

# Appendix 16.1 Contamination Assessment Report



# M74 Junction 5, Raith

## Contamination Assessment Report

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December 2006

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## Document Control Sheet

Project Title M74 Junction 5, Raith  
Document Title Contamination Assessment Report  
Report No M8MFJV/50  
Revision 03  
Status Final  
Control Date 19 December 2006

### *Record of Issue*

Issue	Status	Author	Date	Check	Date	Authorised	Date
01	Draft	I Hughes	Oct 2006	J Heather	Oct 2006	R Ireland	Oct 2006
02	Final Draft	I Hughes W Huston	Nov 2006	J Heather	Nov 2006	R Ireland	Nov 2006
03	Final	I Hughes W Huston	Dec 2006	J Heather	Dec 2006	R Ireland	Dec 2006

### *Distribution*

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WA Fairhurst	R Ireland / M McLaughlin	1

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# 1 Introduction and Brief

MouchelFairhurst Joint Venture (MFJV) was appointed by Transport Scotland as Employer's Representative for the proposed upgrading of the M74 Junction 5, Raith. Part of this upgrading proposes the option of a major underpass to carry traffic flows from the A725 beneath the existing M74. As part of their brief, MFJV designed and supervised a ground investigation to identify geotechnical constraints to the construction of the proposed scheme, under a future Design and Build contract. In addition to this general requirement, MFJV was specifically tasked to provide a geotechnical and geochemical interpretative report. This report details the interpretation of the geochemical results of the recent ground investigation at Junction 5, Raith. This report should be read in conjunction with "*Desk Study Report M74 Junct 5, Raith*" and report "*M74 Raith Interchange Geotechnical Interpretative Report on Construction of Underpass*" which provide a detailed explanation and interpretation of geotechnical issues.

This report presents a qualitative and quantitative assessment and interpretation of the soil, groundwater and surface water quality at Junction 5, Raith, identifying the potential impacts that the proposed construction will present to human health and the water environment.

Construction of the underpass walls and excavation between them to form the base slab will require a substantial dewatering exercise to be designed and implemented. Groundwater and surface water quality at Raith has proved to be generally poor. Therefore, a Quantitative Risk Assessment (QRA) has been undertaken to evaluate the acceptability of discharging the waters arising from the dewatering exercise into surface waters (ponds, ditches and the River Clyde). The QRA bases its evaluation on the dilution of contaminants in the surface waters and use of remedial target concentrations to ensure that surface waters are not polluted.

Furthermore, a Hazardous Waste classification exercise has been undertaken. Localised contamination has been encountered on site where an estimated 170,000m<sup>3</sup> of soils will be excavated with the likelihood of a proportion of re-use on site.

## 2 Recent Ground Investigation

### 2.1 Summary of chemical sampling and testing

This section presents the chemical results obtained during the recent ground investigation exercise.

Based on the findings of the geotechnical desk study report M8MFJV/05, the main sources of contamination considered were sidings, railway lines and collieries (including old mineworkings). Chemical sampling and testing associated with these sources is discussed below.

### 2.2 Soil sampling and testing

The purpose of the soil sampling was to provide data on the presence and distribution of potential contamination at the site. Based on the historical use of the land in the vicinity of the site, potential sources of contamination were targeted. Seven soil samples from trial pits excavated in the location of former railway lines and sidings to the north-east of the site were collected for testing. Fifty additional soil samples were collected at variable depths from different boreholes and trial pits across the site on a non targeted basis. These samples were analysed for a range of contaminants among which the most relevant were heavy metals, additional inorganics, PAH and TPH.

The complete set of soil chemical testing results is contained in the Raeburn Factual Report <sup>(4)</sup>.

### 2.3 Groundwater sampling and testing

Groundwater samples were taken from sixteen borehole locations across the site in order to determine the groundwater quality. Some samples were taken during drilling operations, and some were collected once well installations were constructed. The groundwater samples collected from each borehole were analysed for heavy metals, other inorganics, pH, sulphate, PAH and TPH.

