER CONDITIONS

Given the size and scale and variable remediation works required, it will be possible to ensure that the programme allows for a differentiation in operations to ensure works can proceed in areas depending on the prevailing weather for a specific period of time.

4.4.4. COMPLAINTS MONITORING

All odour complaints will be investigated promptly, and appropriate remedial action will be taken if the complaint is validated. Complaints will be recorded and retained on file.

Complaints to MCC and EA will also be recorded and acted upon. An olfactory assessment survey will be carried out from where the complaint was made and from any convenient locations between the complainant/receptor and the site so that the complaint is quantified. Immediate mitigation measures will be put into place, as detailed within the contingency plan in Section 10.0.

4.5. MCAULIFFE TREATABILITY SCOPE

McAuliffe have utilised samples obtained from the E3P supplementary Site Investigation in 2021. These samples were utilised in the treatability study (ref: MC2906, dated July 2022) to inform a remedial option for the soils within the Manox sector.

The pertinent points from such are included below.

Treatability studies, using the contaminated source materials from the site, although conducted over a relatively short time scale, are enough to understand the behaviour of the mixes and eliminate the potential for failures following full-scale treatment works.

Worst-case leachate testing has been undertaken on the treated materials, as the sample preparation involved a reduction in the particle size/structure of the S/S samples, thus eliminating the macro-encapsulation aspect of the treatment and so relying solely on chemical fixation processes at the microencapsulation level. This is beneficial in understanding potential longer-term behaviour should weathering effects impact the materials in the near-surface ground.

The McAuliffe study has shown there to be enough general reduction potential in the leachability of the worst case, although on the lower cyanide impacted materials present within the source soils, to be able to confirm that there are a number of suitable hydraulic binder system designs that can be used to achieve significant leachability performance, albeit with some modifications to mix designs presented here. It should also be noted that the study has confirmed that the use of the technique will improve the visual and olfactory nature of the most impacted materials likely to be present at the site.

The very high cyanide impacted soil hotspots need a separate assessment of mix design based on the results presented here. However, all the worst-case higher cyanide impacted materials only represent about 4% of the total soils to be treated using S/S across the site. Therefore, McAuliffe need to carry out an additional study on samples that represent the majority of soils to be treated in the full-scale works in order to confirm the most suitable mix design. The results presented here would suggest there are likely to be 3 mix designs adopted:-

- Mix 1. Hydraulic binder system for 96% of materials to be treated
- Mix 2. Hydraulic binder system for circa 2% (lower CN impacted) materials to be treated
- Mix 3. Combination system for circa 2% (very high CN impacted) materials to be treated.

Based on the treatability study, alongside the EA P20 RTM to generate site specific screening values, contaminated materials are deemed to be suitable for stabilisation/solidification. It has been demonstrated that these contaminated soils, once stabilised, will not pose a leaching risk that exceeds the site derived target values which are for the protection of controlled waters, and for those soils which cannot meet the targets (anticipated to be minimal), will be disposed of off-site to a suitable waste management facility.



5. SITE REMEDIATION AND ENABLING WORKS- AREAS 5 AND 7

5.1. REMEDIATION TECHNOLOGY

Considering the site-specific conditions, including the nature of the identified impacts, the geology and the objectives of the remediation, the most-appropriate soil remedial technologies are considered to be:

- Confirmation sampling within the area of blue staining indicating cyanide impact;
- Removal of soils impacted by complex and free cyanide for treatment;
- Removal of soils with volatile naphthalene and any elevated carbon disulphide not previously detected within chemical testing;
- Removal of visual and olfactory impacted soils for hydrocarbons;
- Validation of remediated (and existing) soils utilising both the site derived criteria for the protection of controlled waters and the remedial target values for the protection of human health;
- Full turnover to the base of Made Ground and removal of all surface and underground obstructions;
- Construction of a suitable cover system to mitigate the risk associated with non-volatile/insoluble compounds (to be completed by future developer); and
- Characteristic Situation 2 ground gas mitigation measures to ensure compliance with BS 8485 (2015)+A1(2019), with independent validation of each unit (to be completed by future developer). Post remediation gas monitoring will be required to confirm.

It is considered that these technologies and methodologies will address the identified active pollutant linkages, as detailed in the following subsections. For the avoidance of doubt, all remediation technologies have been written in direct correspondence with McAuliffe who are the chosen remediation contractor for the site.

5.1.1. CONTAMINANTS OF CONCERN (COC)

METALS, PAH, NON-VOLATILE HYDROCARBON (PETROLEUM RANGE) COMPOUNDS

The human health risk drivers for the carcinogenic PAHs and metal CoC are:

- Direct contact with the soil source by future on-site residents; and
- Ingestion of impacted soils by future on-site residents.

Therefore, a cover system is considered to be an appropriate remediation technique to address these impacts, as the installation of a cover system to unsurfaced areas of the site will sever the pathway of contact for human health receptors. A cover system is not considered to be required in future hardstanding areas or beneath buildings, as it can reasonably be assumed that the presence of a hardstanding will prevent direct contact. The cover system will be 700mm in depth with a granular 'no-dig' layer below the subsoil.

CARBON DISULPHIDE

No primary source of Carbon Disulphide is identified within Zone 5 and 7, however detectable traces of the compound are present.

Carbon disulphide (CS_2) is a toxic, dense non-aqueous phase liquid (DNAPL) that is both highly volatile and highly flammable (Kalin et al., 2005). It is present in the environment due to anaerobic activity in sediments (Moret et al., 2000 and Lovelock, 1974). Anthropogenic sources are considered to provide the primary source of CS_2 in the environment (Watts, 2000). Due to its high volatility and that it can ignite or explode when exposed to air (Kalin et al., 2005), remediation of CS_2 contaminated sites is difficult and hazardous. Therefore, the development of a remediation approach that removes CS_2 contamination from soil and groundwater without exposure to air is desirable.

The risk of a primary carbon disulphide source within the Manox site is considered to be low (considering the lines of evidence approach), however detail has been provided within Section 6.0 as RE-9, as provided by McAuliffe, as to the protocol in relation to CS_2.

VOLATILE NAPHTHALENE

Elevated naphthalene has been identified in a discreet location at CP703. The pathway of this contaminant is through inhalation of vapours and as this site is due to be developed for residential housing, the source of the volatile contamination must be removed. A process of hotspot removal should be carried out to do this and full validation sampling of soils left in situ to ensure no remaining risk to future site users.

The areas defined as Phase 5 & 7 will be the subject of a programme of site enabling works, however in the absence of any significant source of potential contamination, no specific soil or groundwater treatment works are proposed in this sector.

E3P has outline the processed and protocols for the site Remediation & Enabling works across these sections which directly correlate to the remediation phasing plan produced by McAuliffe and included in Appendix VIII.

Prior to the commencement of works on site, the contractor must establish all necessary plant, equipment and site welfare facilities as is necessary to complete the contract within the agreed timescales to the rationale as outlined in the following subsections.

For the avoidance of any doubt, the proposed operations as set out within this document are the required performance objectives and validation sampling protocols; however, the specific methods of work deployed to ensure the remediation objectives are achieved in a compliant manner on site will be the responsibility of the appointed contractor.

RE-1 – Pre-commencement Regulatory Compliance

Prior to commencement of any works on site, all reports relating to the assessment of risk to contaminated land should be submitted to the regulatory authorities to gain written approval.

All relevant Standard Rules Permits should be registered with the EA. A mine workings permit will be required in order for drill and grout activities to take place.

The LAPC Part B Notification for deployment of mobile crushing plant should be implemented prior to the establishment of equipment on site.

A CL:AIRE Materials Management Plan (MMP) qualified declaration should be made by the contractor, having obtained full written approval for the remediation strategy from the LPA and Environment Agency.

A trade effluent to sewer consent should be sought for discharge of perched waters.

RE-2 – Environment and Nuisance Control

Management of all works is required so as to ensure that the contractor use all reasonably practicable means in accordance with the Permit to limit environmental nuisance through dust emissions, noise or vibration levels.

All works are to be completed in a manner so as to take account of any structural risk to the adjacent highways.

Temporary works are to be implemented as necessary to support excavations throughout the duration of the works.

RE-3 – Risk to Infrastructure

Site works should be completed in a manner that takes account of associated risk of disturbance to the adjacent infrastructure, in particular, the retaining wall and canal adjacent to the northern boundary. A separate environmental management strategy is recommended in order to address the control of these parameters during the remediation and enabling works.

RE-4 – Identification, Isolation and Treatment Of Invasive Plants

Invasive plant species have been identified on site; the remediation contractor must satisfy themselves with respect to the extent of all species deemed invasive prior to the commencement of works on site. The contractor shall employ a suitably qualified expert to investigate the presence of invasive plant species on or adjacent to the site. Once all invasive plant species are identified, these will be treated in strict accordance with an approved method statement to be submitted to the supervising consultant for review prior to the instigation of any works.

Where invasive plant species are identified at the site boundary, a suitable barrier shall be installed to prevent any future reinfestation of the subject site.

Upon completion of the eradication of all invasive species, a validation report should be prepared documenting all identified invasive plant species, their location and the treatment methodology. Where materials are removed from site, all waste transfer notes/duty of care certificates should be included within the validation statement.

RE-5 – Site Clearance Operations

General site clearance and provision of welfare, offices and site security are to be determined as per the contract requirements.

The site is currently overgrown in multiple areas across Zone 5 with self-seeded vegetation with areas of above- and below-ground structures; this material should be removed in a controlled manner with full compliance with any ecological mitigation measures that are required for the works. Any such measures are outside the scope of this report.

All vegetation should either be stockpiled at a pre-agreed location or alternatively removed from site in accordance with waste permitting regulations.



All root networks are to be removed in accordance with the requirements of the NHBC/LABC.

RE-6 – Delineation, Excavation, Treatment of Visual and Olfactory Hydrocarbon and Naphthalene Impacted Material

An area of visibly identifiable hydrocarbon impact is identified within Zone 5 (WS503) and 7 (CP703); the latter shows an exceedance of volatile naphthalene. It is considered that this material represents an unacceptable risk associated with inhalation of vapours, ingestion of soils and odour nuisance that cannot be mitigated through the construction of a clean cover system.

Furthermore, when considering the prior land use, as yet unidentified potentially volatile/soluble phase compounds cannot be discounted. The proposed remediation works will include the partial depth turnover of all Made Ground under the supervision of an independent geoenvironmental consultant from E3P across Zones 5 & 7.

In the likely event that any as yet unidentified contaminant is identified, this will be the subject of further investigation including laboratory analysis and subsequent assessment of risk within the context of the agreed parameters. Where a theoretical risk to either human health, controlled waters or the wider environs is identified, appropriate remediation works are to be instigated.

Material deemed to be impacted through either visual or olfactory observations or as a result of notable PID readings (> 50 ppm) will be excavated and stockpiled on an impermeable membrane. The membrane will be placed in a suitable quarantine area and/or into the treatment area under the Environmental Permit to negate the risk of soils leaching and dispersal of any odours and/or vapours.

An E3P engineer will regularly monitor the stockpiled material with a PID to determine the need for boundary monitoring (albeit not anticipated). This material will then be subject to detailed laboratory analysis to determine the suitability for reuse/treatment or the requirements for off-site disposal.

Upon completion of the hotspot delineation and excavation of WS503 and CP703, to be completed when enabling works commence, the sides and base of the resulting void(s) where impacted material is present will be chemically validated to confirm that no impacted materials remain in situ.

Hotspot validation samples will be collected at 10 linear metre centres from the side and base of the excavation. Hotspots will be appropriately delineated to ensure full contamination is ‘chased out’.

The results of this validation testing will be directly compared to the site-specific remediation targets (as defined within Appendix III of this report) to demonstrate that no unacceptable level of risk to human health, controlled waters or the wider environment remains.

Interim validation letters for each hotspot should be submitted to the client for approval and sign off by the EHO and EA.

RE-7 – Excavation, Breaking and Processing of All Above- and Below-Ground Structures

Former structures and ponds in conjunction with the substation all require further investigation also one decommissioned. Soils within their vicinity and beneath the former structures each require chemical validation once structures have been removed.

Obstructions, relict foundations and infrastructure (apart from live services) are to be removed from the areas of proposed residential development, to include plot footprints, rear gardens, private driveways, adopted highway and utilities infrastructure (road box) in their entirety.

Artificially hard materials should be broken out and crushed. Stockpiles will be made, validation testing undertaken, and site-won material reused on site where required. Materials will be processed as per the specifications provided in Section 5 using licensed plant.

The E3P drawings denote the extent of known historic features with obstructions; however, it will be the contractor's responsibility to remove all obstructions.

Obstructions encountered within the near-surface soils will be chased to their full depth and removed; if not possible, the obstruction must be surveyed with the location communicated to E3P, the client and the developer.

Where natural soils are present at a relatively shallow depth (northern sector), extreme care should be taken to ensure that the natural cohesive deposits remain undisturbed with a full reduced-level survey to be completed to map the depth of filled/processed material.

RE-8 – Delineation, Excavation and Treatment of Infilled Historical Ponds

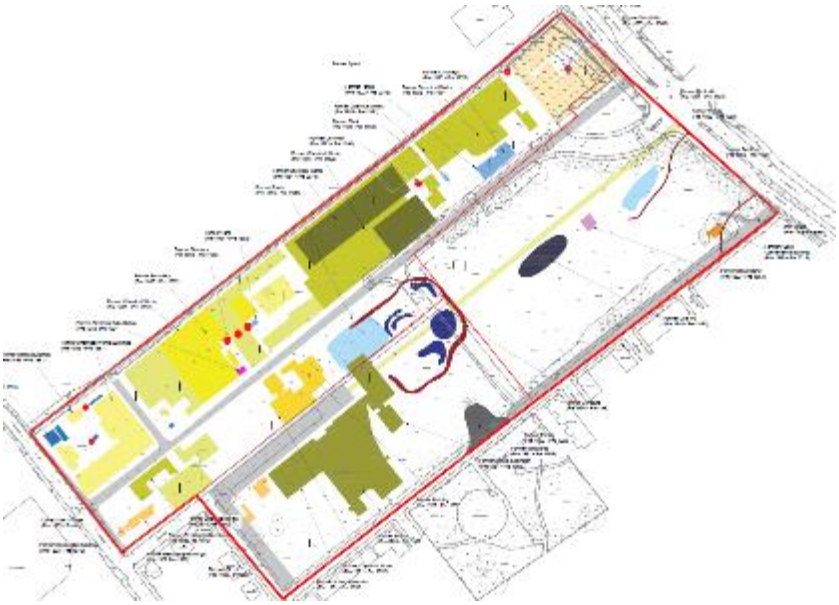
Prior to the commencement of the main earthworks (where possible), all known former infilled ponds should be clearly identified and demarked and investigated to assess the nature of materials and extent of any deleterious elements.

The location of known historic infilled ponds and pits are identified within the E3P Historical Features Plan (Drawing 13-887-003 in Appendix III and in Figure 4.1.

All materials that are deemed to be organic – and thus exhibiting unsatisfactory geotechnical properties – must be removed, with the resulting excavation to be backfilled with materials deemed compliant with the E3P Geotechnical Performance Specification with appropriate compaction for the intended land use.

A suitably qualified geotechnical engineer will need to monitor the works and confirm when all unsuitable material has been excavated and removed from beneath any proposed structure or infrastructure.

FIGURE 4.1 LOCATION OF IDENTIFIED PONDS



RE-9 – Removal of Deleterious Material

All potentially deleterious and soft materials will be delineated, stockpiled and re-used in an area of no development or removed from site by the contractor to a licensed waste facility. Prior to the commencement of the main works, the contractor, under the supervision of E3P, will undertake to complete further confirmatory ground investigations to satisfy themselves with regards to the extent of any buried anthropogenic deleterious materials that are unsuitable for retention within a low-rise residential development.

RE-10 – Cut-And-Filling of Made Ground to Development Levels

The Made Ground is noted to be present to substantial depth in some areas of the site (> 2 m). It is considered that it will be possible to utilise vibro stone columns (VSC) within areas of segregated and placed granular Made Ground to treat the currently unknown potential for differential settlement and ensure a uniform safe allowable bearing pressure (ABP) in the order of 125 kN/m^2. However, the final foundation schedule has not been confirmed and will be addressed by the future developer with a full foundation zoning plan and schedule undertaken as part of their works.

Where the proposed enabling works levels require the current landform to be cut, extreme care should be taken so as not to disturb the underlying stratum prior to the placement of the appropriate platform, in compliance with the E3P Geotechnical Specification.

Where the development levels require material to be filled, site-derived Made Ground must be sorted in a controlled manner prior to replacement, in accordance with the requirements of this specification for the intended land use.

The maximum dry density must be determined in laboratory conditions utilising UKAS-accredited testing prior to the commencement of filling and compaction works. In-situ density testing is required to demonstrate compliance with the E3P Geotechnical Performance Specification.

RE-11 – Placement and Compaction of Upfill Material to Facilitate Ground Improvement by VSC

Where plots are to be prepared in a manner that will facilitate ground improvement by vibro-stone column, materials must be either compliant with the specified grading requirements for a nominally placed and tracked granular aggregate, or alternatively they should be engineered to a defined geotechnical standard.

Materials compliant with VSC grading for granular backfill granular matrix are to be graded with all particles < 125 mm with no more than 10% fines (0.63 micron).

Non-compliant material requiring engineering to geotechnical design: material is to be placed and engineered in accordance with the correct method for the Series 600 classification (1, 2 or 6) with moisture contents to be controlled within acceptable design limits. In-situ density to be confirmed to be > 95% of the laboratory determined maximum (2.5 kg) with < 5% air void ratio.

The final foundation schedule has not been confirmed.

RE-12 – Construction of Temporary Working Platform

Where plots are to be prepared in a manner that will facilitate ground improvement by vibro-stone column, a temporary working platform will be constructed.

The specific design for such a platform should be obtained from E3P; however, as a minimum this will comprise:

- Proof rolling of the subgrade to ensure a California bearing ratio (CBR) > 3%; and
- Placement of 300 mm of certified 6F2 to be rolled and compacted to ensure a CBR > 6%.

RE-13 – REPLACEMENT OF MATERIALS, GEOTECHNICAL ENGINEERING REQUIREMENTS

Material is to be backfilled in strict compliance with the E3P Geotechnical Engineering Specification as presented in detail within Section 6 of this report, which generally requires the reinstatement and compaction criteria presented in Table 5.1.

TABLE 5.1 GEOTECHNICAL ENGINEERING WORKS SCHEDULE

Land Use	Construction Requirement	Requirement
Footprint of Proposed Structure (2 m on All Elevations)	Pile Foundation	Backfill using general method compaction to CBR of 5%.
	Vibro-Stone Column	Particle size distribution (PSD confirmed as < 125 mm with no more than 10% fines (0.63 micron). Or Compaction to achieve > 95% of the laboratory determined maximum dry density (DD) with < 5% air void ratio. CBR > 5% with suitable pile mat.

		PSD testing of backfill material at 1 sample per 2000 m^3 to confirm.
	Traditional Spread Foundation	Ensure no disturbance of natural soil at shallow depth.
Highways	Adopted Estate Road/Drainage	Manual of Contract Documents for Highways Works (MCHW) Series 600 ensuring CBR > 5% in subgrade (engineered fill).
Driveways	Private Drives and Car Parking	Method compaction to CBR > 5%.
Gardens and Public Open Space	N/A	Method compaction to ensure no settlement.

RE-14 – Preparation of Ground for Vibro-Stone Columns Within Tree Influence

Where trees are present, or within their total zone of influence, the contractor must ensure that all cohesive soils are removed to the required depth with the subsequent replacement with a granular blanket to fully mitigate the potential for volumetric instability in the clay soils.

The zone of tree influence will be indicated within the foundation zoning plan and all resultant excavations and subsequent backfilling must be inspected and approved by E3P.

The depth of the granular blanket required will be determined prior to the commencement of the works and in full agreement of the client but will nominally be equal to or in excess of 2.5 × foundation width.

RE-15 – Importation of Bulk Fill

Where there is a net shortfall of material required to achieve the proposed ground levels, it will be necessary to import natural inert soils and aggregate as per the engineering requirements (Section 6).

Imported material must be certified as suitable for use in strict accordance with the E3P chemical and geotechnical performance criteria (See Section 6) and in conjunction with the required duty of care notes and waste transfer exemption.

If recycled aggregates are imported, then laboratory testing should be completed to demonstrate compliance with the Waste and Resources Action Programme (WRAP) protocol.

Where inert soils are imported, laboratory testing should be completed in accordance with the requirements of the pertinent environmental permit (i.e. U1 Standard Rules) or CL:AIRE MMP for the reuse of clean, naturally occurring soils.

RE-16 –Validation of Treatment Compound

As part of the land remediation works, a soil treatment area will be set up in accordance with the McAuliffe phasing plan to treat soils excavated from Manox. Once soils have been treated as per the decided method, have met the chemical criteria levels agreed and placed in situ back into the Manox sector, the treatment compound may be decommissioned.

A phase of chemical validation to shallow soils (0.00 - 0.30 m) across the site will be required to ensure no contaminated soils have been transferred during the treatment process into soils within these zones.

Samples should be obtained and sent for chemical analysis for TPH and BTEX compounds, in line with the contaminants of concern. If exceedances are identified within chemical results, a process of excavation and placement in an area of low sensitivity should be carried out to ensure no residual risk to the end users.

RE-17 – Underground Mine Workings

A separate mine workings and stabilisation report has been prepared (ref: 13-887-R7, dated June 2022) and should be agreed with the Coal Authority prior to works.

Proof drilling on close centres is required to identify the location of the inferred sub-crop within all three seams of coal, this will be completed by drilling linear probe lines under the supervision of the site engineer. When the sub-crop position is confirmed, close centred primary probes will be advanced on a 6m primary grid beneath structures and infrastructure across the sub-crop where <10xT is confirmed, again this will be under the supervision of the site engineer.

It will therefore be necessary to allow for a watching brief during earthworks and ensure inclusion of a suitable mechanism for grouting and plugging of any such features and subsequent amendment to a development layout in the event that an unrecorded mine entry underlies a residential structure.

RE-18 – Preparation of Garden for Cover System

As part of the land remediation works, garden areas will be prepared in a manner that will facilitate the placement of the clean cover system during the development phase of the works. The preparation of the areas requiring clean cover is critical in ensuring delivery of the site in a manner that will ensure no risk to the proposed end users.

Where Made Ground is deemed unsuitable for retention in a garden, the area will be subject to a reduced-level dig to remove unsuitable material to a minimum depth of 700 mm (inclusive of granular break layer) below finished garden level or verified natural stratum (whichever is the shallower).

Excavated soil will be stockpiled pending the results of the appropriate validation testing (to be completed in accordance with this specification) prior to reuse in an area of no sensitivity or, where necessary, this material will be removed from site in accordance with UK waste management legislation.

The placement of certified subsoil and topsoil with an underlying granular break layer, will be completed as part of the developer works/build-phase mitigation plan. All garden areas where a cover system is required will be subject to plot-specific independent validation.



RE-19 – Provision of Subsoil

The shallow natural drift deposits (predominantly granular soils) are deemed suitable for use within the upper 700 mm of clean cover (inclusive of granular break layer) to residential gardens and areas of soft landscaping. It is therefore deemed viable to reuse materials that are cut as part of the wider earthworks or through a soil inversion (regulated by an MMP) to generate the required volumes of material.

The garden and landscaped areas will require depth validation to satisfy the requirement of the Council of Mortgage Lenders (CML) in order to demonstrate that the appropriate thickness has been provided as a growing medium.

RE-20 – Provision of Topsoil

Limited material that would be deemed suitable for use as topsoil is present on site and as such there will be a requirement to import suitable material for use within the proposed development.

Topsoil will require testing in line with the schedule present within Section 7.0 and Table 7.2.

The garden and landscaped areas will require depth validation to satisfy the requirements of the CML in order to demonstrate that the appropriate thickness has been provided.

RE-21– Independent Validation: Watching Brief

Given the site history and potential contamination sources identified within the CSM, a degree of uncertainty remains with regard to the potential for as yet unidentified contamination impact within the near-surface soils and groundwater.

It will therefore be necessary to instigate the site-wide remediation and enabling works under the full-time supervision of a suitably qualified and independent specialist. E3P will undertake full time supervision of the remediation works undertaken by McAuliffe ensuring all works are monitored, ground conditions are recorded and allow any further potential sources to be fully investigated.

RE-22 – Waste Soils Surplus to Requirements

In the event that a surplus of excavation material is present on site, this, in most cases, will be deemed to be a waste in accordance with the Waste Framework Directive (Article 3(1) Waste Framework Directive 2008/98/EE). The waste producer – but ultimately, the landowner – is responsible for the compliant disposal of such materials.

A formal waste classification assessment must be undertaken, irrespective of any future options or considerations for those materials that will removed from site. Waste classification should only be made following the Environment Agency *Technical Guidance WM3 – Guidance on the Classification and Assessment of Waste*.

To remove the surplus material from site it will either need to be sent to a disposal site (landfill), to a permitted treatment facility or, dependent on the waste classification assessment, it may be suitable for use on a permitted land improvement or restoration operation.

Subject to suitability, these soils can be transferred to the receiving site, subject to an approved permit or materials management plan following guidance in the CL:AIRE *Definition of Waste: Code of Practice*.

RE-23 – Works to Public Open Space

No formal development works are proposed within the public open space; however, a number of potentially hazardous features are identified, including former mine entries and shafts. All such features should be searched for by using GPS to coordinate the best-known position. Where any such feature is identified, it should be made safe and clearly signed to limit the potential for future incident.

RE-24 – Validation of Materials for Potable Water Supply Infrastructure

A contaminant risk assessment completed in accordance with the UKWIR assessment framework identified elevated concentrations of potentially volatile/soluble hydrocarbon compounds that necessitate the use of protected water supply pipe-work.

Validation sampling should be completed at 10 m chainage at depths of 0.75 m and 1.50 m within the locality of the potable supply pipes where impacted material is removed, with samples analysed for all pertinent volatile and semi-volatile hydrocarbons and, where necessary, chlorinated/halogenated compounds.

Upon successful remediation of all impacted materials, the post-remediation validation testing will be reviewed by a qualified person to inform an updated UKWIR assessment to be reviewed and approved by the statutory adoption authority.

If unacceptable concentrations remain following remediation, then potable water infrastructure should be constructed in accordance with a suitably robust risk assessment and design compliant with UKWIR.

Where imported material is required to construct the potable water infrastructure pipework, this material will need to comply the requirements of UKWIR pipework thresholds for the specified pipework. For the avoidance of doubt, the PE thresholds are presented in Section 9.3. Failure to meet the required specification may necessitate further remedial works.

RE-25 – Remedial Verification Report

Collation of information relating to site clearance, chemical testing, remedial works, remedial verification, material movements and waste transfer documentation is required, where appropriate.

Complete remedial validation is to be reported in line with regulatory guidance. This will include a detailed risk assessment. The report will be submitted to the local authority for approval following completion.

6. SITE REMEDIATION AND ENABLING WORKS- MANOX ZONE

6.1. REMEDIATION TECHNOLOGY

Considering the site-specific conditions, including the nature of the identified impacts, the geology and the objectives of the remediation, the most-appropriate soil remedial technologies are considered to be:

- Completion of additional pilot trials to explore different mixes with the varying contaminant load;
- Removal with disposal off-site of all primary sources of contamination impact such as the separate phase Tar (Tar Channel – upon identification) and any and all other separate phase aromatic TPH compounds, soils with discoloration indicative of gross cyanide, arsenic and other inorganic impact;
- Removal of all chemical wastes in the solid phase that are deemed to be a primary source capable of generating prolonged and unacceptable risk to controlled waters and the wider environ;
- Controlled removal of all infrastructure such as drains, interceptors and all relict structures considered both a primary source and conduit for lateral migration of contamination;
- Extensive treatment of all impact soils considered a secondary source of contamination impact with validation of soils against the site derived remedial targets;
- Prior to the commencement of any treatment works, extensive further testing will be required by McAuliffe to demonstrate the effectiveness of the selected treatment technology;
- Continued monitoring of odour emissions throughout remediation, following the full protocols put in place by McAuliffe;
- Extensive groundwater monitoring to ensure the fate and transport of all potential contaminant groups is fully understood, and the long-term risks are modelled and mitigated;
- Confirmation sampling within the area of the substation to demonstrate absence of PCB impact or to define requirements for any remediation works;
- Management of all soils impacted by asbestos fibres and consideration of any ACMs present within the sub-structures;
- Completion of a post-remediation vapour risk assessment to determine the potential for any residual volatile risk from the remediated materials and determine the requirement for any vapour membranes to be installed in the proposed dwellings;
- Construction of a suitable cover system to mitigate the risk associated with non-volatile/insoluble compounds; and
- Characteristic Situation 2 ground gas mitigation measures selected units at WS206 to ensure compliance with BS 8485 (2015)+A1(2019), with independent validation of each unit. Post remediation gas monitoring will be required;

It is considered that these technologies and methodologies will address the identified active pollutant linkages, as detailed in the following subsections.

6.1.1. CONTAMINANTS OF CONCERN (COC)

METALS, PAH, NON-VOLATILE HYDROCARBON (PETROLEUM RANGE) COMPOUNDS

The human health risk drivers for the carcinogenic PAHs and metal CoC are:



- Direct contact with the soil source by future on-site residents; and
- Ingestion of impacted soils by future on-site residents.

Therefore, a 700mm cover system (inclusive of granular break layer) is considered to be an appropriate remediation technique to address these impacts, as the installation of a cover system to unsurfaced areas of the site will sever the pathway of contact for human health receptors. The 700mm cover system will be underlain by a granular break 'no dig' layer. A cover system is not considered to be required in future hardstanding areas or beneath buildings, as it can reasonably be assumed that the presence of a hardstanding will prevent direct contact.

ASBESTOS

Asbestos trace fibres have been identified within shallow Made Ground at a number of locations across the site. All ACM-impacted soils must be managed so as to ensure no airborne fibre release during construction or placement of impacted material in such a manner as to ensure no future exposure risk.

Soils will be placed in areas of no unacceptable future risk in accordance with the E3P validation method.

If any visible pieces of asbestos-containing material are identified during the site remediation and enabling work, this material must be dealt with in strict accordance with the Control of Asbestos Regulations (CAR) 2012, UK Waste Management Legislation and the Environmental Protection Act 1994. Due to the close proximity of residential dwellings, asbestos in air monitoring in accordance with HSG248 may be required to confirm that no asbestos fibres have been generated from the enabling works activities.

Should off-site disposal be required, then additional asbestos quantification and waste classification testing should be undertaken to ensure that it is classified correctly and disposed at a suitably licensed facility.

6.2. OVERVIEW OF WORKS

Prior to the commencement of works on site, the contractor must establish all necessary plant, equipment and site welfare facilities as is necessary to complete the contract within the agreed timescales to the rationale as outlined in the following subsections.

For the avoidance of any doubt, the proposed operations as set out herein the document the required performance objectives and validation sampling protocols; however, the specific methods of work deployed to ensure the remediation objectives are achieved in a compliant manner on site will be the responsibility of the appointed contractor.

RE 1 – Pre-commencement Investigation & Assessment
In pursuance of satisfaction of Condition 56 of the approved planning permission, E3P has submitted a supplementary site investigation letter report (13-887-L8, dated July 2022) to the regulators. This letter outlined the findings of the supplementary phase of intrusive Ground Investigation in the Manox sector, to further understand and define the extent of the primary sources of contamination. These works were completed in partnership with McAuliffe Geo-Stream who collected representative samples to be used in their 'Pilot Study / Treatment trial' to accurately define the chemical composition and methodology for the solidification and stabilisation works.

RE 2 – Pre-commencement Pilot Study & Assessment

E3P collected significantly impacted samples, representing a worst-case scenario, during the supplementary site investigation to be used in McAuliffe Geostream's 'Pilot Study / Treatment trial' to accurately define the chemical composition and methodology for the solidification and stabilisation (S/S) works.

The results of the supplementary investigation and treatment trial have been used to inform the McAuliffe detailed Remediation Method Statement for the Manox site in isolation. The full report and treatability study should be read in conjunction with this report and is provided in Appendix VIII.

When considering the remediation solution within the context of the developed CSM, the construction of a suitable physical barrier to the critical receptor (Rochdale Canal) and the reduced viability of the migratory pathway to the underlying aquifer and Shooters Brook, it is proposed that the remediation performance criteria will be defined by a series of site generated remedial target concentrations for the protection of controlled waters. As part of the specific Remediation Method Statement for the Manox sector (A-H), the agreement will be sought from the EA with respect to the SSRTs that demonstrates a significant reduction in mobility potential to ensure long-term protection of controlled waters and the wider environs.

RE 3 – Deployment of EA Mobile Plant Treatment License

The specialist Remediation Contractor McAuliffe Geo-Stream will deploy the appropriate Environmental Permit for the treatment of soil and groundwater using mobile plant.

It is envisaged that the deployment of the MPTL will include all pertinent remediation activities such as removal of visible ACM, stabilisation and solidification of solid phase impacted materials for metalloids, cyanide salts and aromatic (coal tar) hydrocarbon compounds, treatment of perched impacted groundwater and bio-remediation of materials with volatile phase constituents.

RE 4 – Establish Remediation Treatment Train

The specialist Remediation Contractor McAuliffe Geo-Stream will erect all mobile plant, accompanying monitoring equipment in conjunction with the establishment of the requisite site protocols for the process that will accept and treat differing material types entering the treatment train.

The remediation treatment area will be sited in accordance with the McAuliffe phasing plan at a position where minimal risk is posed to off-site receptors.

It is envisaged that the treatment area will be constructed upon completion of the enabling works prior to the commencement of remediation in the Manox sector.

Should site conditions arise, the remediation treatment area, may be relocated to reduce environmental impact to the surrounding properties or expanded should treatment volumes increase.

RE -5 – Construction of Sheet Pile Barrier Wall

A low permeability sheet piled barrier will be constructed along the entirety of the northern boundary, directly adjacent to the boundary with a return of circa 5m around the north west and north east corners, prior to the commencement of remediation works within the Manox sector, in accordance with the design to be agreed by all stakeholders.

The barrier wall with serve as a dual-purpose structure to impede horizontal groundwater flow, protect the site from residual impact associated with the canal and provide a retaining structure where the development platform is to be constructed at a higher elevation than the adjacent tow path.

RE -6 – Delineation and Removal of Primary Source of Contamination

The supplementary ground investigation recently completed, has identified the spatial extent of the most significant primary sources of contamination impact, albeit the specific location of the tar channel has yet to be identified. Slabs and hardstanding will be removed to facilitate clear, unrestricted and safe access to the work area that will subsequently facilitate the removal of all areas of 'primary' contamination impact defined as:

- Separate phase liquid coal tar within historic structures;
- Visible chemical (Cyanide, Arsenic & Lead) impact within Made Ground; and,
- Identify localised areas of separate phase liquid coal tar impact (surface spillage).

All works to be completed under the full-time supervision of a suitably trained E3P engineer who will be responsible for the preparation of an independent validation report.

Grossly impacted materials will enter the 'treatment train' whereby remediation will be instigated by the appropriate method for the contaminant and matrix type in accordance with the MPTL.

Where material is not capable of treatment to achieve the remediation parameters, there will be no option but to remove this to a suitably licensed treatment or recycling facility. To promote sustainable remediation, maximum effort will be made to retain, treat and re-use materials on-site.

RE -7 – Controlled Removal of Impacted Perched Water / Sealing of Conduit

Perched waters confined by historical structures, drainage conduits and anthropogenic materials are identified as a source of impact that is known to be migrating via conduits to the adjacent canal tow path and controlled water receptor.

In the first instance, prior to the commencement of demolition of slabs and foundations, all conduits leading to the northern boundary (tow path) will be identified and sealed to remove the known current exposure pathway.

As demolition is instigated to remove slabs and foundations, all perched waters will be controlled and collected for treatment on site prior to entering the 'treatment train'.

Waters will be subject to on-site treatment for the identified constituents of concern to ensure compliance with the criteria for disposal to foul sewer. Where the requisite criteria cannot be achieved, liquids will be removed from site to a specialist treatment facility.

RE - 8 – Removal of Northern Boundary Wall & Extraction of Material & Replacement.

Material present to the immediate rear of the existing (failing) site retaining wall which forms the boundary to the canal is known to present a complete pollutant linkage associated with the leaching and dissolved phase migration to the tow path and surface water.

Hard standing will be removed and impacted perched waters transferred to the treatment area.

All soil phase material will be extracted and sub-divided into grossly impacted and residually impacted material prior to transportation to the treatment area.

Building materials such as brick and other matrices visibly impacted by cyanide salt, metals or aromatic hydrocarbons will be deemed impacted and also directed to the treatment train.

All material considered not to be significantly impacted will be subject to analysis and stockpiled on-site.

The existing retaining wall will be removed in a controlled manner with protocols to ensure no liquid or solids leave the site boundary.

Chemically suitable site-won materials generated from the site enabling works in Phase 5 & 7 will be used to construct the development profile and temporary works platform.

During the durations of the remediation a solid hoarding will be installed on the boundary to restrict unauthorised access and mitigate environmental emissions leaving site.

RE-9 – Management Protocol for Carbon Disulphide

Whilst no primary source of carbon disulphide has been identified on the site, there remains a potential low risk of carbon disulphide impacted soils in some isolated locations across the Manox site. Carbon disulphide is a highly volatile and extremely flammable compound, having a wider explosive range in air than hydrogen and a lower ignition energy (LEL>1), with an odour of rotting cabbages.

In the event carbon disulphide is identified as present within a location, the area will be isolated and activated persulphate oxidant (OBC) will be injected in situ into the subsurface to degrade the carbon disulphide in a controlled manner.

This approach avoids the production of heat or off-gas and avoids the requirement to excavate soils, preventing the health and safety issues associated with handling carbon disulphide impacted soils.

These protocols have been directly produced and will be implemented by McAuliffe who are the chosen remediation contractor for the project. It is recognised that there are data gaps currently as the exact position of the tar channel has yet to be identified, however E3P will maintain a full time site supervision throughout the remediation works.

RE -10 – Excavation & Treatment of Impacted Made Ground

Extensive excavation works will be required to remove 'secondary' cyanide (salt) and metalloid impact within the Made Ground across the Manox sector.

Aromatic hydrocarbon impact is anticipated within the materials that immediately surround the former tar channel and areas of leakage / spillage. This material will be delineated by way of geo-chemical testing prior to the impacted material entering the treatment train.

Building materials such as brick and other matrices impacted by coal tars that adhere to the surfaces will enter the treatment train.

Works will comprise a full depth turnover of Made Ground with on-site screening to identify the most significantly impacted material that will enter the treatment train.

Material to enter the 'Treatment Train' to ensure solidification/stabilisation and/or bioremediation as required to ensure compliance with site remediation criteria.

The completion of the remediation works in accordance with the options and actions as outlined above will constitute the successful removal and treatment of the known pollution source. A phasing plan for the methodology has been developed by the principal contractors and should be viewed in conjunction with this report (Appendix VIII).

7. VALIDATION SAMPLING PROTOCOL

In accordance with the current requirements of the regulatory authorities, validation samples will be collected from all materials that are to be subject to movement under the protocols outlined within this remediation and enabling works strategy, or for materials to be imported onto site to facilitate the proposed residential development.

Soil samples destined for chemical analysis will be collected at regular intervals in appropriate sampling containers. All samples will subsequently be stored in cooled boxes prior to submission to a UKAS/MCERTS accredited laboratory.

All samples will be collected using appropriate personal protective equipment (PPE) and sampling equipment, which will be cleaned at each sampling location.

A detailed copy of E3P Ltd sampling methodology, QA procedures and laboratory chain of custody forms will be documented within the site records and presented with the final validation report for the site.

Where material is found to contain concentrations of potential contaminants at levels in excess of the site-specific screening criteria (as detailed within Appendix III), E3P will undertake further assessment and recommendations on the appropriate use for the material in question, which may involve the disposal of such materials off site to a suitable waste management facility.

The sampling frequency for materials to be managed under the remediation strategy is presented within Table 6.1.

The chemical threshold criteria for each validation sample will be evaluated depending on their place of reuse on site. The chemical criteria are presented in Appendix IV.

A standalone remediation verification plan will be submitted separately to detail post works validation and verification plans.

TABLE 6.1 SPECIFICATION OF CHEMICAL VALIDATION LABORATORY ANALYSIS

MATERIAL USE	TESTING FREQUENCY	SUITE OF ANALYSIS
Site-Generated		
Site-Generated 6F2	1 Sample per 1000 m^3	A/B/C/D
Site-Won Made Ground General Backfill	1 Sample per 250 m^3 (if contamination identified)	G
Site-Won Made Ground General Backfill	1 Sample per 1000 m^3	A/B/C/D
Site-Won Made Ground General Backfill	1 Sample per 2000 m^3	I
Site-Won Natural Backfill	1 Sample per 2000 m^3	A/B/C/D
Site-Generated Subsoil (450 mm Garden Cover)	1 Sample per 50 m^3	A/B/C/D
Site-Generated Topsoil Cover (150 mm Garden Cover)	1 Sample per 50 m^3	A/B/C/D
Hotspot Validation Samples	1 Sample per 10 m of linear excavation to base and sidewall	E/G
Cyanide Contaminated Materials	1 sample per 500m3 1 sample per 1000m3	J K

MATERIAL USE	TESTING FREQUENCY	SUITE OF ANALYSIS
Imported		
6F2	1 Sample per 1000 m^3	A/B/C/D
Subsoil Greenfield Source (450 mm Garden Cover)	1 Sample per 200 m^3	A/B/C/D
Subsoil Brownfield Source (450 mm Garden Cover)	1 Sample per 50 m^3	A/B/C/D
Topsoil Greenfield Source (150 mm Garden Cover)	1 Sample per 200 m^3	A/B/C/D
Topsoil Brownfield Source (150 mm Garden Cover)	1 Sample per 50 m^3	A/B/C/D
General Engineering Fill (Class 1 and 2 Soil)	1 Sample per 1000 m^3	A/B/C/D

Notes
Suites of Analysis:

A. Speciated PAH.
B. Speciated TPH (C5-C35).
C. Asbestos (ID).
D. CLEA Inorganic Heavy Metals.
E. Speciated PAH, Banded TPH and VOCs.
F. SVOC/Speciated TPH/Speciated cyanide.
G. On-Site Screening for VOC Using Calibrated PID.
H. Leachate 2:1 Speciated PAH and Banded TPH.
I. Leachate Analysis of Inorganic Heavy Metals, TPH, Sulphate and PAH.
J. Leachate Analysis of Inorganic Heavy Metals (specifically free and complex Cyanide)
K. 64 day tank tests

All analysis prescribed above to be completed by UKAS-accredited laboratory.

7.1. REMEDIATION CONTRACTORS SITE MANAGEMENT AND RESPONSIBILITY

The appointed remediation contractor, McAuliffe, will take full and overarching responsibility for all methods of work required to complete the site remediation and enabling operations to ensure the delivery of the site and the completion of the objectives in a safe, legislatively compliant manner that ensures no pollution to the subject site or the wider environs. McAuliffe have also been fully involved in the writing of this Remediation Strategy and providing detail of the relevant protocols where required.

For individual remediation operations as set out within this performance specification, the contractor will provide site-specific methods of work for individual operations pertaining to the removal and treatment of contaminated liquids and soils. For each and every operation as set out herein, the contractor will provide a written methodology of works to be supplied to the supervising geoenvironmental engineer prior to the instigation of operations on site.

The site manager will be responsible for documentation of each day's activities with a full recorded schedule of works completed and corresponding site-specific method statements that have been utilised to ensure the completion of the task to the required standard.



8. MATERIALS MANAGEMENT AND LEGISLATIVE COMPLIANCE

The processing of recycled aggregates will be completed using LAPC Part B licensed plant with the appropriate deployment notification to the local authority prior to commencement of works. All materials that are recovered as recycled aggregate will be compliant with the E3P validation testing requirements and as such would not be deemed to be a waste material.

The relevant LAPC, U1, T5 and WRAP licences, exemptions and protocols provide the legislative framework for material compliance during the site remediation and enabling works to be completed by the specialist contractor under the supervision or E3P.

Where necessary, operations as outlined within the remediation enabling works rationale summarised in this report may be subject to regulation using the appropriate environmental permit, standard rules exemption and materials management plan, to be created in accordance with version 2 of the CL:AIRE *Definition of Waste: Code of Practice (DoW CoP)*.

It is noted that if material is to be imported utilising the CL:AIRE DoW CoP from an alternative development site, then only chemically certified, clean, naturally occurring material can be transferred.

If required, the MMP will be created with due consideration of all proposed remediation and enabling works operations prescribed within this document and will be undertaken by a qualified person with a signed declaration submitted to the EA prior to reuse of materials on the site.

The importation of material for use within the proposed construction of a development platform will be subject to the compliance with the E3P protocol for the importation of materials as set out within the specification for material import included within Appendix IV of this report.



9. ENVIRONMENTAL MONITORING AND VALIDATION

9.1. SITE MANAGEMENT

The tracking of materials will be based on the following hierarchy:

- The principal contractor will have the responsibility for setting out areas of the site on the basis of the contract specification.
- Operatives will have instructions only to excavate and to emplace materials in specified areas as assigned by the site manager/foreman.
- The site manager (employed by the principal contractor) will issue daily instructions to drivers regarding the placement of materials sourced from specific stockpiles or areas, ensuring that appropriate documentary evidence is collected that details which materials are going where and why.

An E3P consultant, who will be in attendance as required, will:

- Inspect the excavation areas and certify that the correct materials are being excavated;
- Conduct spot checks on loaded vehicles to ensure compliance with this remediation strategy; and
- Ensure that any loads that fail visual, olfactory or spot checks either remain on the vehicle or, if unloaded, are excavated and set aside. This material will be treated according to the recommendations of the E3P site engineer.

E3P will conduct an audit of waste consignment notes. All material imported and removed from site will have duty of care/consignment notes, copies of which will be retained on site by the site manager.

Materials directly reusable will be incorporated into the earthworks, subject to operational conditions and phasing of excavations, in which case they will be stockpiled prior to final placement.

9.2. COMPLETION

Following the completion of the remediation works, a report will be compiled by E3P, detailing all site enabling works undertaken, waste consignment notes, and all site investigations, laboratory test certificates and validation testing undertaken.

A certificate of completion of earthworks should be included within the report which should then be issued to the local authority for their approval.

E3P considers that with the adoption of the above best practices the site can be safely redeveloped. The site enabling works process and presence of any residual contamination (if this is the case) should be recorded for future reference by landowners/occupiers. Future development at the site where this may result in penetration of new areas of hardstanding should be subject to no-less-stringent measures with respect to assessment and, where appropriate, monitoring, than those set out herein.

9.3. MITIGATION OF RISK FROM SOILS WITH ASBESTOS FIBRES

9.3.1. PRE-COMMENCEMENT WORKS

Prior to the commencement of works the following requirements must be satisfied:

- Induction of all people that will be involved with the proposed site works; and
- All methodologies must be agreed upon by all parties involved.