During the ground investigation (GI) artesian groundwater conditions were encountered in the north-east of the site. These conditions prevented some boreholes from being drilled to rockhead depth, highlighting the potential difficulties that will be encountered while excavating the area of the proposed underpass. Since the presence of artesian groundwater will affect the progress of the excavation works, it has been proposed to pump out the water from the excavation works area and discharge it to surface water. This likely strategy prompted an extension to the GI to include surface water samples in order to assess the impact of the groundwater discharge into the surface water surrounding the site, as it was anticipated that the pumped water may be from contaminated mine waters.

## 2.4 Surface water sampling and testing

In order to determine the quality of the surface waters thirteen samples were collected and tested for a range of contaminants including heavy metals, other inorganics, pH, sulphate, PAH and TPH. These samples included some of the surrounding ponds, ditches, standing water and the River Clyde, for detailed locations of the surface water sampling exercise refer to Drawing No. M8MFJV.ST3.G.1303 in Appendix 1.

The geochemical results of the investigation are contained in the Raeburn Factual Report <sup>(4)</sup>. All the recent and past exploratory holes and monitoring positions are shown on Drawing No. M8MFJV.ST3.G.1301-1302 in Appendix 1. The most recent have the suffix "4BH".

## 3 Qualitative Risk Assessment and Conceptual Site Model

The Conceptual Site Model (CSM) developed for this study is based on the findings of the recent ground investigation and the proposed development of the M74 Junction 5, Raith.

The CSM identifies pollutant linkages. The risks associated with these linkages are assessed in table 3.1. The principles of environmental risk assessment are presented in Appendix 2.

### 3.1.1 Receptor Characterisation

#### Humans

End users/construction and maintenance workers

#### The Water environment

Surface waters in the surrounding area are considered to be the main receptors, principally the River Clyde.

#### Property

The fabric of the underpass at Junction 5, Raith

### 3.1.2 Source Characterisation

The principle historical sources of contamination at the site are assumed to be former sidings, railway lines, collieries and flooded mineworkings in the surrounding area. These sources have been updated following recent investigations and are as follows:

#### Affecting Human Health

- Elevated localised levels of heavy metals in groundwater
- Elevated localised concentrations of specific PAHs in groundwater
- Elevated localised concentrations of specific PAHs and TPH in soil

#### Affecting the Water Environment

- Elevated localised levels of heavy metals in groundwater
- Elevated localised concentrations of specific PAHs in groundwater

#### Affecting Buildings and Services

- Localised elevated concentrations of sulphate in soil and groundwater

### 3.1.3 Pathway Characterisation

#### Humans

- Inhalation of dusts or vapours
- Ingestion of contaminated soil by hand to mouth activity
- Dermal contact with contaminated soils and waters

#### The Water Environment

- Discharge of contaminated groundwater into surface waters
- Run-off from the site surface entering surface water courses near the site
- Leaching of contaminants from the soil migrating vertically or laterally to groundwater beneath the site
- Movement of dissolved contaminants in soil pore water
- Movement of contaminants via groundwater to surface water bodies

#### Property

- Direct contact of concrete with localised elevated concentrations of sulphate in soil and groundwater

### 3.1.4 Pollutant linkages and Risk Assessment

#### Humans

The development will consist of the construction of an underpass to carry traffic flows from the A275 beneath the existing M74 Junction 5, Raith. The underpass walls and internal road will provide hard cover, which will effectively break the pathway between the contamination sources and end users by creating a physical barrier that will prevent contact between the receptor and the source of contamination.

Construction workers will remain at risk during the construction phase and potentially during any further maintenance work by dermal contact and subsequent ingestion. The risk may be mitigated by adoption of appropriate systems of work, which minimise exposure and by the use of PPE (gloves, overalls, etc.).

No water supplies for drinking purposes will be present.

#### Buildings, Property and Services

Buried concrete structures may be subject to attack from contamination in the soil. Analytical soil chemistry should be assessed in accordance with BRE Special Digest 1:2005 (3<sup>rd</sup> Edition) for appropriate concrete specification, to prevent damage.

Services placed at or near the water table and in contaminated soil may create preferential pathways for the flow of contaminated waters. This can be prevented by

placing services in clean soils, well above the water table or, if this is not possible, backfilling trenches with clean cohesive soils. This will have the added advantage of ensuring future maintenance workers do not encounter ground contamination.