9.3.2. CONTROL, MONITORING AND REPORTING OF GENERAL AERIAL EMISSIONS FROM DUSTS AND PARTICULATES

DAMPING DOWN OF SOILS – MITIGATE PARTICULATE (DUST) EMISSION

During excavation, as outlined within the detailed working methodologies, soils will be regularly damped down using water to control the generation of dust (this may also comprise precipitation). The contractor will determine the best form of dust suppression to be used when a detailed programme has been issued.

If any previously unidentified asbestos-containing materials are identified, these should be dealt with in strict accordance with the *Control of Asbestos Regulations* (2012) and industry best practice as detailed in CIRIA 733.

GENERAL CONTROL OF DUST

The following control measures should be utilised to ensure that dust levels are kept to a minimum at all times:

- Where necessary, haul road, work areas and stockpiles will be damped down with water spray.
- The application of water to haul roads, work areas and stockpiles should be closely monitored by the resident engineer to ensure that soils are not saturated and, therefore, that the potential for water run-off is appropriately mitigated.
- Once completed, any stockpiles will be sealed by compacting at the surface.
- Vehicle speeds and movements on site will be kept to a minimum (< 5 mph) during civil excavation works to reduce the potential to generate dust.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

In accordance with the HSE *Guidance Note em6: Asbestos Essentials, Personal protective equipment (including RPE)*, E3P recommend that all site operatives present within the work area where potential asbestos-impacted soils are being excavated are supplied with the following personal protective equipment:

Overalls:

- Disposable overalls.
  - Type 5 (BS EN ISO 13982-1) are suitable.
  - Cotton overalls hold dust and need specialist laundering.
- Waterproof overalls for outdoor work.
- Use oversized overalls - this will help to prevent ripping at the seams.
- If the cuffs are loose, seal them with tape.
- Avoid wearing a long-sleeved shirt as these are difficult to cover properly.
- Wear the overall legs over footwear as tucking them in lets dust into footwear.
- Wear the hood over the RPE straps.

Failure to utilise and correctly employ PPE will result in immediate cessation of works. Works will not be permitted to recommence until the individual has undergone further training in the use of PPE or the individual is removed from the works area.

At this current time, with the levels of ACM identified within the soils, the above-listed PPE is not considered to be required for all site personnel during the entire management of these soils.

When handling asbestos-impacted soils during the enabling works, asbestos monitoring works should be conducted in accordance with, but not limited to, the following HSE legislation and guidance:

- Health & Safety at Work Act 1974;
- The Control of Asbestos Regulations 2012;
- CL:AIRE, 2016. Control of Asbestos Regulations 2012 - Interpretation for Managing and Working with Asbestos in Soil and Construction and Demolition Materials: Industry guidance;
- Approved Code of Practice L143 Work with materials containing asbestos;
- Management of Health and Safety at Work Regulations 1999;
- HSE Guidance Note HSG248 Asbestos, the analysts guide to sampling and analysis;
- HSE Guidance Note HSG247 Asbestos: The licensed contractors' guide; and
- CIRIA 733 Asbestos in soil and made ground: a guide to understanding and managing risks.

If required, air monitoring in accordance with HSG248 will be undertaken intermittently throughout the duration of the works at a frequency to be determined by the contractor, entirely dependent on whether asbestos-impacted soils are being handled at any given time. In general terms, during any one monitoring period, ten standard monitoring pumps will be run throughout the day, for the appropriate time period to achieve the required limit of detection. These slides will be analysed immediately by the on-site UKAS-accredited laboratory.

Once any monitoring has been analysed by the on-site UKAS-accredited laboratory, the results will be delivered to the resident engineer who will then follow the correct site procedure. The results will then be included within the verification report.

10. GEOTECHNICAL ENGINEERING SPECIFICATION

10.1. E3P GEOTECHNICAL ENGINEERING SPECIFICATION

The overarching philosophy of the site enabling works will be the delivery of the following:

- Preparation of plot footprint (+ 2m on all elevations) in accordance with the E3P geotechnical engineering specification with reengineering of stabilised soils to achieve 95% compaction, 5% air voids. Final foundation solution will be designed by the future developer.
- Engineer all areas of proposed adopted road and private drive to be compliant with the E3P Geotechnical Specification with CBR and elevation defined by the client.

The contractor should employ a suitably experienced engineer to be present on site during these earthwork operations to ensure soil suitability, placement, compaction and testing is undertaken in accordance with this specification and to ensure that any unforeseen circumstances, such as adverse weather, do not compromise the earthworks process.

Works should be halted during periods of intermittent or prolonged rainfall to ensure the materials are not placed in a manner that would result in softening of either the formation or the newly placed material. It will be the contractor's responsibility to determine appropriate weather conditions and determine the suitability of works.

Particular attention must be given to variable weather conditions when re-engineering clay soils as a moisture content fluctuation (± 2%) of the tolerable limit will result in an unacceptable degree of compaction loss.

10.2. LOCALLY-WON FILL MATERIAL

It is proposed to upfill and level the site with material won from the development area. From the site-specific investigations undertaken to date, it is expected that the majority of the soils won from the processing of demolition material will be granular and cohesive soil matrices.

Due to climatic weather conditions and variance in long-term differential settlement associated with even well-compacted granular soils, and the need to facilitate future re-engineering using vibro-replacement stone columns to support a shallow reinforced strip foundation, it is essential that the cut-and-fill process is well controlled and materials are placed/compacted in accordance with this specification.

Where site-won materials are to be used as fill to achieve the required development platform, they must be compacted to ensure in-situ densities that are in excess of 95% of the maximum dry density, as determined using a 4.5 kg laboratory Proctor test.

Materials should only be compacted when the actual moisture content is within 3% (±) of the optimum for the soil matrices as determined by laboratory bench testing.

10.3. CLASSIFICATION OF FILL MATERIAL

This specification should be read in conjunction with the following:

- The Manual of Contract Documents for Highway Works, Volume 1, Specification for Highway Works, Series 600, Earthworks as amended in February 2016; and

- BS 1377-1:2016 Methods of test for soils for civil engineering purposes. General requirements and sample preparation

10.3.1. GENERAL CLASSIFICATION

The contractor should ensure that all earthworks materials comply with Clause 601 of the *Specification for Highway Works and* shall fall into one of the following general classifications as defined in Table 6/1 of the *Specification for Highway Works*.

- General granular fill (Class 1);
- General cohesive fill (Class 2), excluding 2E; or
- Selected granular fill (Class 6).

TABLE 10.1 E3P EARTHWORKS GEOTECHNICAL COMPACTION SPECIFICATION

SOIL/MATERIAL TYPE	CLASS	DESCRIPTION	COMPACTION EQUIPMENT	LAYER THICKNESS	ROLLER PASSES
Granular Fill **(Sand and Gravel Matrices)**	1 A	Sandy Gravel with some cobbles	> 5000 kg vibrating roller	225 mm	4
	1 B	Sand or Gravel of same grading size	> 5000 kg vibrating roller	250 mm	10
	1 C	Coarse gravels with many cobbles	> 5000 kg vibrating roller	400 mm	5
Cohesive Fill **(Clay with Minor Sand and Gravel Component)**	2 A	Wet Clay	> 1000 kg vibrating tamping roller (sheep foot only)	100–225 mm	3
	2 B	Dry Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	225 mm or 125 mm	4 or 12
	2 C	Gravelly Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	225 mm or 125 mm	4 or 12
	2 D	Silty/Sandy Clay	> 5000 kg vibrating roller or 1400 kg tamping (trench roller)	225 mm or 125 mm	4 or 12
Recycled Aggregate Crush **(< 125 mm Well Graded)**	6F2	Any combination of inert hard materials, other colliery spoil, or rock with substantial amounts of clay-like component	> 5000 kg vibrating roller	250 mm	6

10.3.2. USE OF FILL MATERIALS

In addition to any grading requirement, the maximum particle size of any fill material shall be no more than two-thirds of the compacted layer thickness except that cobbles having an equivalent diameter of more than 150 mm shall not be deposited within the restored surface level unless directed otherwise by the engineer. Un-burnt colliery spoil, pulverised fuel ash or furnace bottom ash shall not be used as a fill material.

10.4. GENERAL REQUIREMENTS

The contractor shall employ only plant and working methods that are suited to the materials to be handled and traversed. The contractor shall be responsible for maintaining the nature of the acceptable material so that when it is placed and compacted it remains acceptable in accordance with the contract.

For the purposes of this contract, the proposed earthworks requirements have been split into distinct end use categories, with the corresponding requirements for the earthworks specification assigned to individual areas.

TABLE 10.2 COMPACTION/BACKFILL REQUIREMENTS

LAND USE REQUIREMENT	COMPACTION METHODOLOGY AND GENERAL PERFORMANCE CRITERIA
Traditional Spread Foundation	Ensure no disturbance of natural soil at shallow depth.
Re-Engineering of Soils Using Vibro-Replacement Stone Column (VRSC)	Materials to be placed in a controlled manner to facilitate the construction of vibro-replacement stone columns (VRSC). to limit differential settlement and increase net Allowable Bearing Pressure (ABP) These works are to be completed within the building structure footprint and +2 m of all elevations. Material must be 90% granular in composition with less than 10% fines (which are classified as materials < 60 microns in size). No material greater than 125 mm in size is permitted, with 90% of the soils placed conforming to grading < 90 mm. Material is to be placed when actual moisture content is within tolerable limits of the optimum, with specific attention to soils that are notably wetter than the optimum. Material to be placed in a manner so as to ensure a minimum CBR of 5% at formation to facilitate machine movement and piling mat construction. Where site-won materials are used to upfill, levels must be compacted to an "end product" performance specification where the in-situ density exceeds 95% of the maximum (determined by laboratory conditions). Where rock is present at a shallow depth, the remediation contractor will ensure the substratum is prepared to ensure that a minimum of 1000 mm of appropriately graded granular material is present to the underside of the proposed doubly reinforced concrete strip foundation. The substratum must be prepared to ensure a vibro-stone column treatment depth is not less than 80% of the immediate adjacent profile.
Piled Foundation	All plot footprint (+ 2 m) must be free of any deleterious elements, tree roots and obstructions > 150 mm. Where upfill is proposed, material is to be placed using method compaction specification to achieve a CBR as required by the developer for piling mat construction. Piling mat is to be placed and constructed in accordance with the approved geotechnical engineer's temporary works design.



Adopted Highways (+ 2 m from Back of Footpath)	*Method Compaction – MCHW Specification For Highway Works Series 600* is to be followed, with in-situ validation testing to meet requirement of adoptions authority. A CBR > 5% is required at capping.
Estate Roads	Method Compaction – MCHW Specification For Highway Works Series 600 is to be followed to achieve a CBR > 5%.
Gardens, POS and Other External Areas	Material is to be placed in layers not exceeding 300 mm and must be rolled using dedicated plant (no earth moving equipment) and in general compliance with the requirements of *MCHW Specification For Highway Works Series 600*.

Acceptability shall be determined in accordance with Table 6/1 of the *Specification for Highway Works*.

Laboratory testing for the purposes of determining acceptability and compaction requirements will be conducted by the engineer.

Haulage of material to embankments or other areas of fill shall proceed only with sufficient spreading and compaction. Plant is operating at the place of deposition to ensure compliance with Clause 612 of the *Specification for Highway Works*.

No excavated acceptable material or unacceptable material required to be processed, other than surplus to the requirements of the contract, shall be removed from the site.

Where the excavation reveals a combination of acceptable and unacceptable materials, the contractor shall carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the permanent works without contamination by the unacceptable materials. Unless otherwise described in the contract, classes of fill material required to be deposited separately shall be excavated separately without contamination by other classes of material.

The contractor shall make their own arrangements for the stockpiling of acceptable material, and unacceptable material to be processed, and for the provision of site for this purpose.

The contractor shall ensure that they do not adversely affect the stability of excavations or fills by their methods of stockpiling materials, use of plant or siting of temporary buildings or structures.

Topsoil shall, wherever practicable, be used immediately after its stripping and, if not, shall be stored in stockpiles of heights not exceeding 2 m. Topsoil shall not be stockpiled for more than two years. Topsoil shall not be unnecessarily trafficked, either before stripping or when in a stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

Excavations requiring backfilling shall remain open only for the minimum period necessary.

The contractor shall keep earthworks free of water, including:

- Arranging the rapid removal of water:
  - shed on to the earthworks; and
  - entering the earthworks from any source;
- Provide, where necessary, temporary watercourses, drains, pumping and the like;
- Discharge accumulated water and groundwater into the permanent outfalls of the drainage system where practicable; and

- Provide adequate means for trapping silt on temporary systems discharging into permanent drainage systems.

The contractor shall carry out and maintain groundwater lowering or other treatment as required.

Where materials are designated either Class U1B or Class U2 (according to the *Specification for Highway Works*), the contractor shall carry out any special requirements for their handling. Where such materials are encountered during the progress of the works, the contractor shall make all necessary arrangements for their safe handling and disposal after consultation with the appropriate environmental authority.

10.4.1. CONSTRUCTION OF FILLS – HIGHWAYS

All fills shall be constructed:

- In the locations as shown in the contract drawings to the lines and levels stated therein;
- Of classes of material complying with this specification;
- By deposition, as soon as practicable after excavation, in layers to meet the compaction requirements as required for each class of material as specified; and
- To the requirements of this clause and any other requirements for fill in this specification.

Before commencing work on any area of fill, the contractor shall ensure that:

- The base is sound and stable by excavating and removing any topsoil as soft subsoil;
- Base layers are not exposed until the fill layer is ready for placement; and
- Uncompacted material on the side slopes of previously backfilled zones shall be removed and benches of between 1.0 m and 1.5 m height cut in compacted fill immediately prior to deposition of the new fill to ensure that the new backfill placed against the slope is properly integrated.

Whenever fill is to be placed on surfaces inclined at 1 vertical to 7 horizontal or steeper, the surface shall be benched immediately prior to deposition of the fill in order to achieve horizontal basal surfaces. The benches shall be between 1.0 m and 1.5 m in height.

Areas of fill shall, unless otherwise permitted by the engineer, be constructed evenly over their fullest possible extent and the contractor shall carefully control and direct construction plant and other vehicular traffic uniformly over the area of compacted fill. The minimum plan dimensions of any one panel of backfilling shall be properly integrated with areas of previous backfilling. Damage by construction plant and other vehicular traffic shall be made good by the contractor with material having the same characteristics and strength as the material had before it was damaged.

Temporary slopes within compacted and uncompacted backfill shall be formed at gradients that ensure stability.

10.4.2. CONSTRUCTION OF FILLS – ADOPTED HIGHWAYS, ESTATE ROADS AND CAR PARK

The contractor shall carry out compaction upon the materials that require to be compacted, as soon as practicable after deposition.

Compaction shall be either method as required for the classes of fill in Table 6/1 that require to be compacted.

The contractor shall obtain permission from the overseeing organisation before carrying out compaction requirements as listed in Table 6/1 for the class of material being compacted.



Method compaction shall be undertaken using the plant and methods appropriate to the compaction requirements as listed in Table 6/1 for the class of material being compacted.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account when assessing the amount of compaction required for any layer.

If more than one class of material is being used in such a way that it is not practicable to define the areas in which each class occurs, the contractor shall compact with plant operating as if only the material which required the greater compaction effort is being compacted.

If the results of field tests show densities that indicate the state of the compaction to be inadequate, then if this is due to failure of the contractor to comply with requirements of the contract, the contractor shall carry out such further work as is required to comply with the contract.

Refer to Clause 612/10 of the *MCHW Specification for Highway Works* for definition of plant to be used in accordance with these specified works.

The contractor will be responsible for assessing the class of fill in accordance with Table 6/1 of the *Specification for Highway Works*. Table 6/4 of the *Specification for Highway Works* should then be employed to assess the method of compaction to be employed. The test results and method statements shall be submitted to the consulting engineers for approval.

10.4.3. UNACCEPTABLE MATERIAL

The contractor is solely responsible for ensuring full and detailed analysis of all reported ground conditions and areas of risk in terms of the potential for unacceptable material to be present within the proposed earthworks. Limitations in the available information should be highlighted to the supervising engineer prior to the commencement of earthworks. The contractor is to make full and unequivocal arrangements to investigate the potential presence for unsuitable materials within the earthworks and construction of highway fill. All unsuitable materials are to be identified for removal in accordance with this specification.

Unacceptable material Class U1A shall be:

Material which does not comply with the permitted constituents and material properties of MCHW Table 6/1 and contract specific Appendix 6/1 for acceptable material; and;

Material, or constituents of materials, composed of the following unless otherwise described in contract specific Appendix 6/1:

- Peat, materials from swamps, marshes and bogs;
- Logs, stumps and perishable material;
- Materials in a frozen condition;
- Clay having a liquid limit determined in accordance with BS 1377: Part 2, exceeding 90 or plasticity index determined in accordance with BS 1377: Part 2, exceeding 65; and,
- Material susceptible to spontaneous combustion except unburnt colliery spoil complying with sub-Clause 15 of this Clause;(ii)unacceptable material

Unacceptable material Class U1B shall be:



- Contaminated materials, including controlled wastes (as defined in the Environmental Protection Act 1990 Part IIA) whose level of contamination is above that given either in contract specific Appendix 6/14 or in contract specific Appendix 6/15, but excluding all hazardous wastes (as Volume 1 Series 600 Specification for Highway Works Earthworks W2 Amendment – February 2016 defined in the Hazardous Waste (England and Wales) Regulations 2005) and radioactive wastes (as defined in the Radioactive Substances Act 1993).3(02/16).

Unacceptable material Class U2 shall be:(i) hazardous waste (as defined in the Hazardous Waste (England and Wales) Regulations 2005) and radioactive waste (as defined in the Radioactive Substances Act 1993).4(02/16).

Where required in contract, unacceptable material (other than Class U2) shall be processed by mechanical, chemical or other means to render the material acceptable for use in the permanent works in accordance with the requirements of Table 6/1 and contract specific MCHW Appendix 6/1.

10.5. EARTHWORKS MATERIAL TESTS

Prior testing of the potential sources of fill shall be undertaken by the contractor and submitted to the consulting engineers for approval. This testing shall include, but not necessarily be limited to, the compaction and backfill requirements detailed in Table 10.3.

TABLE 10.3 COMPACTION/BACKFILL REQUIREMENTS

<table>
<tr><th>LAND USE</th><th>COMPACTION METHODOLOGY and GENERAL PERFORMANCE CRITERIA</th></tr>
<tr><td>Liquid and Plastic Limits</td><td>BS 1377: Part 2</td></tr>
<tr><td>Grading</td><td>BS 1377: Part 2</td></tr>
<tr><td>Uniformity Coefficient</td><td>Calculated from grading curve</td></tr>
<tr><td>Moisture Content
Multi-point moisture condition value (MCV) (to assess optimum moisture content).</td><td>BS 1377: Part 2</td></tr>
<tr><td>Organic Matter (Maximum 2.5% Total Organic Content)</td><td>BS 1377: Part 3</td></tr>
<tr><td>Water Soluble Sulphate</td><td>TRL Report 447 Test No 1</td></tr>
<tr><td>Total Sulphate Content</td><td>TRL Report 447 Test No 4</td></tr>
<tr><td>Earthwork In-situ Tests
Subsequent to the filling and compaction of the material, a series of in-situ tests shall be undertaken to confirm the success of the compaction process. This testing shall include, but not necessarily be limited to, the following:

<table><tr><th>Test</th><th>Test Method</th></tr><tr><td>Plate Load Tests (Equivalent CBR of 5%)</td><td>BS 1377: Part 9</td></tr></table>
Disposal of Materials
The contractor shall be responsible for the safe disposal of any excess of unsuitable material found on the site.</td><td>Clause 632 (BS 1377: Part 4)</td></tr>
<tr><td>Proctor Compaction Testing</td><td>BS 1377: Part 4</td></tr>
</table>

10.6. SPECIFICATION FOR GROUND IMPROVEMENT BY VIBRO-STONE COLUMN

The over-arching method and specification for the placement and compaction of non-compliant material where the fine constituent (< 63 micron) exceeds the standard requirements for ground improvement by VSC is given in Table 10.4 & 10.5.

TABLE 10.4 OVERVIEW OF WORKS OPERATIONS

Step 1	Carefully segregate materials excavated during civil engineering works (on site and import) into the following soil types: • Sand/granular soils; • Dry sandy clay; • Wet clay soil; and • Silt. Ensure all stockpiles are sealed to minimise water ingress in approved locations.
Step 2	Analyse bulk sample from each (site-won or imported) soil matrix as per the requirements of the E3P specification for: • Dry density/optimum moisture content (Procter); and • Particle size grading coefficient.
Step 3	On-site observations in conjunction with particle size distribution (PSD) grading will confirm the classification of material and thus the corresponding method for compaction. Site trials will be used to determine the compaction regime for End Product compaction
Step 4	The dry density/moisture content testing should be used to ensure that the material is within ± 3% of the optimum to ensure compaction can be achieved.
Step 5	The classified material should be placed and compacted in accordance with the corresponding method for the material under conditions where the moisture content is within the tolerable limits.
Step 6	Once placed and compacted, the required validation testing should be completed at formation to demonstrate compliance. The testing will include: • In-situ density and air void ratio; • Moisture condition value; and • Undrained shear strength.

TABLE 10.5 COMPACTION AND VALIDATION OF NON-STANDARD MATERIAL BACKFILL TO VSC

REQUIRED PARAMETERS	**THE COMPACTION MUST ACHIEVE THE FOLLOWING MATERIAL PARAMETERS:**	
Verification Testing and Report	**Bulk Density (ρ)**	95% of the maximum dry density and must be within 3% of the optimum moisture content.
	All materials used for upfilling must be durable and inert.	
	In order to verify that the aforementioned material parameters have been attained, representative sampling and testing must be undertaken. All testing will be in accordance with BS EN ISO 17892-1:2014 and BS EN ISO 17892-2:2014. All testing is to be undertaken by a laboratory with the relevant UKAS accreditation. The following tests are required:	
	In-situ Density (ρ)	Approved methods of in-situ testing (i.e. calibrated nuclear density probe (NDP), sand replacement test).
	Moisture Content	Moisture content test.
	In-situ density testing on every 500 m^3 and in each layer of upfill well-spread over site within and around the proposed structures' footprint. Testing must be from a range of depths throughout the treated fill. A minimum of six samples must be taken and tested. A drawing depicting the location of each sample and test point must be provided along with a list of each point and the relevant test/sample depth. A list of all geotechnical testing results for each sample and test must be provided along with the relevant test certificates. If the soils are not suitable, due to the moisture content being higher than the optimum moisture content, then lime modification may also be required. The above is given strictly on the basis that it does not conflict with other elements of the project-specific requirements.	

10.7. CURRENT AND PROPOSED SITE TOPOGRAPHY AND SLOPE INTERACTION

The current and proposed site topography, changes in elevation and any existing or new slopes are beyond the scope of this specification. Where any earth slopes exceed a design gradient of 1(v) in 3(h) either on site or within the conjectured zone of structural influence, extreme care should be taken with a full and detailed geotechnical slope analysis to inform the retained design solution.

11. CONTINGENCY PLAN

The following contingency plan has been created jointly by E3P and McAuliffe to ensure that should any significantly impacted material be encountered during the development, suitable protocols are in place as agreed by all parties.

11.1. TPH IMPACT

TPH impacted soils are widespread across the Manox site and significant investigation has been undertaken thus far which provides a good volume of data to understand the degree of remediation required. It is recognised that there are some data gaps, therefore it is necessary to ensure a contingency is in place in the event of the unexpected identified of TPH impact during the course of the remediation.

If any unexpected impact is identified, in accordance with the validation protocols detailed within the earlier stages of this report, samples of the materials will be analysed to assess the requirement for treatment. If this is required, the impacted materials will be transported in covered wagons to the designated treatment area for either bioremediation or stabilisation/solidification, dependent on the severity of the impact. Remediation will be undertaken with the view to be able to sustainable re-use these soils on site.

11.2. CARBON DISULPHIDE

Whilst no primary source of carbon disulphide has been identified on the site, there remains a potential low risk of carbon disulphide impacted soils in some isolated locations across the Manox site. Carbon disulphide is a highly volatile and extremely flammable compound, having a wider explosive range in air than hydrogen and a lower ignition energy (LEL>1), with an odour of rotting cabbages.

In the event carbon disulphide is identified as present within a location, the area will be isolated and activated persulphate oxidant (OBC) will be injected in situ into the subsurface to degrade the carbon disulphide in a controlled manner.

This approach avoids the production of heat or off-gas and avoids the requirement to excavate soils, preventing the health and safety issues associated with handling carbon disulphide impacted soils

11.3. ODOUR EMISSIONS

In accordance with the requirements by MCC and EA, contingency plans have been put into place to react to situations where monitoring indicates that a potential odour source is not completely under control, meteorological conditions are unfavourable or that adverse impact has occurred.

If excessive odours are detected at the site boundary, at another monitoring point, or a complaint is received, the following remedial procedures will be undertaken:

- Identify the odour source – whether it has originated from site operations or from an off-site source.
- If the odour source is from site operations, the following protocol will be undertaken:
- Report the incident to the site or technical competent manager;
- Identify the point of odour release;
- Identify the cause of the release ie. Machine breakdown, leakage, contamination etc;
- Identify a solution;
- Implement the solution;
- Carry out olfactory tests to check the mitigation measures are working; and,

- Record actions taken on relevant forms and site diary as required.

If the odour is being produced on site, the following protocol will be implemented:

- **Normal operations:** The offending odour will be traced and the reason for the cause of the problem will be investigated. Once solutions are in place, olfactory monitoring will be carried out to ensure the solutions put in place are having the desired effect.

- **Abnormal conditions:** Adverse weather conditions can promote generation of odour and inhibit its effective dispersion. Eg. Hot weather with little wind resulting in increased risk of odour to receptor locations. If this happens, odour causing operations will be minimised until more favourable meteorological conditions return.

11.3.1. CORRECTIVE ACTIONS FOR VARIOUS SITUATIONS

Table 11.1 bellow summarises the various problems that are likely to occur at the site and the standard responses available, which will assist in reducing odour potential.

TABLE 11.1 CORRECTIVE ACTIONS FOR ODOUR CONTROL

PROCESS	PROBLEM	CORRECTION ACTION
Excavation/treatment	Odours due to material being excavated and processed	Consider halting works or dampening down area with odour neutralising product and atomiser plant.
Arisings/groundwater processing	Odourous emissions detected	Olfactory test to be conducted to pinpoint source of odour and ensure contingency and emergency plans are adhered to in full.

11.3.2. LOCAL COMMUNITY LIAISON – ODOUR PANEL

In the extreme event of a significant odour release, neighbours will be contacted to advise them of the situation and the action being taken.

An open-door policy will be encouraged to enable any complaints from neighbouring premises, if received, to be dealt with immediately. The complainant will then be notified of remedial actions taken and any procedures or measures put into place to reduce or ideally eradicate the likelihood of a subsequent complaint.

Volunteers will also be sought from the local area to form an odour panel to provide an impartial assessment of the odour levels coming from the site. Information on how to become a part of the odour panel will be included in the letter notification that will be distributed around the local area ahead of the commencement of the site works.

END OF REPORT

APPENDIX I
LIMITATIONS

1. This report and its findings should be considered in relation to the terms of reference and objectives agreed between E3P and the Client as indicated in Section 1.2.

2. For the work, reliance has been placed on publicly available data obtained from the sources identified. The information is not necessarily exhaustive and further information relevant to the site may be available from other sources. When using the information it has been assumed it is correct. No attempt has been made to verify the information.

3. This report has been produced in accordance with current UK policy and legislative requirements for land and groundwater contamination which are enforced by the local authority and the Environment Agency. Liabilities associated with land contamination are complex and requires advice from legal professionals.

4. During the site walkover, reasonable effort has been made to obtain an overview of the site conditions. However, during the site walkover, no attempt has been made to enter areas of the site that are unsafe or present a risk to health and safety, are locked, barricaded, overgrown, or the location of the area has not been made known or accessible.

5. Access considerations, the presence of services and the activities being carried out on the site limited the locations where sampling locations could be installed and the techniques that could be used.

6. Site sensitivity assessments have been made based on available information at the time of writing and are ultimately for the decision of the regulatory authorities.

7. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials, this is for indicative purposes only and do not constitute or replace full and proper surveys.

8. The executive summary, conclusions and recommendations sections of the report provide an overview and guidance only and should not be specifically relied upon without considering the context of the report in full.

9. E3P cannot be held responsible for any use of the report or its contents for any purpose other than that for which it was prepared. The copyright in this report and other plans and documents prepared by E3P is owned by them and no such plans or documents may be reproduced, published or adapted without written consent. Complete copies of this may, however, be made and distributed by the client as is expected in dealing with matters related to its commission. Should the client pass copies of the report to other parties for information, the whole report should be copied, but no professional liability or warranties shall be extended to other parties by E3P in this connection without their explicit written agreement there to by E3P.

10. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

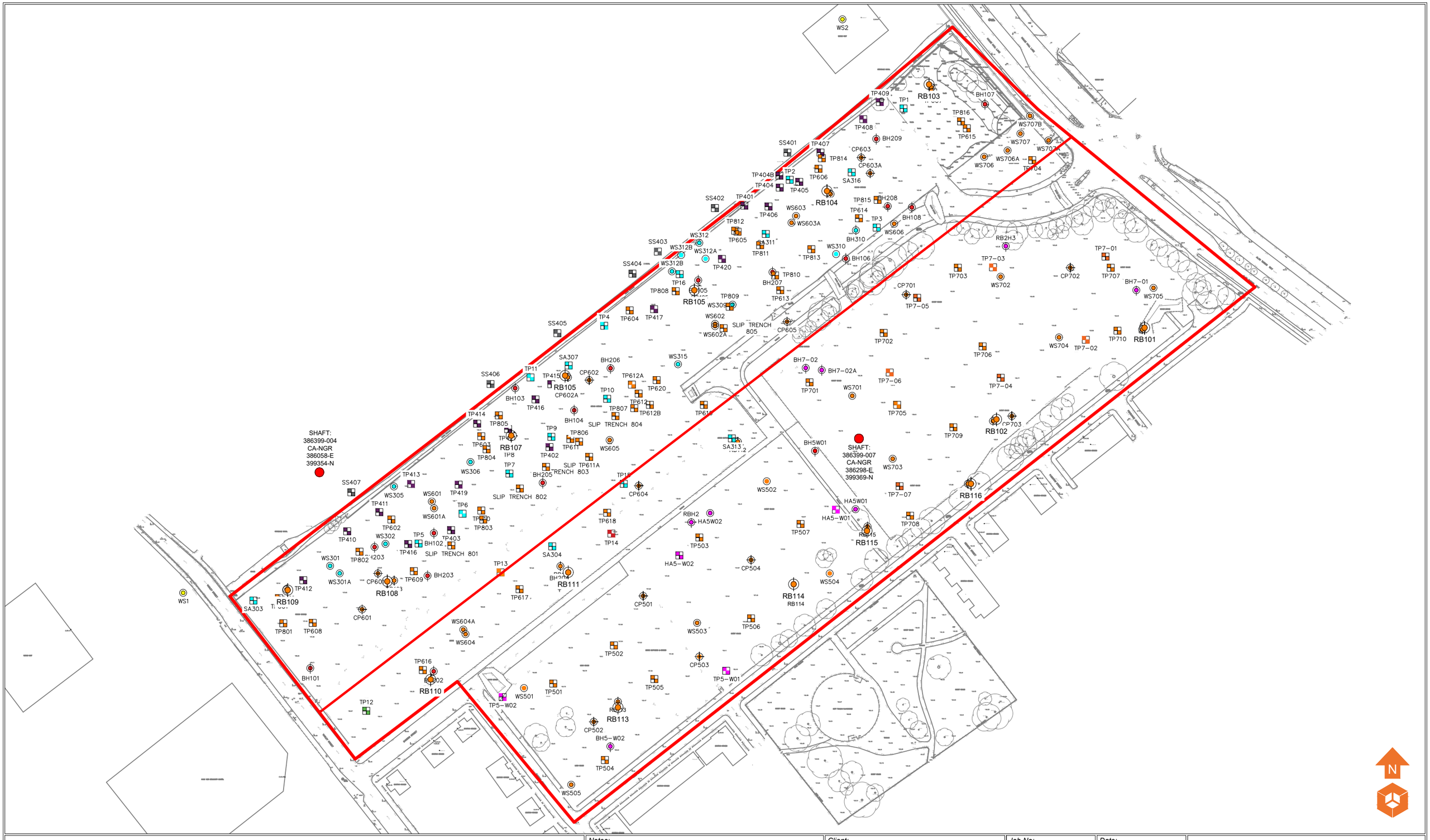
APPENDIX II
GLOSSARY

TERMS

ACM	Asbestos-containing material	**MMP**	Materials management plan
ADS	Acoustic design statement	**ND**	Not detected
AST	Above-ground storage tank	**NDP**	Nuclear density probe
BGS	British Geological Survey	**NMP**	Noise management plan
BSI	British Standards Institute	**NPSE**	Noise policy statement for England
BTEX	Benzene, toluene, ethylbenzene, xylenes	**NR**	Not recorded
CA	Coal Authority	**PAH**	Polycyclic aromatic hydrocarbon
CBR	California bearing ratio	**PCB**	Polychlorinated biphenyl
CIEH	Chartered Institute of Environmental Health	**PI**	Plasticity index
CIRIA	Construction Industry Research Association	**PID**	Photo ionisation detector
CLEA	Contaminated land exposure assessment	**POS**	Public open space
CML	Council of Mortgage Lenders	**PPE**	Personnel protective equipment
CoC	Contaminants of concern	**ProPG**	Professional practice guidance
CSM	Conceptual site model	**QA**	Quality assurance
DNAPL	Dense non-aqueous phase liquid (chlorinated solvents, PCB)	**SGV**	Soil guideline value
DWS	Drinking water standard	**SPH**	Separate-phase hydrocarbon
EA	Environment Agency	**SPT**	Standard penetration test
EQS	Environmental quality standard	**SVOC**	Semi-volatile organic compound
FFL	Finished floor level	**TPH**	Total and speciated petroleum hydrocarbon
GAC	General assessment criteria	**TPH CWG**	Total Petroleum Hydrocarbon (Criteria Working Group)
GL	Ground level	**UKWIR**	United Kingdom Water Infrastructure Risk
GSV	Gas screening value	**UST**	Underground storage tank
HCV	Health criteria value	**VCC**	Vibro-concrete column
ICSM	Initial conceptual site model	**VOC**	Volatile organic compound
LEL	Lower explosive limit	**VRSC**	Vibro-replacement stone columns
LMRL	Lower method reporting limit	**VSC**	Vibro-stone columns
LNAPL	Light non-aqueous phase liquid (petrol, diesel, kerosene)	**WHO**	World Health Organisation
MCV	Moisture condition value	**WRAP**	Waste and Resources Action Programme
MIBK	Methyl isobutyl ketone	**WTE**	Water table elevation

m	Metres	**ppm**	Parts per million
km	Kilometres	**mg/m^3**	Milligram per metre cubed
% v/v	Percent volume in air	**m bgl bgl**	Metres below ground level
mb	Millibars (atmospheric pressure)	**m bcl**	Metre below cover level
l/hr	Litres per hour	**mAOD**	Metres above ordnance datum (sea level)
µg/l	Micrograms per litre (parts per billion)	**kN/m^2**	Kilonewtons per metre squared
ppb	Parts per billion	**µm**	Micrometre
mg/kg	Milligrams per kilogram (parts per million)	**SSRT**	Site Specific Remediation Target
PSD	Particle Size Distribution	**DD**	Dry Density
CL:AIRE	Contaminated Land: Applications in Real Environments	**Mc**	Moisture Content
ρ	Bulk Density	**GPR**	Ground Penetrating Radar
NDP	Nuclear Density Probe	**FFL**	Finished Floor Level
LEL	Lower Explosive Limit	**UKWIR**	UK Water Industry Research
CIRIA	Construction Industry Research and Information Association	**LOD**	Limit of Detection

APPENDIX III
DRAWINGS



Location Symbols

- Approximate Window Sample Probehole Location with Install
- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Rotary Borehole Location
- Approximate Cable Percussive Borehole Location
- Approximate Rotary Borehole Location
- Approximate Test Location
- Approximate Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Trial Pit Location

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	R2	30.09.2021	REVISION	HM	GC
P1	R1	30.01.2020	REVISION	LM	EM
P1	-	21.01.2020	DRAFT	HM	MD

Client: Engie

Job No: 13-887

Date: 30.09.2021

Drawing No: 005

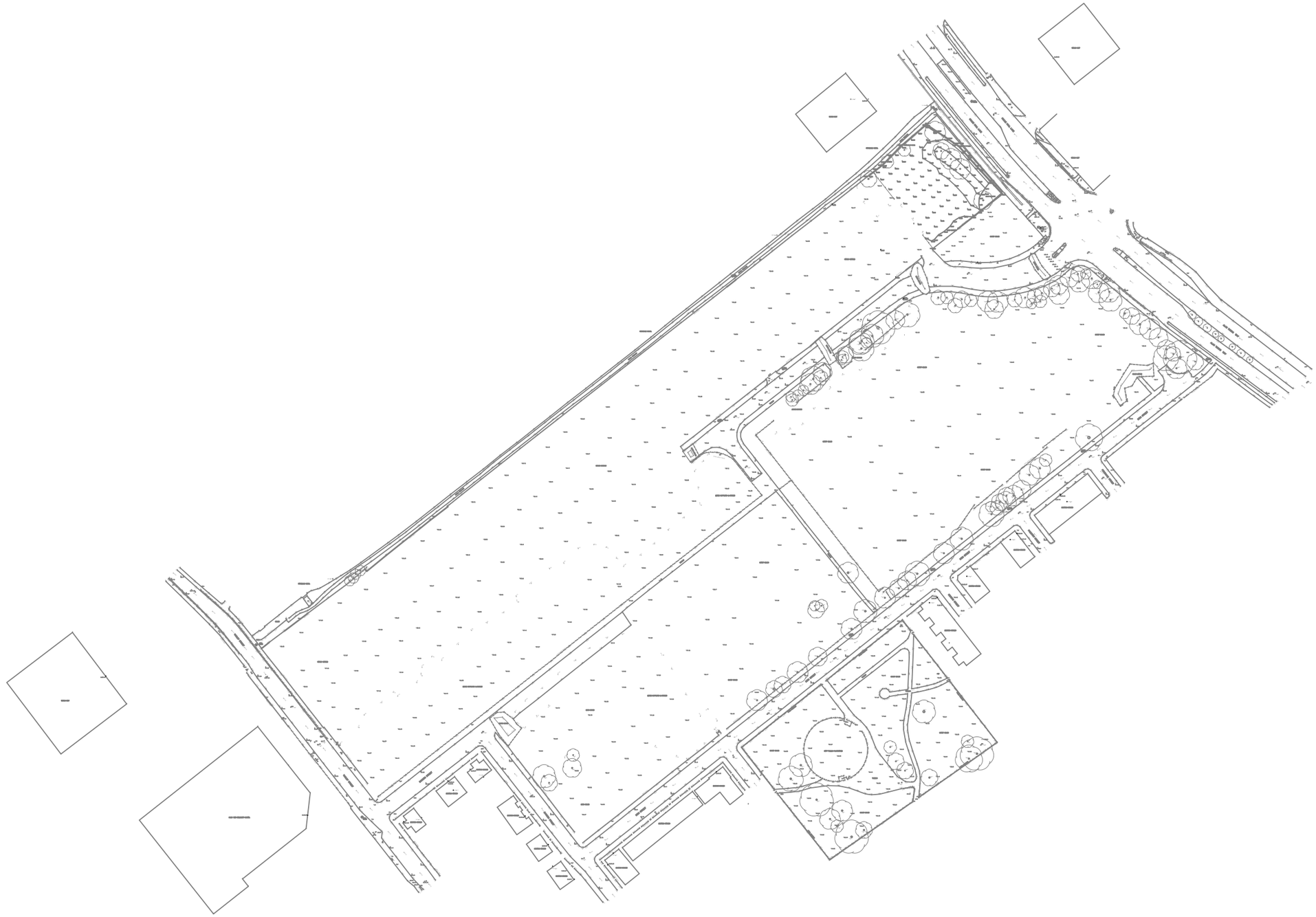
Scale: NTS

Job Title: Manox

Drawing Title: Exploratory Hole Location Plan

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N

P1	-	14.01.2020	DRAFT	HM	MD
Phase	Revision	Date	Issue	Drawn	Checked

Notes:

Client: Engie

Job No: 13-887

Date: 14.01.2020

Drawing No: 002

Scale: NTS

Job Title: Manox

Drawing Title: Site Location

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P1	-	03.02.2020	DRAFT	LM	EM
Phase	Revision	Date	Issue	Drawn	Checked

Notes:

Client: Engie

Job No: 13-887

Date: 03.02.2020

Drawing No: 002

Scale: NTS

Job Title: Manox

Drawing Title: Proposed Development Plan

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Historical Features

- Former Streets (Pre 1893 - Present)
- Former Residential Buildings (Pre 1893 - Pre 1979)
- Former Chemical Works (Pre1893 - Pre 1995)
- Former Tank (Pre 1893 - Pre 2019)
- Former Ponds (Pre 1893 - Pre 1908)
- Former Ponds (Pre 1990 - Pre 1992)
- Former Chemical Works (Pre 1984 - 1995)
- Former Chimney (Pre 1894 - Pre 1992)
- Former Contours (Pre 1893 - Pre 1992)
- Former School (Pre 1893 - Pre 1992)
- Former Band Stand (Pre 1893 - Pre 1951)
- Former Wool Mill (Pre1893 - Pre 1968)
- Former Footpath (Pre 1893 - Pre 1922)
- Former Building (Pre 1990 - Pre 2019)
- Former Electrical Sub-Station (Pre 1948 - Pre 1991)
- Former Structures (Pre 1891 - Pre 1908)
- Former Coal Pit (Pre 1848 - Pre 1891)

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	R1	03.08.2020	REVISION	HM	OJ
P1	-	22.01.2020	DRAFT	HM	MD

Client: Engie

Job No: 13-887

Date: 03.08.2020

Drawing No: 003

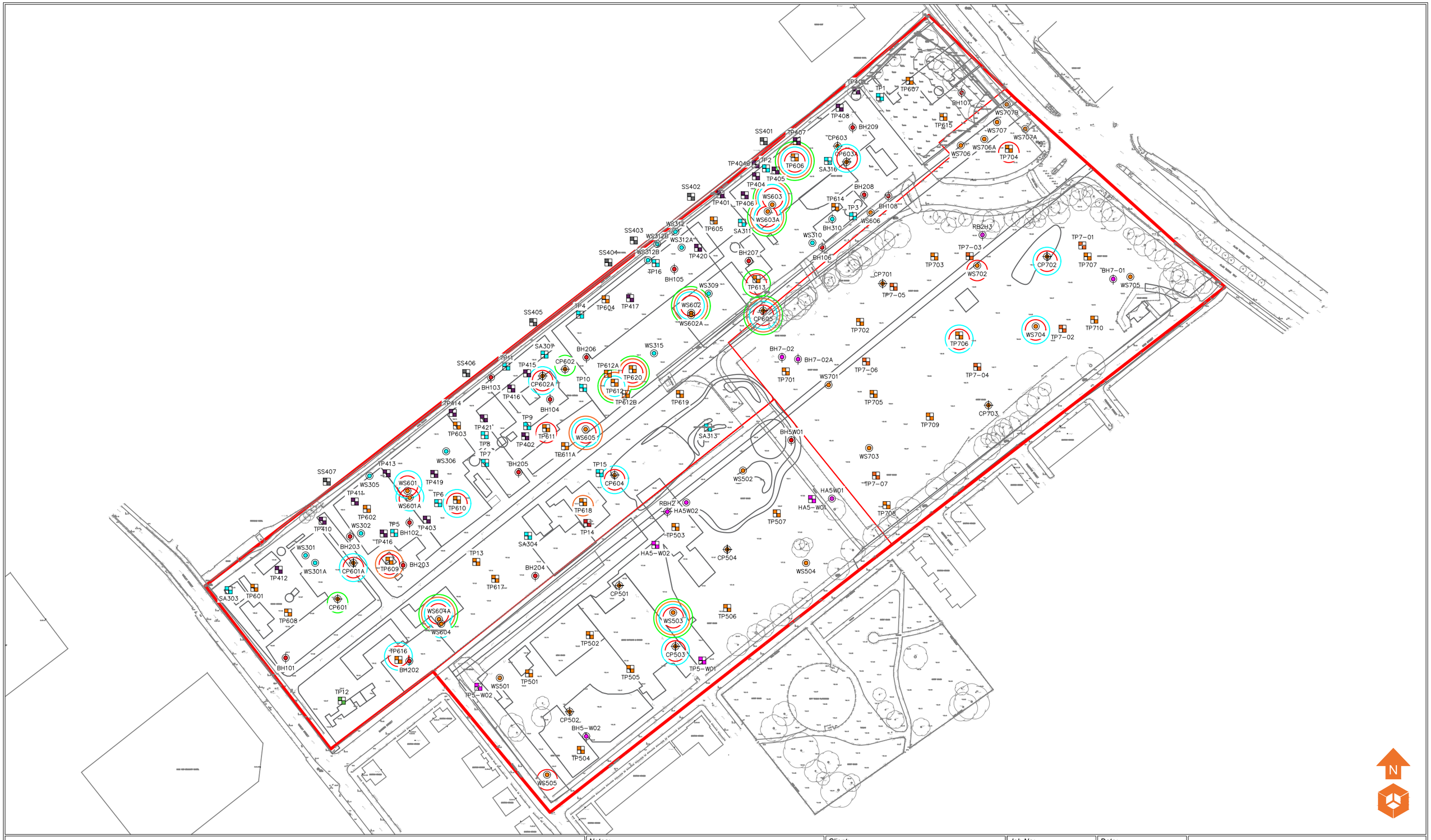
Scale: NTS

Job Title: Manox

Drawing Title: Historical Features Plan

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Location Symbols

- Approximate Window Sample Probehole Location with Install
- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Rotary Borehole Location
- Approximate Cable Percussive Borehole Location
- Approximate Rotary Borehole Location
- Approximate Test Location
- Approximate Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Trial Pit Location

Contamination Exceedances

- Metals
- Total Cyanide
- PAH
- TPH

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	R1	03.08.2020	REVISION	HM	OJ
P1	-	31.01.2020	DRAFT	LM	EM

Client: Engie

Job No: 13-887

Date: 03.08.2020

Drawing No: 007

Scale: NTS

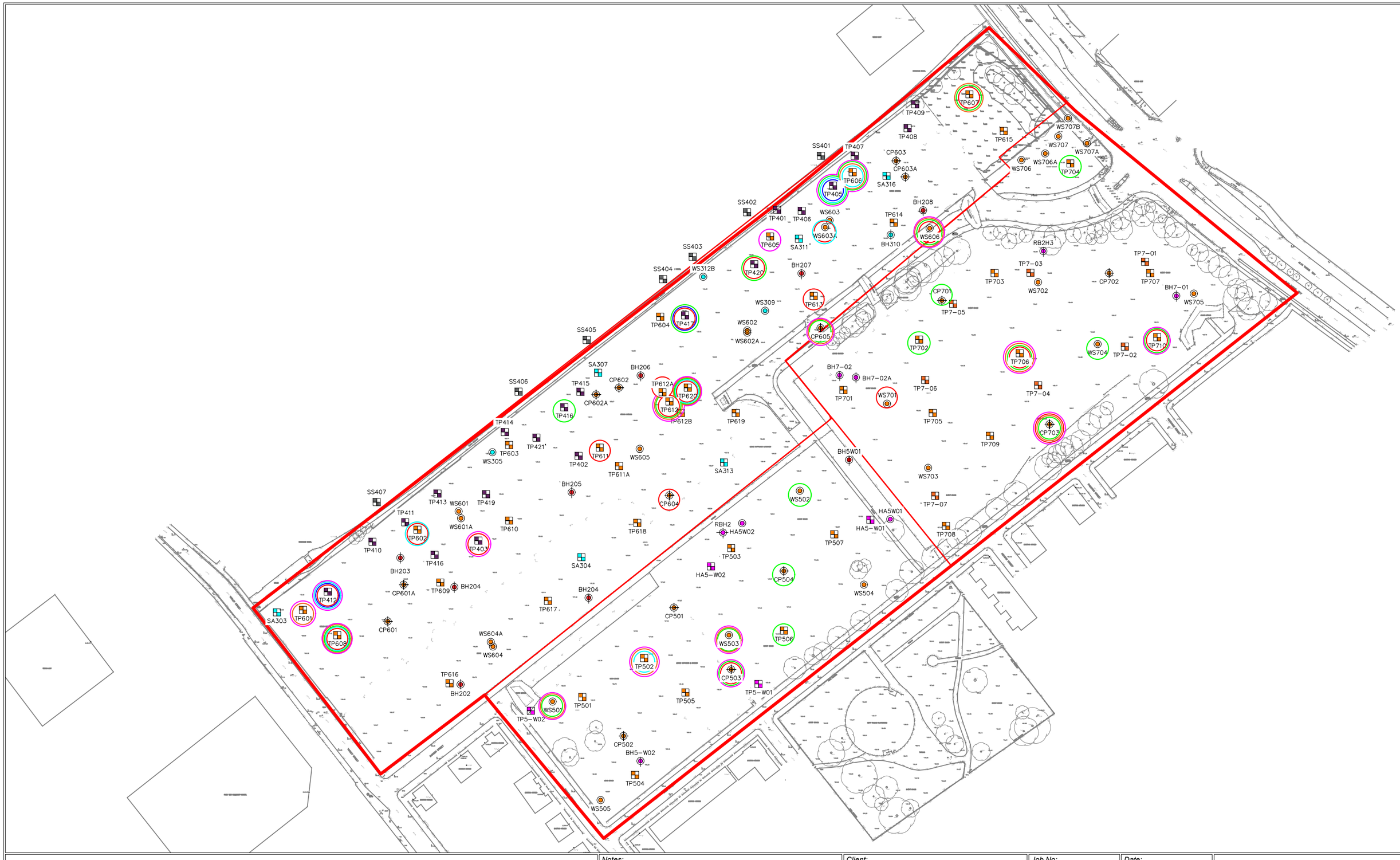
Job Title: Manox

Drawing Title: EQS Contamination Exceedance Plan

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Soakaway Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)

Contamination Exceedances

- Metals
- Phenols
- Naphthalene
- Total PAH
- TPH
- SVOC

Notes:

P1	-	03.02.2020	DRAFT	LM	EM
Phase	Revision	Date	Issue	Drawn	Checked

Client: Engie

Job No: 13-887

Date: 03.02.2020

Drawing No: 009

Scale: NTS

Job Title: Manox

Drawing Title: Soil Exceedance Plan

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Location taken from URS 2004 site audit. Tar channel backfilled with gravel saturated in seperate phase hydrocarbon product.
Depth confirmed by URS.
Tar channel located in URS TP6/TP7/TP9/TP10, Brick built structure filled with coarse gravel channel <2.00m wide inlet pipe at TPS

Possible location of feeder pipe that originated from chemical works on northern side of canal.