### The Water Environment

There is localised contaminated groundwater (with heavy metals and PAH) present on site; however, chemical analysis of the surface water (ponds, ditches and the River Clyde) surrounding the site have shown similar levels of heavy metals and PAH, to those recorded in groundwater.

The groundwater beneath the site is not considered a receptor for the purposes of this report. The River Clyde is considered the final receptor of the drained and discharged contaminated groundwater.

Run-off entering surface water courses near the site will be minimal and controlled by drainage systems, therefore no assessment of this potential pollutant linkage is required.

Leaching of contaminants from the soil migrating vertically or laterally to groundwater beneath the site is not considered a significant pollutant linkage since the contamination with heavy metals and PAH is minimal and localised. Movement of dissolved contaminants in soil pore water will be minimal since the contamination is localised across the site.

Table 1 presents a summary of the current qualitative risk assessment and Conceptual Site Model at M74 Junction 5, Raith.

The possibility of the pumping operation mobilising contaminated groundwater is real and is discussed later.

**Table 1 Current Qualitative Risk Assessment and Conceptual Site Model**

Sources	Pathway	Receptor(s)	Assessment	Severity	Likelihood	Risk rating	Further Action Required
Localised soil and groundwater contamination with heavy metals, PAH, TPH and Sulphate	Ingestion, dermal contact	Humans: maintenance and construction workers	Direct contact with potential contamination is likely during construction works.	High	High	High	Safe systems of work to minimise exposure and appropriate PPE to be used
	Inhalation, ingestion, dermal contact	Humans: end users	In the tunnel and motorway the pathway to human receptors from potential contamination will be broken by hard standing.	High	Low	Low	No
	Direct contact	Buried concrete structures	Concrete foundations will come into contact with and may be affected by potentially aggressive contaminants within the soil and groundwater.	High	Moderate	Moderate	Yes - Assessment using BRE Special Digest 1:2005 (3 <sup>rd</sup> Ed)
	Discharge of groundwater into the surface waters	The river Clyde, ponds and ditches	Groundwater discharge will negatively impact the River Clyde and surface ponds in light of their present poor quality	High	High	High	Yes – Tier 2 Quantitative Risk Assessment

Risk Ratings

High -

Moderate -

Low -

The available information indicates a significant possibility of harm to a receptor requiring further investigation, assessment or treatment.

The available information indicates a potential for significant harm to a receptor requiring further investigation and assessment.

The available information does not indicate a significant potential for harm to a receptor requiring further investigation. This does not indicate zero risk

## 4 Quantitative Risk Assessment

### 4.1 Tier 1 Quantitative risk assessment (QRA)

A Tier 1 QRA has been undertaken to determine the significance of the concentrations of all recorded contaminants within the soil, groundwater and surface water. The concentrations were compared with a range of appropriate assessment criteria.

### 4.2 Assessment criteria

The screening criteria used to assess the quality of groundwater at Raith were based on an ecological assessment in light of the proposed developments and are detailed as follows:

#### 4.2.1 Groundwater and surface water assessment criteria

- Environmental Quality Standards (EQS) List for Freshwater (2004)
- Dutch RIVM report 711710 023 (2001) SRCeco values for groundwater
- Maryland Clean-up standards (2001)
- The Water Supply (Water Quality) (Scotland) Regulations (2001)

The River Clyde is considered to be the significant surface water receptor, and, in the first instance UK EQS values are used to assess the risks posed to this receptor. In the absence of EQS values, screening values from sources detailed above were used. A range of EQS values are provided for certain inorganic determinands, based on the bicarbonate content ( $\text{HCO}_3^-$ ) of the water. A chemical analysis for bicarbonate content ( $\text{HCO}_3^-$ ) from samples indicates a range of 279mg/l to 903mg/l for groundwaters and 238mg/l to 287mg/l for site surface waters. A water sample taken from the River Clyde, recorded a bicarbonate content ( $\text{HCO}_3^-$ ) of 99mg/l. Therefore, the appropriate EQS values have been selected based on the site specific bicarbonate content data.