URS - Seperate phase for TP8 and TP4.
-Up hydraulic gradient of Topsoil Hotspot

LNAPL

Tar Channel

Geotextile Barrier
Land to south
remediated in 1993

- Seperate phase migration appears limited.
- Localised hydrocarbon spillages across site, mainly low solubility TPH/PAH

CSM Features

- DNAPL
- Tar Channel
- Geotextile Barrier
- Tar Pipe

Notes:

P1	R1	04.08.2020	REVISION	HM	OJ
P1	-	04.02.2020	DRAFT	LM	EM
Phase	Revision	Date	Issue	Drawn	Checked

Client: Engie

Job No: 13-887

Date: 04.08.2020

Drawing No: 011

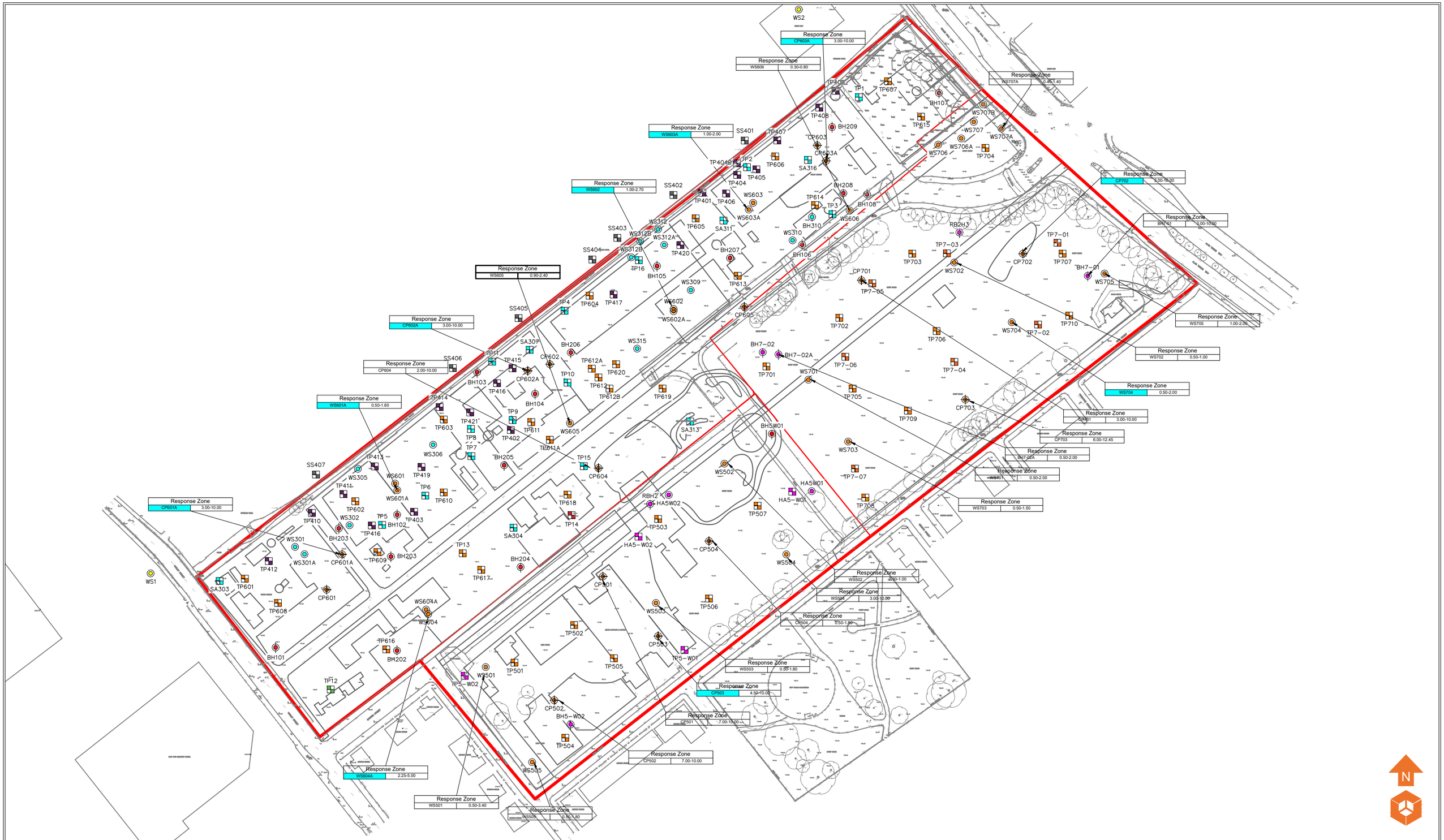
Scale: NTS

Job Title: Manox

Drawing Title: Tar Channel and DNAPL Manox Site

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Offsite Canal Sampling Point (E3P July 2020)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (ERM 2009)
- Wells E3P Located July 2020

Notes:

RSK well data used throughout the drawing.

Phase	Revision	Date	Issue	Drawn	Checked
P1	R4	04.08.2020	REVISION	HM	EM
P1	R3	03.08.2020	REVISION	HM	EM
P1	R2	20.07.2020	REVISION	LM	EM
P1	R1	30.01.2020	REVISION	LM	EM
P1	-	21.01.2020	DRAFT	HM	MD

Client: Engie

Job No: 13-887

Date: 04.08.2020

Drawing No: 019

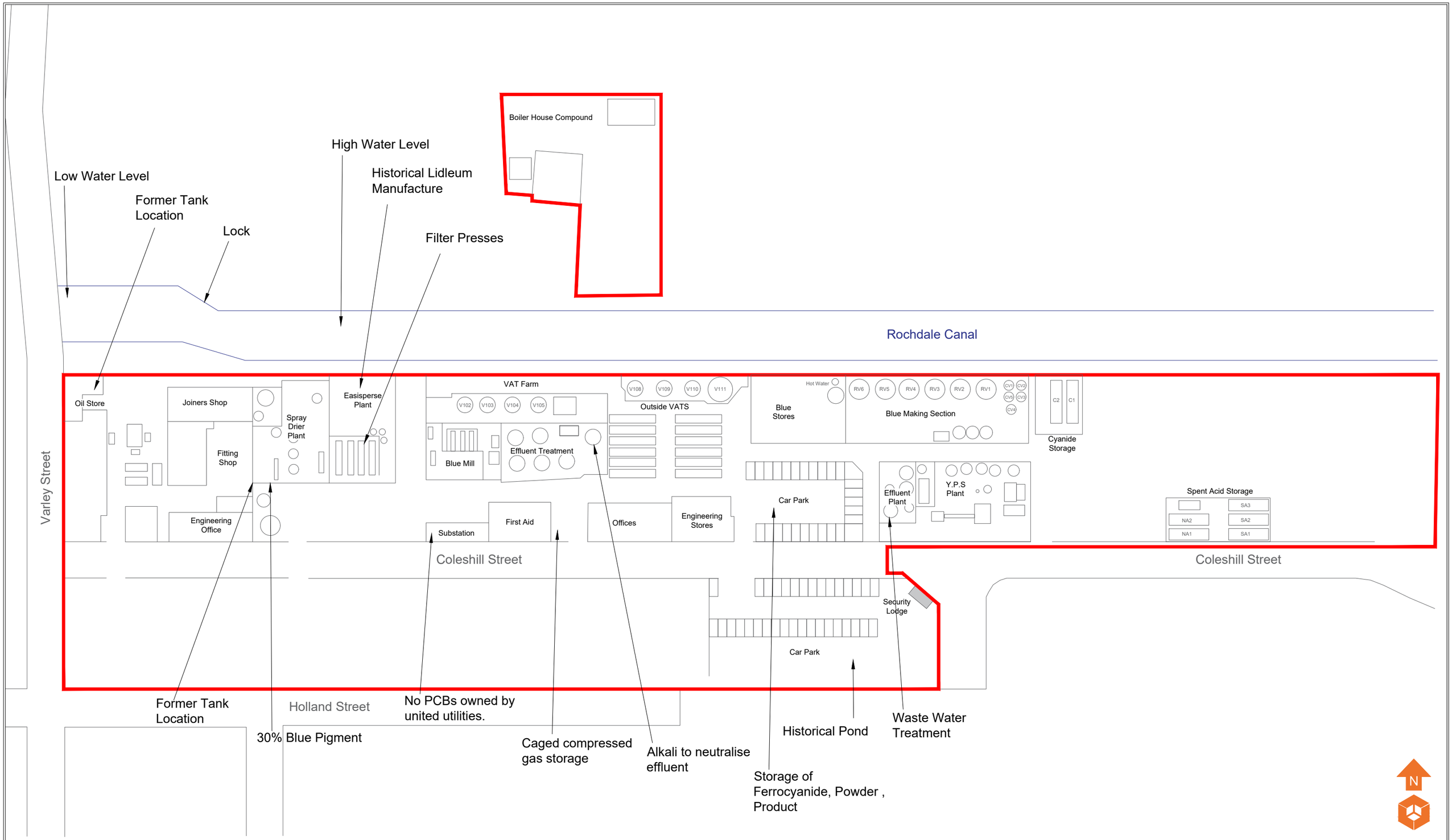
Scale: NTS

Job Title: Manox

Drawing Title: Zone of Repose Plan

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P1	R1	30.07.2020	REVISION	LM	MD
P1	-	20.07.2020	DRAFT	LM	MD
Phase	Revision	Date	Issue	Drawn	Checked

Notes:

Client: Engie

Job No: 13-887

Date: 30.07.2020

Drawing No: 020

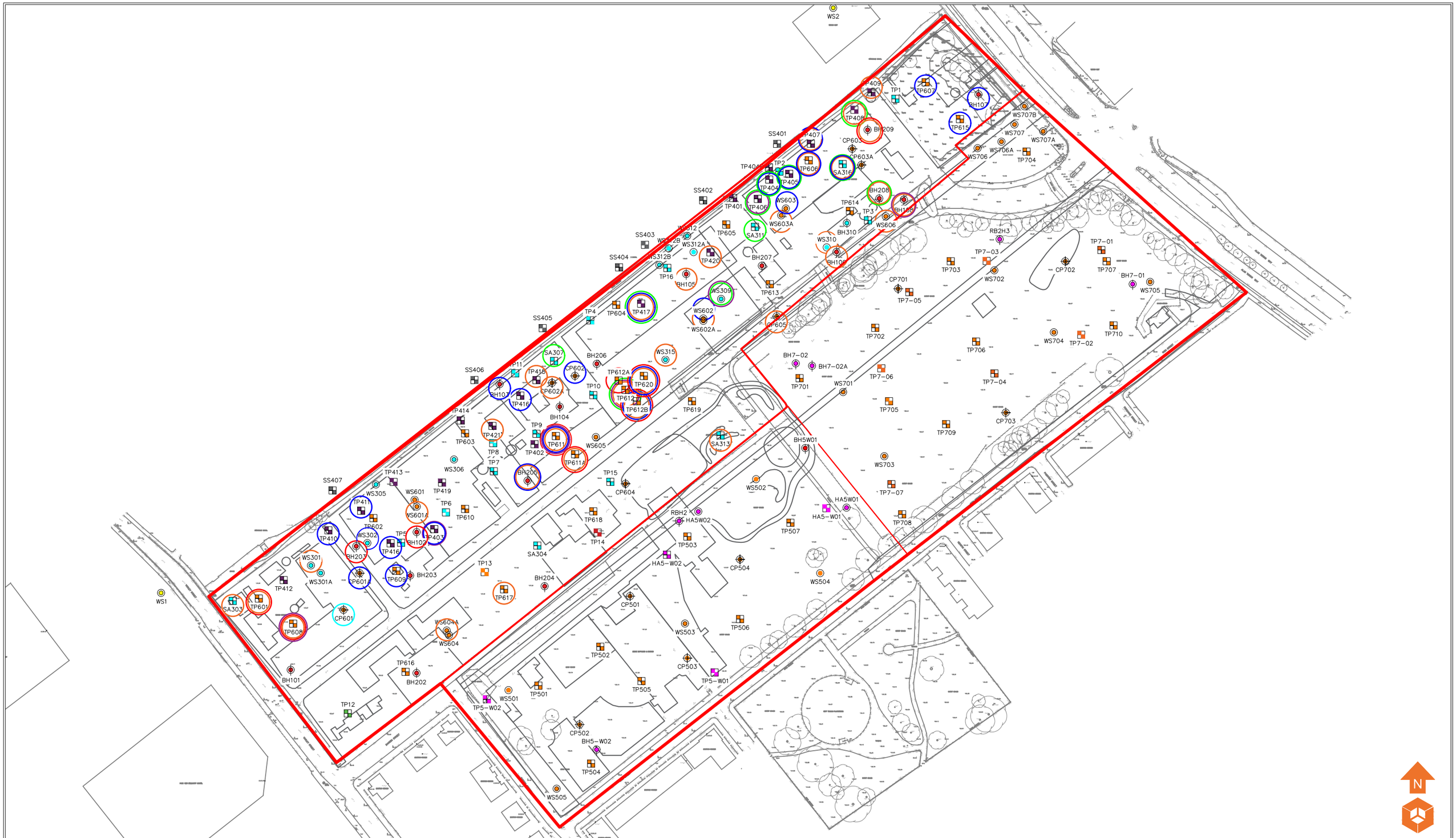
Scale: NTS

Job Title: Manox

Drawing Title: Former Manox Works Plan

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Blue Staining
- HC Odour
- Oilysheen
- PID reading high
- TAR / LNAPL / DNAPL

Notes:

Data for Manox site only

Client:

Engie

Job No: 13-887

Date: 13.11.2020

Drawing No: 021

Scale: NTS

Phase	Revision	Date	Issue	Drawn	Checked
P1	R3	13.11.2020	REVISION	LM	OJ
P1	R2	10.11.2020	REVISION	LM	OJ
P1	R1	04.08.2020	REVISION	HM	OJ
P1	-	20.07.2020	DRAFT	LM	MD

Job Title:

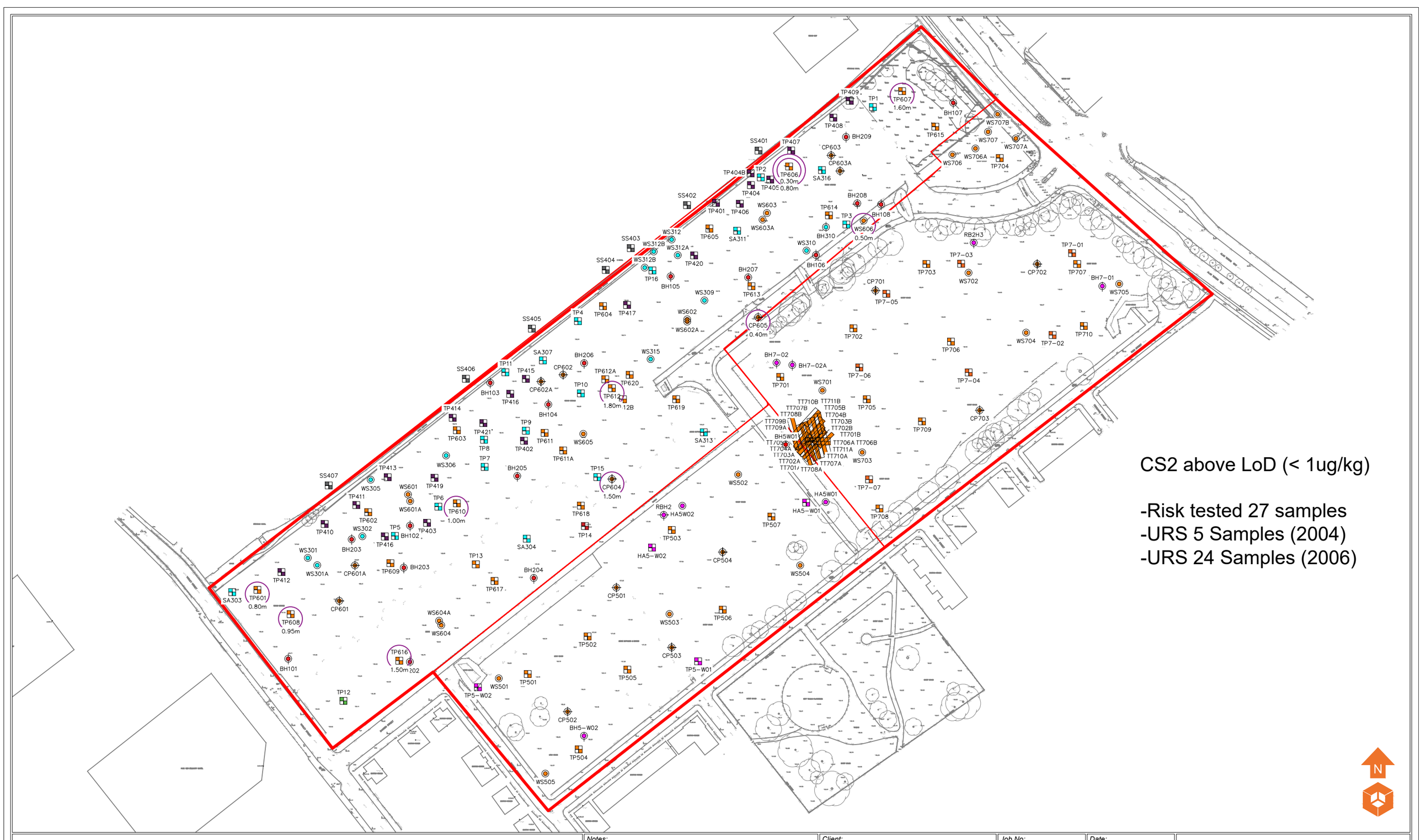
Manox

Drawing Title:

Visual Olfactory Contamination Plan - Manox Area

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- CS2 above LoD (< 1ug/kg)

Notes:

Client: Engie

Job No: 13-887

Date: 20.07.2020

Drawing No: 022

Scale: NTS

P1	R1	20.07.2020	REVISION	LM	MD
Phase	Revision	Date	Issue	Drawn	Checked

Job Title: Manox

Drawing Title: Carbon Disulphate Plan

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Cyanide (Soils)
GAC 791 mg/kg

Cyanide EQS
GAC 1ug/l

Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
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- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Total Cyanide (Water)
- Total Cyanide (Soil)
- Water Exceedance - Cyanide (E3P 2020)

Notes:
Data for Manox site only

Client:
Engie

Job No: 13-887

Date: 04.08.2020

Drawing No: 023

Scale: NTS

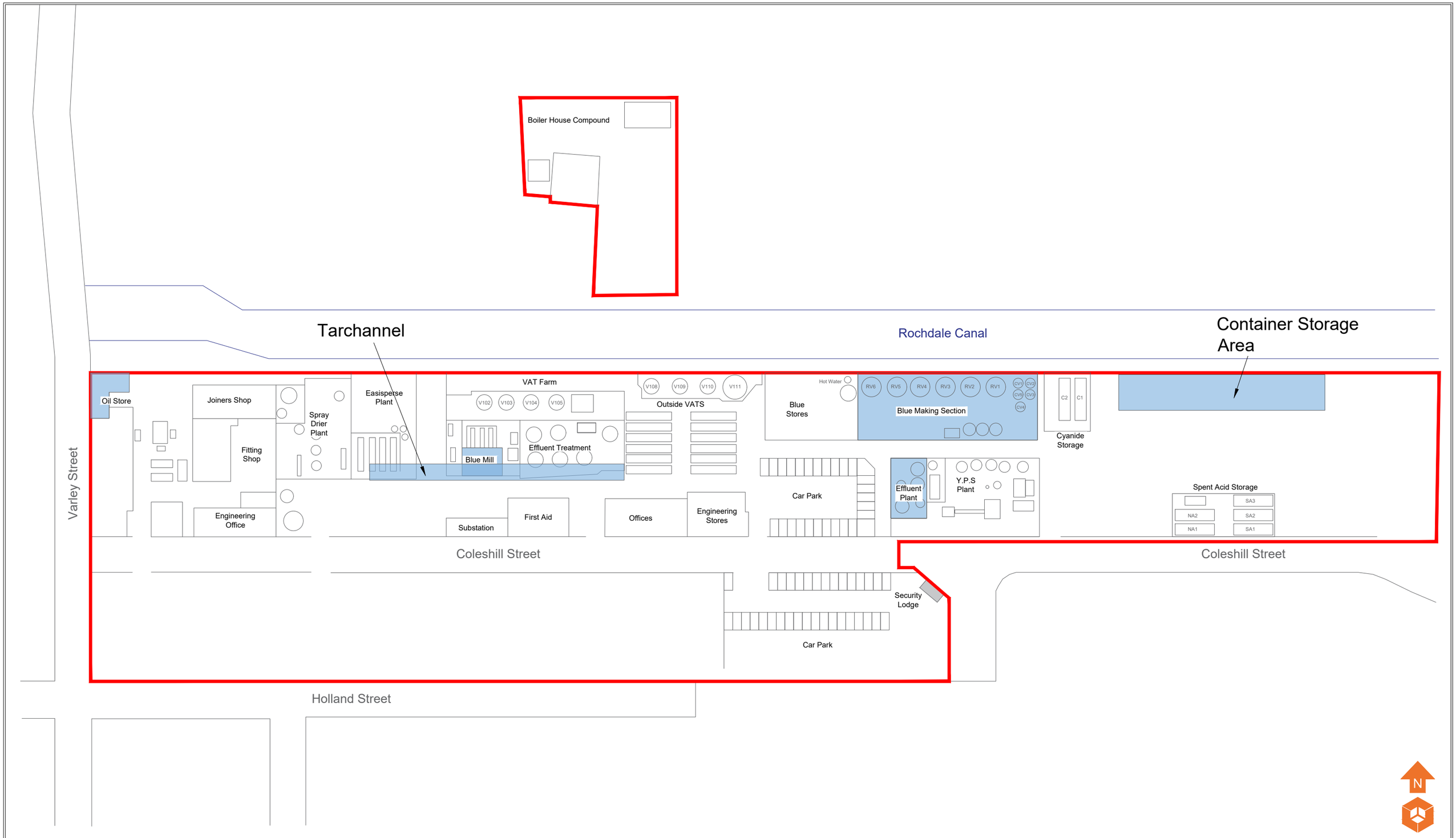
Phase	Revision	Date	Issue	Drawn	Checked
P1	R2	04.08.2020	REVISION	HM	OJ
P1	R1	03.08.2020	REVISION	HM	OJ
P1	-	20.07.2020	REVISION	LM	MD

Job Title:
Manox

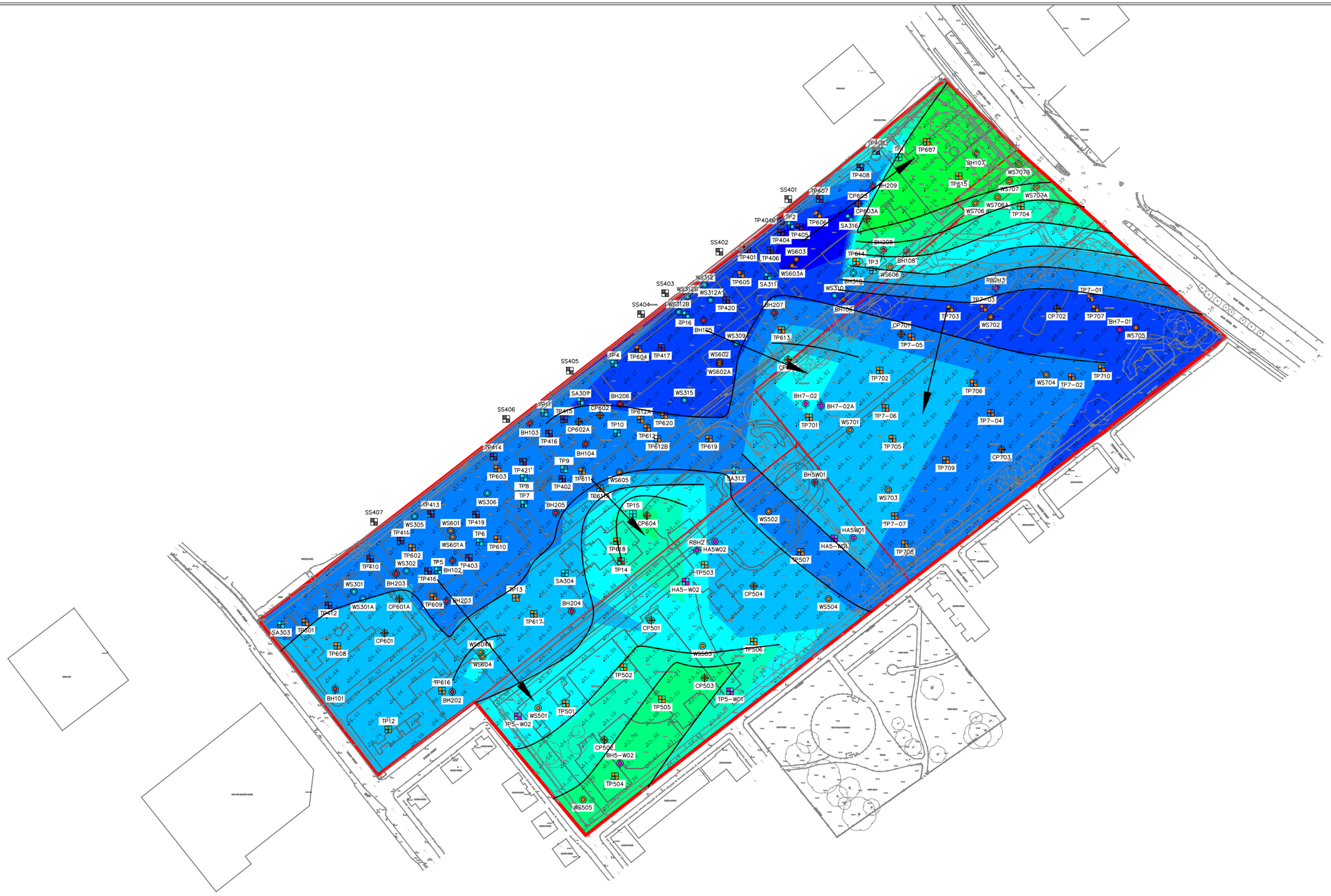
Drawing Title:
Cyanide Exceedance Plan

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Notes:				Client: Engie	Job No: 13-887	Date: 20.07.2020	e3p Environmental Engineering Partnership Ltd, Taylor Road, Trafford Park, Urmston, Manchester, M41 7JQ, Tel: 0161 707 9612, E-mail: info@e3p.co.uk, Website: www.e3p.co.uk
					Drawing No: 024	Scale: 1:1000 @ A3	
P1	REVA	20.07.2020	CB	MD	Job Title: Manox	Drawing Title: Main Contamination Sources	The client must not amend any drawing, design or other intellectual property produced by E3P Ltd without permission in writing from E3P Ltd in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amended drawing, design or intellectual property.
Phase	Issue	Date	Drawn	Checked			



Location Symbols

- Approximate Window Sample Probehole Location with Install
- Approximate Window Sample Probehole Location
- Approximate Trial Pit Location
- Approximate Trial Trench Location
- Approximate Groundwater Flow

Depth to Groundwater AOD (m)

- Depth to Groundwater 51.00 - 51.99m
- Depth to Groundwater 52.00 - 52.99m
- Depth to Groundwater 53.00 - 53.99m
- Depth to Groundwater 54.00 - 54.99m
- Depth to Groundwater 55.00 - 55.99m
- Depth to Groundwater 56.00 - 56.99m
- Depth to Groundwater 57.00 - 57.99m
- Depth to Groundwater >58.00

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	R1	29.07.2020	REVISION	HM	OJ
P1	-	28.07.2020	DRAFT	HM	OJ

Client: Engie

Job Title: Manox

Job No: 13-887

Date: 29.07.2020

Drawing No: 025

Scale: NTS

Drawing Title: Depth to Ground Water (AOD) Plan

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Circa 6.00m of contaminated material removed from chemical manufacturing facility north of canal in 1990 by Travis Morgan

Chemical Works to the North Identified as Manufacturing:

-Carbon Disulphide, Sulphuric Dioxide
-Sulphates
-Sulphuric Acid
-Sulphur Cyanide
(Some Material Removed)

Location of Former Footbridge
Reported "Tor Pipe"

Localised Spillage

Tarchannel

Rochdale Canal

Container Storage Area

Boiler House Compound

Oil Store
Joiners Shop
Spray Drier Plant
Easisperse Plant
Fitting Shop
Engineering Office
Blue Mill
Substation
First Aid
VAT Farm
V102 V103 V104 V105
Outside VATS
V108 V109 V110 V111
Effluent Treatment
Offices
Engineering Stores
Blue Stores
Hot Water
RV6 RV5 RV4 RV3 RV2 RV1
CV7 CV8 CV9 CV6
Blue Making Section
C2 C1
Cyanide Storage
Car Park
Effluent Plant
Y.P.S Plant
Spent Acid Storage
SA3 SA2 SA1 NA2 NA1
Varley Street
Coleshill Street
Coleshill Street
Security Lodge
Car Park
Holland Street

Former warehousing for chemical works subject to bulk excavation and removal of contaminated soil & groundwater in 1993 under the supervision of Aspinall.

Geotextile barrier installed adjacent to Coleshill Street to prevent any re-impact from chemical works to the north.

Primary on Site Contamination Sources:

-Historical Bass Foundry and Lindeum Works
-Tor Waste - Incinerated
-Tor Tank Storage in West
-Service Channel (Tar)

N

Phase	Revision	Date	Issue	Drawn	Checked
P1	R1	04.08.2020	REVISION	HM	OJ
P1	-	30.07.2020	DRAFT	LM	MD

Notes:
This Drawing Defines the Known Operations By Degussa in ~ 2004

Client:
Engie

Job No:
13-887

Date:
04.08.2020

Drawing No:
026

Scale:
NTS

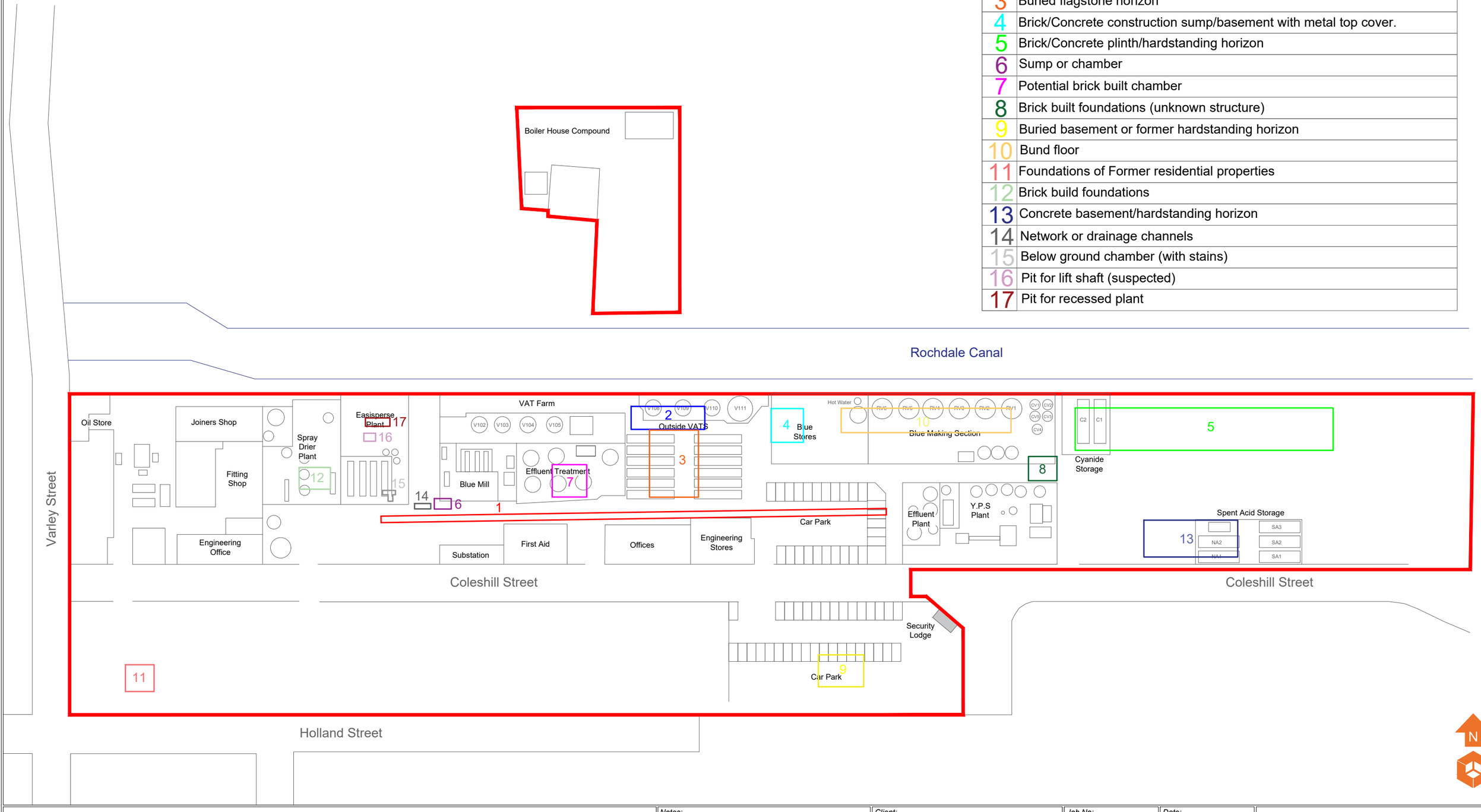
Job Title:
Manox

Drawing Title:
Main Contamination Sources
Degussa Operations

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1	Inferred position of Tar channel
2	Reinforced concrete bund base and concrete hardstanding
3	Buried flagstone horizon
4	Brick/Concrete construction sump/basement with metal top cover.
5	Brick/Concrete plinth/hardstanding horizon
6	Sump or chamber
7	Potential brick built chamber
8	Brick built foundations (unknown structure)
9	Buried basement or former hardstanding horizon
10	Bund floor
11	Foundations of Former residential properties
12	Brick build foundations
13	Concrete basement/hardstanding horizon
14	Network or drainage channels
15	Below ground chamber (with stains)
16	Pit for lift shaft (suspected)
17	Pit for recessed plant



P1	REVA	30.07.2020	LM	MD
Phase	Issue	Date	Drawn	Checked

Notes:

Client: Engie

Job No: 13-887

Date: 30.07.2020

Drawing No: 027

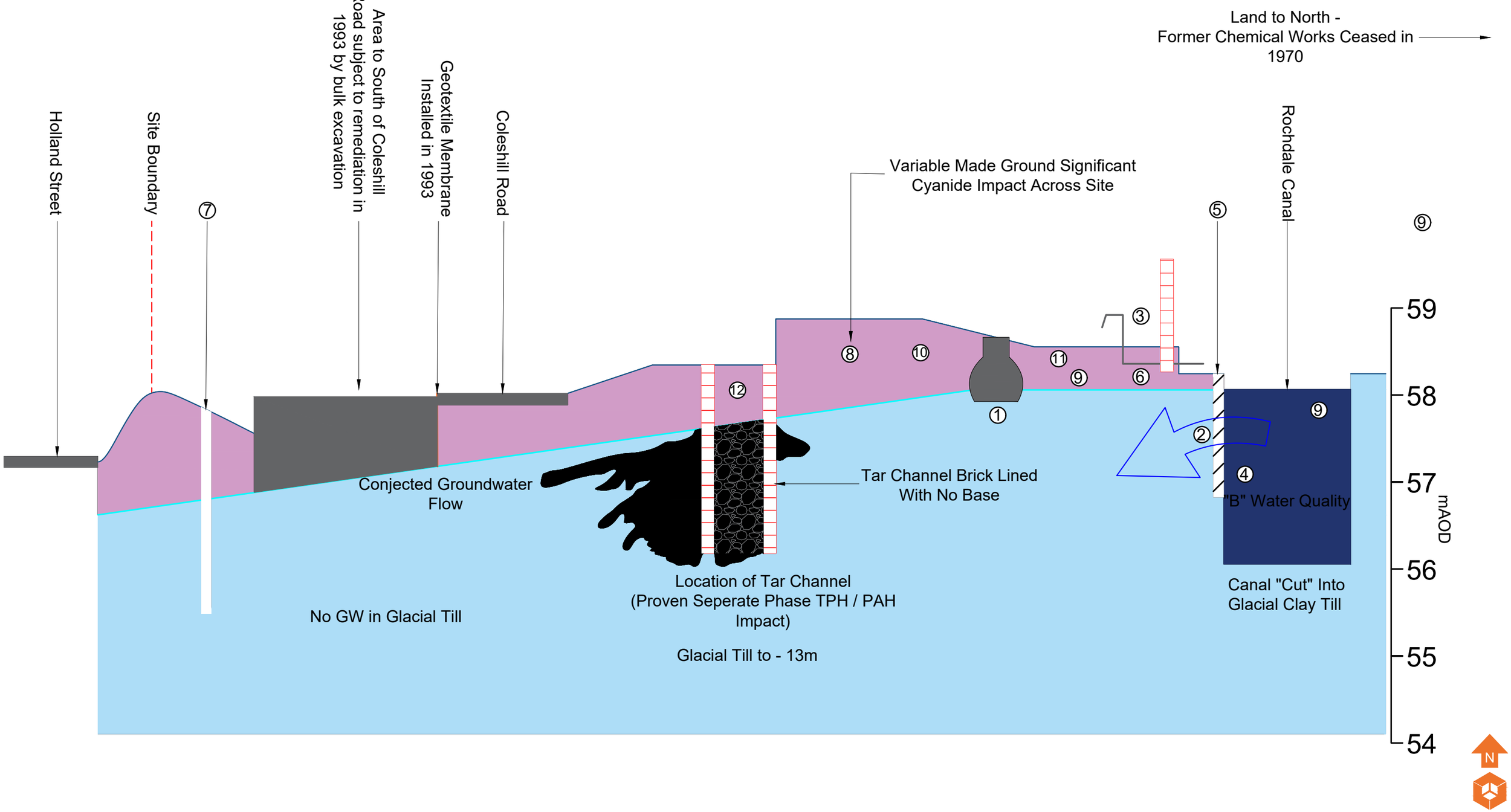
Scale: 1:1000 @ A3

Job Title: Manox

Drawing Title: Location of Known Below Ground Structures

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Location Symbols

1. Localised seperate phase TPH (With PAH) impact of near surface representation of surface spilalge. (Not deliniated) Limited migration to south down hydraulic gradient. Vertical migration confined by clay walls
2. Canal "Up" hydraulic graient likely scenerario is canal is contributing to hydrology & shallow pearched water confined above law permeability clay.
3. Former / Remenant drainage infrastrucutre represents a prefertial pathway to canal. All infrastructure to be removed & pathway negated
4. Canal wall lining limit hydraulic impact
5. ERM Investigation confirmed visual leakage of contaminants through boundary wall to canal considered to be leaching not GW hydraulic conductivity.
6. Perched water confirmed by walls at higher elevation to canal and is seaping through and impacting. remediation to solidify and stabilise cyanide impact will remove this pathway
7. Monitoring wells down hydraulic gradient do not show significant cyanide impact
8. Made ground in Manox sector impacted by semi volatile and volatile organic compounds. No tox data readily available to inform robust SSRI's mitigate pathway by vapor membrane.
9. Carbon disulphide (CS2) off site primary source CS2 impact known in canal and sediment. Low level CS2 impact onsite no primary CS2 source identified on Manox.
10. Significant aromatic semi volatile PAH/SVOC impact on site in MG across Manox.
11. Significant arsenic and lead impact in MG multiple instances of discoloration (Blue and Green) suggesting primary source.
12. Salt glazed feeder pipe to tar channel

Conjected Groundwater Flow

Rochdale Canal

Tar Channel

Glacial Clay Till

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	R1	03.08.2020	REVISION	HM	MD
P1	-	31.07.2020	DRAFT	HM	MD

Client: Engie

Job No: 13-887

Date: 03.08.2020

Drawing No: 028

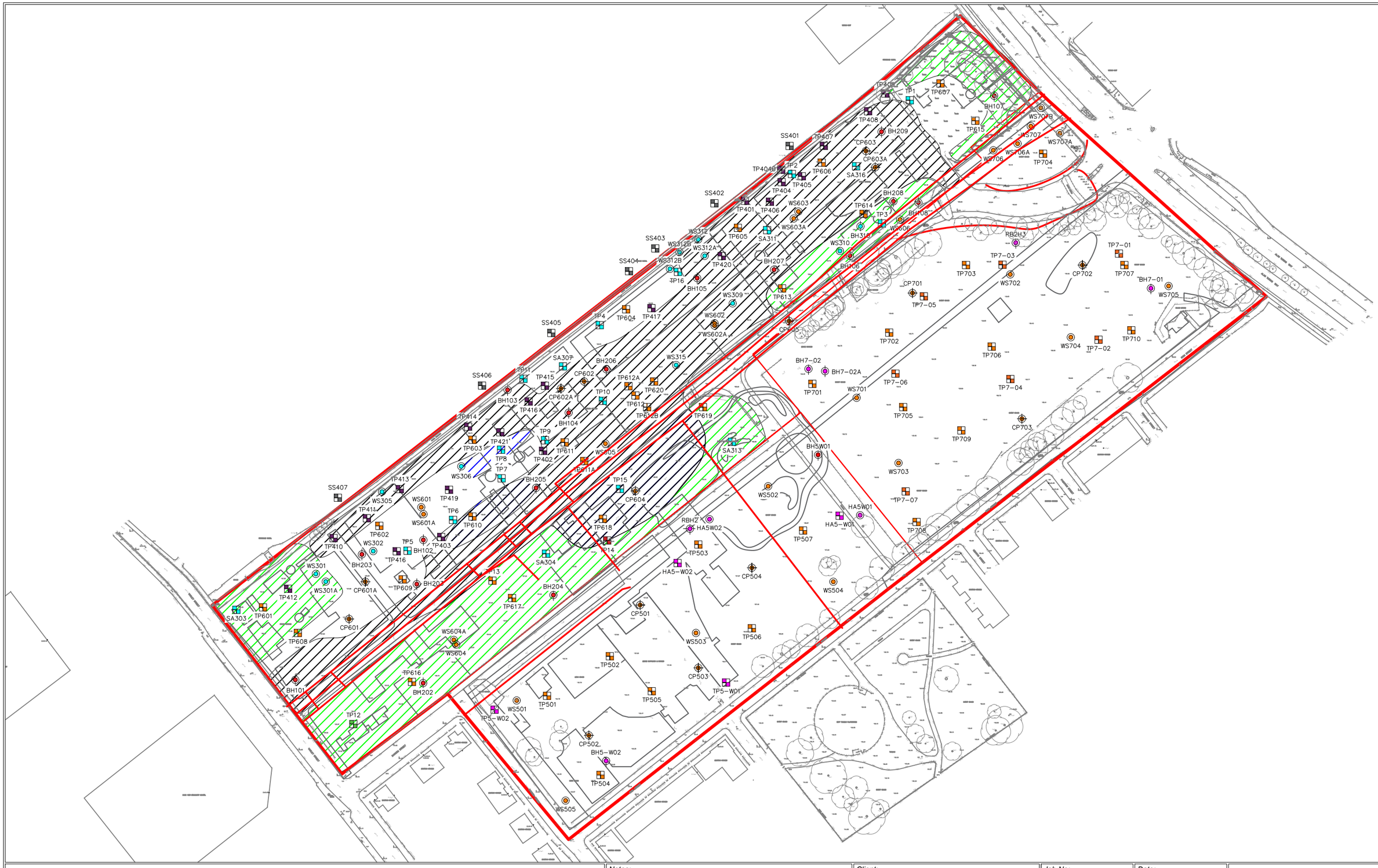
Scale: NTS

Job Title: Manox

Drawing Title: Canal Impact Section Plan

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Stockpile
- Vegetation / Trees
- Hardstanding
- Services (BT/Gas/Electricity/Sewer/Surface water)

Notes:

Client: Engie

Job No: 13-887

Date: 03.08.2020

Drawing No: 032

Scale: NTS

Phase	Revision	Date	Issue	Drawn	Checked
P1	-	03.08.2020	DRAFT	HM	OJ

Job Title: Manox

Drawing Title: Constaints Plan

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
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- Approximate Trial Pit Location (Westlakes 2019)
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- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)
- Tar/LNAP/DNAPL

Notes: Data for Manox site only

Client: Engie

Job No: 13-887

Date: 04.08.2020

Drawing No: 033

Scale: NTS

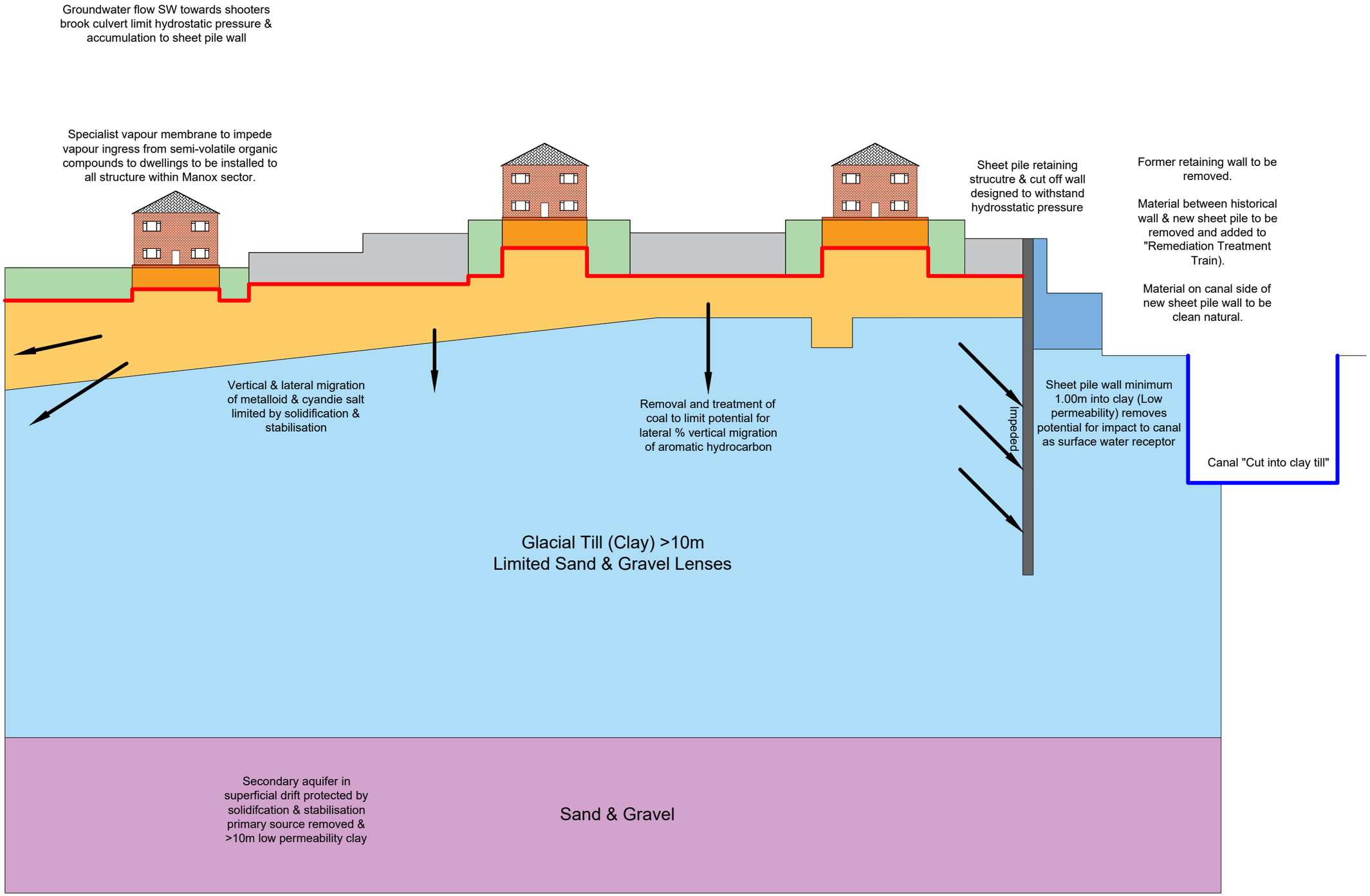
Phase	Revision	Date	Issue	Drawn	Checked
P1	-	04.08.2020	DRAFT	HM	OJ

Job Title: Manox

Drawing Title: Seperate Phase Contamination Plan

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CSM Features

- Inert import & Sub-Structure
- Inert import & Highways & Driveways
- 1000mm clean cover to garden / Landscaping to remove direct exposure
- Full depth excavation of made ground across Manox site. All material enters "Remediation Train" prior to treatment, analysis & Re-use
- Glacial Till (Clay)
- Sand & Gravel
- Subformation or "Remediation platform level" Gardens 1000mm / Roads / Drives & Plots - 750mm

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	-	17.11.2020	DRAFT	HM	EM

Client: Engie

Job No: 13-887

Date: 17.11.2020

Drawing No: 034

Scale: NTS

Job Title: Manox

Drawing Title: Post Remediation Developed Conceptual Site Model

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Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
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- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
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- Approximate Trial Pit Location (Westlakes 2019)
- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)

Remediation Issues

- Hardstanding / Obstruction
- Soft / Loose natural ground
- Dense Vegetation
- Semi - mature Trees
- Carbon Disulphide detected, removal required between 1.50 - 1.60m
- Visual / Olfactory Contamination
- Human health exceedance requiring removal

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	-	10.11.2020	REVISION	LM	OJ

Client: Engie

Job No: 13-887

Date: 10.11.2020

Drawing No: 034

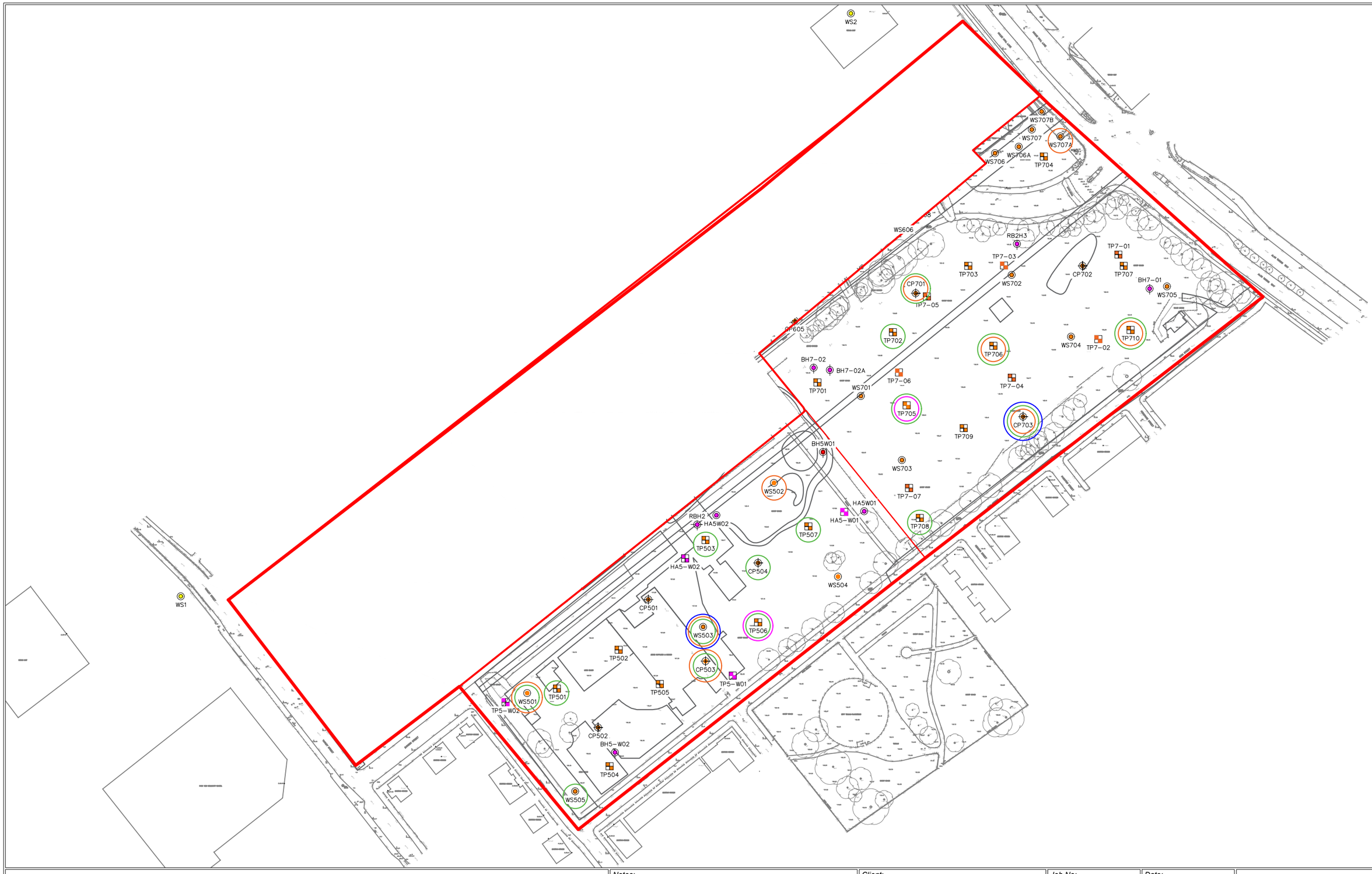
Scale: NTS

Job Title: Manox

Drawing Title: Zone 5 and Zone 7 Remediation Issues Plan

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Location Symbols

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- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
- Approximate Trial Pit Location (Westlakes 2019)
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- Approximate Window Sample Probehole Location (Westlakes 2019)
- Approximate Cable Percussive Borehole Location (Westlakes 2019)
- Approximate Rotary Borehole Location (Parson Brickenhoff 2007)
- Approximate Test Location (Parson Brickenhoff 2007)
- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)

Contamination Exceedances

- PAH
- TPH
- Carbon Dioxide
- Heavy Metals

Notes:

Client: Engie

Job No: 13-887

Date: 10.11.2020

Drawing No: 035

Scale: NTS

Phase	Revision	Date	Issue	Drawn	Checked
P1	-	10.11.2020	REVISION	LM	OJ

Job Title: Manox

Drawing Title: Zone 5 and Zone 7 Human Health Exceedances Plan

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Post Remediation gas + vapour monitoring required



Full turnover of Made Ground and 1000mm cover system within all residential gardens.

Location Symbols

- Approximate Rotary Borehole Location (URS 2004)
- Approximate Trial Pit Location (URS 2006)
- Approximate Window Sample Probehole Location (URS 2006)
- Approximate Shell and Auger Location (URS 2006)
- Approximate Trial Pit Location (ERM 2009)
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- Approximate Sample Probehole Location (Parson Brickenhoff 2007)
- Approximate Trial Pit Location (Parson Brickenhoff 2007)

Remediation Issues Plan

- Hardstanding / Obstruction
- Areas requiring Treatment
- Dense Vegetation
- Asbestos hotspot requiring removal

Notes:

Phase	Revision	Date	Issue	Drawn	Checked
P1	-	10.11.2020	REVISION	LM	OJ

Client: Engie

Job No: 13-887

Date: 10.11.2020

Drawing No: 036

Scale: NTS

Job Title: Manox

Drawing Title: Remediation Issues Plan

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APPENDIX IV
E3P REMEDIATION/ VALIDATION CRITERIA

HUMAN HEALTH REMEDIATION TARGETS – LOW-RISE RESIDENTIAL END USE

DETERMINANT	UNITS	WITHIN COVER SYSTEM 700MM (GARDEN)	HARD STANDING AND BENEATH 700MM COVER	PUBLIC OPEN SPACE 700 mm COVER	PUBLIC OPEN SPACE > 600 mm & BENEARH HARDSTAND >1000MM	PATH -WAY
Arsenic	mg/kg	37[(i)]	40[(ii)]	79[(iii)]	640[(iv)]	1
Cadmium	mg/kg	11[(i)]	85[(ii)]	120[(iii)]	532[(iv)]	1
Chromium (Hexavalent)	mg/kg	6[(i)]	6[(ii)]	7.7[(iii)]	220[(iv)]	1
Lead	mg/kg	210[(vi)]	330[(vii)]	760[(viii)]	760[(viii)]	1
Elemental Mercury	mg/kg	1.2[(i)]	1.2[(ii)]	16[(iii)]	30[(iv)]	2
Nickel	mg/kg	180[(i)]	180[(ii)]	230[(iii)]	3400[(iv)]	1
Selenium	mg/kg	250[(i)]	430[(ii)]	1100[(iii)]	1800[(iv)]	1
Copper	mg/kg	2400[(i)]	7100[(ii)]	12,000[(iii)]	44,000[(iv)]	1
Total Cyanide	mg/kg	791	791	791	791	1
Zinc	mg/kg	3700[(i)]	40,000[(ii)]	81,000[(iii)]	170,000[(iv)]	1
Phenol	mg/kg	280[(i)(xi)]	280[(xiv)(xi)]	760[(iii)(xi)]	760[(iv)(xi)]	2
Naphthalene	mg/kg	2.3[(i)(xi)]	2.3[(xiv)(xi)]	1200[(iv)(xi)]	1200[(iv)(xi)]	2
Acenaphthylene	mg/kg	170[(i)(xi)]	500[(v)]	15,000[(iii)(xi)]	29,000[(iv)(xi)]	3
Acenaphthene	mg/kg	210[(i)(xi)]	500[(v)]	15,000[(iii)(xi)]	29,000[(iv)(xi)]	1
Fluorene	mg/kg	170[(i)(xi)]	500[(v)]	9900[(iii)(xi)]	20,000[(iv)(xi)]	1
Phenanthrene	mg/kg	95[(i)(xi)]	500[(v)]	3100[(iii)(xi)]	6200[(iv)(xi)]	3
Anthracene	mg/kg	500[(i)(xi)]	500[(v)]	74,000[(iii)(xi)]	150,000[(iv)(xi)]	3
Fluoranthene	mg/kg	280[(i)(xi)]	500[(v)]	3100[(iii)(xi)]	6300[(iv)(xi)]	3
Pyrene	mg/kg	500[(i)(xi)]	500[(v)]	7400[(iii)(xi)]	15,000[(iv)(xi)]	3
Benzo(a)Anthracene	mg/kg	7.2[(i)(xi)]	11[(ii)(xi)]	29[(iii)(xi)]	49[(iv)(xi)]	3
Chrysene	mg/kg	15[(i)(xi)]	30[(ii)(xi)]	57[(iii)(xi)]	93[(iv)(xi)]	3
Benzo(b)Fluoranthene	mg/kg	2.6[(i)(xi)]	3.9[(ii)(xi)]	7.1[(iii)(xi)]	13[(iv)(xi)]	3
Benzo(k)Fluoranthene	mg/kg	77[(i)(xi)]	110[(ii)(xi)]	190[(iii)(xi)]	370[(iv)(xi)]	3
Benzo(a)Pyrene	mg/kg	2.2[(i)(xi)]	3.2[(ii)(xi)]	5.7[(iii)(xi)]	11[(iv)(xi)]	3
Indeno(123-cd)Pyrene	mg/kg	27[(i)(xi)]	45[(ii)(xi)]	82[(iii)(xi)]	150[(iv)(xi)]	3
Dibenzo(a,h)Anthracene	mg/kg	0.24[(i)(xi)]	0.31[(ii)(xi)]	0.57[(iii)(xi)]	1.1[(iv)(xi)]	3
Benzo(ghi)Perylene	mg/kg	320[(i)(xi)]	360[(ii)(xi)]	640[(iii)(xi)]	1400[(iv)(xi)]	3
TPH C_5-C_6 (aliphatic)	mg/kg	42[(i)(xi)]	42[(ii)(xi)]	42[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_6-C_8 (aliphatic)	mg/kg	100[(i)(xi)]	100[(ii)(xi)]	100[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_8-C_{10} (aliphatic)	mg/kg	27[(i)(xi)]	27[(ii)(xi)]	27[(ii)(xi)]	10,000[(xiv)(xi)]	2

TPH C_{10}-C_{12} (aliphatic)	mg/kg	130[(i)(xi)]	130[(ii)(xi)]	130[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_{12}-C_{16} (aliphatic)	mg/kg	1000[(xiv)(xi)]	1000[(xiv)(xi)]	1000[(xiv)(xi)]	10,000[(xiv)(xi)]	1
TPH C_{16}-C_{21} (aliphatic)	mg/kg	1000[(xiv)(xi)]	1000[(xiv)(xi)]	1000[(xiv)(xi)]	10,000[(xiv)(xi)]	1
TPH C_{21}-C_{35} (aliphatic)	mg/kg					1
TPH C_5-C_7 (aromatic)	mg/kg	70[(i)(xi)]	370[(ii)(xi)]	370[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_7-C_8 (aromatic)	mg/kg	130[(i)(xi)]	860[(ii)(xi)]	860[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_8-C_{10} (aromatic)	mg/kg	34[(i)(xi)]	47[(ii)(xi)]	47[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_{10}-C_{12} (aromatic)	mg/kg	74[(i)(xi)]	250[(ii)(xi)]	250[(ii)(xi)]	10,000[(xiv)(xi)]	2
TPH C_{12}-C_{16} (aromatic)	mg/kg	140[(i)(xi)]	1800[(ii)(xi)]	1800[(ii)(xi)]	10,000[(xiv)(xi)]	1
TPH C_{16}-C_{21} (aromatic)	mg/kg	260[(i)(xi)]	1900[(ii)(xi)]	1900[(ii)(xi)]	10,000[(xiv)(xi)]	1
TPH C_{21}-C_{35} (aromatic)	mg/kg	1000[(xiv)(xi)]	1900[(ii)(xi)]	1900[(ii)(xi)]	10,000[(xiv)(xi)]	1
Asbestos	Fibres Volume Weight (%)	NFD	0.001%	NFD	0.1%	4

Notes 1

NFD = No Fibres Detected

Asbestos will be screened visually on site by a qualified environmental consultant and where potential ACM is identified, representative samples will be subject to quantitative analysis of % volume by weight.

Should any ACM be identified within the soil matrices, further detailed % assessment would be required when the reported laboratory result exceeds the limit of detection for the analytical method at 0.01% by volume (weight).

Notes 2
Excludes matrices where free product is observed.

No viable exposure pathway beneath hardstanding and cover system.

Notes 3
Main exposure pathways: 1 = soil ingestion, 2 = vapour inhalation (indoor), 3 = dermal contact and ingestion, 4 = dust inhalation.

Abbreviations: GAC = general assessment criteria, n = number of samples, MC = maximum concentration, N/A = Not Applicable (no exceedance of assessment criteria), Loc of MC = location of exceedances.

i. Value derived from LQM Suitable 4 Use Levels (S4ULs) for residential end use with plant uptake.
ii. Value derived from LQM Suitable 4 Use Levels (S4ULs) for residential end use without plant uptake – these levels used below 600 mm cover system within residential gardens as soils will be present within a residential setting yet soils will not be disturbed and garden plants will not reach these soils.
iii. Value derived from LQM Suitable 4 Use Levels (S4ULs) for public open space (POS) residential.
iv. Value derived from LQM Suitable 4 Use Levels (S4ULs) for public open space (POS) park – these levels used below 300 mm POS cover system as soils will not be disturbed by any future site users and exposure to these soils will be similar to a park end use.

v. Value derived from LQM Suitable 4 Use Levels (S4ULs) alongside assessment with WM3 to ensure that materials remaining on site do not exceed the WM3 toxicity criteria for hazardous waste.
vi. Value derived from Category 4 Screening Levels (C4SL) for residential land use with homegrown produce.
vii. Value derived from Category 4 Screening Levels (C4SL) for residential land use without homegrown produce.
viii. Value derived from Category 4 Screening Levels (C4SL) for public open space (POS) residential.
ix. Value derived from Category 4 Screening Levels (C4SL) for public open space (POS) park.
x. Mercury – based on elemental mercury.
xi. PAH and TPH levels used are for 1% SOM.
xii. Xylenes based on p-xylene (o-xylene 2600 mg/kg, m-xylene 3500 mg/kg) and is capped by its solubility.
xiii. Value derived from LQM Suitable 4 Use Levels (S4ULs) for residential end use with plant uptake due to the volatilisation risk.
xiv. BTEX is not SOM-related due to inhalation pathway.

SITE SPECIFIC REMEDIATION TARGETS FOR THE PROTECTION OF CONTROLLED WATERS

Contaminant	Level 3 Remedial Target Concentration		
	Soils (mg/kg)	Waters (mg/l)	Waters (ug/l)
Source Area 1 – Tar Channel			
TPH Aromatic C8-C10	1060	**0.854**	854
TPH Aromatic C10-C12	**1920**	**0.959**	959
TPH Aromatic C12-C16	**30.8**	**0.0102**	10.2
TPH Aromatic C16-C21	**717**	**0.164**	164
TPH Aromatic C21-C35	18300	**0.456**	456
TPH Aliphatic C8-C10	304000	12.8	12800
TPH Aliphatic C10-C12	1.99 E+07	119	119000
TPH Aliphatic C12-C16	4.01E+06	0.796	796
TPH Aliphatic C16-C21	3.79 E+09	0.695	695
TPH Aliphatic C21-C35	3.79 E+09	0.695	695
2-methylnaphthalene	3340	164000	164000000
Carbazole	2.89E+8	6.84E+12	6.84E+15
Dibenzofuran	2.89E+8	6.84E+12	6.84E+15
Source Area 2 - Manox			
	Soils (mg/kg)	**Leachate (mg/l)**	**Leachate (ug/l)**
Arsenic	**1090**	**2.18**	2180
Cyanide	**219**	**2.18**	2180
Copper	**21.9**	**0.218**	218
Lead	**1090**	**2.18**	2180

APPENDIX V
E3P MATERIAL IMPORT CRITERIA

SITE OF IMPORTATION ADDRESS		**E3P** TAYLOR ROAD MANCHESTER, M41 7JQ +44 (0) 161 707 9612 info@e3p.co.uk
Client		
Main Contractor		
Earthworks Contractor		
Haulier		
Date of Planned Import		

Overview of Planned Material Import	
Material Source (Site of Origin) and Postcode	
Site Investigation Report	Report Title and Reference: Date: Information Supplied By:
Reason for Generation of Excess Material at Site of Origin	
Chemical Test Results for Stockpile at Site of Origin	Date: Laboratory Certificate Ref: Organisation Responsible for Stockpile Sampling:
Geotechnical Material Classification and Testing	**Delete as Appropriate:** Class 1 / Class 2 / Class 6 / Topsoil
Pictures of Material Stockpile Pending Transportation	Delete as Appropriate: Yes / No
Person or Organisation Responsible for Ensuring Quality Control at Site of Origin	
Quantity of Material to Be Imported (m^3)	
Proposed Area of Deposition (Site of Reuse)	
Waste Exemption/Permit or CL:AIRE MMP	**Delete as Appropriate:** U1 Standard Rules / CL:AIRE MMP (Direct Transfer) / Bespoke

APPENDIX VI
CONTRACTOR PRE-COMMENCEMENT CHECK SHEET

GEOTECHNICAL ENABLING WORKS PRE-START FORM

Prior to the commencement of any site remediation or enabling works, this form will be completed by E3P, in the presence of the appointed contractor, to ensure that all pertinent remediation and enabling works activities are fully discussed and understood.

Activity	Testing Responsibility	Contractors Method Statement Required (Y/N)	Comment/Action
Deployment of Environmental Permit			Ref No:
Deployment of LAPC Part B – Mobile Plant Permit			Ref No:
CL:AIRE MMP and Qualified Person Declaration			Ref No:
Identification of All Invasive Plant Species and Production of Eradication Plan with Appropriate Supervision by Specialist			Appointed specialist:
Removal of All Vegetation			Note disposal location:
Removal of All Root Bulbs and Root Networks			Note disposal location:
Identification of Contamination Hotpots, Removal of Material and Stockpile			Rationale:
Legislatively Compliant Procedure to Deal with Contamination Excavated from Hotspot			Rationale:
Processing and Recycling of Aggregate with Geotechnical and Chemical Validation Testing			Note stockpile location and anticipated volume:
Stockpiling of Subsoil and Certification of Suitability for Reuse			Stockpile location:
Decommission of All Redundant Drainage Infrastructure			
Decommission of All Former Interceptors			
Decommission of All Former Above- and Below-Ground Tanks			
Removal of All Asbestos to a Licensed Facility			
Engineering of Plots for Shallow Spread Foundation in Accordance with E3P Geotechnical Specification			Plot Numbers

Activity	Testing Responsibility	Contractors Method Statement Required (Y/N)	Comment/Action
Engineering of Plots for VSC in Accordance with E3P Geotechnical Specification			Plot Numbers.
Engineering of Plots for Pile Foundation in Accordance with E3P Geotechnical Specification			Plot Numbers
Engineering of Plots for Raft Foundation in Accordance with E3P Geotechnical Specification			Plot Numbers
Stockpiling of Topsoil and Certification of Suitability for Reuse			Stockpile location
Engineering of Highways Bulk Upfill in Accordance with E3P Specification with Compliant Validation Testing			Upfill specification
Engineering of Highways Subgrade in Accordance with E3P Specification with Compliant Validation Testing			Upfill specification
Engineering of Highways Capping in Accordance with E3P Specification with Compliant Validation Testing			Upfill specification
Cut-and-Fill the Development Site to Clients' Required Elevation with As-Built Survey			Required formation elevations

APPENDIX VII
CONTRACTOR COMPLETION CHECK SHEET

GEOTECHNICAL ENABLING WORKS COMPLETION FORM

Upon completion of all site remediation and enabling works, this form will be completed by E3P, in the presence of the appointed contractor, to ensure that all pertinent geotechnical enabling works activities are complete or, where a deviation from the specification has occurred, all future limitations and issues are documented for the client's records.

Activity	Complete			Signature
	Yes	No	N/A	(initial)
Eradication of all invasive plant species				
Removal of all vegetation				
Removal of all root bulbs and root networks				
Stockpiling of topsoil and certification of suitability for reuse				
Stockpiling of subsoil and certification of suitability for reuse				
Stockpile all recycled aggregate with geotechnical and chemical validation testing				
Removal of all relict foundations and infrastructure in their entirety				
Decommission of all redundant drainage infrastructure				
Decommission of all former interceptors				
Decommission of all former above- and below-ground tanks				
Removal of all waste materials to a licensed facility				
Removal of all asbestos to a licensed facility				
Engineering of all plots for shallow spread foundation in accordance with E3P Geotechnical Specification				
Engineering of all plots for VSC in accordance with E3P Geotechnical Specification				
Engineering of all plots for pile foundation in accordance with E3P Geotechnical Specification				
Engineering of all plots for raft foundation in accordance with E3P Geotechnical Specification				
Engineering of highways bulk upfill in accordance with E3P Specification with compliant validation testing				
Engineering of highways subgrade in accordance with E3P Specification with compliant validation testing				
Engineering of highways capping in accordance with E3P Specification with compliant validation testing				
Cut-and-fill the development site to client's required elevation with as-built survey				

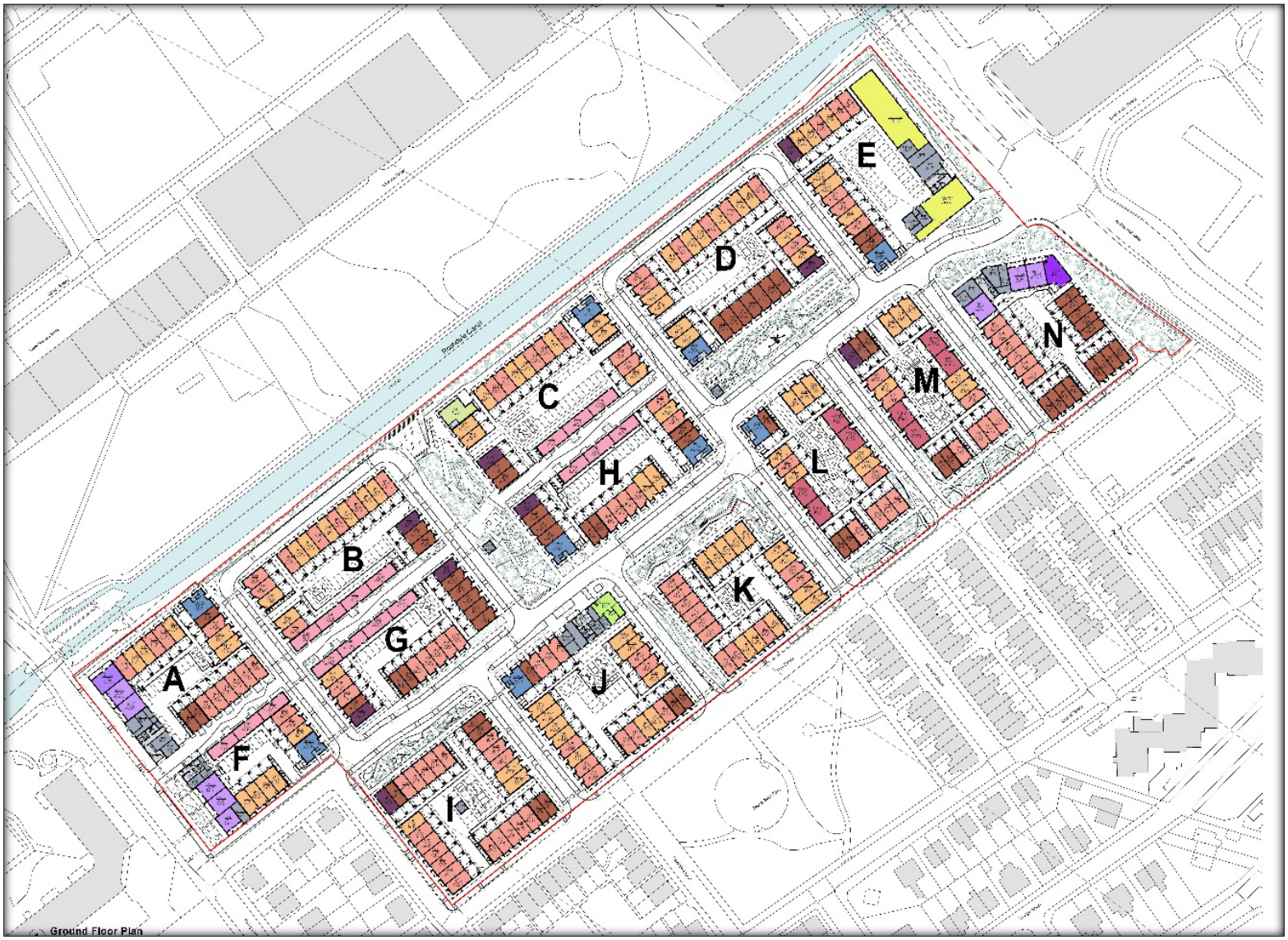
POST-REMEDIATION AND ENABLING LIMITATIONS

All and every deviation from the approved specification for works should be documented by the remediation and enabling works contractor below.

APPENDIX VIII
MCAULIFFE DOCUMENTS

Manox Enabling Works – Phasing
Proposed Layout

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Manox Enabling Works – Phasing
Current T=0-1 weeks

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Manox Enabling Works – Phasing
Current T=1-5 weeks – Site Set up and Clearance

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Manox Enabling Works – Phasing
Current T=5-10 weeks – Hot Spot Removal/Clearance

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Manox Enabling Works – Phasing
Current T=11-17 weeks – Sheet piling and Eathworks

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Manox Enabling Works – Phasing
Current T=17-26 weeks – Sheet Piling and Mineworkings

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Manox Enabling Works – Phasing
Current T=27-31 weeks – Remediation, Piling Mats and Archaeology.

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Manox Enabling Works – Phasing
Current T=32-59 weeks – Remediation and Archaeology.

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Manox Enabling Works – Phasing
Current T=60-70 weeks – Mine workings and Treatment

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Manox Enabling Works – Phasing
Current T=70-77 weeks – Pile mats

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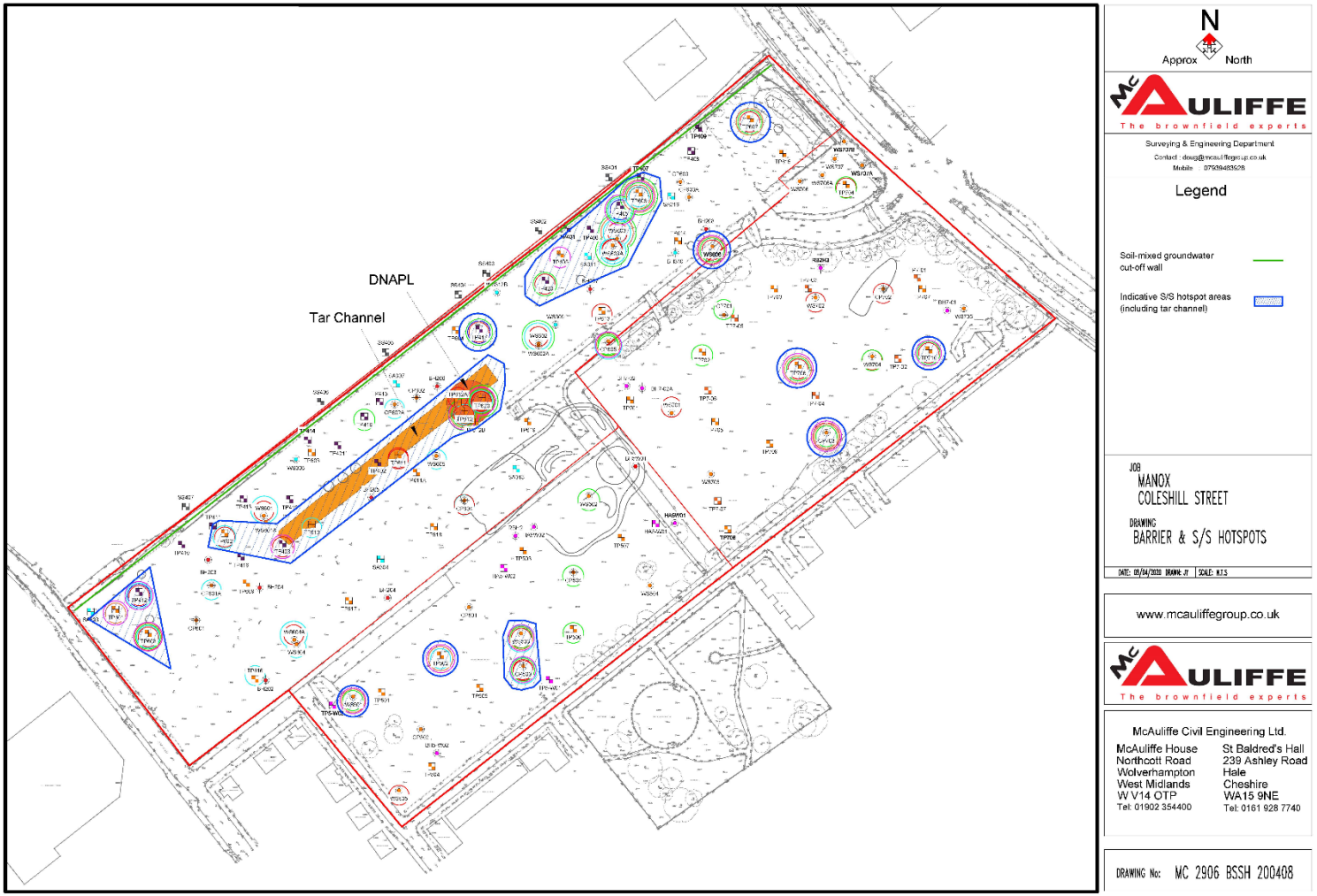


Manox Enabling Works – Phasing Current T=78 weeks – Remediation and Earthworks.

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Hotspot Location Plan



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McAuliffe Civil Engineering Limited

Stabilisation/Solidification Treatability Report

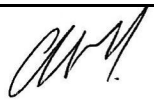
Job No:	MC2906
Job Name:	Manox Site
Report No:	MC2906 Manox S/S Treatability
Client:	Engie
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE
Date:	July 2022

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Section 2 **Stabilisation/Solidification Technique**

Section 3 **Treatability Study**

Section 4 **Results - Brief Outline Summary**

Section 5 **Discussion and Conclusions**

APPENDICES

Appendix A: Trial Pit Location Plan

Appendix B: Laboratory Test Report Certificates

Appendix C: References

1 Introduction

McAuliffe were instructed by Engie to undertake stabilisation/solidification treatability works on contaminated soils present on the Manox site, north of Coleshill Street, Miles Platting, Manchester. This report details the works done and presents the results of leachability testing carried out on samples of each trial mix. It concludes with a discussion on the relative performance of the various mixes considering the full-scale treatment works required to be carried out on the soils at the site.

2 Stabilisation/Solidification Technique

In the UK S/S techniques are well established for ground treatment of multiple contaminants. The process is an enhanced approach that has been applied to a broad range of contaminated soils, dredge and other media, contaminated with a wide variety of hazardous substances. At its simplest, the process involves mixing chemicals, reagents and binding agents into the contaminated media in order to change and immobilise the contaminants within the material. The resulting chemical reactions and physical changes chemically fix the contaminants, so removing the risks to human health and the wider environment.

The ability to treat multiple contaminant types within the same media is a key benefit of the S/S process, as it means it can be used in complex contamination situations such as are found when treating heavy industrial, coke and town gas sites. Experience has shown that chemical and physical test results from laboratory-scale studies provide a good indication of the expected performance in the full-scale works.

3 Treatability Study

Bulk soil samples of contaminated soils were taken from trial pits excavated at the site, at locations in the most heavily impacted areas, particularly around the tar channel location, for use in the trials by E3P. A plan of their locations is included in Appendix A. It should be noted that, based on the data obtained from previous site investigations, these samples do not represent the majority of the soils potentially requiring across the site, but a worst case scenario, probably amounting to only around 4% of the total treatment volume.

Total concentration and leachate analyses were carried out on the various samples taken, with laboratory certificates presented in Appendix B. The summarised results from the samples used in the treatability works are presented in Tables 1a and b. Batch leachate testing was carried out using BS EN12457 Part 2, with a liquid to solids ratio of 10:1, as this represents worst case environmental stress scenarios.

Preparation of S/S samples for leachate testing does not require drying, as particle size reduction and general disaggregation is not impacted by moisture content, due to the nature of stabilised materials.

Sample Reference		TP803	TP807	TP810	TP813	TP814	TP816
Analytical Parameter (Soil Analysis)	Units						
Stone Content	%	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Moisture Content	%	27	19	16	18	8.0	9.3
Total mass of sample received	kg	0.40	0.50	0.50	1.2	0.60	0.50
General Inorganics							
pH - Manual	pH Units	-	8.2	8.6	7.1	8.0	
pH - Automated	pH Units	-	-	-	-	-	
Total Cyanide	mg/kg	840	5000	1200	2800	9500	8.6
Complex Cyanide	mg/kg						8.6
Free Cyanide	mg/kg						< 1.0
Total Sulphate as SO4	mg/kg		5100	3900	31000	140000	
Water Soluble SO4 (2:1 Leach. Equiv.) 1hr extraction	g/l	-	1.7	0.33	1.8	3.0	
Water Soluble SO4 (2:1 Leach. Equiv.) 1hr extraction	mg/kg	-	3400	660	3700	6100	
Water Soluble SO4 (2:1 Leach. Equiv.) 1hr extraction	mg/l	-	1700	328	1830	3050	
Sulphide	mg/kg	-	410	5.8	100	220	
Total Sulphur	mg/kg	-	26000	2100	23000	55000	
Total Organic Carbon (TOC)	%	2.6	3.7	1.7	-	5.0	
Total Organic Carbon (TOC)	%	-	-	-	8.7	-	
Total Phenols							
Total Phenols (monohydric)	mg/kg	-	< 1.0	< 1.0	210	7.9	< 1.0
Speciated PAHs							
Naphthalene	mg/kg	1.8	-	0.33	2900	-	< 0.05
Acenaphthylene	mg/kg	< 0.05	-	< 0.05	< 0.05	-	< 0.05
Acenaphthene	mg/kg	2.9	-	0.20	180	-	< 0.05
Fluorene	mg/kg	2.2	-	< 0.05	200	-	< 0.05
Phenanthrene	mg/kg	7.1	-	0.84	370	-	< 0.05
Anthracene	mg/kg	1.3	-	< 0.05	83	-	< 0.05
Fluoranthene	mg/kg	3.8	-	0.87	130	-	< 0.05
Pyrene	mg/kg	3.4	-	0.85	98	-	< 0.05
Benzo(a)anthracene	mg/kg	1.7	-	0.68	31	-	< 0.05
Chrysene	mg/kg	1.6	-	0.58	23	-	< 0.05
Benzo(b)fluoranthene	mg/kg	1.2	-	0.61	15	-	< 0.05
Benzo(k)fluoranthene	mg/kg	0.77	-	0.51	7.5	-	< 0.05
Benzo(a)pyrene	mg/kg	1.4	-	0.70	9.8	-	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	0.56	-	0.45	6.5	-	< 0.05
Dibenz(a,h)anthracene	mg/kg	0.21	-	< 0.05	2.7	-	< 0.05
Benzo(ghi)perylene	mg/kg	0.81	-	0.60	7.1	-	< 0.05
Total PAH							
Speciated Total EPA-16 PAHs	mg/kg	30.7	-	7.22	4070	-	< 0.80
Heavy Metals / Metalloids							
Arsenic (aqua regia extractable)	mg/kg	68	3600	73	98	45	6.7
Barium (aqua regia extractable)	mg/kg	180	-	-	-	-	
Beryllium (aqua regia extractable)	mg/kg	2.6	-	-	-	-	
Boron (water soluble)	mg/kg	0.9	-	-	-	-	
Chromium (III)	mg/kg						19
Chromium (aqua regia extractable)	mg/kg	-	21	35	40	24	19
Copper (aqua regia extractable)	mg/kg	110	42000	240	210	58	19
Lead (aqua regia extractable)	mg/kg	200	2300	230	760	280	21
Mercury (aqua regia extractable)	mg/kg	1.7	< 0.3	< 0.3	1.5	0.9	< 0.3
Nickel (aqua regia extractable)	mg/kg	46	29	49	16	9.5	17
Selenium (aqua regia extractable)	mg/kg	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vanadium (aqua regia extractable)	mg/kg	73	-	-	-	-	
Zinc (aqua regia extractable)	mg/kg	140	560	440	130	120	42
Monoaromatics & Oxygenates							
Benzene	µg/kg	-	< 1.0	-	-	220	< 1.0
Toluene	µg/kg	-	< 1.0	-	-	210	< 1.0
Ethylbenzene	µg/kg	-	< 1.0	-	-	230	< 1.0
p & m-xylene	µg/kg	-	< 1.0	-	-	470	< 1.0
o-xylene	µg/kg	-	< 1.0	-	-	650	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/kg	-	< 1.0	-	-	< 1.0	< 1.0
Petroleum Hydrocarbons							
TPH-CWG - Aliphatic >EC10 - EC12	mg/kg	-	< 1.0	-	-	180	< 1.0
TPH-CWG - Aliphatic >EC12 - EC16	mg/kg	-	7.8	-	-	240	< 2.0
TPH-CWG - Aliphatic >EC16 - EC21	mg/kg	-	30	-	-	98	< 8.0
TPH-CWG - Aliphatic >EC21 - EC35	mg/kg	-	70	-	-	130	< 8.0

TPH-CWG - Aliphatic >EC35 - EC40 EH_CU_1D_AL	mg/kg						< 10
TPH-CWG - Aliphatic (EC5 - EC35)	mg/kg	-	110	-	-	650	
TPH-CWG - Aromatic >EC5 - EC7	mg/kg	-	< 0.001	-	-	0.22	< 0.001
TPH-CWG - Aromatic >EC7 - EC8	mg/kg	-	< 0.001	-	-	0.21	< 0.001
TPH-CWG - Aromatic >EC8 - EC10	mg/kg	-	< 0.001	-	-	11	< 0.001
TPH-CWG - Aromatic >EC10 - EC12	mg/kg	-	4.4	-	-	600	< 1.0
TPH-CWG - Aromatic >EC12 - EC16	mg/kg	-	31	-	-	2700	< 2.0
TPH-CWG - Aromatic >EC16 - EC21	mg/kg	-	100	-	-	1800	< 10
TPH-CWG - Aromatic >EC21 - EC35	mg/kg	-	120	-	-	630	< 10
TPH-CWG - Aromatic >EC35 - EC40 EH_CU_1D_AR	mg/kg						< 10
TPH-CWG - Aromatic (EC5 - EC35)	mg/kg	-	250	-	-	5800	
TPH Total C5 - C40 EH_CU+HS_1D_TOTAL	mg/kg						< 10
TPH (C5 - C6)	mg/kg	< 1.0	-	< 1.0	79	-	
TPH (C6 - C8)	mg/kg	< 0.1	-	< 0.1	130	-	
TPH (C8 - C10)	mg/kg	< 0.1	-	< 0.1	300	-	
TPH (C10 - C12)	mg/kg	4.8	-	2.1	6300	-	
TPH (C12 - C16)	mg/kg	16	-	11	4000	-	
TPH (C16 - C21)	mg/kg	20	-	33	3900	-	
TPH (C21 - C35)	mg/kg	34	-	120	2400	-	
TPH (C35 - C40)	mg/kg	16	-	27	110	-	
TPH Total C5 - C40	mg/kg	90	-	190	17000	-	
VOCs							
Isopropylbenzene	µg/kg	-	< 1.0	-	-	55	< 1.0
1,3,5-Trimethylbenzene	µg/kg	-	< 1.0	-	-	1700	< 1.0
1,2,4-Trimethylbenzene	µg/kg	-	< 1.0	-	-	8300	< 1.0
p-Isopropyltoluene	µg/kg	-	< 1.0	-	-	460	< 1.0
SVOCs							
Aniline	mg/kg	-	< 0.1	-	-	9.4	< 0.1
2-Methylnaphthalene	mg/kg	-	3.8	-	-	440	< 0.1
Acenaphthylene	mg/kg	-	0.29	-	-	< 0.05	< 0.05
Acenaphthene	mg/kg	-	17	-	-	630	< 0.05
2,4-Dinitrotoluene	mg/kg	-	< 0.2	-	-	< 0.2	< 0.2
Dibenzofuran	mg/kg	-	6.6	-	-	620	< 0.2
Fluorene	mg/kg	-	9.6	-	-	500	< 0.05
Phenanthrene	mg/kg	-	21	-	-	1200	< 0.05
Anthracene	mg/kg	-	4.8	-	-	300	< 0.05
Carbazole	mg/kg	-	< 0.3	-	-	70	< 0.3
Anthraquinone	mg/kg	-	< 0.3	-	-	39	< 0.3
Fluoranthene	mg/kg	-	20	-	-	310	< 0.05
Pyrene	mg/kg	-	17	-	-	210	< 0.05
Benzo(a)anthracene	mg/kg	-	5.6	-	-	34	< 0.05
Chrysene	mg/kg	-	5.3	-	-	31	< 0.05
Benzo(b)fluoranthene	mg/kg	-	5.5	-	-	11	< 0.05
Benzo(k)fluoranthene	mg/kg	-	5.9	-	-	3.5	< 0.05
Benzo(a)pyrene	mg/kg	-	3.0	-	-	5.3	< 0.05
Indeno(1,2,3-cd)pyrene	mg/kg	-	1.3	-	-	2.5	< 0.05
Dibenz(a,h)anthracene	mg/kg	-	0.44	-	-	< 0.05	< 0.05
Benzo(ghi)perylene	mg/kg	-	2.0	-	-	3.0	< 0.05

Table 1a. Baseline Soils Solids Results
(Only determinants with any results above LoD presented)

Sample Reference		TP813	TP816	TP814
Analytical Parameter (Leachate Analysis)	**Units**			
General Inorganics				
pH	pH Units	7.5		
Total Cyanide (Low Level 1 µg/l)	µg/l	17000	340	11000
Complex Cyanide (Low Level)	µg/l		330	10000
Free Cyanide (Low Level 1 µg/l)	µg/l		8	500
Total Phenols				
Total Phenols (monohydric)	µg/l	3000	4.7	67
Speciated PAHs				
Naphthalene	µg/l	3100	< 0.01	< 0.01
Acenaphthylene	µg/l	1.2	< 0.01	4.3
Acenaphthene	µg/l	12	< 0.01	180
Fluorene	µg/l	5.9	< 0.01	53
Fluoranthene	µg/l	< 0.01	< 0.01	3.9
Pyrene	µg/l	< 0.01	< 0.01	1.6
Total PAH				
Total EPA-16 PAHs	µg/l	3200	< 0.2	240
Heavy Metals / Metalloids				
Arsenic (dissolved)	µg/l	16	8.5	9.3
Cadmium (dissolved)	µg/l	< 0.08	0.26	0.21
Chromium (hexavalent)	µg/l	< 5.0	< 5.0	< 5.0
Chromium (III)	µg/l		< 5.0	< 5.0
Chromium (dissolved)	µg/l	1.0	1.9	1.1
Copper (dissolved)	µg/l	18	7.1	< 0.7
Lead (dissolved)	µg/l	4.4	10	6.5
Mercury (dissolved)	µg/l	< 0.5	< 0.5	< 0.5
Nickel (dissolved)	µg/l	2.6	5.0	2.6
Selenium (dissolved)	µg/l	< 4.0	< 4.0	< 4.0
Zinc (dissolved)	µg/l	4.8	8.6	3.8
Monoaromatics & Oxygenates				
Benzene	µg/l	7500	< 1.0	< 1.0
Toluene	µg/l	11000	< 1.0	< 1.0
Ethylbenzene	µg/l	780	< 1.0	< 1.0
p & m-xylene	µg/l	5300	< 1.0	< 1.0
o-xylene	µg/l	2400	< 1.0	< 1.0
MTBE (Methyl Tertiary Butyl Ether)	µg/l	< 10	< 10	< 10
Petroleum Hydrocarbons				
TPH1 (C10 - C40)	µg/l	7200		
TPH-CWG - Aromatic >C5 - C7	µg/l	7500	< 1.0	< 1.0

TPH-CWG - Aromatic >C7 - C8	µg/l	11000	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10	µg/l	9100	< 1.0	23
TPH-CWG - Aromatic >C10 - C12	µg/l	4100	< 10	640
TPH-CWG - Aromatic >C12 - C16	µg/l	2700	< 10	400
TPH-CWG - Aromatic >C16 - C21	µg/l	320	< 10	130
TPH-CWG - Aromatic (C5 - C35)	µg/l	35000		
TPH Total C5 - C40 EH+HS_1D_TOTAL_#1_#2_MS	µg/l		< 10	1200
VOCs				
1,3,5-Trimethylbenzene	µg/l		< 1.0	7.4
1,2,4-Trimethylbenzene	µg/l		< 1.0	16
SVOCs				
Aniline	µg/l		< 0.05	21
2,4-Dimethylphenol	µg/l		< 0.05	23
Acenaphthylene	µg/l		< 0.01	4.3
Acenaphthene	µg/l		< 0.01	180
Dibenzofuran	µg/l		< 0.05	110
Fluorene	µg/l		< 0.01	53
Carbazole	µg/l		< 0.05	40
Anthraquinone	µg/l		< 0.05	49
Fluoranthene	µg/l		< 0.01	3.9
Pyrene	µg/l		< 0.01	1.6

Table 1b. Baseline Soils Batch Leachate Results
(Only determinants with any results above LoD presented)

Treatment mixes selected were based on those that have been successful in targeting similar contaminants and soil types on previous projects. A total of 21 different base-mixes were used, incorporating various combinations of Ordinary Portland cement (OPC), quicklime (QL), granulated ground blast furnace slag (GGBS), bentonite and granular activated carbon (GAC), together with an alkaline oxidation step included for some of the high Cyanide impacted material mixes. This was done using Sodium Hypochlorite (NaOCl) (15% solution) and Sodium Hydroxide (NaOH) (20% solution) as an initial pre-treatment stage, before the addition of other additives. Some particle size reduction was undertaken on the source soils, with material greater than 15mm being removed. This was to ensure that the materials were comparable with the 500g 80mm x 110mm plastic sample tubs used for batch leachate testing and the 60mm x 70mm plastic sample tubes used for the tank tests.