PAH concentrations were assessed against the Dutch RIVM SRCeco. When EQS values or Dutch RIVM SRCeco values are not published the Water Supply (Water Quality) (Scotland) Regulations (2006) and Maryland Clean-up Standards were used for some inorganic and organic contaminants. TPH concentrations were assessed against the former Drinking Water Standard. It is important to mention that drinking water standards were used only in complete absence of ecological assessment criteria.

### 4.3 Chemical results

#### 4.3.1 Groundwater results

Table 2 presents a summary of the contaminants in the groundwater that exceeded their respective assessment criteria. The complete set of groundwater chemical testing results is contained in the Raeburn Factual Report <sup>(4)</sup>.

The results presented in Table 2 highlights the inorganic and organic compounds that recorded elevated concentrations when compared with the assessment criteria based on site specific bicarbonate levels of greater than 250mg/l (279mg/l to 903mg/l).

It is evident that the groundwater quality within the site is relatively poor, with elevated aluminium, manganese, magnesium, benzo(a)pyrene and indeno(123-cd)pyrene widespread across the site. A detailed review of the results indicates that groundwater contamination by iron, chloride, sulphate, TPH, anthracene, and fluoranthene is localised. The limit of detection for Free Cyanide is higher than the assessment criteria and therefore it must be conservatively assumed that Free Cyanide is a risk to the environment.

In accordance with White Young Green's chemistry assessment <sup>(11)</sup>, the water analysis indicates that the groundwater appears to be contaminated with pyrite oxidation products. White Young Green's assessment concludes that the concentrations recorded indicate that the groundwater has been in minor contact with coal measures strata, as opposed to higher concentrations that would positively indicate that the groundwater had been in contact with old coal mine workings.

**Table 2 Summary of the Groundwater Analysis Results**

Determinand	Number of Samples	Assessment Criteria (AC) mg/l	Min conc. In samples mg/l	Max conc. In samples mg/l	No. of Samples Exceeding
Aluminium	11	0.015 <sup>(1)</sup>	<0.01	0.14	7 (64%)
Iron	9	1 <sup>(1)</sup>	<0.01	1.36	1 (11%)
Copper	12	0.001 <sup>(1a)</sup> 0.028 <sup>(1b)</sup>	<0.002	<0.02	12 (100%)* 0 (0%)
Chromium	12	0.005 <sup>(1a)</sup> 0.05 <sup>(1b)</sup>	<0.002	0.031	8 (67%) 0 (0%)
Lead	12	0.004 <sup>(1a)</sup> 0.02 <sup>(1b)</sup>	<0.006	<0.02	58 (7%) 0 (0%)
Manganese	9	0.030 <sup>(1)</sup>	0.04	0.47	9 (100%)
Zinc	11	0.008 <sup>(1a)</sup> 0.05 <sup>(1b)</sup>	<0.01	0.05	11 (100%)* 0 (0%)
Magnesium	8	50 <sup>(3)</sup>	14	95	6 (75%)
Chloride	8	250 <sup>(1)</sup>	21.4	330	2 (25%)
Sulphate	11	400 <sup>(1)</sup>	30	405	1 (9%)

Determinand	Number of Samples	Assessment Criteria (AC) mg/l	Min conc. In samples mg/l	Max conc. In samples mg/l	No. of Samples Exceeding
Cyanide free	9	0.001 <sup>(1)</sup>	<0.05	<0.05	9 (100%)*
Anthracene	9	0.00002 <sup>(1)</sup>	<0.00001	<0.00005	1 (8%)
Fluoranthene	9	0.00002 <sup>(1)</sup>	<0.00001	<0.00005	2 (22%)
Benzo(a)pyrene	9	0.00003 <sup>(1)</sup>	<0.00001	<0.00009	6 (67%)
Indeno(123-cd)pyrene	9	0.000036 <sup>(2)</sup>	<0.00001	0.00011	6 (67%)
PAH sum of 4 <sup>#</sup>	9	0.0001 <sup>(3)</sup>	0.00003	0.00031	6 (67%)
TPH	11	0.01 <sup>(4)</sup>	<0.01	0.07	8 (73%)