Due to the potential for relatively high localised variability of contaminant concentrations to be present, as identified from previous investigations, two main composites of the samples were produced for the trial, based on the results from the baseline testing. One with a lower Cyanide (CN) concentration (although still relatively high – combining samples from TP803, TP810 and TP816 – visually characterised as a *very cohesive clay material*), the other with a very high CN concentration (combining samples from TP807, TP813 and TP814 – visually characterised as a *dark/black sticky clay with very strong hydrocarbon odour*).

The composite soils were mixed with various admixture formulations and at varying addition rates, using water to binder ratios of 0.3 to 0.5, to form homogenous mixes and then each mix placed into two sample containers as detailed above, one for the batch test and the other for the tank test and left to cure/hydrate in a high humidity environment until required for testing. Table 2 shows the composition of each of the mixes used in the study.

						LOW CN MIXES								HIGH CN MIXES			LOW CN MIXES		HIGH CN MIXES	
Mix No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**
Mass in g																					
Soil	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900	900
OPC	27	18.9	18	22.5	22.1	17.2	27	31.9	34.4	30	30	19.6	27	24.5	27	27	27	30	21.6	27	24.9
Quicklime				22.5	22.2	11.5			22.9			13.1	27	16.5	16.5	27	36			9.8	8.3
Bentonite	18	12.6	18					21.37													
GGBS	45	31.5	36	45	27.7	34.4	54	63.8	68.7	60	60	39.3	54	49	54	54	54	50	36	54	49.9
NaOH (20%)											25	16		25.3	37.5	50.6					
NaOH (25%)																	60.8				
NaOCL										46.7	45.5	30		47	70.5	94	141				
GAC																		10	14.4	18	24.9
water	16.4	18.9	21.6	36	28.8	25.3	24.3	40.9	63	45	45	29	32.4	27	0	0		24	17.3	27.2	25
25% QL soln										20											
% binder addition																					
OPC	3	2.1	2	2.5	2.5	1.9	3	3.5	3.8	3.3	3.3	2.2	3	2.7	3	3	3	3.3	2.4	3	2.76
Quicklime				2.5	2.5	1.3			2.5			1.5	3	1.8	2	3	4			1	0.92
Bentonite	2	1.4	2					2.4													
GGBS	5	3.5	4	5	3	3.8	6	7.1	7.6	6.6	6.6	4.4	6	5.4	6	6	6	5.5	4	6	5.4
GAC																		1.1	1.6	2	2.76
total % binder addition	10	7	8	10	8	7	9	13	14	10	10	8	12	10	11	12	13	10	8	12	12
water/binder (w/b)	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.35	0.5	0.5	0.5	0.4	0.3	0.3	0	0	0	0.3	0.3	0.3	0.3

Table 2. S/S Mix Designs used in the Treatability Work

4 Results – Brief Outline Summary

Summarised batch leachate results for each of the different mix designs are shown in Tables 3a and b. Summarised tank test results for Mixes 5 and 14 are shown in Tables 4a and b, respectively.

Lower CN impacted soils mixes

The initial mixes that incorporated bentonite were particularly poor at fixing CN. However, when replaced with 2.5% QL there was a significant reduction in CN leachability. With a reduction in QL and overall binder addition, the CN leachability again increased. An increase in addition rate of both GGBS and QL (Mix 10) had a marked improvement in reducing the leachate concentrations of both CN and SO_4. Of note is the reduction in PAH leachability with the higher addition rate of bentonite in Mix 9, which is also evident with Mixes 19 and 20 with inclusion of relatively small quantities of GAC.

OPC and pozzolanic waste forms rely heavily on pH control for metal containment. Normally a high pH is desirable as metal hydroxides have minimum solubility in the range of between 7.5 - 11. However, some metals such as Cr, Cu and Ni can exhibit amphoteric behaviour, having higher solubilities at both high and low pH, with the lowest at around pH 9 - 10. This is generally demonstrated in the results for the metals leachability. It can be seen that Arsenic is fixed more strongly with a combination of GGBS and QL in the binder.

The additional of the alkaline oxidation step (Mixes 11 & 12) did not generally have any beneficial effects on reducing leachability.

Higher CN impacted soils mixes

High levels of CN are generally very difficult to stabilise and fix, especially with hydraulic binder systems. It has a tendency to slow down their reactivity and if the cyanide content is too high, even kill it. The chemical form of the cyanide also has its importance but on that point the very limited scientific literature that exists does not give any detail.

Notwithstanding the above comments, Mix 14 was chosen to assess the potential performance of a standard hydraulic binder with the very high CN impacted materials. Mixes 15 – 18 incorporated an initial alkaline oxidation step in an attempt reduce the CN levels to a point manageable with the subsequent addition of a hydraulic binder system. The results would tend to suggest that the oxidation approach was in effective and Mix 14 actually showing the lowest CN leachate concentration, although still well above the baselines. The GAC mixes (Mixes 21 and 22) were not effective against the high CN levels.

Sample Reference		Baseline (TP816)	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5	Mix 6	Mix 7	Mix 9	Mix 10	Mix 11	Mix 12	Mix 13	Mix 19	Mix 20
Analytical Parameter (Leachate Analysis)	**Units**															
General Inorganics																
pH (automated)	pH Units		11.5	11.4	11.4	12.2	12.4	12.1	11.6	11.7	12.3	11.9	11.8	12.2	11.3	11.1
Total Cyanide (Low Level 1 µg/l)	µg/l	**340**	10000	14000	18000	160	190	860	3400	2300	18	770	3500	300	6500	9900
Complex Cyanide (Low Level)	µg/l	**330**	10000	13000	18000	160	190	860	3400	2300	18	760	3500	300	6500	9900
Free Cyanide (Low Level 1 µg/l)	µg/l	**8**	40	41	55	< 1	< 1	1	5	2	< 1	8	13	< 1	< 1	3
Sulphate as SO_4	µg/l		66400	74300	105000	23300	24800	36100	116000	68.5	20.6	48.5	54.3	32.1	104	83.7
Total Phenols																
Total Phenols (monohydric)	µg/l	**4.7**	2.0	1.7	1.9	< 1.0	2.5	< 1.0	2.2	11	11	16	14	16	6.6	7.5
Speciated PAHs																
Naphthalene	µg/l	**< 0.01**	1.0	1.5	1.8	2.6	1.5	4.7	2.9	< 0.01	5.4	1.7	4.1	1.8	< 0.01	< 0.01
Acenaphthylene	µg/l	**< 0.01**	< 0.01	< 0.01	0.24	< 0.01	< 0.01	< 0.01	0.42	< 0.01	0.44	< 0.01	0.23	< 0.01	< 0.01	< 0.01
Acenaphthene	µg/l	**< 0.01**	1.4	1.4	1.5	0.79	1.0	0.90	2.1	< 0.01	2.1	0.29	0.90	0.28	< 0.01	< 0.01
Fluorene	µg/l	**< 0.01**	0.75	0.71	0.74	0.35	0.65	0.32	1.0	< 0.01	0.82	< 0.01	0.69	0.21	< 0.01	< 0.01
Phenanthrene	µg/l	**< 0.01**	0.74	0.60	0.59	0.33	0.61	< 0.01	0.69	< 0.01	0.58	< 0.01	0.72	< 0.01	< 0.01	< 0.01
Total PAH																
Total EPA-16 PAHs	µg/l	**< 0.2**	4.0	4.1	4.8	4.1	3.7	6.0	7.1	< 0.2	9.3	2.0	6.6	2.3	< 0.2	< 0.2
Heavy Metals / Metalloids																
Arsenic (dissolved)	µg/l	**8.5**	6.8	7.8	7.1	1.8	1.8	< 1.0	3.7	5.5	1.0	< 1.0	5.4	< 1.0	12	12
Chromium (hexavalent)	µg/l	**< 5.0**	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Chromium (III)	µg/l	**< 5.0**	6.4	5.8	< 5.0	7.5	10	6.9	< 5.0	< 5.0	< 5.0	12	< 5.0	< 5.0	8.7	5.3
Chromium (dissolved)	µg/l	**1.9**	6.4	5.8	3.9	7.5	10	6.9	3.0	3.5	2.5	12	4.1	4.1	8.7	5.3
Copper (dissolved)	µg/l	**7.1**	43	28	68	29	150	33	20	28	16	11	21	34	22	12
Lead (dissolved)	µg/l	**10**	1.9	2.4	4.3	2.4	1.6	3.3	3.5	3.9	1.2	2.4	4.0	3.6	3.2	3.1
Mercury (dissolved)	µg/l	**< 0.5**	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Nickel (dissolved)	µg/l	**5.0**	19	9.9	18	9.8	39	13	9.4	11	9.2	6.2	5.4	23	3.8	3.7
Selenium (dissolved)	µg/l	**< 4.0**	11	7.7	9.5	< 4.0	< 4.0	< 4.0	< 4.0	9.4	< 4.0	12	< 4.0	14	8.1	< 4.0
Zinc (dissolved)	µg/l	**8.6**	4.1	4.0	1.8	7.2	5.4	4.4	2.6	7.8	7.3	6.5	7.8	4.7	3.3	4
Monoaromatics & Oxygenates																
Petroleum Hydrocarbons																
VOCs																
Trichloromethane	µg/l	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	390	140	< 1.0	< 1.0
SVOCs																

Table 3a: Summary of S/S Trial Batch Leachability Results (lower CN impacted soil mixes)
(Only determinants with any results above LoD presented)

above baseline

Sample Reference		Baseline (TP813)	Baseline (TP814)	Mix 14	Mix 15	Mix 16	Mix 17	Mix 18	Mix 21	Mix 22
Analytical Parameter (Leachate Analysis)	**Units**									
General Inorganics										
pH (automated)	pH Units	**7.5**		12.3	11.7	11.7	12	12.2	11.5	11.4
Total Cyanide (Low Level 1 µg/l)	µg/l	**17000**	**11000**	20000	69000	59000	20000	28000	64000	78000
Complex Cyanide (Low Level)	µg/l		**10000**	20000	69000	55000	15000	18000	64000	78000
Free Cyanide (Low Level 1 µg/l)	µg/l		**500**	59	130	4300	4600	10000	170	150
Sulphate as SO_4	mg/l			128	218	266	221	154	243	298
Total Phenols										
Total Phenols (monohydric)	µg/l	**3000**	**67**	32	35	25	31	31	9.9	9
Speciated PAHs										
Naphthalene	µg/l	**3100**	**< 0.01**	110	94	65	61	71	20	16
Acenaphthylene	µg/l	**1.2**	**4.3**	1.0	0.97	0.77	0.93	0.98	0.34	0.23
Acenaphthene	µg/l	**12**	**180**	70	51	36	37	38	24	19
Fluorene	µg/l	**5.9**	**53**	26	19	16	16	17	12	9.9
Phenanthrene	µg/l	**< 0.01**	**< 0.01**	20	14	10	11	14	12	11
Anthracene	µg/l	**< 0.01**	**< 0.01**	5.1	3.9	3.1	3.5	3.9	3.4	2.7
Fluoranthene	µg/l	**< 0.01**	**3.9**	1.5	1.0	0.84	1.1	1.1	1.7	1.3
Pyrene	µg/l	**< 0.01**	**1.6**	0.71	0.42	0.27	0.51	0.4	0.78	0.61
Total PAH										
Total EPA-16 PAHs	µg/l	**3200**	**240**	240	180	130	130	150	74	60
Heavy Metals / Metalloids										
Arsenic (dissolved)	µg/l	**16**	**9.3**	25	87	91	68	64	130	140
Cadmium (dissolved)	µg/l	**< 0.08**	**0.21**	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Chromium (dissolved)	µg/l	**1.0**	**1.1**	3.3	2.1	2.2	2.7	3.0	2	1.9
Copper (dissolved)	µg/l	**18**	**< 0.7**	330	420	400	440	320	76	54
Lead (dissolved)	µg/l	**4.4**	**6.5**	8.8	3.4	5.1	5.0	6.0	5.5	2.2
Nickel (dissolved)	µg/l	**2.6**	**2.6**	34	50	43	58	39	12	5.3
Selenium (dissolved)	µg/l	**< 4.0**	**< 4.0**	11	10	< 4.0	< 4.0	< 4.0	< 4.0	6.2
Zinc (dissolved)	µg/l	**4.8**	**3.8**	14	11	3.1	3.7	3.7	3.6	3
Monoaromatics & Oxygenates										
Benzene	µg/l	**7500**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/l	**11000**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	**780**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/l	**5300**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/l	**2400**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons										
TPH-CWG - Aromatic >C5 - $C7_{HS\_1D\_AR}$	µg/l	**7500**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - $C8_{HS\_1D\_AR}$	µg/l	**11000**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0

TPH-CWG - Aromatic >C8 - C10 $_{HS\_1D\_AR}$	µg/l	**9100**	**23**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C10 - C12 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**4100**	**640**	690	710	440	350	320	92	85
TPH-CWG - Aromatic >C12 - C16 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**2700**	**400**	1300	1300	770	760	620	270	210
TPH-CWG - Aromatic >C16 - C21 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**320**	**130**	1000	850	600	520	480	180	140
TPH-CWG - Aromatic >C21 - C35 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**< 10**	**< 10**	200	130	280	230	220	73	36
TPH Total C5 - C40 $_{EH+HS\_1D\_TOTAL\_\#1\_\#2\_MS}$	µg/l			3200	3000	2100	1900	1600	610	470
VOCs										
Trichloromethane	µg/l		**< 1.0**	< 1.0	< 1.0	10	18	67	< 1.0	< 1.0
SVOCs										
Aniline	µg/l		**21**	8.8	9.9	12	16	15	2.6	1.3
2,4-Dimethylphenol	µg/l		**23**	< 0.05	< 0.05	8.2	8.9	7.6	< 0.05	< 0.05
2-Methylnaphthalene	µg/l		**< 0.05**	20	20	9.9	9.3	12	7.4	6.3
Acenaphthylene	µg/l	**1.2**	**4.3**	1.0	0.97	0.77	0.93	0.98	0.34	0.23
Acenaphthene	µg/l	**12**	**180**	70	51	36	37	38	24	19
Dibenzofuran	µg/l		**110**	41	33	21	20	22	14	11
Carbazole	µg/l		**40**	30	21	14	17	19	9	7.8
Anthraquinone	µg/l		**49**	9.1	9.9	13	14	19	3.8	2.7

Table 3b: S/S Trial Batch Leachability Results (higher CN impacted soil mixes)
(Only determinants with any results above LoD presented)

above baseline

Sample Reference		Baseline Batch (TP816)	Mix 5 6h	Mix 5 1d	Mix 5 2.25d	Mix 5 4d	Mix 5 9d	Mix 5 16d	Mix 5 36d	Mix 5 64d
Analytical Parameter (Leachate Analysis)	**Units**									
General Inorganics										
pH (automated)	pH Units		11.3	11.7	11.7	11.9	11.9	12	12.2	12.2
Electrical Conductivity	µS/cm		390	700	790	1400	1900	1700	2700	2600
Total Cyanide (Low Level 1 µg/l)	µg/l	**340**	< 1.0	5.6	12	23	35	27	65	61
Complex Cyanide (Low Level)	µg/l	**330**	< 1.0	5.6	12	21	35	25	63	61
Free Cyanide (Low Level 1 µg/l)	µg/l	**8**	< 1	< 1	< 1	2	< 1	2	2	< 1
Sulphate as SO_4	mg/l		2.7	6.7	7.9	9.9	17.2	12.7	22.6	21.4
Chloride	mg/l		3.3	3.7	3.5	3.9	6.6	5.4	7.6	6.6
Total Phenols										
Total Phenols (monohydric)	µg/l	**4.7**	9.3	8.7	6.5	< 1.0	< 1.0	< 1.0	4.8	2.4
Speciated PAHs										
Heavy Metals / Metalloids										
Arsenic (dissolved)	µg/l	**8.5**	1.2	< 1.0	5.1	< 1.0	< 1.0	3.6	< 1.0	< 1.0
Cadmium (dissolved)	µg/l	**0.26**	< 0.08	< 0.08	< 0.08	0.08	< 0.08	< 0.08	< 0.08	< 0.08
Chromium (dissolved)	µg/l	**1.9**	1.9	1.7	1.7	2.4	3.2	2.3	3.1	2.7
Copper (dissolved)	µg/l	**7.1**	8.6	7.4	9.8	7.4	17	15	25	30
Lead (dissolved)	µg/l	**10**	3.5	5.4	4.5	4.8	5.9	4.8	6.4	8.6
Nickel (dissolved)	µg/l	**5.0**	3.6	4.2	5.7	4.3	7.9	7.8	12	13
Selenium (dissolved)	µg/l	**< 4.0**	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	9.5
Zinc (dissolved)	µg/l	**8.6**	10	5.1	12	4.4	4.9	9.1	5.7	7.3
Calcium (dissolved)	mg/l		92	120	120	120	190	230	320	250
Monoaromatics & Oxygenates										
Petroleum Hydrocarbons										
VOCs										
SVOCs										

Table 4a: Summary of S/S Trial Tank Test Results - Mix 5 (lower CN impacted soil mix)
(Only determinants with any results above LoD presented)

above baseline

Sample Reference		Baseline Batch (TP813)	Baseline Batch (TP814)	Mix 14 6h	Mix 14 1d	Mix 14 2.25d	Mix 14 4d	Mix 14 9d	Mix 14 16d	Mix 14 36d	Mix 14 64d
Analytical Parameter (Leachate Analysis)	**Units**										
General Inorganics											
pH (automated)	pH Units	**7.5**		10.8	11.2	11.1	11.3	11.4	11.6	11.7	11.5
Electrical Conductivity	µS/cm			170	280	260	350	540	680	760	770
Total Cyanide (Low Level 1 µg/l)	µg/l	**17000**	**11000**	220	1100	470	1000	1900	3200	2600	5300
Complex Cyanide (Low Level)	µg/l		**10000**	220	1100	440	1000	1900	2700	2600	5200
Free Cyanide (Low Level 1 µg/l)	µg/l		**500**	2	10	27	< 1	< 1	430	< 1	86
Sulphate as SO_4	mg/l			8.1	13.6	12.4	29.1	45.1	75	11.3	92.7
Chloride	mg/l			9.5	10	12	14	25	33	31	40
Total Phenols											
Total Phenols (monohydric)	µg/l	**3000**	**67**	1.6	1.5	7.5	7.1	11	6.1	8.7	9
Speciated PAHs											
Naphthalene	µg/l	**3100**	**< 0.01**	4.6	8.1	6.7	9.7	16	20	16	19
Acenaphthylene	µg/l	**1.2**	**4.3**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.16	< 0.01	0.27
Acenaphthene	µg/l	**12**	**180**	2.5	4.6	3.8	4.5	7.4	8.7	8	7.3
Fluorene	µg/l	**5.9**	**53**	0.95	1.9	1.7	2.1	3	3.7	3.3	2.7
Phenanthrene	µg/l	**< 0.01**	**< 0.01**	0.75	1.5	1.3	1.9	2.1	2.8	3.2	2.4
Anthracene	µg/l	**< 0.01**	**< 0.01**	< 0.01	0.34	0.33	0.2	0.63	0.85	0.57	0.46
Fluoranthene	µg/l	**< 0.01**	**3.9**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.37	0.46	< 0.01
Pyrene	µg/l	**< 0.01**	**1.6**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.17	0.26	< 0.01
Total PAH											
Total EPA-16 PAHs	µg/l	**3200**	**240**	8.8	16	14	18	29	37	31	33
Heavy Metals / Metalloids											
Arsenic (dissolved)	µg/l	**16**	**9.3**	3.2	6.3	6.4	15	34	41	47	62
Cadmium (dissolved)	µg/l	**< 0.08**	**0.21**	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08	< 0.08
Chromium (dissolved)	µg/l	**1.0**	**1.1**	0.9	1.1	0.4	1.3	0.8	1.3	1.3	1.4
Copper (dissolved)	µg/l	**18**	**< 0.7**	26	15	20	30	46	71	97	130
Lead (dissolved)	µg/l	**4.4**	**6.5**	5.2	4.8	5.1	4.3	3.3	2.5	10	3.4
Nickel (dissolved)	µg/l	**2.6**	**2.6**	5	2.8	4.1	4.9	6.2	5.8	6.3	5.4
Selenium (dissolved)	µg/l	**< 4.0**	**< 4.0**	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	9.4
Zinc (dissolved)	µg/l	**4.8**	**3.8**	9.8	7.6	6.9	5	5.5	11	34	7.2
Calcium (dissolved)	mg/l			15	31	26	35	65	82	77	98
Monoaromatics & Oxygenates											
Benzene	µg/l	**7500**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Toluene	µg/l	**11000**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Ethylbenzene	µg/l	**780**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
p & m-xylene	µg/l	**5300**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-xylene	µg/l	**2400**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Petroleum Hydrocarbons											

TPH-CWG - Aromatic >C5 - C7 $_{HS\_1D\_AR}$	µg/l	**7500**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C7 - C8 $_{HS\_1D\_AR}$	µg/l	**11000**	**< 1.0**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C8 - C10 $_{HS\_1D\_AR}$	µg/l	**9100**	**23**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
TPH-CWG - Aromatic >C10 - C12 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**4100**	**640**	26	35	21	65	70	72	16	70
TPH-CWG - Aromatic >C12 - C16 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**2700**	**400**	60	80	24	98	200	170	140	190
TPH-CWG - Aromatic >C16 - C21 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**320**	**130**	110	120	12	97	190	150	170	200
TPH-CWG - Aromatic >C21 - C35 $_{EH\_1D\_AR\_\#1\_\#2\_MS}$	µg/l	**< 10**	**< 10**	< 10	< 10	< 10	< 10	98	< 10	46	90
TPH Total C5 - C40 $_{EH+HS\_1D\_TOTAL\_\#1\_\#2\_MS}$	µg/l			190	240	57	260	560	400	370	550
VOCs											
1,3,5-Trimethylbenzene	µg/l		**7.4**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	µg/l		**16**	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
SVOCs											
Aniline	µg/l		**21**	2.9	3.9	2.8	4.2	9.9	11	5.7	23
2,4-Dimethylphenol	µg/l		**23**	0.47	0.54	0.46	< 0.05	1.7	< 0.05	1.2	< 0.05
2-Methylnaphthalene	µg/l		**< 0.05**	1.1	2	1.8	2.3	3.1	3.3	3.5	3
Dibenzofuran	µg/l		**110**	1.5	2.8	2.6	3	4.4	5.6	5.4	4.2
Phenanthrene	µg/l	**< 0.01**	**< 0.01**	0.75	1.5	1.3	1.9	2.1	2.8	3.2	2.4
Anthracene	µg/l	**< 0.01**	**< 0.01**	< 0.01	0.34	0.33	0.2	0.63	0.85	0.57	0.46
Carbazole	µg/l		**40**	0.63	1.1	1.1	2	3.4	5.6	7.1	7.6
Anthraquinone	µg/l		**49**	< 0.05	0.74	0.56	1	1.8	2.4	4.1	3.9
Fluoranthene	µg/l	**< 0.01**	**3.9**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.37	0.46	< 0.01
Pyrene	µg/l	**< 0.01**	**1.6**	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.17	0.26	< 0.01

Table 4b: Summary of S/S Trial Tank Test Results - Mix 14 (higher CN impacted soil mix)
(Only determinants with any results above LoD presented)

above baseline

Phenols were significantly reduced with all typical OPC/GGBS/QL mixes, with addition of the GAC showing the largest reduction. These mixes also had the best impact on reducing Naphthalene. The lighter end TPH aromatics' leachability was significantly reduced, again with the addition of the GAC seemingly having a marked beneficial effect on the C10-C12 range. The results for the C16-C21 range were disappointing and is probably due to the high CN concentrations affecting the generation of sufficient hydration complexes within the matrix.

Tank tests

In addition to the batch leachate testing, mix 5 and mix 14 (low CN impacted soils and high CN impacted soils, respectively) were selected for tank testing, in accordance with the EA NEN 7375:2004 standard test method, to provide an indication of the potential reduction in the level of leachability that might be expected from this test as compared to the more aggressive batch test. These were two standard hydraulic binder systems that could be practicably used in the full-scale works. Mix 5 showed some potential to achieve an acceptable level of performance. It was also of interest to assess the level of reduction that could be possible with Mix 14 on high CN impacted soil hotspots.

The 64d results for Mix 5 on the lower CN impacted materials were acceptable, with only the amphoteric behaviour of some of the metals again generating higher leachate concentrations. This mix should also be able to target higher concentrations of TPH present across the site.

Although greatly reduced from the batch leachate test result, CN was still high, with a concentration of 5,300ug/l at 64d. This is would be expected to be the case for a hydraulic binder. However, the result does highlight the reduction possible with the mush less aggressive test methos, which can be used to assess likely reductions across al the mixes used in the study. Most PAHs were reduced, with the exception of Phenanthrene and Anthracene. All the TPH aromatics were greatly reduced which provides a good indication of the likely performance of Mix 5 on higher TPH concentrations.

5 Discussion and Conclusions

Cement-based fixation and encapsulation additives have been used successfully for many years for the immobilisation of contaminants, particularly within soils and sludges. Most of this success is based on results of treatability studies in developing suitable treatment mix designs, which are usually conducted over short time periods, typically from 28 to 42 days after treatment.

The main concern regarding the long-term behaviour of S/S treated material, is the environmental impact that may occur should a treated material 'fail'. Failure will be related to the dominant deterioration mechanisms prevailing at the service location and the variation in pH conditions of the system, in particular, the impact on the leachability of metal complexes.

The environmental impact, due to the deterioration of the material could be in the form of vapour, or particulate emissions and/or leachates. The degree of impact will depend on the pathway and receptor. Therefore, treatment specifications for S/S material are now generally based on probabilistic risk assessments. Even considering the variance in treatment performance demonstrated, the leachate results generated by the mixes trialled in this study provide an indication of the level of treatment performance possible with the most highly contaminated soil hotspots on the Manox site.

It is vital to identify and understand the potentially destructive mechanisms that could affect the long-term performance of the S/S material at a site. 'Intrinsic' actions are as a result of poor workmanship, poor design, reactions between waste components and binders and reactions between different waste components. 'Extrinsic' actions, which include physical and chemical weathering, mechanical damage, biological attack and attack by aggressive water, are as a result of the final environmental exposure conditions. It is a widely held view that the presence of organic contaminants can have a detrimental impact on the hydration of Portland cement. However, provided such effects can be controlled to acceptable limits, the fact that contaminants are immobilised by various mechanisms as the materials undergo hydration and their leaching potential is reduced, can provide the required degree of treatment for the final service environment.

In addition to the above mechanisms, macro-encapsulation of contaminants will also occur. This is where contaminants are physically entrapped in the discontinuous pores within the larger structural matrix of the solidified material. This aspect of the immobilisation is mainly dependent on the physical integrity of the S/S material. The tank leachate testing of monolithic samples have generally demonstrated a good level of reduction in leachable concentrations, as compared to standard batch tests on the same materials.

Treatability studies, using the contaminated source materials from the site, although conducted over a relatively short time scale, are enough to understand the behaviour of the mixes and eliminate the potential for failures following full-scale treatment works. A fundamental aspect of the testing regime is that worst-case leachate testing has been undertaken on the treated materials, as the sample

preparation involved a reduction in the particle size/structure of the S/S samples, thus eliminating the macroencapsulation aspect of the treatment and so relying solely on chemical fixation processes at the microencapsulation level. This is beneficial in understanding potential longer-term behaviour should weathering effects impact on the materials in the near surface ground. Particle reduction seeks to simulate more extreme effects of mechanisms, such as carbonation, sulphate attack and freeze-thaw, which might reduce the physical integrity of the material depending on severity. This, therefore, provides an understanding of the effects of worst-case leaching potential. As data from most on-site studies is only available for a maximum of 20 to 30 years, reliance is placed on the results of modelling in order to provide confidence in the much longer-term performance. Further information on the results of such studies is provided in the references listed in Appendix C.

This study has shown there to be enough general reduction potential in the leachability of the worst case, although on the lower CN impacted materials present within the source soils, to be able to confirm that there are a number of suitable hydraulic binder system designs that can be used to achieve significant leachability performance, albeit with some modifications to mix designs presented here. It should also be noted that the study has confirmed that the use of the technique will improve the visual and olfactory nature of the most impacted materials likely to be present at the site.

The very high CN impacted soil hotspots would need a separate assessment of mix design based on the results presented here. However, all the worst case higher CN impacted materials only represents about 4% of the total soils to be treated using S/S across the site. Therefore, we would need to carry out an additional study on samples that represent the majority of soils to be treated in the full-scale works in order to confirm the most suitable mix design. The results presented here would suggest there is likely to be 3no, mix designs adopted:-

Mix 1. Hydraulic binder system for 96% of materials to be treated

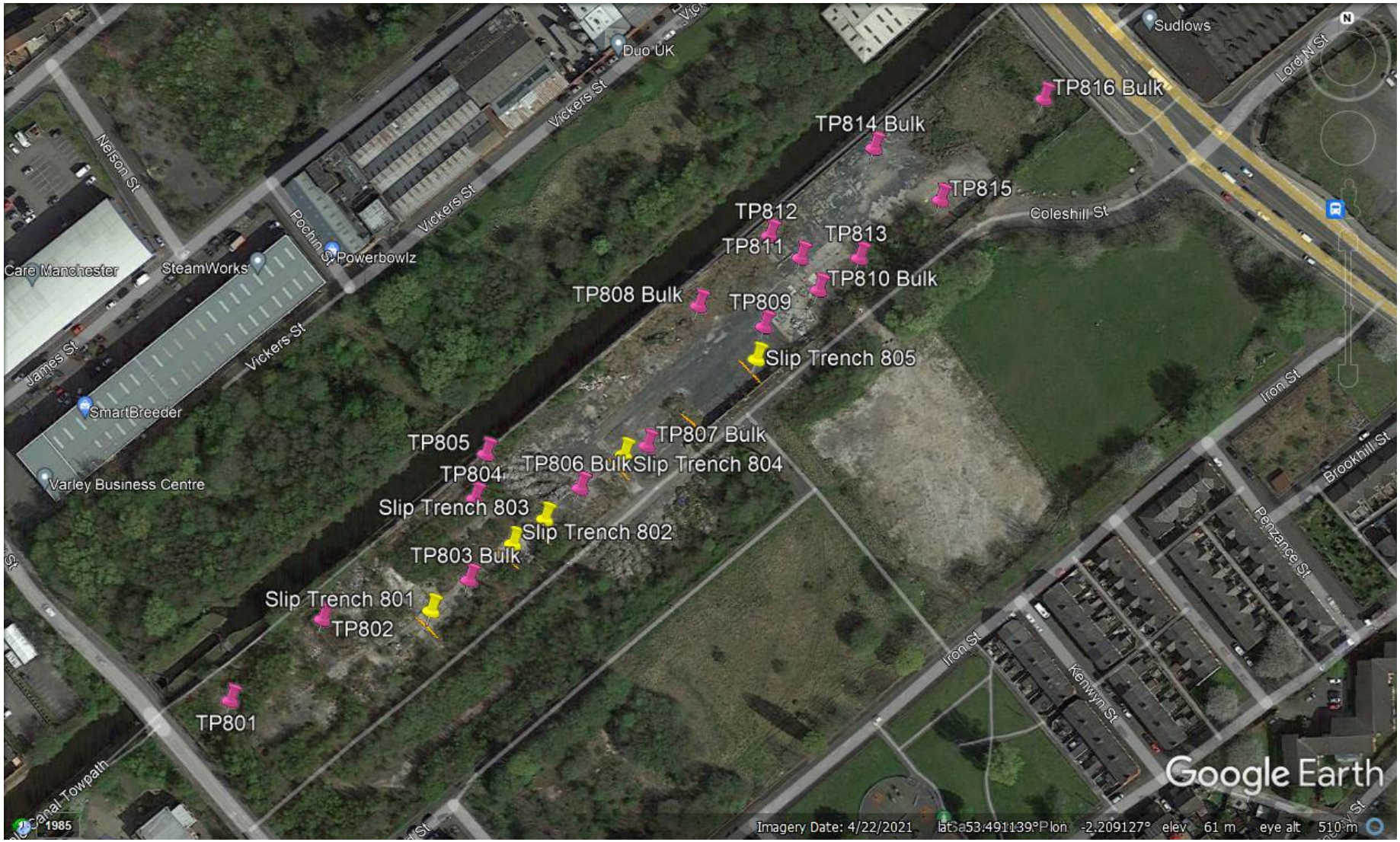
Mix 2. Hydraulic binder system for circa 2% (lower CN impacted) materials to be treated

Mix 3. Combination system for circa 2% (very high CN impacted) materials to be treated.

We hope that this report provides the required level of information needed to demonstrate the suitability and potential effectiveness of S/S treatment approach for the most impacted soils at the site.

APPENDIX A

TRIAL PIT LOCATION PLAN



Trial Pit Sampling Locations

APPENDIX B

LABORATORY TEST REPORT CERTIFICATES

APPENDIX C

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APPENDIX IX
P20 RTM SHEETS

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	2-methylnaphthalene			
Target Concentration (C_T)	0.1	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		2-methylnaphthalene		
Target concentration	C_T	0.1	mg/l	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	7.22E-02	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	2.45E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.99E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.99E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.1	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**2-methylnaphthalene**		from Level 1
Target concentration	C_T	**0.1**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**1.25E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		2.49E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		2-methylnaphthalene		from Level 1
Target Concentration	C_T	0.1	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		252	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	3.60E+02	days	
Calculated decay rate	λ	1.93E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.99E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	4.27E+02	fraction
Decay rate used	λ	4.51E-06	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	5.91E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	7.45E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.34E+01**	**fraction**
Calculated soil leachate concentration	Co	1.26E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**1.68E+01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.34E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**7.45E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	2.45E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.99E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

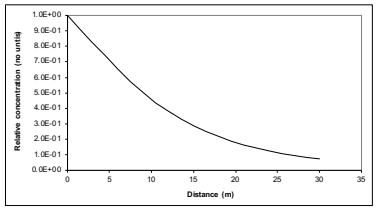
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.01E-01
1.5	9.08E-01	9.19E-02
3.0	8.23E-01	8.33E-02
4.5	7.39E-01	7.47E-02
6.0	6.55E-01	6.63E-02
7.5	5.75E-01	5.82E-02
9.0	5.03E-01	5.08E-02
10.5	4.38E-01	4.43E-02
12.0	3.80E-01	3.85E-02
13.5	3.30E-01	3.34E-02
15.0	2.87E-01	2.91E-02
16.5	2.50E-01	2.53E-02
18.0	2.17E-01	2.20E-02
19.5	1.89E-01	1.92E-02
21.0	1.65E-01	1.67E-02
22.5	1.44E-01	1.46E-02
24.0	1.26E-01	1.28E-02
25.5	1.10E-01	1.12E-02
27.0	9.67E-02	9.78E-03
28.5	8.48E-02	8.58E-03
30.0	7.45E-02	7.54E-03

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		2-methylnaphthalene		from Level 1
Target Concentration	C_T	1.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	5.90E-02	mg/l	TP406
Half life for degradation of contaminant in water	$t_{1/2}$	2.80E+01	days	
Calculated decay rate	λ	2.48E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	estimate based on site data
Plume thickness at source	Sy	1.20E+00	m	from level 2
Saturated aquifer thickness	da	1.30E+00	m	based on borehole data
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	SR3-clay loam
Effective porosity of aquifer	n	5.60E-01	fraction	SR3- clay loam
Hydraulic gradient	i	1.00E-02	fraction	site data
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	SR3- clay loam
Distance to compliance point	x	3.00E+01	m	distance to Rochdale Canal
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	1.99E+02	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	4.06E+02	fraction
Decay rate used	λ	6.10E-05	d^{-1}
Rate of contaminant flow due to retardation	u	5.72E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	3.60E-08	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.64E+06**	

Remedial Targets

Remedial Target		**1.64E+05**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**3.60E-08**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	2.45E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.99E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

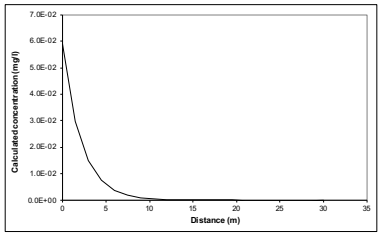
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	5.9E-02
1.5	2.99E-02
3.0	1.51E-02
4.5	7.52E-03
6.0	3.70E-03
7.5	1.80E-03
9.0	8.74E-04
10.5	4.23E-04
12.0	2.05E-04
13.5	9.89E-05
15.0	4.79E-05
16.5	2.32E-05
18.0	1.12E-05
19.5	5.46E-06
21.0	2.65E-06
22.5	1.29E-06
24.0	6.30E-07
25.5	3.08E-07
27.0	1.50E-07
28.5	7.36E-08
30.0	3.60E-08

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	Carbazole			
Target Concentration (C_T)	0.1	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Carbazole**		
Target concentration	C_T	**0.1**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.26E-03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.01E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.07E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**4.07E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.1	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Carbazole**		from Level 1
Target concentration	C_T	**0.1**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**1.25E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		5.09E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Carbazole		from Level 1
Target Concentration	C_T	0.1	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		19.8	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.80E+01	days	
Calculated decay rate	λ	2.48E-02	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	8.73E+02	fraction
Decay rate used	λ	2.84E-05	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.89E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.31E-06	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**7.64E+05**	**fraction**
Calculated soil leachate concentration	Co	4.86E-02	mg/l

Remedial Targets

Level 3 Remedial Target	**9.55E+05**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	3.89E+08	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point	**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration C_{ED}/C_0	**1.31E-06**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

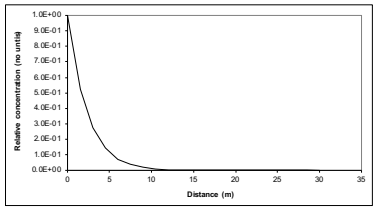
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	3.89E-03
1.5	5.25E-01	2.04E-03
3.0	2.75E-01	1.07E-03
4.5	1.43E-01	5.56E-04
6.0	7.33E-02	2.85E-04
7.5	3.73E-02	1.45E-04
9.0	1.88E-02	7.32E-05
10.5	9.48E-03	3.69E-05
12.0	4.77E-03	1.85E-05
13.5	2.40E-03	9.32E-06
15.0	1.20E-03	4.68E-06
16.5	6.06E-04	2.36E-06
18.0	3.05E-04	1.19E-06
19.5	1.54E-04	5.98E-07
21.0	7.75E-05	3.01E-07
22.5	3.92E-05	1.52E-07
24.0	1.98E-05	7.70E-08
25.5	1.00E-05	3.90E-08
27.0	5.08E-06	1.98E-08
28.5	2.58E-06	1.00E-08
30.0	1.31E-06	5.09E-09

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		Carbazole		from Level 1
Target Concentration	C_T	1.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	2.10E-02	mg/l	TP406
Half life for degradation of contaminant in water	$t_{1/2}$	7.00E+00	days	
Calculated decay rate	λ	9.90E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	estimate based on site data
Plume thickness at source	Sy	1.20E+00	m	from level 2
Saturated aquifer thickness	da	1.30E+00	m	based on borehole data
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	SR3-clay loam
Effective porosity of aquifer	n	5.60E-01	fraction	SR3- clay loam
Hydraulic gradient	i	1.00E-02	fraction	site data
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	SR3- clay loam
Distance to compliance point	x	3.00E+01	m	distance to Rochdale Canal
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	8.29E+02	fraction
Decay rate used	λ	1.19E-04	d^{-1}
Rate of contaminant flow due to retardation	u	2.80E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	3.07E-16	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**6.84E+13**	

Remedial Targets

Remedial Target		**6.84E+12**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**3.07E-16**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

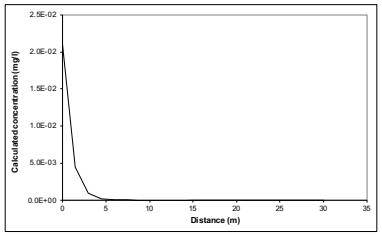
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	2.1E-02
1.5	4.43E-03
3.0	9.30E-04
4.5	1.93E-04
6.0	3.94E-05
7.5	7.98E-06
9.0	1.61E-06
10.5	3.24E-07
12.0	6.51E-08
13.5	1.31E-08
15.0	2.63E-09
16.5	5.31E-10
18.0	1.07E-10
19.5	2.16E-11
21.0	4.37E-12
22.5	8.85E-13
24.0	1.79E-13
25.5	3.64E-14
27.0	7.40E-15
28.5	1.51E-15
30.0	3.07E-16

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	Dibenzofuran			
Target Concentration (C_T)	0.1	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Dibenzofuran**		
Target concentration	C_T	**0.1**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.26E-03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.01E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.07E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**4.07E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.1	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Dibenzofuran**		from Level 1
Target concentration	C_T	**0.1**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**1.25E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		5.09E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Dibenzofuran		from Level 1
Target Concentration	C_T	0.1	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		237	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.80E+01	days	
Calculated decay rate	λ	2.48E-02	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	8.73E+02	fraction
Decay rate used	λ	2.84E-05	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.89E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	1.31E-06	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**7.64E+05**	**fraction**
Calculated soil leachate concentration	Co	5.82E-01	mg/l

Remedial Targets

Level 3 Remedial Target		**9.55E+05**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.89E+08	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**1.31E-06**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

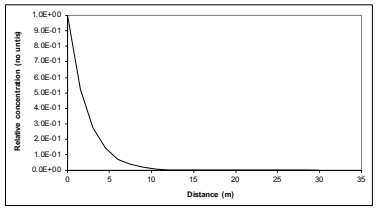
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	4.66E-02
1.5	5.25E-01	2.45E-02
3.0	2.75E-01	1.28E-02
4.5	1.43E-01	6.66E-03
6.0	7.33E-02	3.41E-03
7.5	3.73E-02	1.73E-03
9.0	1.88E-02	8.76E-04
10.5	9.48E-03	4.41E-04
12.0	4.77E-03	2.22E-04
13.5	2.40E-03	1.12E-04
15.0	1.20E-03	5.61E-05
16.5	6.06E-04	2.82E-05
18.0	3.05E-04	1.42E-05
19.5	1.54E-04	7.15E-06
21.0	7.75E-05	3.61E-06
22.5	3.92E-05	1.82E-06
24.0	1.98E-05	9.22E-07
25.5	1.00E-05	4.67E-07
27.0	5.08E-06	2.37E-07
28.5	2.58E-06	1.20E-07
30.0	1.31E-06	6.09E-08

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		Dibenzofuran		from Level 1
Target Concentration	C_T	1.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	4.80E-02	mg/l	TP406
Half life for degradation of contaminant in water	$t_{1/2}$	7.00E+00	days	
Calculated decay rate	λ	9.90E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	estimate based on site data
Plume thickness at source	Sy	1.20E+00	m	from level 2
Saturated aquifer thickness	da	1.30E+00	m	based on borehole data
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	SR3-clay loam
Effective porosity of aquifer	n	5.60E-01	fraction	SR3- clay loam
Hydraulic gradient	i	1.00E-02	fraction	site data
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	SR3- clay loam
Distance to compliance point	x	3.00E+01	m	distance to Rochdale Canal
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	8.29E+02	fraction
Decay rate used	λ	1.19E-04	d^{-1}
Rate of contaminant flow due to retardation	u	2.80E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	7.01E-16	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**6.84E+13**	

Remedial Targets

Remedial Target		**6.84E+12**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**7.01E-16**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

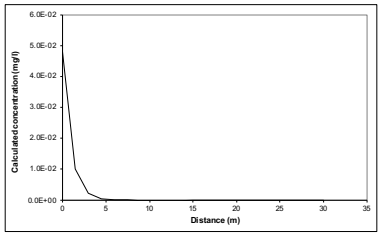
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.8E-02
1.5	1.01E-02
3.0	2.13E-03
4.5	4.40E-04
6.0	9.00E-05
7.5	1.82E-05
9.0	3.68E-06
10.5	7.40E-07
12.0	1.49E-07
13.5	2.99E-08
15.0	6.02E-09
16.5	1.21E-09
18.0	2.45E-10
19.5	4.94E-11
21.0	9.99E-12
22.5	2.02E-12
24.0	4.10E-13
25.5	8.32E-14
27.0	1.69E-14
28.5	3.44E-15
30.0	7.01E-16

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	Naphthalene			
Target Concentration (C_T)	0.1	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**Naphthalene**		
Target concentration	**C_T**	**0.1**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	6.20E-03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	6.46E+02	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.24E+01**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.28E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.1	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Naphthalene**		from Level 1
Target concentration	C_T	**0.1**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**1.25E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		6.60E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	0.1	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		819	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	
Calculated decay rate	λ	2.69E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	8.73E+02	fraction
Decay rate used	λ	3.08E-06	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.89E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.98E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.51E+01**	**fraction**
Calculated soil leachate concentration	Co	1.55E+01	mg/l

Remedial Targets

Level 3 Remedial Target		**3.14E+01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.66E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.98E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

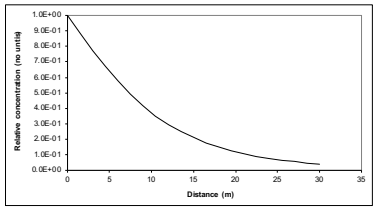
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.24E+00
1.5	8.80E-01	1.09E+00
3.0	7.73E-01	9.60E-01
4.5	6.73E-01	8.35E-01
6.0	5.78E-01	7.17E-01
7.5	4.92E-01	6.11E-01
9.0	4.17E-01	5.17E-01
10.5	3.52E-01	4.36E-01
12.0	2.96E-01	3.68E-01
13.5	2.49E-01	3.10E-01
15.0	2.10E-01	2.61E-01
16.5	1.77E-01	2.20E-01
18.0	1.49E-01	1.85E-01
19.5	1.26E-01	1.57E-01
21.0	1.07E-01	1.32E-01
22.5	9.02E-02	1.12E-01
24.0	7.64E-02	9.49E-02
25.5	6.48E-02	8.05E-02
27.0	5.51E-02	6.84E-02
28.5	4.68E-02	5.81E-02
30.0	3.98E-02	4.95E-02

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		Naphthalene		from Level 1
Target Concentration	C_T	1.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.10E-03	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	2.00E+01	days	
Calculated decay rate	λ	3.47E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.24E+01	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	1.08E+02	fraction
Decay rate used	λ	3.22E-04	d^{-1}
Rate of contaminant flow due to retardation	u	2.15E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	2.07E-10	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.91E+07**	

Remedial Targets

Remedial Target		**3.91E+06**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**2.07E-10**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	6.46E+02	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.24E+01	l/kg

Define dispersivity (click brown cell and use pull down list)

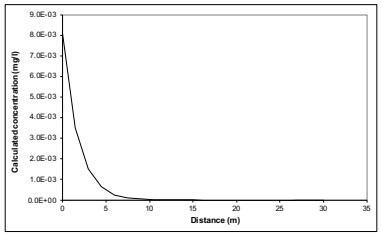
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.1E-03
1.5	3.51E-03
3.0	1.51E-03
4.5	6.42E-04
6.0	2.69E-04
7.5	1.12E-04
9.0	4.63E-05
10.5	1.91E-05
12.0	7.89E-06
13.5	3.25E-06
15.0	1.34E-06
16.5	5.55E-07
18.0	2.30E-07
19.5	9.52E-08
21.0	3.95E-08
22.5	1.64E-08
24.0	6.83E-09
25.5	2.84E-09
27.0	1.19E-09
28.5	4.95E-10
30.0	2.07E-10

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aliphatic C8-10			
Target Concentration (C_T)	0.3	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aliphatic C8-10**		
Target concentration	**C_T**	**0.3**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	4.15E+01	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	3.02E+04	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**2.45E+03**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**7.37E+02**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.3	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aliphatic C8-10**		from Level 1
Target concentration	C_T	**0.3**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		9.21E+03	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C8-10		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		20	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.28E+02	days	
Calculated decay rate	λ	3.04E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.45E+03	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	5.26E+03	fraction
Decay rate used	λ	5.78E-07	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	4.80E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.03E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.30E+01**	**fraction**
Calculated soil leachate concentration	Co	8.14E-03	mg/l

Remedial Targets

Level 3 Remedial Target		**1.24E+02**	**mg/l**
Ogata Banks		**or**	
		3.04E+05	**mg/kg**
Distance to compliance point		**30**	**m**
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.03E-02**	**fraction**

For comparison with measured pore water concentration.
This assumes Level 1 Remedial Target is based on Target Concentration.
For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	3.02E+04	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.45E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

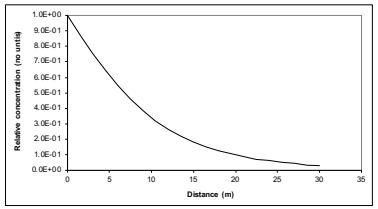
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	6.51E-04
1.5	8.69E-01	5.66E-04
3.0	7.53E-01	4.90E-04
4.5	6.46E-01	4.20E-04
6.0	5.47E-01	3.56E-04
7.5	4.60E-01	2.99E-04
9.0	3.84E-01	2.50E-04
10.5	3.19E-01	2.08E-04
12.0	2.65E-01	1.73E-04
13.5	2.20E-01	1.44E-04
15.0	1.83E-01	1.19E-04
16.5	1.52E-01	9.92E-05
18.0	1.27E-01	8.25E-05
19.5	1.06E-01	6.87E-05
21.0	8.80E-02	5.73E-05
22.5	7.35E-02	4.79E-05
24.0	6.14E-02	4.00E-05
25.5	5.14E-02	3.35E-05
27.0	4.31E-02	2.80E-05
28.5	3.61E-02	2.35E-05
30.0	3.03E-02	1.97E-05

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C8-10		from Level 1
Target Concentration	C_T	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	5.00E-03	mg/l	*TP406*
Half life for degradation of contaminant in water	$t_{1/2}$	2.28E+02	days	
Calculated decay rate	λ	3.04E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	2.45E+03	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	4.99E+03	fraction
Decay rate used	λ	6.09E-07	d^{-1}
Rate of contaminant flow due to retardation	u	4.65E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	1.17E-04	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.27E+01**	

Remedial Targets

Remedial Target		**1.28E+01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**1.17E-04**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	3.02E+04	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	2.45E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	5.0E-03
1.5	4.30E-03
3.0	3.68E-03
4.5	3.11E-03
6.0	2.59E-03
7.5	2.14E-03
9.0	1.76E-03
10.5	1.44E-03
12.0	1.18E-03
13.5	9.68E-04
15.0	7.94E-04
16.5	6.52E-04
18.0	5.36E-04
19.5	4.41E-04
21.0	3.64E-04
22.5	3.00E-04
24.0	2.48E-04
25.5	2.05E-04
27.0	1.70E-04
28.5	1.41E-04
30.0	1.17E-04

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aliphatic C10-12			
Target Concentration (C_T)	0.3	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aliphatic C10-12**		
Target concentration	**C_T**	**0.3**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	6.44E+01	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	2.40E+05	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.95E+04**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.85E+03**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.3	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aliphatic C10-12**		from Level 1
Target concentration	C_T	**0.3**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		7.31E+04	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C10-12		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		425	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.12E+02	days	
Calculated decay rate	λ	6.19E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.95E+04	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	4.17E+04	fraction
Decay rate used	λ	1.48E-07	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	6.05E-07	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.68E-03	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.72E+02**	**fraction**
Calculated soil leachate concentration	Co	2.18E-02	mg/l

Remedial Targets

Level 3 Remedial Target		**1.02E+03**	**mg/l**
Ogata Banks		**or**	
		1.99E+07	**mg/kg**
Distance to compliance point		**30**	**m**
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.68E-03**	**fraction**

For comparison with measured pore water concentration.
This assumes Level 1 Remedial Target is based on Target Concentration.
For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	2.40E+05	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.95E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

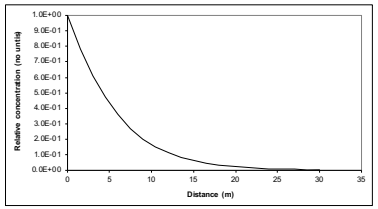
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.75E-03
1.5	7.82E-01	1.36E-03
3.0	6.09E-01	1.06E-03
4.5	4.70E-01	8.21E-04
6.0	3.59E-01	6.26E-04
7.5	2.71E-01	4.73E-04
9.0	2.04E-01	3.56E-04
10.5	1.53E-01	2.66E-04
12.0	1.14E-01	1.99E-04
13.5	8.53E-02	1.49E-04
15.0	6.38E-02	1.11E-04
16.5	4.77E-02	8.33E-05
18.0	3.57E-02	6.24E-05
19.5	2.68E-02	4.68E-05
21.0	2.01E-02	3.51E-05
22.5	1.51E-02	2.64E-05
24.0	1.14E-02	1.98E-05
25.5	8.56E-03	1.49E-05
27.0	6.45E-03	1.13E-05
28.5	4.87E-03	8.50E-06
30.0	3.68E-03	6.42E-06

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Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		TPH Aliphatic C10-12		from Level 1
Target Concentration	C_T	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	3.70E-02	mg/l	TP406
Half life for degradation of contaminant in water	$t_{1/2}$	1.12E+02	days	
Calculated decay rate	λ	6.19E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.95E+04	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	3.97E+04	fraction
Decay rate used	λ	1.56E-07	d^{-1}
Rate of contaminant flow due to retardation	u	5.85E-07	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	9.33E-05	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.96E+02**	

Remedial Targets

Remedial Target		**1.19E+02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**9.33E-05**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	2.40E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.95E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0
For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x
Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	3.7E-02
1.5	2.85E-02
3.0	2.18E-02
4.5	1.65E-02
6.0	1.23E-02
7.5	9.06E-03
9.0	6.67E-03
10.5	4.89E-03
12.0	3.59E-03
13.5	2.63E-03
15.0	1.93E-03
16.5	1.42E-03
18.0	1.04E-03
19.5	7.67E-04
21.0	5.66E-04
22.5	4.18E-04
24.0	3.09E-04
25.5	2.28E-04
27.0	1.69E-04
28.5	1.26E-04
30.0	9.33E-05

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aliphatic C12-16			
Target Concentration (C_T)	0.3	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
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The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aliphatic C12-16**		
Target concentration	**C_T**	**0.3**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.71E+02	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.37E+06	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.36E+05**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.31E+05**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.3	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aliphatic C12-16**		from Level 1
Target concentration	C_T	**0.3**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.63E+06	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C12-16		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		504	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	3.65E+03	days	
Calculated decay rate	λ	1.90E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.36E+05	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	9.34E+05	fraction
Decay rate used	λ	2.03E-10	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.70E-08	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.07E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.45E+00**	**fraction**
Calculated soil leachate concentration	Co	1.16E-03	mg/l

Remedial Targets

Level 3 Remedial Target		**9.20E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		4.01E+06	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.07E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.37E+06	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.36E+05	l/kg

Define dispersivity (click brown cell and use pull down list)

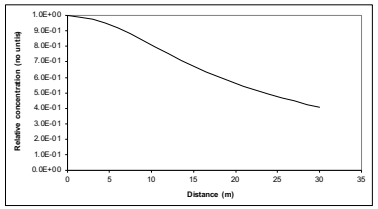
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	9.25E-05
1.5	9.89E-01	9.15E-05
3.0	9.76E-01	9.02E-05
4.5	9.53E-01	8.82E-05
6.0	9.20E-01	8.51E-05
7.5	8.80E-01	8.14E-05
9.0	8.37E-01	7.74E-05
10.5	7.93E-01	7.34E-05
12.0	7.51E-01	6.94E-05
13.5	7.10E-01	6.57E-05
15.0	6.72E-01	6.21E-05
16.5	6.36E-01	5.88E-05
18.0	6.03E-01	5.57E-05
19.5	5.72E-01	5.29E-05
21.0	5.43E-01	5.02E-05
22.5	5.16E-01	4.77E-05
24.0	4.91E-01	4.54E-05
25.5	4.68E-01	4.33E-05
27.0	4.46E-01	4.13E-05
28.5	4.26E-01	3.94E-05
30.0	4.07E-01	3.77E-05

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C12-16		from Level 1
Target Concentration	C_T	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.08E-01	mg/l	*TP406*
Half life for degradation of contaminant in water	$t_{1/2}$	3.65E+03	days	
Calculated decay rate	λ	1.90E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.36E+05	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	8.88E+05	fraction
Decay rate used	λ	2.14E-10	d^{-1}
Rate of contaminant flow due to retardation	u	2.62E-08	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	4.07E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.65E+00**	

Remedial Targets

Remedial Target		**7.96E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**4.07E-02**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.37E+06	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.36E+05	l/kg

Define dispersivity (click brown cell and use pull down list)

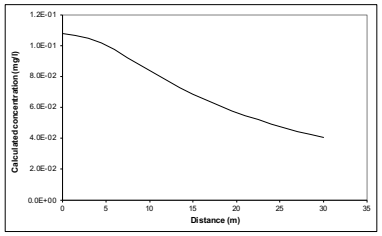
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.1E-01
1.5	1.07E-01
3.0	1.05E-01
4.5	1.02E-01
6.0	9.74E-02
7.5	9.25E-02
9.0	8.74E-02
10.5	8.23E-02
12.0	7.75E-02
13.5	7.30E-02
15.0	6.88E-02
16.5	6.49E-02
18.0	6.13E-02
19.5	5.80E-02
21.0	5.49E-02
22.5	5.21E-02
24.0	4.94E-02
25.5	4.70E-02
27.0	4.48E-02
28.5	4.27E-02
30.0	4.07E-02

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aliphatic C16-21			
Target Concentration (C_T)	0.3	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aliphatic C16-21**		
Target concentration	**C_T**	**0.3**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.07E+03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.75E+09	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.67E+08**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.40E+08**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.3	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aliphatic C16-21**		from Level 1
Target concentration	**C_T**	**0.3**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.75E+09	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C16-21		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		1170	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	8.56E+03	days	
Calculated decay rate	λ	8.10E-05	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.67E+08	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	1.00E+09	fraction
Decay rate used	λ	8.09E-14	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.52E-11	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.62E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.16E+00**	**fraction**
Calculated soil leachate concentration	Co	2.50E-06	mg/l

Remedial Targets

Level 3 Remedial Target		**8.12E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.79E+09	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.62E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.75E+09	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.67E+08	l/kg

Define dispersivity (click brown cell and use pull down list)

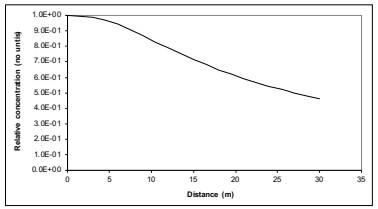
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	2.00E-07
1.5	9.95E-01	1.99E-07
3.0	9.88E-01	1.98E-07
4.5	9.71E-01	1.95E-07
6.0	9.43E-01	1.89E-07
7.5	9.08E-01	1.82E-07
9.0	8.69E-01	1.74E-07
10.5	8.29E-01	1.66E-07
12.0	7.89E-01	1.58E-07
13.5	7.51E-01	1.51E-07
15.0	7.15E-01	1.43E-07
16.5	6.81E-01	1.37E-07
18.0	6.50E-01	1.30E-07
19.5	6.20E-01	1.24E-07
21.0	5.93E-01	1.19E-07
22.5	5.67E-01	1.14E-07
24.0	5.43E-01	1.09E-07
25.5	5.21E-01	1.04E-07
27.0	5.00E-01	1.00E-07
28.5	4.80E-01	9.62E-08
30.0	4.62E-01	9.26E-08

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		TPH Aliphatic C16-21		from Level 1
Target Concentration	C_T	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.70E-02	mg/l	TP406
Half life for degradation of contaminant in water	$t_{1/2}$	8.56E+03	days	
Calculated decay rate	λ	8.10E-05	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	estimate based on site data
Plume thickness at source	Sy	1.20E+00	m	from level 2
Saturated aquifer thickness	da	1.30E+00	m	based on borehole data
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	SR3-clay loam
Effective porosity of aquifer	n	5.60E-01	fraction	SR3- clay loam
Hydraulic gradient	i	1.00E-02	fraction	site data
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	SR3- clay loam
Distance to compliance point	x	3.00E+01	m	distance to Rochdale Canal
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	time variant options only
Parameters values determined from options				
Partition coefficient	Kd	4.67E+08	l/kg	see options
Longitudinal dispersivity	ax	3.00E+00	m	see options
Transverse dispersivity	az	3.00E-01	m	see options
Vertical dispersivity	ay	3.00E-02	m	see options

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	9.51E+08	fraction
Decay rate used	λ	8.51E-14	d^{-1}
Rate of contaminant flow due to retardation	u	2.44E-11	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	3.76E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.32E+00**	

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.75E+09	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.67E+08	l/kg

Define dispersivity (click brown cell and use pull down list)

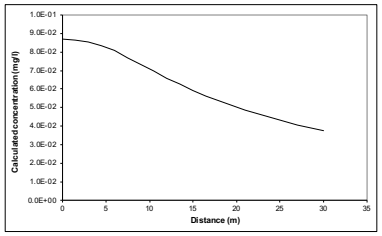
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.7E-02
1.5	8.65E-02
3.0	8.57E-02
4.5	8.37E-02
6.0	8.07E-02
7.5	7.71E-02
9.0	7.33E-02
10.5	6.96E-02
12.0	6.59E-02
13.5	6.25E-02
15.0	5.93E-02
16.5	5.64E-02
18.0	5.36E-02
19.5	5.10E-02
21.0	4.87E-02
22.5	4.65E-02
24.0	4.44E-02
25.5	4.25E-02
27.0	4.07E-02
28.5	3.91E-02
30.0	3.76E-02

Remedial Targets

Remedial Target		**6.95E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**3.76E-02**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aliphatic C21-35			
Target Concentration (C_T)	0.3	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aliphatic C21-35**		
Target concentration	**C_T**	**0.3**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.07E+03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.75E+09	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.67E+08**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.40E+08**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.3	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aliphatic C21-35**		from Level 1
Target concentration	C_T	**0.3**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E+00**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.75E+09	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C21-35		from Level 1
Target Concentration	C_T	0.3	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		7560	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	8.56E+03	days	
Calculated decay rate	λ	8.10E-05	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.67E+08	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	1.00E+09	fraction
Decay rate used	λ	8.09E-14	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.52E-11	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.62E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.16E+00**	**fraction**
Calculated soil leachate concentration	Co	1.62E-05	mg/l

Remedial Targets

Level 3 Remedial Target		**8.12E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.79E+09	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.62E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.75E+09	l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.67E+08	l/kg

Define dispersivity (click brown cell and use pull down list)

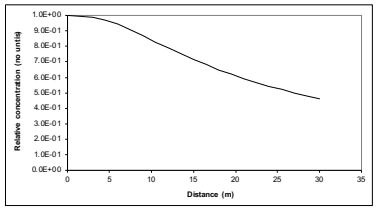
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.29E-06
1.5	9.95E-01	1.29E-06
3.0	9.88E-01	1.28E-06
4.5	9.71E-01	1.26E-06
6.0	9.43E-01	1.22E-06
7.5	9.08E-01	1.18E-06
9.0	8.69E-01	1.12E-06
10.5	8.29E-01	1.07E-06
12.0	7.89E-01	1.02E-06
13.5	7.51E-01	9.73E-07
15.0	7.15E-01	9.26E-07
16.5	6.81E-01	8.82E-07
18.0	6.50E-01	8.41E-07
19.5	6.20E-01	8.03E-07
21.0	5.93E-01	7.67E-07
22.5	5.67E-01	7.34E-07
24.0	5.43E-01	7.03E-07
25.5	5.21E-01	6.74E-07
27.0	5.00E-01	6.47E-07
28.5	4.80E-01	6.22E-07
30.0	4.62E-01	5.98E-07

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aliphatic C21-35		from Level 1
Target Concentration	C_T	3.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	9.40E-01	mg/l	*TP406*
Half life for degradation of contaminant in water	$t_{1/2}$	8.56E+03	days	
Calculated decay rate	λ	8.10E-05	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.67E+08	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	9.51E+08	fraction
Decay rate used	λ	8.51E-14	d^{-1}
Rate of contaminant flow due to retardation	u	2.44E-11	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	4.06E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**2.32E+00**	

Remedial Targets

Remedial Target		**6.95E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**4.06E-01**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.75E+09	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.67E+08	l/kg

Define dispersivity (click brown cell and use pull down list)

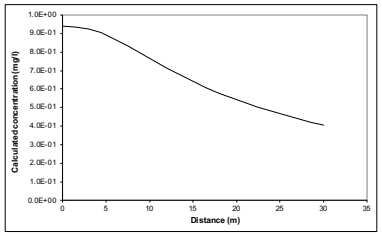
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	9.4E-01
1.5	9.35E-01
3.0	9.26E-01
4.5	9.04E-01
6.0	8.71E-01
7.5	8.33E-01
9.0	7.92E-01
10.5	7.52E-01
12.0	7.13E-01
13.5	6.76E-01
15.0	6.41E-01
16.5	6.09E-01
18.0	5.79E-01
19.5	5.51E-01
21.0	5.26E-01
22.5	5.02E-01
24.0	4.80E-01
25.5	4.59E-01
27.0	4.40E-01
28.5	4.22E-01
30.0	4.06E-01

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aromatic C8-C10			
Target Concentration (C_T)	0.02	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C8-C10**		
Target concentration	**C_T**	**0.02**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	2.53E-01	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	1.58E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.29E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**2.58E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.02	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C8-C10**		from Level 1
Target concentration	C_T	**0.02**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**2.50E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		3.23E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C8-C10		from Level 1
Target Concentration	C_T	0.02	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		277	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.28E+02	days	*Conservative Estimate*
Calculated decay rate	λ	3.04E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	2.77E+02	fraction
Decay rate used	λ	1.10E-05	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	9.12E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.03E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.30E+01**	**fraction**
Calculated soil leachate concentration	Co	2.15E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**8.25E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.06E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.03E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.58E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

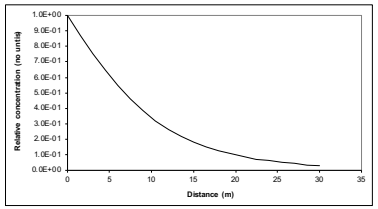
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.72E-01
1.5	8.69E-01	1.49E-01
3.0	7.53E-01	1.29E-01
4.5	6.46E-01	1.11E-01
6.0	5.47E-01	9.39E-02
7.5	4.60E-01	7.89E-02
9.0	3.84E-01	6.59E-02
10.5	3.19E-01	5.48E-02
12.0	2.65E-01	4.56E-02
13.5	2.20E-01	3.79E-02
15.0	1.83E-01	3.15E-02
16.5	1.52E-01	2.62E-02
18.0	1.27E-01	2.18E-02
19.5	1.06E-01	1.81E-02
21.0	8.80E-02	1.51E-02
22.5	7.35E-02	1.26E-02
24.0	6.14E-02	1.05E-02
25.5	5.14E-02	8.82E-03
27.0	4.31E-02	7.39E-03
28.5	3.61E-02	6.20E-03
30.0	3.03E-02	5.20E-03

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C8-C10		from Level 1
Target Concentration	C_T	2.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	4.31E+00	mg/l	WS603
Half life for degradation of contaminant in water	$t_{1/2}$	2.28E+02	days	*Conservative Estimate*
Calculated decay rate	λ	3.04E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	2.63E+02	fraction
Decay rate used	λ	1.16E-05	d^{-1}
Rate of contaminant flow due to retardation	u	8.83E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	1.01E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**4.27E+01**	

Remedial Targets

Remedial Target		**8.54E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.01E-01**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.58E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	4.3E+00
1.5	3.70E+00
3.0	3.17E+00
4.5	2.67E+00
6.0	2.23E+00
7.5	1.84E+00
9.0	1.51E+00
10.5	1.24E+00
12.0	1.02E+00
13.5	8.34E-01
15.0	6.84E-01
16.5	5.61E-01
18.0	4.62E-01
19.5	3.80E-01
21.0	3.13E-01
22.5	2.58E-01
24.0	2.14E-01
25.5	1.77E-01
27.0	1.46E-01
28.5	1.21E-01
30.0	1.01E-01

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aromatic C10-C12			
Target Concentration (C_T)	0.03	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C10-C12**		
Target concentration	C_T	**0.03**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	7.22E-02	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	2.51E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**2.04E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**6.13E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.03	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C10-C12**		from Level 1
Target concentration	C_T	**0.03**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltraton - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**3.75E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		7.66E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C10-C12		from Level 1
Target Concentration	C_T	0.03	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		48100	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	
Calculated decay rate	λ	2.69E-03	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	2.77E+02	fraction
Decay rate used	λ	9.71E-06	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	9.12E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.98E-02	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.51E+01**	**fraction**
Calculated soil leachate concentration	Co	2.35E+02	mg/l

Remedial Targets

Level 3 Remedial Target		**9.41E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.92E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.98E-02**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.58E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

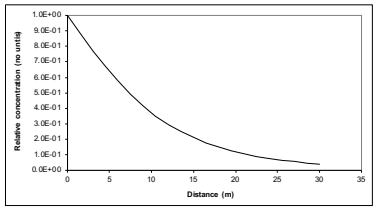
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.88E+01
1.5	8.80E-01	1.66E+01
3.0	7.73E-01	1.46E+01
4.5	6.73E-01	1.27E+01
6.0	5.78E-01	1.09E+01
7.5	4.92E-01	9.27E+00
9.0	4.17E-01	7.85E+00
10.5	3.52E-01	6.62E+00
12.0	2.96E-01	5.58E+00
13.5	2.49E-01	4.70E+00
15.0	2.10E-01	3.96E+00
16.5	1.77E-01	3.33E+00
18.0	1.49E-01	2.81E+00
19.5	1.26E-01	2.38E+00
21.0	1.07E-01	2.01E+00
22.5	9.02E-02	1.70E+00
24.0	7.64E-02	1.44E+00
25.5	6.48E-02	1.22E+00
27.0	5.51E-02	1.04E+00
28.5	4.68E-02	8.82E-01
30.0	3.98E-02	7.50E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C10-C12		from Level 1
Target Concentration	C_T	3.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.76E+00	mg/l	WS603A
Half life for degradation of contaminant in water	$t_{1/2}$	2.58E+02	days	
Calculated decay rate	λ	2.69E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.29E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	2.63E+02	fraction
Decay rate used	λ	1.02E-05	d^{-1}
Rate of contaminant flow due to retardation	u	8.83E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	5.51E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.20E+01**	

Remedial Targets

Remedial Target		**9.59E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**5.51E-02**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.58E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.29E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.8E+00
1.5	1.54E+00
3.0	1.33E+00
4.5	1.14E+00
6.0	9.66E-01
7.5	8.10E-01
9.0	6.75E-01
10.5	5.62E-01
12.0	4.67E-01
13.5	3.89E-01
15.0	3.23E-01
16.5	2.69E-01
18.0	2.25E-01
19.5	1.88E-01
21.0	1.57E-01
22.5	1.31E-01
24.0	1.10E-01
25.5	9.25E-02
27.0	7.77E-02
28.5	6.54E-02
30.0	5.51E-02

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aromatic C12-C16			
Target Concentration (C_T)	0.002	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C12-C16**		
Target concentration	C_T	**0.002**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	1.26E-03	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	5.01E+03	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**4.07E+02**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**8.15E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.002	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C12-C16**		from Level 1
Target concentration	C_T	**0.002**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**2.50E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.02E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C12-C16		from Level 1
Target Concentration	C_T	0.002	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		14300	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	1.84E+03	days	
Calculated decay rate	λ	3.77E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	8.73E+02	fraction
Decay rate used	λ	4.31E-07	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	2.89E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.31E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**3.02E+00**	**fraction**
Calculated soil leachate concentration	Co	3.51E+01	mg/l

Remedial Targets

Level 3 Remedial Target		**7.56E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		3.08E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.31E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

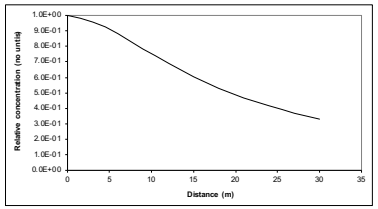
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.81E+00
1.5	9.79E-01	2.75E+00
3.0	9.56E-01	2.68E+00
4.5	9.24E-01	2.60E+00
6.0	8.82E-01	2.48E+00
7.5	8.35E-01	2.35E+00
9.0	7.86E-01	2.21E+00
10.5	7.37E-01	2.07E+00
12.0	6.91E-01	1.94E+00
13.5	6.46E-01	1.82E+00
15.0	6.05E-01	1.70E+00
16.5	5.67E-01	1.59E+00
18.0	5.32E-01	1.49E+00
19.5	4.99E-01	1.40E+00
21.0	4.69E-01	1.32E+00
22.5	4.41E-01	1.24E+00
24.0	4.16E-01	1.17E+00
25.5	3.92E-01	1.10E+00
27.0	3.70E-01	1.04E+00
28.5	3.50E-01	9.82E-01
30.0	3.31E-01	9.29E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C12-C16		from Level 1
Target Concentration	C_T	2.00E-03	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	5.71E+00	mg/l	WS603
Half life for degradation of contaminant in water	$t_{1/2}$	9.20E+02	days	
Calculated decay rate	λ	7.53E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	4.07E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	8.29E+02	fraction
Decay rate used	λ	9.08E-07	d^{-1}
Rate of contaminant flow due to retardation	u	2.80E-05	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	1.12E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**5.10E+00**	

Remedial Targets

Remedial Target		**1.02E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**1.12E+00**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	5.01E+03	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	4.07E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

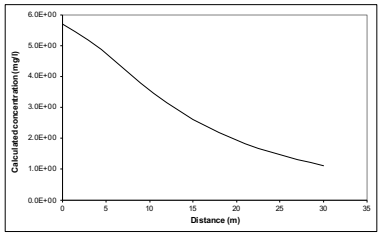
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	5.7E+00
1.5	5.46E+00
3.0	5.19E+00
4.5	4.87E+00
6.0	4.52E+00
7.5	4.15E+00
9.0	3.79E+00
10.5	3.46E+00
12.0	3.15E+00
13.5	2.87E+00
15.0	2.62E+00
16.5	2.39E+00
18.0	2.19E+00
19.5	2.00E+00
21.0	1.84E+00
22.5	1.68E+00
24.0	1.55E+00
25.5	1.42E+00
27.0	1.31E+00
28.5	1.21E+00
30.0	1.12E+00

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aromatic C16-C21			
Target Concentration (C_T)	0.05	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C16-C21**		
Target concentration	**C_T**	**0.05**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	6.95E-04	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	1.41E+04	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.15E+03**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.74E+01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.05	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C16-C21**		from Level 1
Target concentration	C_T	**0.05**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**6.25E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		7.17E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C16-C21		from Level 1
Target Concentration	C_T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4440	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	7.30E+03	days	
Calculated decay rate	λ	9.50E-05	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.15E+03	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	2.46E+03	fraction
Decay rate used	λ	3.86E-08	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	1.03E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.55E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.20E+00**	**fraction**
Calculated soil leachate concentration	Co	3.87E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**1.37E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.58E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.55E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.41E+04	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.15E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

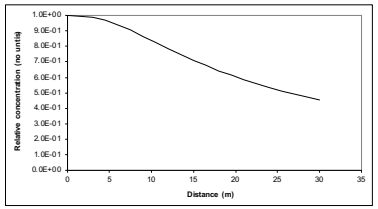
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	3.10E-01
1.5	9.94E-01	3.08E-01
3.0	9.87E-01	3.06E-01
4.5	9.69E-01	3.00E-01
6.0	9.40E-01	2.91E-01
7.5	9.04E-01	2.80E-01
9.0	8.65E-01	2.68E-01
10.5	8.24E-01	2.55E-01
12.0	7.84E-01	2.43E-01
13.5	7.46E-01	2.31E-01
15.0	7.09E-01	2.20E-01
16.5	6.75E-01	2.09E-01
18.0	6.43E-01	1.99E-01
19.5	6.14E-01	1.90E-01
21.0	5.86E-01	1.81E-01
22.5	5.60E-01	1.73E-01
24.0	5.36E-01	1.66E-01
25.5	5.13E-01	1.59E-01
27.0	4.92E-01	1.53E-01
28.5	4.73E-01	1.46E-01
30.0	4.55E-01	1.41E-01

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C16-C21		from Level 1
Target Concentration	C_T	5.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.15E-01	mg/l	WS603
Half life for degradation of contaminant in water	$t_{1/2}$	1.90E+03	days	
Calculated decay rate	λ	3.65E-04	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.15E+03	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	2.34E+03	fraction
Decay rate used	λ	1.56E-07	d^{-1}
Rate of contaminant flow due to retardation	u	9.94E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	2.48E-01	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**3.28E+00**	

Remedial Targets

Remedial Target		**1.64E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**2.48E-01**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.41E+04	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.15E+03	l/kg

Define dispersivity (click brown cell and use pull down list)

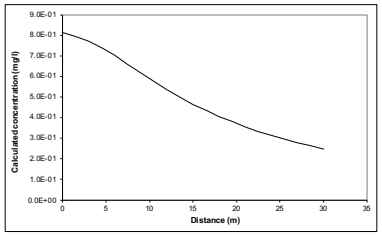
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.2E-01
1.5	7.97E-01
3.0	7.75E-01
4.5	7.44E-01
6.0	7.05E-01
7.5	6.62E-01
9.0	6.19E-01
10.5	5.77E-01
12.0	5.38E-01
13.5	5.01E-01
15.0	4.67E-01
16.5	4.36E-01
18.0	4.07E-01
19.5	3.81E-01
21.0	3.57E-01
22.5	3.35E-01
24.0	3.15E-01
25.5	2.96E-01
27.0	2.79E-01
28.5	2.63E-01
30.0	2.48E-01

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	TPH Aromatic C21-35			
Target Concentration (C_T)	0.05	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

Calculate for non-polar organic chemicals

Contaminant		**TPH Aromatic C21-35**		
Target concentration	**C_T**	**0.05**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	CLEA-SR3
Air filled soil porosity	θa	1.40E-01	fraction	CLEA-SR3
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	CLEA-SR3
Henry's Law constant	H	2.48E-05	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd		l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc	8.12E-02	fraction	Site soil data
Organic carbon partition coefficient	Koc	1.26E+05	l/kg	*LQM-CIEH*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.02E+04**	**l/kg**	*Calculated value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.11E+02**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.05	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**TPH Aromatic C21-35**		from Level 1
Target concentration	**C_T**	**0.05**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% Infiltration - Met Office**	
Area of contaminant source	A	1.00E+03	m^2	**100m x 10m**	Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+02	m	**100m**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**CLEA-SR3**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**site data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**10m**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**1.25E+01**		
Level 2 Remedial Target		**6.25E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		6.39E+03	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C21-35		from Level 1
Target Concentration	C_T	0.05	mg/l	from Level 1
Dilution Factor	DF	1.25E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4560	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	2.12E+03	days	
Calculated decay rate	λ	3.27E-04	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.20E+00	g/cm^3	*CLEA-SR3*
Effective porosity of aquifer	n	5.60E-01	fraction	*CLEA-SR3*
Hydraulic gradient	i	1.09E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+99	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.02E+04	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.52E-02	m/d
Retardation factor	Rf	2.19E+04	fraction
Decay rate used	λ	1.49E-08	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.09E-02	fraction
Rate of contaminant flow due to retardation	u	1.15E-06	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	3.49E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.86E+00**	**fraction**
Calculated soil leachate concentration	Co	4.46E-01	mg/l

Remedial Targets

Level 3 Remedial Target		**1.79E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.83E+04	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**3.49E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.26E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.02E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

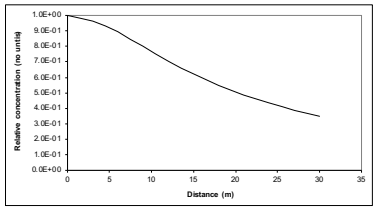
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.57E-02
1.5	9.81E-01	3.50E-02
3.0	9.61E-01	3.43E-02
4.5	9.31E-01	3.32E-02
6.0	8.92E-01	3.18E-02
7.5	8.47E-01	3.02E-02
9.0	7.99E-01	2.85E-02
10.5	7.51E-01	2.68E-02
12.0	7.06E-01	2.52E-02
13.5	6.62E-01	2.36E-02
15.0	6.22E-01	2.22E-02
16.5	5.84E-01	2.09E-02
18.0	5.49E-01	1.96E-02
19.5	5.17E-01	1.85E-02
21.0	4.87E-01	1.74E-02
22.5	4.60E-01	1.64E-02
24.0	4.34E-01	1.55E-02
25.5	4.10E-01	1.46E-02
27.0	3.88E-01	1.39E-02
28.5	3.68E-01	1.31E-02
30.0	3.49E-01	1.25E-02

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

	Variable	Value	Unit	Source
Contaminant		TPH Aromatic C21-35		from Level 1
Target Concentration	C_T	5.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.15E-01	mg/l	WS603
Half life for degradation of contaminant in water	$t_{1/2}$	5.30E+02	days	
Calculated decay rate	λ	1.31E-03	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	1.00E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3-clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3- clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3- clay loam*
Distance to compliance point	x	3.00E+01	m	*distance to Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.02E+04	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters

	Variable		
Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	2.08E+04	fraction
Decay rate used	λ	6.28E-08	d^{-1}
Rate of contaminant flow due to retardation	u	1.12E-06	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{ED}	8.94E-02	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**9.11E+00**	

Remedial Targets

Remedial Target		**4.56E-01**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	**C_{ED}/C_0**	**8.94E-02**	**mg/l**	Ogata Banks
after		**1.0E+100**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

Calculate for non-polar organic chemicals

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd		l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	8.12E-02	fraction
Organic carbon partition coefficient	Koc	1.26E+05	l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.02E+04	l/kg

Define dispersivity (click brown cell and use pull down list)

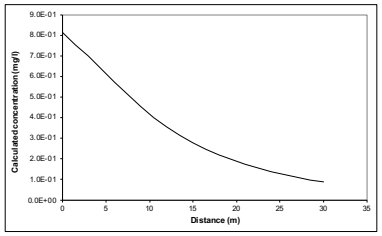
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	8.2E-01
1.5	7.57E-01
3.0	7.00E-01
4.5	6.38E-01
6.0	5.75E-01
7.5	5.13E-01
9.0	4.55E-01
10.5	4.04E-01
12.0	3.57E-01
13.5	3.16E-01
15.0	2.80E-01
16.5	2.49E-01
18.0	2.21E-01
19.5	1.96E-01
21.0	1.75E-01
22.5	1.56E-01
24.0	1.39E-01
25.5	1.24E-01
27.0	1.11E-01
28.5	9.97E-02
30.0	8.94E-02

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	23rd February 2023		Version:	1
Contaminant	Arsenic			
Target Concentration (C_T)	0.01	mg/l	Origin of C_T:	UK DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Arsenic**		
Target concentration	C_T	**0.01**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	5.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Arsenic**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+01	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.07E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**9.56E+01**		
Level 2 Remedial Target		**9.56E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		4.78E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4810	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Calculated soil leachate concentration	Co	9.61E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.09E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

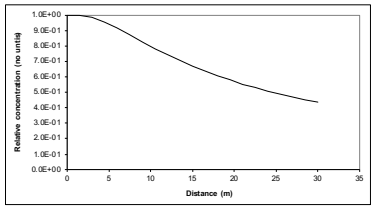
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	1.01E-01
1.5	1.00E+00	1.01E-01
3.0	9.88E-01	9.94E-02
4.5	9.58E-01	9.64E-02
6.0	9.18E-01	9.23E-02
7.5	8.73E-01	8.78E-02
9.0	8.28E-01	8.32E-02
10.5	7.84E-01	7.89E-02
12.0	7.43E-01	7.47E-02
13.5	7.05E-01	7.09E-02
15.0	6.70E-01	6.73E-02
16.5	6.37E-01	6.41E-02
18.0	6.07E-01	6.11E-02
19.5	5.80E-01	5.83E-02
21.0	5.55E-01	5.58E-02
22.5	5.31E-01	5.34E-02
24.0	5.10E-01	5.12E-02
25.5	4.90E-01	4.92E-02
27.0	4.71E-01	4.74E-02
28.5	4.54E-01	4.56E-02
30.0	4.38E-01	4.40E-02

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.0085	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Soil leachate concentration	Co	8.50E-03	

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.09E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

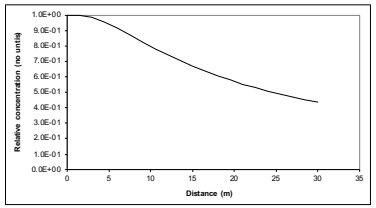
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	8.89E-05
1.5	1.00E+00	8.89E-05
3.0	9.88E-01	8.79E-05
4.5	9.58E-01	8.52E-05
6.0	9.18E-01	8.16E-05
7.5	8.73E-01	7.76E-05
9.0	8.28E-01	7.36E-05
10.5	7.84E-01	6.97E-05
12.0	7.43E-01	6.61E-05
13.5	7.05E-01	6.27E-05
15.0	6.70E-01	5.95E-05
16.5	6.37E-01	5.67E-05
18.0	6.07E-01	5.40E-05
19.5	5.80E-01	5.16E-05
21.0	5.55E-01	4.93E-05
22.5	5.31E-01	4.72E-05
24.0	5.10E-01	4.53E-05
25.5	4.90E-01	4.35E-05
27.0	4.71E-01	4.19E-05
28.5	4.54E-01	4.03E-05
30.0	4.38E-01	3.89E-05

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Manox**			
Site Address:	**Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE**			
Completed by:	**Stephanie Cox**			
Date:	**24-Feb-23**		**Version:**	**1**
Contaminant	**Copper**			
Target Concentration (C_T)	**0.001**	**mg/l**	**Origin of C_T:**	**EQS**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Copper**		
Target concentration	C_T	**0.001**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	1.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.00E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Copper**		from Level 1
Target concentration	C_T	**0.001**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+01	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.07E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**9.56E+01**		
Level 2 Remedial Target		**9.56E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		9.59E+00	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Copper		from Level 1
Target Concentration	C_T	0.001	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		933	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	2.05E+02	fraction
Decay rate used	λ	3.39E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	1.15E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Calculated soil leachate concentration	Co	9.30E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**2.18E-01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.19E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	1.00E+02	l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

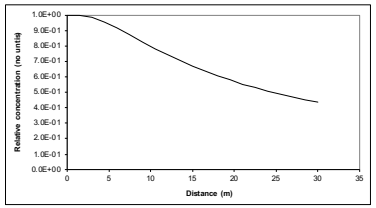
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	9.72E-02
1.5	1.00E+00	9.72E-02
3.0	9.88E-01	9.61E-02
4.5	9.58E-01	9.32E-02
6.0	9.18E-01	8.92E-02
7.5	8.73E-01	8.49E-02
9.0	8.28E-01	8.05E-02
10.5	7.84E-01	7.62E-02
12.0	7.43E-01	7.23E-02
13.5	7.05E-01	6.86E-02
15.0	6.70E-01	6.51E-02
16.5	6.37E-01	6.20E-02
18.0	6.07E-01	5.91E-02
19.5	5.80E-01	5.64E-02
21.0	5.55E-01	5.39E-02
22.5	5.31E-01	5.17E-02
24.0	5.10E-01	4.96E-02
25.5	4.90E-01	4.76E-02
27.0	4.71E-01	4.58E-02
28.5	4.54E-01	4.41E-02
30.0	4.38E-01	4.26E-02

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Copper		from Level 1
Target Concentration	C_T	0.001	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.0071	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	2.05E+02	fraction
Decay rate used	λ	3.39E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	1.15E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Soil leachate concentration	Co	7.10E-03	

Remedial Targets

Level 3 Remedial Target		**2.18E-01**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.19E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 1.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 1.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

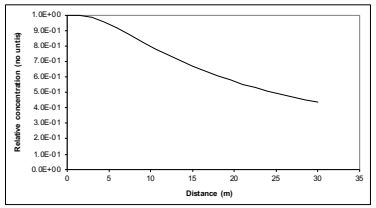
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	7.43E-05
1.5	1.00E+00	7.43E-05
3.0	9.88E-01	7.34E-05
4.5	9.58E-01	7.12E-05
6.0	9.18E-01	6.82E-05
7.5	8.73E-01	6.48E-05
9.0	8.28E-01	6.15E-05
10.5	7.84E-01	5.82E-05
12.0	7.43E-01	5.52E-05
13.5	7.05E-01	5.24E-05
15.0	6.70E-01	4.97E-05
16.5	6.37E-01	4.73E-05
18.0	6.07E-01	4.51E-05
19.5	5.80E-01	4.31E-05
21.0	5.55E-01	4.12E-05
22.5	5.31E-01	3.95E-05
24.0	5.10E-01	3.78E-05
25.5	4.90E-01	3.64E-05
27.0	4.71E-01	3.50E-05
28.5	4.54E-01	3.37E-05
30.0	4.38E-01	3.25E-05

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Manox**			
Site Address:	**Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE**			
Completed by:	**Stephanie Cox**			
Date:	**24th February 2023**		**Version:**	**1**
Contaminant	**Cyanide**			
Target Concentration (C_T)	**0.01**	**mg/l**	**Origin of C_T:**	**UK DWS**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Cyanide**		
Target concentration	C_T	**0.01**	**mg/l**	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	1.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Cyanide**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+01	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.07E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**9.56E+01**		
Level 2 Remedial Target		**9.56E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		9.59E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Cyanide		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		8270	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Calculated soil leachate concentration	Co	8.24E+01	mg/l

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.19E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

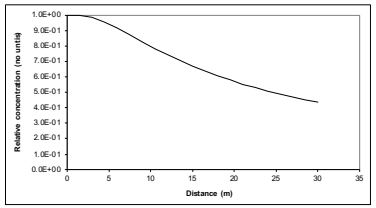
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	8.62E-01
1.5	1.00E+00	8.62E-01
3.0	9.88E-01	8.52E-01
4.5	9.58E-01	8.26E-01
6.0	9.18E-01	7.91E-01
7.5	8.73E-01	7.52E-01
9.0	8.28E-01	7.13E-01
10.5	7.84E-01	6.76E-01
12.0	7.43E-01	6.41E-01
13.5	7.05E-01	6.08E-01
15.0	6.70E-01	5.77E-01
16.5	6.37E-01	5.49E-01
18.0	6.07E-01	5.24E-01
19.5	5.80E-01	5.00E-01
21.0	5.55E-01	4.78E-01
22.5	5.31E-01	4.58E-01
24.0	5.10E-01	4.39E-01
25.5	4.90E-01	4.22E-01
27.0	4.71E-01	4.06E-01
28.5	4.54E-01	3.91E-01
30.0	4.38E-01	3.77E-01

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Cyanide		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.34	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Soil leachate concentration	Co	3.40E-01	

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.19E+02	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

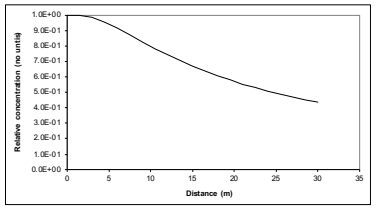
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	3.56E-03
1.5	1.00E+00	3.56E-03
3.0	9.88E-01	3.51E-03
4.5	9.58E-01	3.41E-03
6.0	9.18E-01	3.26E-03
7.5	8.73E-01	3.10E-03
9.0	8.28E-01	2.94E-03
10.5	7.84E-01	2.79E-03
12.0	7.43E-01	2.64E-03
13.5	7.05E-01	2.51E-03
15.0	6.70E-01	2.38E-03
16.5	6.37E-01	2.27E-03
18.0	6.07E-01	2.16E-03
19.5	5.80E-01	2.06E-03
21.0	5.55E-01	1.97E-03
22.5	5.31E-01	1.89E-03
24.0	5.10E-01	1.81E-03
25.5	4.90E-01	1.74E-03
27.0	4.71E-01	1.68E-03
28.5	4.54E-01	1.61E-03
30.0	4.38E-01	1.56E-03

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Feb-23		Version:	1
Contaminant	Lead			
Target Concentration (C_T)	0.01	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Lead**		
Target concentration	C_T	**0.01**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	5.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Lead**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	1.00E+01	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	1.00E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.07E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**9.56E+01**		
Level 2 Remedial Target		**9.56E-01**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		4.78E+02	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Lead		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		6690]	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Calculated soil leachate concentration	Co	#VALUE!	mg/l

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.09E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

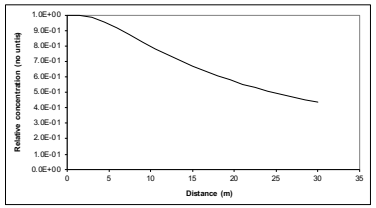
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	#VALUE!
1.5	1.00E+00	#VALUE!
3.0	9.88E-01	#VALUE!
4.5	9.58E-01	#VALUE!
6.0	9.18E-01	#VALUE!
7.5	8.73E-01	#VALUE!
9.0	8.28E-01	#VALUE!
10.5	7.84E-01	#VALUE!
12.0	7.43E-01	#VALUE!
13.5	7.05E-01	#VALUE!
15.0	6.70E-01	#VALUE!
16.5	6.37E-01	#VALUE!
18.0	6.07E-01	#VALUE!
19.5	5.80E-01	#VALUE!
21.0	5.55E-01	#VALUE!
22.5	5.31E-01	#VALUE!
24.0	5.10E-01	#VALUE!
25.5	4.90E-01	#VALUE!
27.0	4.71E-01	#VALUE!
28.5	4.54E-01	#VALUE!
30.0	4.38E-01	#VALUE!

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Lead		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	9.56E+01		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.01	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	1.00E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.07E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.01E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	2.35E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.01E-02	fraction
Rate of contaminant flow due to retardation	u	2.30E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	4.38E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**2.29E+00**	**fraction**
Soil leachate concentration	Co	1.00E-02	

Remedial Targets

Level 3 Remedial Target		**2.18E+00**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		1.09E+03	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**4.38E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

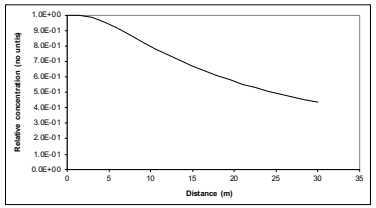
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.05E-04
1.5	1.00E+00	1.05E-04
3.0	9.88E-01	1.03E-04
4.5	9.58E-01	1.00E-04
6.0	9.18E-01	9.60E-05
7.5	8.73E-01	9.13E-05
9.0	8.28E-01	8.66E-05
10.5	7.84E-01	8.20E-05
12.0	7.43E-01	7.77E-05
13.5	7.05E-01	7.37E-05
15.0	6.70E-01	7.01E-05
16.5	6.37E-01	6.67E-05
18.0	6.07E-01	6.35E-05
19.5	5.80E-01	6.07E-05
21.0	5.55E-01	5.80E-05
22.5	5.31E-01	5.56E-05
24.0	5.10E-01	5.33E-05
25.5	4.90E-01	5.12E-05
27.0	4.71E-01	4.93E-05
28.5	4.54E-01	4.75E-05
30.0	4.38E-01	4.58E-05

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment

Site Name:	**Manox**			
Site Address:	**Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE**			
Completed by:	**Stephanie Cox**			
Date:	**23rd February 2023**		**Version:**	**1**
Contaminant	**Arsenic**			
Target Concentration (C_T)	**0.01**	**mg/l**	**Origin of C_T:**	**UK DWS**

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Arsenic**		
Target concentration	C_T	**0.01**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	5.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Arsenic**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.12E+02	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	8.60E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**3.79E+00**		
Level 2 Remedial Target		**3.79E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.90E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		4810	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	3.09E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Calculated soil leachate concentration	Co	9.61E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**5.68E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.84E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E+02	l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

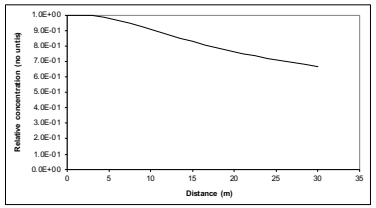
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.54E+00
1.5	1.00E+00	2.54E+00
3.0	9.98E-01	2.53E+00
4.5	9.88E-01	2.50E+00
6.0	9.70E-01	2.46E+00
7.5	9.47E-01	2.40E+00
9.0	9.23E-01	2.34E+00
10.5	8.99E-01	2.28E+00
12.0	8.74E-01	2.22E+00
13.5	8.51E-01	2.16E+00
15.0	8.29E-01	2.10E+00
16.5	8.09E-01	2.05E+00
18.0	7.89E-01	2.00E+00
19.5	7.71E-01	1.95E+00
21.0	7.53E-01	1.91E+00
22.5	7.37E-01	1.87E+00
24.0	7.21E-01	1.83E+00
25.5	7.07E-01	1.79E+00
27.0	6.93E-01	1.76E+00
28.5	6.80E-01	1.72E+00
30.0	6.67E-01	1.69E+00

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Arsenic		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.0085	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	3.09E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Soil leachate concentration	Co	8.50E-03	

Remedial Targets

Level 3 Remedial Target		**5.68E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.84E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

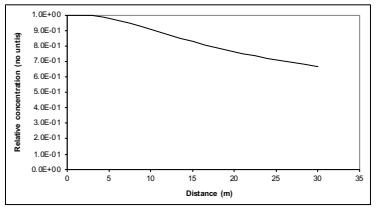
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	23rd February 2023
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.24E-03
1.5	1.00E+00	2.24E-03
3.0	9.98E-01	2.24E-03
4.5	9.88E-01	2.21E-03
6.0	9.70E-01	2.17E-03
7.5	9.47E-01	2.12E-03
9.0	9.23E-01	2.07E-03
10.5	8.99E-01	2.01E-03
12.0	8.74E-01	1.96E-03
13.5	8.51E-01	1.91E-03
15.0	8.29E-01	1.86E-03
16.5	8.09E-01	1.81E-03
18.0	7.89E-01	1.77E-03
19.5	7.71E-01	1.73E-03
21.0	7.53E-01	1.69E-03
22.5	7.37E-01	1.65E-03
24.0	7.21E-01	1.62E-03
25.5	7.07E-01	1.58E-03
27.0	6.93E-01	1.55E-03
28.5	6.80E-01	1.52E-03
30.0	6.67E-01	1.50E-03

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Feb-23		Version:	1
Contaminant	Copper			
Target Concentration (C_T)	0.001	mg/l	Origin of C_T:	EQS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		Copper		
Target concentration	C_T	0.001	mg/l	
Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	1.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.00E-01**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.001	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Copper**		from Level 1
Target concentration	C_T	**0.001**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.12E+02	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	8.60E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**3.79E+00**		
Level 2 Remedial Target		**3.79E-03**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		3.80E-01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Feb-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Input Parameters	Variable	Value	Unit	Source
Contaminant		Copper		from Level 1
Target Concentration	C_T	0.001	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		933	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	2.05E+02	fraction
Decay rate used	λ	3.39E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	1.54E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Calculated soil leachate concentration	Co	9.30E+00	mg/l

Remedial Targets

Level 3 Remedial Target		**5.68E-03**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		5.70E-01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 1.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 1.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

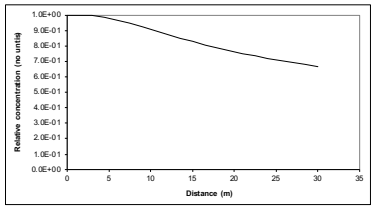
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.45E+00
1.5	1.00E+00	2.45E+00
3.0	9.98E-01	2.45E+00
4.5	9.88E-01	2.42E+00
6.0	9.70E-01	2.38E+00
7.5	9.47E-01	2.32E+00
9.0	9.23E-01	2.26E+00
10.5	8.99E-01	2.20E+00
12.0	8.74E-01	2.14E+00
13.5	8.51E-01	2.09E+00
15.0	8.29E-01	2.03E+00
16.5	8.09E-01	1.98E+00
18.0	7.89E-01	1.94E+00
19.5	7.71E-01	1.89E+00
21.0	7.53E-01	1.85E+00
22.5	7.37E-01	1.81E+00
24.0	7.21E-01	1.77E+00
25.5	7.07E-01	1.73E+00
27.0	6.93E-01	1.70E+00
28.5	6.80E-01	1.67E+00
30.0	6.67E-01	1.64E+00

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Copper		from Level 1
Target Concentration	C_T	0.001	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.0071	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	2.05E+02	fraction
Decay rate used	λ	3.39E-103	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	1.54E-04	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Soil leachate concentration	Co	7.10E-03	

Remedial Targets

Level 3 Remedial Target		**5.68E-03**	**mg/l**
Ogata Banks		**or**	
		5.70E-01	**mg/kg**
Distance to compliance point		**30**	**m**
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0**	**6.67E-01**	**fraction**

For comparison with measured pore water concentration.
This assumes Level 1 Remedial Target is based on Target Concentration.
For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 1.00E+02 — l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 1.00E+02 — l/kg

Define dispersivity (click brown cell and use pull down list)

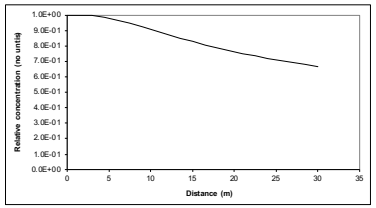
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	1.87E-03
1.5	1.00E+00	1.87E-03
3.0	9.98E-01	1.87E-03
4.5	9.88E-01	1.85E-03
6.0	9.70E-01	1.82E-03
7.5	9.47E-01	1.77E-03
9.0	9.23E-01	1.73E-03
10.5	8.99E-01	1.68E-03
12.0	8.74E-01	1.64E-03
13.5	8.51E-01	1.59E-03
15.0	8.29E-01	1.55E-03
16.5	8.09E-01	1.51E-03
18.0	7.89E-01	1.48E-03
19.5	7.71E-01	1.44E-03
21.0	7.53E-01	1.41E-03
22.5	7.37E-01	1.38E-03
24.0	7.21E-01	1.35E-03
25.5	7.07E-01	1.32E-03
27.0	6.93E-01	1.30E-03
28.5	6.80E-01	1.27E-03
30.0	6.67E-01	1.25E-03

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24th February 2023		Version:	1
Contaminant	Cyanide			
Target Concentration (C_T)	0.01	mg/l	Origin of C_T:	UK DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Cyanide**		
Target concentration	C_T	**0.01**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	1.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**1.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**1.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Cyanide**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.12E+02	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	8.60E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**3.79E+00**		
Level 2 Remedial Target		**3.79E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		3.80E+00	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Cyanide		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		8270	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	3.09E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Calculated soil leachate concentration	Co	8.24E+01	mg/l

Remedial Targets

Level 3 Remedial Target		**5.68E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		5.70E+00	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient	Kd	5.00E+02	l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
Acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	5.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

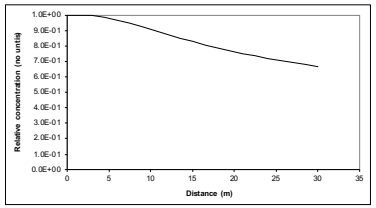
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration	Concentration
	(No units)	mg/l
0	1.0E+00	2.17E+01
1.5	1.00E+00	2.17E+01
3.0	9.98E-01	2.17E+01
4.5	9.88E-01	2.15E+01
6.0	9.70E-01	2.11E+01
7.5	9.47E-01	2.06E+01
9.0	9.23E-01	2.01E+01
10.5	8.99E-01	1.95E+01
12.0	8.74E-01	1.90E+01
13.5	8.51E-01	1.85E+01
15.0	8.29E-01	1.80E+01
16.5	8.09E-01	1.76E+01
18.0	7.89E-01	1.72E+01
19.5	7.71E-01	1.68E+01
21.0	7.53E-01	1.64E+01
22.5	7.37E-01	1.60E+01
24.0	7.21E-01	1.57E+01
25.5	7.07E-01	1.54E+01
27.0	6.93E-01	1.51E+01
28.5	6.80E-01	1.48E+01
30.0	6.67E-01	1.45E+01

Remedial Targets Worksheet , Release 3.2

Calculation of contaminant concentration in groundwater from a soil source

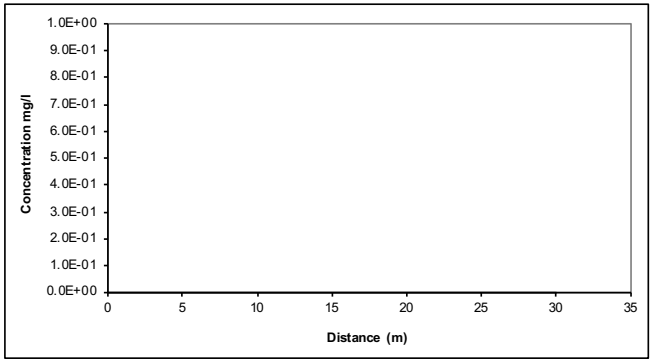
Only input required is Soil Contaminant Concentration

	Input Parameters			
	Soil contaminant concentration	C_0	0.00E+00	mg/kg
Level 1 Parameters				
	Water filled soil porosity	θ_W	4.20E-01	fraction
	Air filled soil porosity	θa	1.40E-01	fraction
	Bulk density	ρ	1.14E+00	g/cm^3
	Henry's Law constant	H	0.00E+00	dimensionless
	Soil water partition coefficient used in Level Assessment	Kd	1.00E+02	l/kg
	Factor (partitioning between soil and water)		1.00E+02	dimensionless
Level 2 Parameters	**Dilution Factor**	DF	3.79E+00	
Level 3 Parameters	**Attenuation factor (C_O/C_{ED})**	AF	1.50E+00	

Predicted concentrations at compliance point

Level 1	C	0.00E+00	mg/l	No dilution or attenuation
Level 2	C	0.00E+00	mg/l	Dilution taken into account
Level 3	C	0.00E+00	mg/l	Dilution and attenuation taken into account

Predicted concentrations between source and compliance point - Level 3



Distance m	Concentration mg/l
0.00	0.00E+00
1.50	0.00E+00
3.00	0.00E+00
4.50	0.00E+00
6.00	0.00E+00
7.50	0.00E+00
9.00	0.00E+00
10.50	0.00E+00
12.00	0.00E+00
13.50	0.00E+00
15.00	0.00E+00
16.50	0.00E+00
18.00	0.00E+00
19.50	0.00E+00
21.00	0.00E+00
22.50	0.00E+00
24.00	0.00E+00
25.50	0.00E+00
27.00	0.00E+00
28.50	0.00E+00
30.00	0.00E+00

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu) | Variable | Value | Unit | Source

Contaminant		Cyanide		from Level 1
Target Concentration	C_T	1.00E-02	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 1 direction

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to dissolved pollutants only

				Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	1.40E+01	mg/l	*TP706*
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+100	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-102	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	8.60E+01	m	*estimate based on site data*
Plume thickness at source	Sy	1.20E+00	m	*from level 2*
Saturated aquifer thickness	da	1.30E+00	m	*based on borehole data*
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.00E-02	fraction	*site data*
Hydraulic conductivity of aquifer	K	1.30E+00	m/d	*SR3 clay loam*
Distance to compliance point	x	3.00E+01	m	*Hypothetical monitoring point downstream*
Distance (lateral) to compliance point perpendicular to flow direction	z	0.00E+00	m	
Distance (depth) to compliance point perpendicular to flow direction	y	0.00E+00	m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	1.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.00E+00	m	*see options*
Transverse dispersivity	az	3.00E-01	m	*see options*
Vertical dispersivity	ay	3.00E-02	m	*see options*

Calculated Parameters | Variable

Groundwater flow velocity	v	2.32E-02	m/d
Retardation factor	Rf	2.05E+02	fraction
Decay rate used	λ	3.39E-104	d^{-1}
Rate of contaminant flow due to retardation	u	1.13E-04	m/d
Contaminant concentration at distance x, assuming one-way vertical dispersion	C_{CED}	8.80E+00	mg/l
Attenuation factor (one way vertical dispersion, CO/CED)	**AF**	**1.59E+00**	

Remedial Targets

Remedial Target		**1.59E-02**	**mg/l**	For comparison with measured groundwater concentration.
Ogata Banks				
Distance to compliance point		**30**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**8.80E+00**	**mg/l**	Ogata Banks
after		**1.0E+101**	**days**	

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	1.00E+02	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$		l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	1.00E+02	l/kg

Define dispersivity (click brown cell and use pull down list)

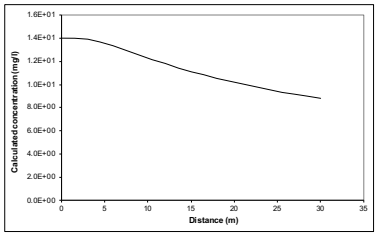
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}(x))^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Calculated concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Concentration
	mg/l
0	1.4E+01
1.5	1.40E+01
3.0	1.39E+01
4.5	1.37E+01
6.0	1.34E+01
7.5	1.30E+01
9.0	1.26E+01
10.5	1.22E+01
12.0	1.18E+01
13.5	1.14E+01
15.0	1.11E+01
16.5	1.08E+01
18.0	1.05E+01
19.5	1.03E+01
21.0	1.00E+01
22.5	9.78E+00
24.0	9.56E+00
25.5	9.35E+00
27.0	9.16E+00
28.5	8.98E+00
30.0	8.80E+00

Porosity Calculator

These results are not carried through to any of the other worksheets

DRY BULK DENSITY DATA

Variable	Value	Unit	justification
Natural Moisture Content	0.00	% wt	
Particle Density	2.78	tonnes/m^3	(Change this number only if you have specific information)
Dry Bulk Density	0.00	tonnes/m^3	
Calculated Parameters			
Voids Ratio	#DIV/0!	fraction	
Initial Saturation	#DIV/0!	%	
Total porosity	**1.000**	**fraction**	
Air Filled Porosity	**#DIV/0!**	**fraction**	
Water Filled Porosity	**#DIV/0!**	**fraction**	

WET BULK DENSITY DATA

Variable	Value	Unit	
Moisture Content	0.00	% wt	
Particle Density	2.78	tonnes/m^3	(Change this number only if you have specific information)
Actual (wet) Bulk Density (i.e. at natural MC)	0.00	tonnes/m^3	
Calculated Parameters			
Voids Ratio	#DIV/0!	fraction	
dry bulk density	0.00	tonnes/m^3	
Initial Saturation	#DIV/0!	%	
Total porosity	**1.000**	**fraction**	**#DIV/0!**
Air Filled Porosity	**#DIV/0!**	**fraction**	
Water Filled Porosity	**#DIV/0!**	**fraction**	

Analytical solutions provided by David Hall, Golder Associates (UK) Ltd

Simple hydrogeological calculations

(These are not specific to, or required in, the Remedial Targets Methodology)

Parameter	symbol		unit	justification
Hydraulic conductivity	K	0.00E+00	m/d	
Hydraulic gradient	i	0.00E+00	unitless	
Effective porosity of aquifer	n	0.00E+00	fraction	
Thickness of saturated aquifer	b	0.00E+00	m	
Width of aquifer perpendicular to flow	w	0.00E+00	m	
Distance to receptor	x	0.00E+00	m	
Bulk density of aquifer materials	ρ	0.00E+00	g/cm^3	
Soil-water partition co-efficient	Kd	0.00E+00	l/kg	
Retardation factor of pollutant	R	#DIV/0!		

Groundwater flow velocity	v(GW)	#DIV/0!	m/s	#DIV/0!	m/day	#DIV/0!	m/year
Time for groundwater to reach receptor	t(GW)	#DIV/0!	seconds	#DIV/0!	days	#DIV/0!	years
Rate of groundwater flow through aquifer	Q	0.00E+00	m^3/s	0.00E+00	m^3/day	0.00E+00	m^3/year

Contaminant flow velocity	v(contam)	#DIV/0!	m/s	#DIV/0!	m/day	#DIV/0!	m/year
Time for contaminant to reach receptor	t(contam)	#DIV/0!	seconds	#DIV/0!	days	#DIV/0!	years

Level 1 Calculation Sheet

Contaminant **Cyanide**

Parameter	Value	Units
(carried over from input sheet)		
C_T	1.00E-02	mg/l
Kd	1.00E+02	l/kg
foc		fraction
koc		l/kg
θ_w	4.20E-01	fraction
θa	1.40E-01	fraction
ρ	1.14E+00	g/cm3
H	0.00E+00	dimensionless
Koc,n		l/kg
Koc,i		l/kg
pH		pH units
pKa		
foc (ionic)		fraction

Calculations (Refer toTable 4.3, R&D Publication 20)

Selected option User specified value for partition coefficient

	calc	calc	Calc Kd	l/kg
Calculation of partition coefficient for ionic organic chemical				
Partition coefficient used in Level 1 Assessment			1.00E+02	l/kg

Calculated Remedial Target **1.00E+00 mg/kg** **for Cyanide**

Factor (partitioning between soil and water) 1.00E+02

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24th February 2023
Version:	1

Level 2 Calculation Sheet

Contaminant **Cyanide**

Site assessed:
Date:
Version:

Parameter	Value	Units		
(carried over from input sheet)				
Mz	1.30E+00	m		
L	4.12E+02	m		
da	1.30E+00	m		Calculated
Inf	1.47E-05	m/d		Dilution Factor
K	1.30E+00	m/d		
i	1.00E-02		Calculation based on target concentration	3.79E+00
		m3/d		
A	0.00E+00	m2	Calculation based on observed contaminant concentration	#DIV/0!
		m3/d		
Cc	0.00E+00	mg/l		
C_T	1.00E-02	mg/l		
Cu	0.00E+00	mg/l		
w	8.60E+01	m		

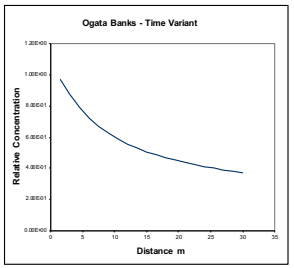
Manox	
24th February 2023	
1	

OGATA BANKS SOLUTION

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	1.000E-02	mg/l
DF	3.790E+00	
λ	6.810E-104	$days^{-1}$
Sz	8.600E+01	m
Sy	1.300E+00	m
Kd	5.000E+02	l/kg
ρ	1.140E+00	g/cm3
n	5.600E-01	
i	1.358E-02	
K	1.300E+00	m/d
x	3.000E+01	m
z	0.000E+00	m
y	0.000E+00	m
t	9.990E+100	days
ax	3.000E+00	m
az	3.000E-01	m
ay	3.000E-02	m

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

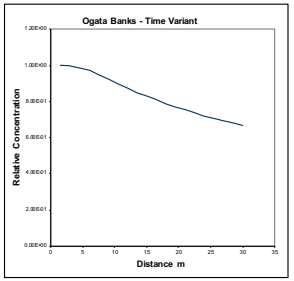
	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4	EXP	Term 5	ERFC	Term 6a	ERF	Term 6b	ERF	Term 7a	ERF	Term 7b	ERF	Relative Concentration
1	1.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.00E-01	1.65E+00	5.08E+47	0	3.21E+01	1	-3.21E+01	-1	1.53E+00	0.96974	-1.53E+00	-0.96974	9.70E-01
2	3	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.00E+00	2.72E+00	5.08E+47	0	2.27E+01	1	-2.27E+01	-1	1.08E+00	0.87449	-1.08E+00	-0.87449	8.74E-01
3	4.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.50E+00	4.48E+00	5.08E+47	0	1.85E+01	1	-1.85E+01	-1	8.85E-01	0.78904	-8.85E-01	-0.78904	7.89E-01
4	6	0.13	0.00E+00	1.00E+00	-5.08E+47	2	2.00E+00	7.39E+00	5.08E+47	0	1.60E+01	1	-1.60E+01	-1	7.66E-01	0.72134	-7.66E-01	-0.72134	7.21E-01
5	7.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	2.50E+00	1.22E+01	5.08E+47	0	1.43E+01	1	-1.43E+01	-1	6.85E-01	0.66744	-6.85E-01	-0.66744	6.67E-01
6	9	0.13	0.00E+00	1.00E+00	-5.08E+47	2	3.00E+00	2.01E+01	5.08E+47	0	1.31E+01	1	-1.31E+01	-1	6.25E-01	0.62359	-6.25E-01	-0.62359	6.24E-01
7	10.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	3.50E+00	3.31E+01	5.08E+47	0	1.21E+01	1	-1.21E+01	-1	5.79E-01	0.58717	-5.79E-01	-0.58717	5.87E-01
8	12	0.13	0.00E+00	1.00E+00	-5.08E+47	2	4.00E+00	5.46E+01	5.08E+47	0	1.13E+01	1	-1.13E+01	-1	5.42E-01	0.55634	-5.42E-01	-0.55634	5.56E-01
9	13.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	4.50E+00	9.00E+01	5.08E+47	0	1.07E+01	1	-1.07E+01	-1	5.11E-01	0.52984	-5.11E-01	-0.52984	5.30E-01
10	15	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.00E+00	1.48E+02	5.08E+47	0	1.01E+01	1	-1.01E+01	-1	4.84E-01	0.50676	-4.84E-01	-0.50676	5.07E-01
11	16.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.50E+00	2.45E+02	5.08E+47	0	9.66E+00	1	-9.66E+00	-1	4.62E-01	0.48642	-4.62E-01	-0.48642	4.86E-01
12	18	0.13	0.00E+00	1.00E+00	-5.08E+47	2	6.00E+00	4.03E+02	5.08E+47	0	9.25E+00	1	-9.25E+00	-1	4.42E-01	0.46833	-4.42E-01	-0.46833	4.68E-01
13	19.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	6.50E+00	6.65E+02	5.08E+47	0	8.89E+00	1	-8.89E+00	-1	4.25E-01	0.45211	-4.25E-01	-0.45211	4.52E-01
14	21	0.13	0.00E+00	1.00E+00	-5.08E+47	2	7.00E+00	1.10E+03	5.08E+47	0	8.57E+00	1	-8.57E+00	-1	4.09E-01	0.43746	-4.09E-01	-0.43746	4.37E-01
15	22.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	7.50E+00	1.81E+03	5.08E+47	0	8.28E+00	1	-8.28E+00	-1	3.96E-01	0.42413	-3.96E-01	-0.42413	4.24E-01
16	24	0.13	0.00E+00	1.00E+00	-5.08E+47	2	8.00E+00	2.98E+03	5.08E+47	0	8.01E+00	1	-8.01E+00	-1	3.83E-01	0.41195	-3.83E-01	-0.41195	4.12E-01
17	25.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	8.50E+00	4.91E+03	5.08E+47	0	7.77E+00	1	-7.77E+00	-1	3.72E-01	0.40076	-3.72E-01	-0.40076	4.01E-01
18	27	0.13	0.00E+00	1.00E+00	-5.08E+47	2	9.00E+00	8.10E+03	5.08E+47	0	7.55E+00	1	-7.55E+00	-1	3.61E-01	0.39043	-3.61E-01	-0.39043	3.90E-01
19	28.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	9.50E+00	1.34E+04	5.08E+47	0	7.35E+00	1	-7.35E+00	-1	3.51E-01	0.38086	-3.51E-01	-0.38086	3.81E-01
20	30	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.00E+01	2.20E+04	5.08E+47	0	7.17E+00	1	-7.17E+00	-1	3.43E-01	0.37196	-3.43E-01	-0.37196	3.72E-01



Calc	Value	
v	0.0315	m/d
Rc	1018.8571	
u	0.0000	m/d

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) -USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4	EXP	Term 5	ERFC	Term 6a	ERF	Term 6b	ERF	Term 7a	ERF	Term 7b	ERF	Relative Concentration
1	1.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.00E-01	1.65E+00	5.08E+47	0	3.21E+01	1	-3.21E+01	-1	3.06E+00	0.99999	-3.06E+00	-0.99999	1.00E+00
2	3	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.00E+00	2.72E+00	5.08E+47	0	2.27E+01	1	-2.27E+01	-1	2.17E+00	0.99782	-2.17E+00	-0.99782	9.98E-01
3	4.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.50E+00	4.48E+00	5.08E+47	0	1.85E+01	1	-1.85E+01	-1	1.77E+00	0.98765	-1.77E+00	-0.98765	9.88E-01
4	6	0.13	0.00E+00	1.00E+00	-5.08E+47	2	2.00E+00	7.39E+00	5.08E+47	0	1.60E+01	1	-1.60E+01	-1	1.53E+00	0.96974	-1.53E+00	-0.96974	9.70E-01
5	7.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	2.50E+00	1.22E+01	5.08E+47	0	1.43E+01	1	-1.43E+01	-1	1.37E+00	0.94737	-1.37E+00	-0.94737	9.47E-01
6	9	0.13	0.00E+00	1.00E+00	-5.08E+47	2	3.00E+00	2.01E+01	5.08E+47	0	1.31E+01	1	-1.31E+01	-1	1.25E+00	0.92312	-1.25E+00	-0.92312	9.23E-01
7	10.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	3.50E+00	3.31E+01	5.08E+47	0	1.21E+01	1	-1.21E+01	-1	1.16E+00	0.89855	-1.16E+00	-0.89855	8.99E-01
8	12	0.13	0.00E+00	1.00E+00	-5.08E+47	2	4.00E+00	5.46E+01	5.08E+47	0	1.13E+01	1	-1.13E+01	-1	1.08E+00	0.87449	-1.08E+00	-0.87449	8.74E-01
9	13.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	4.50E+00	9.00E+01	5.08E+47	0	1.07E+01	1	-1.07E+01	-1	1.02E+00	0.85139	-1.02E+00	-0.85139	8.51E-01
10	15	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.00E+00	1.48E+02	5.08E+47	0	1.01E+01	1	-1.01E+01	-1	9.69E-01	0.82941	-9.69E-01	-0.82941	8.29E-01
11	16.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	5.50E+00	2.45E+02	5.08E+47	0	9.66E+00	1	-9.66E+00	-1	9.24E-01	0.80863	-9.24E-01	-0.80863	8.09E-01
12	18	0.13	0.00E+00	1.00E+00	-5.08E+47	2	6.00E+00	4.03E+02	5.08E+47	0	9.25E+00	1	-9.25E+00	-1	8.85E-01	0.78904	-8.85E-01	-0.78904	7.89E-01
13	19.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	6.50E+00	6.65E+02	5.08E+47	0	8.89E+00	1	-8.89E+00	-1	8.50E-01	0.77058	-8.50E-01	-0.77058	7.71E-01
14	21	0.13	0.00E+00	1.00E+00	-5.08E+47	2	7.00E+00	1.10E+03	5.08E+47	0	8.57E+00	1	-8.57E+00	-1	8.19E-01	0.75319	-8.19E-01	-0.75319	7.53E-01
15	22.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	7.50E+00	1.81E+03	5.08E+47	0	8.28E+00	1	-8.28E+00	-1	7.91E-01	0.7368	-7.91E-01	-0.7368	7.37E-01
16	24	0.13	0.00E+00	1.00E+00	-5.08E+47	2	8.00E+00	2.98E+03	5.08E+47	0	8.01E+00	1	-8.01E+00	-1	7.66E-01	0.72134	-7.66E-01	-0.72134	7.21E-01
17	25.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	8.50E+00	4.91E+03	5.08E+47	0	7.77E+00	1	-7.77E+00	-1	7.43E-01	0.70674	-7.43E-01	-0.70674	7.07E-01
18	27	0.13	0.00E+00	1.00E+00	-5.08E+47	2	9.00E+00	8.10E+03	5.08E+47	0	7.55E+00	1	-7.55E+00	-1	7.22E-01	0.69292	-7.22E-01	-0.69292	6.93E-01
19	28.5	0.13	0.00E+00	1.00E+00	-5.08E+47	2	9.50E+00	1.34E+04	5.08E+47	0	7.35E+00	1	-7.35E+00	-1	7.03E-01	0.67984	-7.03E-01	-0.67984	6.80E-01
20	30	0.13	0.00E+00	1.00E+00	-5.08E+47	2	1.00E+01	2.20E+04	5.08E+47	0	7.17E+00	1	-7.17E+00	-1	6.85E-01	0.66744	-6.85E-01	-0.66744	6.67E-01



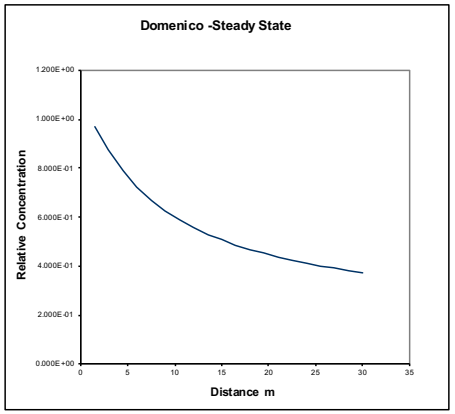
Date:	24th February 2023
Version:	1

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	1.000E-02	mg/l
DF	3.790E+00	
λ	6.810E-104	$days^{-1}$
Sz	8.600E+01	m
Sy	1.300E+00	m
Kd	5.000E+02	l/kg
ρ	1.140E+00	g/cm3
n	5.600E-01	
i	1.358E-02	
K	1.300E+00	m/d
x	3.000E+01	m
z	0.000E+00	m
y	0.000E+00	m
ax	3.000E+00	m
az	3.000E-01	m
ay	3.000E-02	m

DOMENICO (STEADY STATE)

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

	X	Term 1	Term 2	EXP	Term 3A	ERF	Term 3B	ERF	Term 4A	ERF	Term 4B	ERF	Relative Concentration
1	1.5	0.25	0.00E+00	1.00E+00	3.21E+01	1	-3.21E+01	-1	1.53E+00	0.97	-1.53E+00	-0.9697	9.697E-01
2	3	0.25	0.00E+00	1.00E+00	2.27E+01	1	-2.27E+01	-1	1.08E+00	0.874	-1.08E+00	-0.8745	8.745E-01
3	4.5	0.25	0.00E+00	1.00E+00	1.85E+01	1	-1.85E+01	-1	8.85E-01	0.789	-8.85E-01	-0.789	7.890E-01
4	6	0.25	0.00E+00	1.00E+00	1.60E+01	1	-1.60E+01	-1	7.66E-01	0.721	-7.66E-01	-0.7213	7.213E-01
5	7.5	0.25	0.00E+00	1.00E+00	1.43E+01	1	-1.43E+01	-1	6.85E-01	0.667	-6.85E-01	-0.6674	6.674E-01
6	9	0.25	0.00E+00	1.00E+00	1.31E+01	1	-1.31E+01	-1	6.25E-01	0.624	-6.25E-01	-0.6236	6.236E-01
7	10.5	0.25	0.00E+00	1.00E+00	1.21E+01	1	-1.21E+01	-1	5.79E-01	0.587	-5.79E-01	-0.5872	5.872E-01
8	12	0.25	0.00E+00	1.00E+00	1.13E+01	1	-1.13E+01	-1	5.42E-01	0.556	-5.42E-01	-0.5563	5.563E-01
9	13.5	0.25	0.00E+00	1.00E+00	1.07E+01	1	-1.07E+01	-1	5.11E-01	0.53	-5.11E-01	-0.5298	5.298E-01
10	15	0.25	0.00E+00	1.00E+00	1.01E+01	1	-1.01E+01	-1	4.84E-01	0.507	-4.84E-01	-0.5068	5.068E-01
11	16.5	0.25	0.00E+00	1.00E+00	9.66E+00	1	-9.66E+00	-1	4.62E-01	0.486	-4.62E-01	-0.4864	4.864E-01
12	18	0.25	0.00E+00	1.00E+00	9.25E+00	1	-9.25E+00	-1	4.42E-01	0.468	-4.42E-01	-0.4683	4.683E-01
13	19.5	0.25	0.00E+00	1.00E+00	8.89E+00	1	-8.89E+00	-1	4.25E-01	0.452	-4.25E-01	-0.4521	4.521E-01
14	21	0.25	0.00E+00	1.00E+00	8.57E+00	1	-8.57E+00	-1	4.09E-01	0.437	-4.09E-01	-0.4375	4.375E-01
15	22.5	0.25	0.00E+00	1.00E+00	8.28E+00	1	-8.28E+00	-1	3.96E-01	0.424	-3.96E-01	-0.4241	4.241E-01
16	24	0.25	0.00E+00	1.00E+00	8.01E+00	1	-8.01E+00	-1	3.83E-01	0.412	-3.83E-01	-0.412	4.120E-01
17	25.5	0.25	0.00E+00	1.00E+00	7.77E+00	1	-7.77E+00	-1	3.72E-01	0.401	-3.72E-01	-0.4008	4.008E-01
18	27	0.25	0.00E+00	1.00E+00	7.55E+00	1	-7.55E+00	-1	3.61E-01	0.39	-3.61E-01	-0.3904	3.904E-01
19	28.5	0.25	0.00E+00	1.00E+00	7.35E+00	1	-7.35E+00	-1	3.51E-01	0.381	-3.51E-01	-0.3809	3.809E-01
20	30	0.25	0.00E+00	1.00E+00	7.17E+00	1	-7.17E+00	-1	3.43E-01	0.372	-3.43E-01	-0.372	3.720E-01

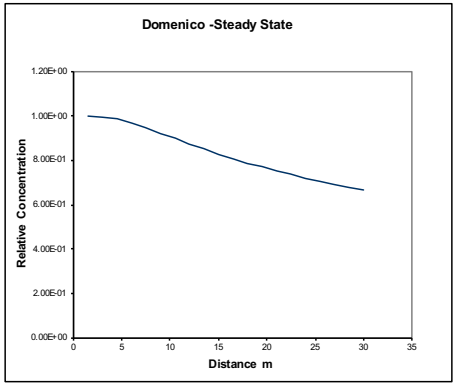


Calc	Value	
v	3.15E-02	m/d
Rc	1.02E+03	
u	3.09E-05	m/d

DOMENICO (STEADY STATE)

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3A	ERF	Term 3B	ERF	Term 4A	ERF	Term 4B	ERF	Relative Concentration
1	1.5	0.25	0.00E+00	1.00E+00	3.21E+01	1	-3.21E+01	-1	3.06E+00	1	-3.06E+00	-1	1.00E+00
2	3	0.25	0.00E+00	1.00E+00	2.27E+01	1	-2.27E+01	-1	2.17E+00	0.998	-2.17E+00	-0.9978	9.98E-01
3	4.5	0.25	0.00E+00	1.00E+00	1.85E+01	1	-1.85E+01	-1	1.77E+00	0.988	-1.77E+00	-0.9876	9.88E-01
4	6	0.25	0.00E+00	1.00E+00	1.60E+01	1	-1.60E+01	-1	1.53E+00	0.97	-1.53E+00	-0.9697	9.70E-01
5	7.5	0.25	0.00E+00	1.00E+00	1.43E+01	1	-1.43E+01	-1	1.37E+00	0.947	-1.37E+00	-0.9474	9.47E-01
6	9	0.25	0.00E+00	1.00E+00	1.31E+01	1	-1.31E+01	-1	1.25E+00	0.923	-1.25E+00	-0.9231	9.23E-01
7	10.5	0.25	0.00E+00	1.00E+00	1.21E+01	1	-1.21E+01	-1	1.16E+00	0.899	-1.16E+00	-0.8985	8.99E-01
8	12	0.25	0.00E+00	1.00E+00	1.13E+01	1	-1.13E+01	-1	1.08E+00	0.874	-1.08E+00	-0.8745	8.74E-01
9	13.5	0.25	0.00E+00	1.00E+00	1.07E+01	1	-1.07E+01	-1	1.02E+00	0.851	-1.02E+00	-0.8514	8.51E-01
10	15	0.25	0.00E+00	1.00E+00	1.01E+01	1	-1.01E+01	-1	9.69E-01	0.829	-9.69E-01	-0.8294	8.29E-01
11	16.5	0.25	0.00E+00	1.00E+00	9.66E+00	1	-9.66E+00	-1	9.24E-01	0.809	-9.24E-01	-0.8086	8.09E-01
12	18	0.25	0.00E+00	1.00E+00	9.25E+00	1	-9.25E+00	-1	8.85E-01	0.789	-8.85E-01	-0.789	7.89E-01
13	19.5	0.25	0.00E+00	1.00E+00	8.89E+00	1	-8.89E+00	-1	8.50E-01	0.771	-8.50E-01	-0.7706	7.71E-01
14	21	0.25	0.00E+00	1.00E+00	8.57E+00	1	-8.57E+00	-1	8.19E-01	0.753	-8.19E-01	-0.7532	7.53E-01
15	22.5	0.25	0.00E+00	1.00E+00	8.28E+00	1	-8.28E+00	-1	7.91E-01	0.737	-7.91E-01	-0.7368	7.37E-01
16	24	0.25	0.00E+00	1.00E+00	8.01E+00	1	-8.01E+00	-1	7.66E-01	0.721	-7.66E-01	-0.7213	7.21E-01
17	25.5	0.25	0.00E+00	1.00E+00	7.77E+00	1	-7.77E+00	-1	7.43E-01	0.707	-7.43E-01	-0.7067	7.07E-01
18	27	0.25	0.00E+00	1.00E+00	7.55E+00	1	-7.55E+00	-1	7.22E-01	0.693	-7.22E-01	-0.6929	6.93E-01
19	28.5	0.25	0.00E+00	1.00E+00	7.35E+00	1	-7.35E+00	-1	7.03E-01	0.68	-7.03E-01	-0.6798	6.80E-01
20	30	0.25	0.00E+00	1.00E+00	7.17E+00	1	-7.17E+00	-1	6.85E-01	0.667	-6.85E-01	-0.6674	6.67E-01



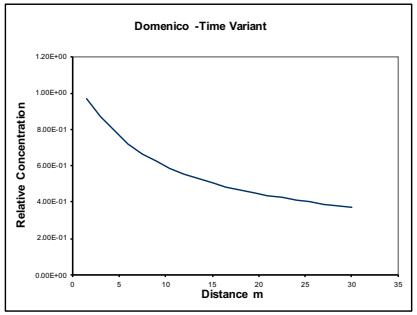
Date:	24th February 2023
Version:	1

DOMENICO (TIME VARIANT)

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	0.01	mg/l
DF	3.7904	
λ	6.810E-104	$days^{-1}$
Sz	8.600E+01	m
Sy	1.300E+00	m
Kd	5.000E+02	l/kg
ρ	1.140E+00	g/cm3
n	5.600E-01	
i	1.358E-02	
K	1.300E+00	m/d
x	3.000E+01	m
z	0.000E+00	m
y	0.000E+00	m
t	9.990E+100	days
ax	3.000E+00	m
az	3.000E-01	m
ay	3.000E-02	m

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

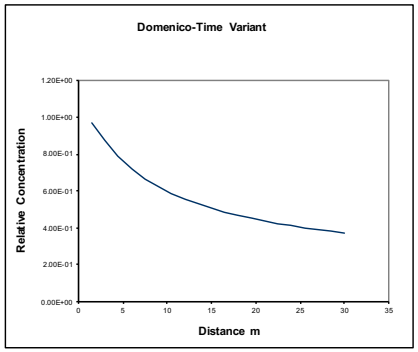
	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4A	ERF	Term 4B	ERF	Term 5A	ERF	Term 5B	ERF	Relative Concentration
	m														
1	1.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	3.21E+01	1	-3.21E+01	-1	1.53E+00	0.9697	-1.53E+00	-0.97	9.70E-01
2	3	0.125	0.00E+00	1.00E+00	-5.08E+47	2	2.27E+01	1	-2.27E+01	-1	1.08E+00	0.8745	-1.08E+00	-0.874	8.74E-01
3	4.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.85E+01	1	-1.85E+01	-1	8.85E-01	0.789	-8.85E-01	-0.789	7.89E-01
4	6	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.60E+01	1	-1.60E+01	-1	7.66E-01	0.7213	-7.66E-01	-0.721	7.21E-01
5	7.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.43E+01	1	-1.43E+01	-1	6.85E-01	0.6674	-6.85E-01	-0.667	6.67E-01
6	9	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.31E+01	1	-1.31E+01	-1	6.25E-01	0.6236	-6.25E-01	-0.624	6.24E-01
7	10.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.21E+01	1	-1.21E+01	-1	5.79E-01	0.5872	-5.79E-01	-0.587	5.87E-01
8	12	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.13E+01	1	-1.13E+01	-1	5.42E-01	0.5563	-5.42E-01	-0.556	5.56E-01
9	13.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.07E+01	1	-1.07E+01	-1	5.11E-01	0.5298	-5.11E-01	-0.53	5.30E-01
10	15	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.01E+01	1	-1.01E+01	-1	4.84E-01	0.5068	-4.84E-01	-0.507	5.07E-01
11	16.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	9.66E+00	1	-9.66E+00	-1	4.62E-01	0.4864	-4.62E-01	-0.486	4.86E-01
12	18	0.125	0.00E+00	1.00E+00	-5.08E+47	2	9.25E+00	1	-9.25E+00	-1	4.42E-01	0.4683	-4.42E-01	-0.468	4.68E-01
13	19.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.89E+00	1	-8.89E+00	-1	4.25E-01	0.4521	-4.25E-01	-0.452	4.52E-01
14	21	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.57E+00	1	-8.57E+00	-1	4.09E-01	0.4375	-4.09E-01	-0.437	4.37E-01
15	22.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.28E+00	1	-8.28E+00	-1	3.96E-01	0.4241	-3.96E-01	-0.424	4.24E-01
16	24	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.01E+00	1	-8.01E+00	-1	3.83E-01	0.412	-3.83E-01	-0.412	4.12E-01
17	25.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.77E+00	1	-7.77E+00	-1	3.72E-01	0.4008	-3.72E-01	-0.401	4.01E-01
18	27	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.55E+00	1	-7.55E+00	-1	3.61E-01	0.3904	-3.61E-01	-0.39	3.90E-01
19	28.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.35E+00	1	-7.35E+00	-1	3.51E-01	0.3809	-3.51E-01	-0.381	3.81E-01
20	30	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.17E+00	1	-7.17E+00	-1	3.43E-01	0.372	-3.43E-01	-0.372	3.72E-01



Calc	Value	
v	3.15E-02	m/d
Rc	1.02E+03	
u	3.09E-05	m/d

Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4A	ERF	Term 4B	ERF	Term 5A	ERF	Term 5B	ERF	Relative Concentration
	m														
1	1.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	3.21E+01	1	-3.21E+01	-1	3.06E+00	1	-3.06E+00	-1	1.00E+00
2	3	0.125	0.00E+00	1.00E+00	-5.08E+47	2	2.27E+01	1	-2.27E+01	-1	2.17E+00	0.9978	-2.17E+00	-0.998	9.98E-01
3	4.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.85E+01	1	-1.85E+01	-1	1.77E+00	0.9876	-1.77E+00	-0.988	9.88E-01
4	6	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.60E+01	1	-1.60E+01	-1	1.53E+00	0.9697	-1.53E+00	-0.97	9.70E-01
5	7.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.43E+01	1	-1.43E+01	-1	1.37E+00	0.9474	-1.37E+00	-0.947	9.47E-01
6	9	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.31E+01	1	-1.31E+01	-1	1.25E+00	0.9231	-1.25E+00	-0.923	9.23E-01
7	10.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.21E+01	1	-1.21E+01	-1	1.16E+00	0.8985	-1.16E+00	-0.899	8.99E-01
8	12	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.13E+01	1	-1.13E+01	-1	1.08E+00	0.8745	-1.08E+00	-0.874	8.74E-01
9	13.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.07E+01	1	-1.07E+01	-1	1.02E+00	0.8514	-1.02E+00	-0.851	8.51E-01
10	15	0.125	0.00E+00	1.00E+00	-5.08E+47	2	1.01E+01	1	-1.01E+01	-1	9.69E-01	0.8294	-9.69E-01	-0.829	8.29E-01
11	16.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	9.66E+00	1	-9.66E+00	-1	9.24E-01	0.8086	-9.24E-01	-0.809	8.09E-01
12	18	0.125	0.00E+00	1.00E+00	-5.08E+47	2	9.25E+00	1	-9.25E+00	-1	8.85E-01	0.789	-8.85E-01	-0.789	7.89E-01
13	19.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.89E+00	1	-8.89E+00	-1	8.50E-01	0.7706	-8.50E-01	-0.771	7.71E-01
14	21	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.57E+00	1	-8.57E+00	-1	8.19E-01	0.7532	-8.19E-01	-0.753	7.53E-01
15	22.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.28E+00	1	-8.28E+00	-1	7.91E-01	0.7368	-7.91E-01	-0.737	7.37E-01
16	24	0.125	0.00E+00	1.00E+00	-5.08E+47	2	8.01E+00	1	-8.01E+00	-1	7.66E-01	0.7213	-7.66E-01	-0.721	7.21E-01
17	25.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.77E+00	1	-7.77E+00	-1	7.43E-01	0.7067	-7.43E-01	-0.707	7.07E-01
18	27	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.55E+00	1	-7.55E+00	-1	7.22E-01	0.6929	-7.22E-01	-0.693	6.93E-01
19	28.5	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.35E+00	1	-7.35E+00	-1	7.03E-01	0.6798	-7.03E-01	-0.68	6.80E-01
20	30	0.125	0.00E+00	1.00E+00	-5.08E+47	2	7.17E+00	1	-7.17E+00	-1	6.85E-01	0.6674	-6.85E-01	-0.667	6.67E-01



Date:	24th February 2023
Version:	1

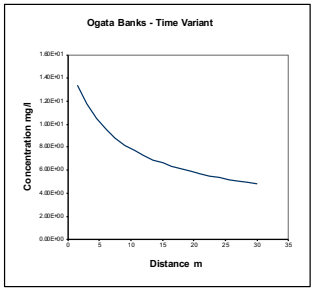
OGATA BANKS SOLUTION

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	0.01	mg/l
Co	1.40E+01	mg/l
λ	3.39E-104	$days^{-1}$
Sz	8.60E+01	m
Sy	1.20E+00	m
Kd	1.00E+02	l/kg
ρ	1.14E+00	g/cm3
n	5.60E-01	
i	1.00E-02	
K	1.30E+00	m/d
x	3.00E+01	m
z	0.00E+00	m
y	0.00E+00	m
t	9.99E+100	days
ax	3.00E+00	m
az	3.00E-01	m
ay	3.00E-02	m

Vertical dispersion option: Simulate vertical dispersion in 1 direction

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

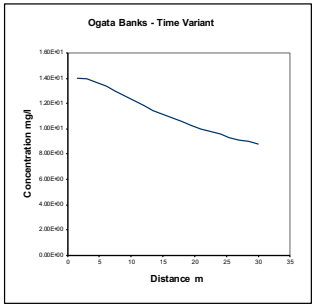
	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4	EXP	Term 5	ERFC	Term 6a	ERF	Term 6b	ERF	Term 7a	ERF	Term 7b	ERF	Concentration
1	1.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.0E-01	1.6E+00	9.7E+47	0.000	3.2E+01	1	-3.2E+01	-1	1.4E+00	0.9545	-1.4E+00	-0.9545	1.34E+01
2	3	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.0E+00	2.7E+00	9.7E+47	0.000	2.3E+01	1	-2.3E+01	-1	1.0E+00	0.8427	-1.0E+00	-0.8427	1.18E+01
3	4.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.5E+00	4.5E+00	9.7E+47	0.000	1.9E+01	1	-1.9E+01	-1	8.2E-01	0.7518	-8.2E-01	-0.75179	1.05E+01
4	6	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	2.0E+00	7.4E+00	9.7E+47	0.000	1.6E+01	1	-1.6E+01	-1	7.1E-01	0.6827	-7.1E-01	-0.68269	9.56E+00
5	7.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	2.5E+00	1.2E+01	9.7E+47	0.000	1.4E+01	1	-1.4E+01	-1	6.3E-01	0.6289	-6.3E-01	-0.62891	8.80E+00
6	9	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	3.0E+00	2.0E+01	9.7E+47	0.000	1.3E+01	1	-1.3E+01	-1	5.8E-01	0.5858	-5.8E-01	-0.58578	8.20E+00
7	10.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	3.5E+00	3.3E+01	9.7E+47	0.000	1.2E+01	1	-1.2E+01	-1	5.3E-01	0.5503	-5.3E-01	-0.55031	7.70E+00
8	12	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	4.0E+00	5.5E+01	9.7E+47	0.000	1.1E+01	1	-1.1E+01	-1	5.0E-01	0.5205	-5.0E-01	-0.5205	7.29E+00
9	13.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	4.5E+00	9.0E+01	9.7E+47	0.000	1.1E+01	1	-1.1E+01	-1	4.7E-01	0.495	-4.7E-01	-0.49501	6.93E+00
10	15	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.0E+00	1.5E+02	9.7E+47	0.000	1.0E+01	1	-1.0E+01	-1	4.5E-01	0.4729	-4.5E-01	-0.47291	6.62E+00
11	16.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.5E+00	2.4E+02	9.7E+47	0.000	9.7E+00	1	-9.7E+00	-1	4.3E-01	0.4535	-4.3E-01	-0.45351	6.35E+00
12	18	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	6.0E+00	4.0E+02	9.7E+47	0.000	9.3E+00	1	-9.3E+00	-1	4.1E-01	0.4363	-4.1E-01	-0.4363	6.11E+00
13	19.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	6.5E+00	6.7E+02	9.7E+47	0.000	8.9E+00	1	-8.9E+00	-1	3.9E-01	0.4209	-3.9E-01	-0.4209	5.89E+00
14	21	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	7.0E+00	1.1E+03	9.7E+47	0.000	8.6E+00	1	-8.6E+00	-1	3.8E-01	0.407	-3.8E-01	-0.40702	5.70E+00
15	22.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	7.5E+00	1.8E+03	9.7E+47	0.000	8.3E+00	1	-8.3E+00	-1	3.7E-01	0.3944	-3.7E-01	-0.39442	5.52E+00
16	24	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	8.0E+00	3.0E+03	9.7E+47	0.000	8.0E+00	1	-8.0E+00	-1	3.5E-01	0.3829	-3.5E-01	-0.38292	5.36E+00
17	25.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	8.5E+00	4.9E+03	9.7E+47	0.000	7.8E+00	1	-7.8E+00	-1	3.4E-01	0.3724	-3.4E-01	-0.37237	5.21E+00
18	27	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	9.0E+00	8.1E+03	9.7E+47	0.000	7.6E+00	1	-7.6E+00	-1	3.3E-01	0.3626	-3.3E-01	-0.36265	5.08E+00
19	28.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	9.5E+00	1.3E+04	9.7E+47	0.000	7.4E+00	1	-7.4E+00	-1	3.2E-01	0.3536	-3.2E-01	-0.35364	4.95E+00
20	30	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.0E+01	2.2E+04	9.7E+47	0.000	7.2E+00	1	-7.2E+00	-1	3.2E-01	0.3453	-3.2E-01	-0.34528	4.83E+00



Calc	Value	
v	2.32E-02	m/d
Rc	2.05E+02	
u	1.13E-04	m/d

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4	EXP	Term 5	ERFC	Term 6a	ERF	Term 6b	ERF	Term 7a	ERF	Term 7b	ERF	Concentration
1	1.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.0E-01	1.6E+00	9.7E+47	0.000	3.2E+01	1	-3.2E+01	-1	2.8E+00	0.9999	-2.8E+00	-0.99994	1.40E+01
2	3	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.0E+00	2.7E+00	9.7E+47	0.000	2.3E+01	1	-2.3E+01	-1	2.0E+00	0.9953	-2.0E+00	-0.99532	1.39E+01
3	4.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.5E+00	4.5E+00	9.7E+47	0.000	1.9E+01	1	-1.9E+01	-1	1.6E+00	0.9791	-1.6E+00	-0.97908	1.37E+01
4	6	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	2.0E+00	7.4E+00	9.7E+47	0.000	1.6E+01	1	-1.6E+01	-1	1.4E+00	0.9545	-1.4E+00	-0.9545	1.34E+01
5	7.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	2.5E+00	1.2E+01	9.7E+47	0.000	1.4E+01	1	-1.4E+01	-1	1.3E+00	0.9264	-1.3E+00	-0.92636	1.30E+01
6	9	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	3.0E+00	2.0E+01	9.7E+47	0.000	1.3E+01	1	-1.3E+01	-1	1.2E+00	0.8975	-1.2E+00	-0.89753	1.26E+01
7	10.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	3.5E+00	3.3E+01	9.7E+47	0.000	1.2E+01	1	-1.2E+01	-1	1.1E+00	0.8694	-1.1E+00	-0.86943	1.22E+01
8	12	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	4.0E+00	5.5E+01	9.7E+47	0.000	1.1E+01	1	-1.1E+01	-1	1.0E+00	0.8427	-1.0E+00	-0.8427	1.18E+01
9	13.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	4.5E+00	9.0E+01	9.7E+47	0.000	1.1E+01	1	-1.1E+01	-1	9.4E-01	0.8176	-9.4E-01	-0.81758	1.14E+01
10	15	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.0E+00	1.5E+02	9.7E+47	0.000	1.0E+01	1	-1.0E+01	-1	8.9E-01	0.7941	-8.9E-01	-0.7941	1.11E+01
11	16.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	5.5E+00	2.4E+02	9.7E+47	0.000	9.7E+00	1	-9.7E+00	-1	8.5E-01	0.7722	-8.5E-01	-0.7722	1.08E+01
12	18	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	6.0E+00	4.0E+02	9.7E+47	0.000	9.3E+00	1	-9.3E+00	-1	8.2E-01	0.7518	-8.2E-01	-0.75179	1.05E+01
13	19.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	6.5E+00	6.7E+02	9.7E+47	0.000	8.9E+00	1	-8.9E+00	-1	7.8E-01	0.7327	-7.8E-01	-0.73274	1.03E+01
14	21	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	7.0E+00	1.1E+03	9.7E+47	0.000	8.6E+00	1	-8.6E+00	-1	7.6E-01	0.715	-7.6E-01	-0.71495	1.00E+01
15	22.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	7.5E+00	1.8E+03	9.7E+47	0.000	8.3E+00	1	-8.3E+00	-1	7.3E-01	0.6983	-7.3E-01	-0.6983	9.78E+00
16	24	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	8.0E+00	3.0E+03	9.7E+47	0.000	8.0E+00	1	-8.0E+00	-1	7.1E-01	0.6827	-7.1E-01	-0.68269	9.56E+00
17	25.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	8.5E+00	4.9E+03	9.7E+47	0.000	7.8E+00	1	-7.8E+00	-1	6.9E-01	0.668	-6.9E-01	-0.66802	9.35E+00
18	27	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	9.0E+00	8.1E+03	9.7E+47	0.000	7.6E+00	1	-7.6E+00	-1	6.7E-01	0.6542	-6.7E-01	-0.65422	9.16E+00
19	28.5	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	9.5E+00	1.3E+04	9.7E+47	0.000	7.4E+00	1	-7.4E+00	-1	6.5E-01	0.6412	-6.5E-01	-0.6412	8.98E+00
20	30	1.75	0.0E+00	1.0E+00	-9.7E+47	2.000	1.0E+01	2.2E+04	9.7E+47	0.000	7.2E+00	1	-7.2E+00	-1	6.3E-01	0.6289	-6.3E-01	-0.62891	8.80E+00



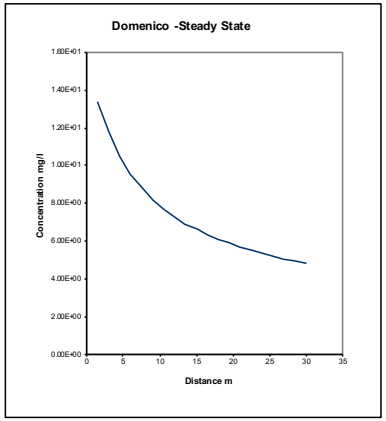
Date:	24th February 2023
Version:	1

DOMENICO (STEADY STATE)

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	0.01	mg/l
Co	1.40E+01	mg/l
λ	3.39E-104	days^{-1}
Sz	8.60E+01	m
Sy	1.20E+00	m
Kd	1.00E+02	l/kg
ρ	1.14E+00	g/cm3
n	5.60E-01	
i	1.00E-02	
K	1.30E+00	m/d
x	3.00E+01	m
z	0.00E+00	m
y	0.00E+00	m
ax	3.00E+00	m
az	3.00E-01	m
ay	3.00E-02	m

Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

	X	Term 1	Term 2	EXP	Term 3A	ERF	Term 3B	ERF	Term 4A	ERF	Term 4B	ERF	Concentration
1	1.5	3.5	0.00E+00	1.00E+00	3.21E+01	1	-3.21E+01	-1	1.41E+00	0.954	-1.41E+00	-0.9545	1.34E+01
2	3	3.5	0.00E+00	1.00E+00	2.27E+01	1	-2.27E+01	-1	1.00E+00	0.843	-1.00E+00	-0.8427	1.18E+01
3	4.5	3.5	0.00E+00	1.00E+00	1.85E+01	1	-1.85E+01	-1	8.16E-01	0.752	-8.16E-01	-0.7518	1.05E+01
4	6	3.5	0.00E+00	1.00E+00	1.60E+01	1	-1.60E+01	-1	7.07E-01	0.683	-7.07E-01	-0.6827	9.56E+00
5	7.5	3.5	0.00E+00	1.00E+00	1.43E+01	1	-1.43E+01	-1	6.32E-01	0.629	-6.32E-01	-0.6289	8.80E+00
6	9	3.5	0.00E+00	1.00E+00	1.31E+01	1	-1.31E+01	-1	5.77E-01	0.586	-5.77E-01	-0.5858	8.20E+00
7	10.5	3.5	0.00E+00	1.00E+00	1.21E+01	1	-1.21E+01	-1	5.35E-01	0.55	-5.35E-01	-0.5503	7.70E+00
8	12	3.5	0.00E+00	1.00E+00	1.13E+01	1	-1.13E+01	-1	5.00E-01	0.52	-5.00E-01	-0.5205	7.29E+00
9	13.5	3.5	0.00E+00	1.00E+00	1.07E+01	1	-1.07E+01	-1	4.71E-01	0.495	-4.71E-01	-0.495	6.93E+00
10	15	3.5	0.00E+00	1.00E+00	1.01E+01	1	-1.01E+01	-1	4.47E-01	0.473	-4.47E-01	-0.4729	6.62E+00
11	16.5	3.5	0.00E+00	1.00E+00	9.66E+00	1	-9.66E+00	-1	4.26E-01	0.454	-4.26E-01	-0.4535	6.35E+00
12	18	3.5	0.00E+00	1.00E+00	9.25E+00	1	-9.25E+00	-1	4.08E-01	0.436	-4.08E-01	-0.4363	6.11E+00
13	19.5	3.5	0.00E+00	1.00E+00	8.89E+00	1	-8.89E+00	-1	3.92E-01	0.421	-3.92E-01	-0.4209	5.89E+00
14	21	3.5	0.00E+00	1.00E+00	8.57E+00	1	-8.57E+00	-1	3.78E-01	0.407	-3.78E-01	-0.407	5.70E+00
15	22.5	3.5	0.00E+00	1.00E+00	8.28E+00	1	-8.28E+00	-1	3.65E-01	0.394	-3.65E-01	-0.3944	5.52E+00
16	24	3.5	0.00E+00	1.00E+00	8.01E+00	1	-8.01E+00	-1	3.54E-01	0.383	-3.54E-01	-0.3829	5.36E+00
17	25.5	3.5	0.00E+00	1.00E+00	7.77E+00	1	-7.77E+00	-1	3.43E-01	0.372	-3.43E-01	-0.3724	5.21E+00
18	27	3.5	0.00E+00	1.00E+00	7.55E+00	1	-7.55E+00	-1	3.33E-01	0.363	-3.33E-01	-0.3626	5.08E+00
19	28.5	3.5	0.00E+00	1.00E+00	7.35E+00	1	-7.35E+00	-1	3.24E-01	0.354	-3.24E-01	-0.3536	4.95E+00
20	30	3.5	0.00E+00	1.00E+00	7.17E+00	1	-7.17E+00	-1	3.16E-01	0.345	-3.16E-01	-0.3453	4.83E+00



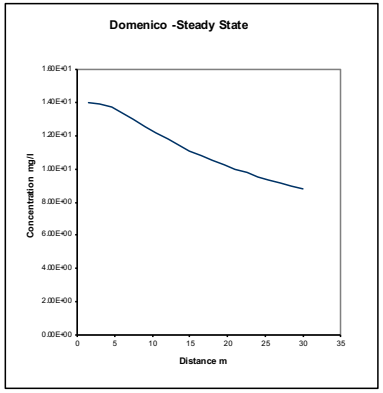
Vertical dispersion optior Simulate vertical dispersion in 1 direction

Calc	Value	
v	2.32E-02	m/d
Rc	2.05E+02	
u	1.13E-04	m/d

DOMENICO (STEADY STATE)

Calculations for source located at top of aquifer (ie vertical dispersion in one direction) - USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3A	ERF	Term 3B	ERF	Term 4A	ERF	Term 4B	ERF	Concentration
1	1.5	3.5	0.00E+00	1.00E+00	3.21E+01	1	-3.21E+01	-1	2.83E+00	1	-2.83E+00	-0.9999	1.40E+01
2	3	3.5	0.00E+00	1.00E+00	2.27E+01	1	-2.27E+01	-1	2.00E+00	0.995	-2.00E+00	-0.9953	1.39E+01
3	4.5	3.5	0.00E+00	1.00E+00	1.85E+01	1	-1.85E+01	-1	1.63E+00	0.979	-1.63E+00	-0.9791	1.37E+01
4	6	3.5	0.00E+00	1.00E+00	1.60E+01	1	-1.60E+01	-1	1.41E+00	0.954	-1.41E+00	-0.9545	1.34E+01
5	7.5	3.5	0.00E+00	1.00E+00	1.43E+01	1	-1.43E+01	-1	1.26E+00	0.926	-1.26E+00	-0.9264	1.30E+01
6	9	3.5	0.00E+00	1.00E+00	1.31E+01	1	-1.31E+01	-1	1.15E+00	0.898	-1.15E+00	-0.8975	1.26E+01
7	10.5	3.5	0.00E+00	1.00E+00	1.21E+01	1	-1.21E+01	-1	1.07E+00	0.869	-1.07E+00	-0.8694	1.22E+01
8	12	3.5	0.00E+00	1.00E+00	1.13E+01	1	-1.13E+01	-1	1.00E+00	0.843	-1.00E+00	-0.8427	1.18E+01
9	13.5	3.5	0.00E+00	1.00E+00	1.07E+01	1	-1.07E+01	-1	9.43E-01	0.818	-9.43E-01	-0.8176	1.14E+01
10	15	3.5	0.00E+00	1.00E+00	1.01E+01	1	-1.01E+01	-1	8.94E-01	0.794	-8.94E-01	-0.7941	1.11E+01
11	16.5	3.5	0.00E+00	1.00E+00	9.66E+00	1	-9.66E+00	-1	8.53E-01	0.772	-8.53E-01	-0.7722	1.08E+01
12	18	3.5	0.00E+00	1.00E+00	9.25E+00	1	-9.25E+00	-1	8.16E-01	0.752	-8.16E-01	-0.7518	1.05E+01
13	19.5	3.5	0.00E+00	1.00E+00	8.89E+00	1	-8.89E+00	-1	7.84E-01	0.733	-7.84E-01	-0.7327	1.03E+01
14	21	3.5	0.00E+00	1.00E+00	8.57E+00	1	-8.57E+00	-1	7.56E-01	0.715	-7.56E-01	-0.715	1.00E+01
15	22.5	3.5	0.00E+00	1.00E+00	8.28E+00	1	-8.28E+00	-1	7.30E-01	0.698	-7.30E-01	-0.6983	9.78E+00
16	24	3.5	0.00E+00	1.00E+00	8.01E+00	1	-8.01E+00	-1	7.07E-01	0.683	-7.07E-01	-0.6827	9.56E+00
17	25.5	3.5	0.00E+00	1.00E+00	7.77E+00	1	-7.77E+00	-1	6.86E-01	0.668	-6.86E-01	-0.668	9.35E+00
18	27	3.5	0.00E+00	1.00E+00	7.55E+00	1	-7.55E+00	-1	6.67E-01	0.654	-6.67E-01	-0.6542	9.16E+00
19	28.5	3.5	0.00E+00	1.00E+00	7.35E+00	1	-7.35E+00	-1	6.49E-01	0.641	-6.49E-01	-0.6412	8.98E+00
20	30	3.5	0.00E+00	1.00E+00	7.17E+00	1	-7.17E+00	-1	6.32E-01	0.629	-6.32E-01	-0.6289	8.80E+00



Date:	24th February 2023
Version:	1

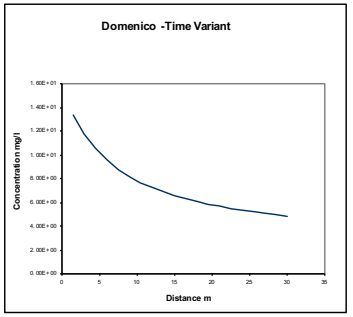
DOMENICO (TIME VARIANT)

Contaminant	Cyanide	
Input	**Value**	**Units**
C_T	0.01	mg/l
Co	1.40E+01	mg/l
λ	3.39E-104	days^{-1}
Sz	8.60E+01	m
Sy	1.20E+00	m
Kd	1.00E+02	l/kg
ρ	1.14E+00	g/cm3
n	5.60E-01	
i	1.00E-02	
K	1.30E+00	m/d
x	3.00E+01	m
z	0.00E+00	m
y	0.00E+00	m
t	9.99E+100	days
ax	3.00E+00	m
az	3.00E-01	m
ay	3.00E-02	m
Vertical dispersion option	Simulate vertical dispersion in 1 direction	

Calc	Value	
v	2.32E-02	m/d
Rc	2.05E+02	
u	1.13E-04	m/d

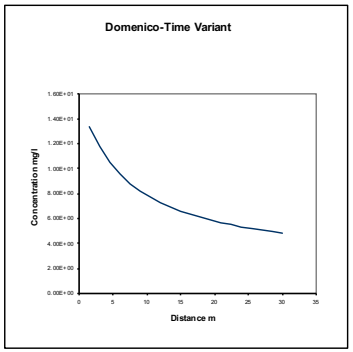
Calculations for source located in centre of aquifer (ie vertical dispersion in two directions)

	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4A	ERF	Term 4B	ERF	Term 5A	ERF	Term 5B	ERF	Concentration
	m														
1	1.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	3.21E+01	1	-3.21E+01	-1	1.41E+00	0.9545	-1.41E+00	-0.954	1.34E+01
2	3	1.75	0.00E+00	1.00E+00	-9.72E+47	2	2.27E+01	1	-2.27E+01	-1	1.00E+00	0.8427	-1.00E+00	-0.843	1.18E+01
3	4.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.85E+01	1	-1.85E+01	-1	8.16E-01	0.7518	-8.16E-01	-0.752	1.05E+01
4	6	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.60E+01	1	-1.60E+01	-1	7.07E-01	0.6827	-7.07E-01	-0.683	9.56E+00
5	7.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.43E+01	1	-1.43E+01	-1	6.32E-01	0.6289	-6.32E-01	-0.629	8.80E+00
6	9	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.31E+01	1	-1.31E+01	-1	5.77E-01	0.5858	-5.77E-01	-0.586	8.20E+00
7	10.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.21E+01	1	-1.21E+01	-1	5.35E-01	0.5503	-5.35E-01	-0.55	7.70E+00
8	12	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.13E+01	1	-1.13E+01	-1	5.00E-01	0.5205	-5.00E-01	-0.52	7.29E+00
9	13.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.07E+01	1	-1.07E+01	-1	4.71E-01	0.495	-4.71E-01	-0.495	6.93E+00
10	15	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.01E+01	1	-1.01E+01	-1	4.47E-01	0.4729	-4.47E-01	-0.473	6.62E+00
11	16.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	9.66E+00	1	-9.66E+00	-1	4.26E-01	0.4535	-4.26E-01	-0.454	6.35E+00
12	18	1.75	0.00E+00	1.00E+00	-9.72E+47	2	9.25E+00	1	-9.25E+00	-1	4.08E-01	0.4363	-4.08E-01	-0.436	6.11E+00
13	19.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.89E+00	1	-8.89E+00	-1	3.92E-01	0.4209	-3.92E-01	-0.421	5.89E+00
14	21	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.57E+00	1	-8.57E+00	-1	3.78E-01	0.407	-3.78E-01	-0.407	5.70E+00
15	22.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.28E+00	1	-8.28E+00	-1	3.65E-01	0.3944	-3.65E-01	-0.394	5.52E+00
16	24	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.01E+00	1	-8.01E+00	-1	3.54E-01	0.3829	-3.54E-01	-0.383	5.36E+00
17	25.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.77E+00	1	-7.77E+00	-1	3.43E-01	0.3724	-3.43E-01	-0.372	5.21E+00
18	27	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.55E+00	1	-7.55E+00	-1	3.33E-01	0.3626	-3.33E-01	-0.363	5.08E+00
19	28.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.35E+00	1	-7.35E+00	-1	3.24E-01	0.3536	-3.24E-01	-0.354	4.95E+00
20	30	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.17E+00	1	-7.17E+00	-1	3.16E-01	0.3453	-3.16E-01	-0.345	4.83E+00



Calculations for source located at top of aquifer (ie vertical dispersion in one direction only) - USED FOR LEVEL ASSESSMENT

	X	Term 1	Term 2	EXP	Term 3	ERFC	Term 4A	ERF	Term 4B	ERF	Term 5A	ERF	Term 5B	ERF	Concentration
	m														
1	1.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	3.21E+01	1	-3.21E+01	-1	2.83E+00	0.9999	-2.83E+00	-1	1.40E+01
2	3	1.75	0.00E+00	1.00E+00	-9.72E+47	2	2.27E+01	1	-2.27E+01	-1	2.00E+00	0.9953	-2.00E+00	-0.995	1.39E+01
3	4.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.85E+01	1	-1.85E+01	-1	1.63E+00	0.9791	-1.63E+00	-0.979	1.37E+01
4	6	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.60E+01	1	-1.60E+01	-1	1.41E+00	0.9545	-1.41E+00	-0.954	1.34E+01
5	7.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.43E+01	1	-1.43E+01	-1	1.26E+00	0.9264	-1.26E+00	-0.926	1.30E+01
6	9	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.31E+01	1	-1.31E+01	-1	1.15E+00	0.8975	-1.15E+00	-0.898	1.26E+01
7	10.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.21E+01	1	-1.21E+01	-1	1.07E+00	0.8694	-1.07E+00	-0.869	1.22E+01
8	12	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.13E+01	1	-1.13E+01	-1	1.00E+00	0.8427	-1.00E+00	-0.843	1.18E+01
9	13.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.07E+01	1	-1.07E+01	-1	9.43E-01	0.8176	-9.43E-01	-0.818	1.14E+01
10	15	1.75	0.00E+00	1.00E+00	-9.72E+47	2	1.01E+01	1	-1.01E+01	-1	8.94E-01	0.7941	-8.94E-01	-0.794	1.11E+01
11	16.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	9.66E+00	1	-9.66E+00	-1	8.53E-01	0.7722	-8.53E-01	-0.772	1.08E+01
12	18	1.75	0.00E+00	1.00E+00	-9.72E+47	2	9.25E+00	1	-9.25E+00	-1	8.16E-01	0.7518	-8.16E-01	-0.752	1.05E+01
13	19.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.89E+00	1	-8.89E+00	-1	7.84E-01	0.7327	-7.84E-01	-0.733	1.03E+01
14	21	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.57E+00	1	-8.57E+00	-1	7.56E-01	0.715	-7.56E-01	-0.715	1.00E+01
15	22.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.28E+00	1	-8.28E+00	-1	7.30E-01	0.6983	-7.30E-01	-0.698	9.78E+00
16	24	1.75	0.00E+00	1.00E+00	-9.72E+47	2	8.01E+00	1	-8.01E+00	-1	7.07E-01	0.6827	-7.07E-01	-0.683	9.56E+00
17	25.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.77E+00	1	-7.77E+00	-1	6.86E-01	0.668	-6.86E-01	-0.668	9.35E+00
18	27	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.55E+00	1	-7.55E+00	-1	6.67E-01	0.6542	-6.67E-01	-0.654	9.16E+00
19	28.5	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.35E+00	1	-7.35E+00	-1	6.49E-01	0.6412	-6.49E-01	-0.641	8.98E+00
20	30	1.75	0.00E+00	1.00E+00	-9.72E+47	2	7.17E+00	1	-7.17E+00	-1	6.32E-01	0.6289	-6.32E-01	-0.629	8.80E+00



Date:	24th February 2023
Version:	1

Hydrogeological risk assessment for land contamination

Remedial Targets Worksheet , Release 3.2

First released: 2006. Version 3.2: January 2013

This worksheet has been produced in combination with the document 'Remedial Targets Methodology: Hydrogeological risk assessment for land contamination (Environment Agency 2006).

Users of this worksheet should always refer to the User Manual to the Remedial Targets Methodology and to relevant guidance on UK legislation and policy, in order to understand how this procedure should be applied in an appropriate context.

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The calculation of equations in this worksheet has been independently checked by Entec (UK) Ltd on behalf of the Environment Agency.

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IMPORTANT: To enable MS Excel worksheet, click Tools, Add -Ins, Analysis Tool Pak and Analysis Tool Pak-VBA (to calculate error functions).

Details to be completed for each assessment				
Site Name:	Manox			
Site Address:	Land north of Coleshill Street, Miles Platting, Manchester, M40 7LE			
Completed by:	Stephanie Cox			
Date:	24-Jan-23		Version:	1
Contaminant	Lead			
Target Concentration (C_T)	0.01	mg/l	Origin of C_T:	DWS

This worksheet can be used to determine remedial targets for soils (Worksheets Level 1 Soil, Level 2 and Level 3 Soil) or to determine remedial targets for groundwater (Level 3 Groundwater). For Level 3, parameter values must be entered separately dependent on whether the assessment is for soil or groundwater. For soil, remedial targets are calculated as either mg/kg (for comparision with soil measurements) or mg/l (for comparison with leaching tests or pore water concentrations).
Site details entered on this page are automatically copied to Level 1, 2 and 3 Worksheets.
Worksheet options are identified by brown background and employ a pull-down menus. Data entry are identified as blue background.
Data origin / justification should be noted in cells coloured yellow and fully documented in subsequent reports.
Data carried forward from an earlier worksheet are identified by a light green background
It is recommended that a copy of the original worksheet is saved (all data fields in the original copy are blank).

The spreadsheet also includes a porosity calculation worksheet, a soil impact calculation worksheet and a worksheet that performs some simple hydrogeological calculations.

Remedial Targets Worksheet , Release 3.2

Level 1 - Soil

Environment Agency

Select the method of calculating the soil water Partition Co-efficient by using the pull down menu below

User specified value for partition coefficient

Contaminant		**Lead**		
Target concentration	**C_T**	**0.01**	**mg/l**	

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**
Standard entry				
Water filled soil porosity	θ_W	4.20E-01	fraction	SR3 Clay loam
Air filled soil porosity	θa	1.40E-01	fraction	SR3 Clay loam
Bulk density of soil zone material	ρ	1.14E+00	g/cm^3	SR3 Clay loam
Henry's Law constant	H	0.00E+00	dimensionless	*LQM-CIEH*
Entry if specify partition coefficient (option)				
Soil water partition coefficient	Kd	5.00E+02	l/kg	
Entry for non-polar organic chemicals (option)				
Fraction of organic carbon (in soil)	foc		fraction	Site soil data
Organic carbon partition coefficient	Koc		l/kg	*EA Guidance*
Entry for ionic organic chemicals (option)				
Sorption coefficient for neutral species	$K_{oc,n}$		l/kg	
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg	
pH value	pH		pH units	
Acid dissociation constant	pKa			
Fraction of organic carbon (in soil)	foc		fraction	
Soil water partition coefficient used in Level Assessment	**Kd**	**5.00E+02**	**l/kg**	*Specified value*

This sheet calculates the Level 1 remedial target for soils(mg/kg) based on a selected target concentration and theoretical calculation of soil water partitioning. Three options are included for determining the partition coefficient.

The measured soil concentration as mg/kg should be compared with the Level 1 remedial target to determine the need for further action.

Level 1 Remedial Target

Level 1 Remedial Target	**5.00E+00**	**mg/kg**	**(for comparison with soil analyses)**
	or		
	0.01	**mg/l**	**(for comparison with leachate test results)**

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 2 - Soil

Contaminant		**Lead**		from Level 1
Target concentration	C_T	**0.01**	**mg/l**	from Level 1

This sheet calculates the Level 2 remedial target for soils (mg/kg) or for pore water (mg/l).

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 2 remedial target to determine the need for further action. Equations presented in 'Hydrogeological risk assessment for land contamiantion' (Environment Agency 2006)

Input Parameters	**Variable**	**Value**	**Unit**	**Source of parameter value**	
Standard entry					
Infiltration	Inf	1.47E-05	m/d	**1% infiltration - Met Office**	
Area of contaminant source	A		m^2		Not used in calculation
Entry for groundwater flow below site					
Length of contaminant source in direction of groundwater flow	L	4.12E+02	m	**Site data measurement**	
Saturated aquifer thickness	da	1.30E+00	m	**borehole data**	
Hydraulic Conductivity of aquifer in which dilution occurs	K	1.30E+00	m/d	**SR3 Clay loam**	
Hydraulic gradient of water table	i	1.00E-02	fraction	**Site modelling data**	
Width of contaminant source perpendicular to groundwater flow	w	8.60E+01	m	**Site data measurement**	Not used in calculation
Background concentration of contaminant in groundwater beneath site	Cu		mg/l		
Define mixing zone depth by specifying or calculating depth (using pull down list)		**Calculate**			
Enter mixing zone thickness	Mz		m		
Calculated mixing zone thickness	Mz	1.30E+00	m		

Calculated Parameters

Dilution Factor	**DF**	**3.79E+00**		
Level 2 Remedial Target		**3.79E-02**	**mg/l**	**For comparison with measured pore water concentration. This assumes Level 1 Remedial Target is based on Target Concentration.**
		or		
		1.90E+01	**mg/kg**	**For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water**

Additional option

Calculation of impact on receptor

Concentration of contaminant in contaminated discharge (entering receptor)	Cc	0.00E+00	mg/l	
Calculated concentration within receptor (dilution only)		0.00E+00	mg/l	0

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	24-Jan-23
Version:	1

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Lead		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil concentration as mg/kg		
Enter soil concentration		6690	mg/kg	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	3.09E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Calculated soil leachate concentration	Co	1.34E+01	mg/l

Remedial Targets

Level 3 Remedial Target	**5.68E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks	**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
	2.84E+01	**mg/kg**	For comparison with measured soil concentration. This assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Distance to compliance point	**30**	**m**	
Ratio of Compliance Point to Source Concentration	**C_{ED}/C_0 6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

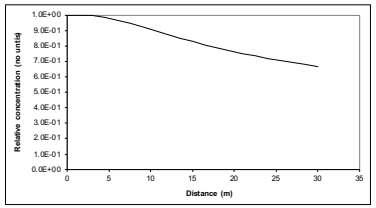
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	3.53E+00
1.5	1.00E+00	3.53E+00
3.0	9.98E-01	3.52E+00
4.5	9.88E-01	3.48E+00
6.0	9.70E-01	3.42E+00
7.5	9.47E-01	3.34E+00
9.0	9.23E-01	3.26E+00
10.5	8.99E-01	3.17E+00
12.0	8.74E-01	3.08E+00
13.5	8.51E-01	3.00E+00
15.0	8.29E-01	2.93E+00
16.5	8.09E-01	2.85E+00
18.0	7.89E-01	2.78E+00
19.5	7.71E-01	2.72E+00
21.0	7.53E-01	2.66E+00
22.5	7.37E-01	2.60E+00
24.0	7.21E-01	2.54E+00
25.5	7.07E-01	2.49E+00
27.0	6.93E-01	2.44E+00
28.5	6.80E-01	2.40E+00
30.0	6.67E-01	2.35E+00

Remedial Targets Worksheet , Release 3.2

Level 3 - Soil

See Note

Environment Agency

Input Parameters	Variable	Value	Unit	Source
Contaminant		Lead		from Level 1
Target Concentration	C_T	0.01	mg/l	from Level 1
Dilution Factor	DF	3.79E+00		from Level 2

Select analytical solution (click on brown cell below, then on pull-down menu)

Ogata Banks — Equations in HRA publication

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: **Apply degradation rate to dissolved pollutants only**

	Variable	Value	Unit	Source of parameter value
Enter source concentration		Soil leachate concentration as mg/l		
Enter soil leachate concentration		0.01	mg/l	
Half life for degradation of contaminant in water	$t_{1/2}$	9.99E+99	days	*Conservative Estimate*
Calculated decay rate	λ	6.94E-101	$days^{-1}$	calculated
Width of plume in aquifer at source	Sz	8.60E+01	m	from Level 2
Plume thickness in aquifer at source	Sy	1.30E+00	m	from Level 2
Bulk density of aquifer materials	ρ	1.14E+00	g/cm^3	*SR3 clay loam*
Effective porosity of aquifer	n	5.60E-01	fraction	*SR3 clay loam*
Hydraulic gradient	i	1.36E-02	fraction	from Level 2 (adjusted)
Hydraulic conductivity of saturated aquifer	K	1.30E+00	m/d	from Level 2
Distance to compliance point	x	3.00E+01	m	*Rochdale Canal*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	9.99E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	5.00E+02	l/kg	*see options*
Longitudinal dispersivity	ax	3.000	m	*see options*
Transverse dispersivity	az	0.300	m	*see options*
Vertical dispersivity	ay	0.030	m	*see options*

Parameter values should be checked against Level 1 and 2

Calculated Parameters	Variable		
Groundwater flow velocity	v	3.15E-02	m/d
Retardation factor	Rf	1.02E+03	fraction
Decay rate used	λ	6.81E-104	d^{-1}
Hydraulic gradient used in aquifer flow down-gradient	i	1.36E-02	fraction
Rate of contaminant flow due to retardation	u	3.09E-05	m/d
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	6.67E-01	fraction
Attenuation factor (C_0/C_{ED})	**AF**	**1.50E+00**	**fraction**
Soil leachate concentration	Co	1.00E-02	

Remedial Targets

Level 3 Remedial Target		**5.68E-02**	**mg/l**	For comparison with measured pore water concentration.
Ogata Banks		**or**		This assumes Level 1 Remedial Target is based on Target Concentration.
		2.84E+01	**mg/kg**	For comparison with measured soil concentration. This
Distance to compliance point		**30**	**m**	assumes Level 1 Remedial Target calculated from soil-water partitioning equation.
Ratio of Compliance Point to Source Concentration	C_{ED}/C_0	**6.67E-01**	**fraction**	Ogata Banks

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99

Enter method of defining partition co-efficient (using pull down list)

User specified value for partition coefficient

Entry if specify partition coefficient (option)

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Entry for non-polar organic chemicals (option)

Fraction of organic carbon in aquifer — foc — fraction
Organic carbon partition coefficient — Koc — l/kg

Entry for ionic organic chemicals (option)

Sorption coefficient for related species — $K_{oc,n}$ — l/kg
Sorption coefficient for ionised species — $K_{oc,i}$ — l/kg
pH value — pH
Acid dissociation constant — pKa
Fraction of organic carbon in aquifer — foc — fraction

Soil water partition coefficient — Kd — 5.00E+02 l/kg

Define dispersivity (click brown cell and use pull down list)

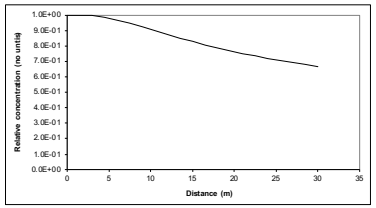
Dispersivities 10%, 1%, 0.1% of pathway length

		Enter value	Calc value	Xu & Eckstein	
Longitudinal dispersivity	**ax**	0.00E+00	3.00E+00	2.13E+00	m
Transverse dispersivity	**az**	0.00E+00	3.00E-01	2.13E-01	m
Vertical dispersivity	**ay**	0.00E+00	3.00E-02	2.13E-02	m

Note values of dispersivity must be > 0

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

Note
This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best described by an electron limited degradation such as oxidation by O_2, NO_3, SO_4 etc than an alternative solution should be used



Note: 'Relative concentration' is the ratio of calculated concentation at a given position compared to the source concentration. The calculations assume plume disperses from the top of the aquifer. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

This sheet calculates the Level 3 remedial target for soils(mg/kg) or for pore water (mg/l), based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.By setting a long travel time (e.g. 9E99) it will give the steady state solution, which should always be used when calculating remedial targets.

The measured soil concentration as mg/kg or pore water concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.9E+99.

Site being assessed:	Manox
Completed by:	Stephanie Cox
Date:	########
Version:	1

Calculated (relative) concentrations for distance-concentration graph

Ogata Banks
From calculation sheet

Distance	Relative concentration (No units)	Concentration mg/l
0	1.0E+00	2.64E-03
1.5	1.00E+00	2.64E-03
3.0	9.98E-01	2.63E-03
4.5	9.88E-01	2.61E-03
6.0	9.70E-01	2.56E-03
7.5	9.47E-01	2.50E-03
9.0	9.23E-01	2.44E-03
10.5	8.99E-01	2.37E-03
12.0	8.74E-01	2.31E-03
13.5	8.51E-01	2.25E-03
15.0	8.29E-01	2.19E-03
16.5	8.09E-01	2.13E-03
18.0	7.89E-01	2.08E-03
19.5	7.71E-01	2.03E-03
21.0	7.53E-01	1.99E-03
22.5	7.37E-01	1.94E-03
24.0	7.21E-01	1.90E-03
25.5	7.07E-01	1.86E-03
27.0	6.93E-01	1.83E-03
28.5	6.80E-01	1.79E-03
30.0	6.67E-01	1.76E-03