<sup>(1)</sup> Environmental Quality Standards (EQS) List for Freshwater (2004)

<sup>(1a)</sup> Environmental Quality Standards (EQS) List for Freshwater (0 - 50mg CaCO<sub>3</sub>/l values) (2004)

<sup>(1b)</sup> Environmental Quality Standards (EQS) List for Freshwater (> 250mg CaCO<sub>3</sub>/l values) (2004)

<sup>(2)</sup> Dutch RIVM report 711710 023 (2001) SRCeco values for groundwater

<sup>(3)</sup> The Water Supply (Water Quality) (Scotland) Regulations (2001)

<sup>(4)</sup> UK Drinking Water Inspectorate Regulations (1989)

# PAH sum of 4 includes: benzo(b,k)fluoranthene, benzo(ghi)perylene and indeno(123-cd)pyrene

\* Exceeds as Limit of Detection above Assessment Criteria.

### 4.3.2 Surface water results

Table 3 presents a summary of the contaminants in surface waters that exceeded their respective assessment criteria. The complete set of groundwater chemical testing results is contained in the Raeburn Factual Report <sup>(4)</sup>.

The results presented in Table 3 highlights the inorganic and organic compounds that recorded elevated concentrations when compared with their respective assessment criteria based on site specific bicarbonate levels of 200mg/l to 250mg/l (for ponds and ditches) and 50mg/l to 100mg/l (for the River Clyde).

In general, the main, widespread contaminants exceeding the assessment criteria in the surface waters (ponds and ditches) are aluminium, lead, manganese, anthracene, fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene and PAH (sum of 4). Iron, sodium and ammonia contaminations locally exceeded their respective assessment criteria in ponds and ditches. The limits of detection for free cyanide, lead, anthracene, fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene and PAH (sum of 4) are higher than the assessment criteria and therefore it must be conservatively assumed these determinands pose a risk to the environment.

The water hardness of the ponds and ditches is higher than in the River Clyde. This will have the effect of making most metallic contaminants less mobile, therefore reducing the impact of these contaminants on the water environment.

The surface water results presented in Table 3 are similar to that of the groundwater beneath the site, and in some specific cases (e.g. manganese) surface waters recorded higher concentrations for contaminants than the groundwater.

Table 3 Summary of Surface Water Results.

Determinand	Ditch 1	Ditch 2	Ditch 4	Ditch 3	Pond 1 (SSSI)	Pond 4	Pond 5	Standing 1	River Clyde 2	A.C.
Aluminium (mg/l)	0.10	0.10	0.08	0.10	0.08	0.16	0.09	0.28	0.11	0.015 <sup>(1)</sup>
Copper (mg/l)	<0.02	<0.02	<0.02	<0.02	0.004	0.02	<0.02	<0.02	<0.002	0.01 <sup>(1a)*</sup> 0.028 <sup>(1b)</sup>
Lead (mg/l)	<0.025	<0.025	<0.025	<0.025	<0.002	<0.025	<0.025	<0.025	0.002	0.01 <sup>(1a)*</sup> 0.02 <sup>(1b)*</sup>
Iron (mg/l)	0.15	0.14	0.07	0.09	0.11	0.28	0.18	3.64	0.31	1 <sup>(1)</sup>
Manganese (mg/l)	0.15	0.39	0.67	0.69	0.30	1.00	0.04	0.20	0.08	0.030 <sup>(1)</sup>
Sodium (mg/l)	36	61	128	135	90	185	30	11	19	170 <sup>(1)</sup>
Ammonia (mg/l)	0.22	0.20	0.47	0.18	0.69	0.34	0.31	3.65	<0.05	0.5 <sup>(3)</sup>
Cyanide free (mg/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.001 <sup>(1)*</sup>
Anthracene (ug/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.02 <sup>(1)*</sup>
Fluoranthene (ug/l)	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	<0.01	0.02 <sup>(1)*</sup>
Benzo(a)pyrene (ug/l)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.01	0.03 <sup>(1)*</sup>
Indeno(123-cd)pyrene (ug/l)	<0.05	<0.05	<0.05	<0.05	<0.01	<0.05	<0.05	<0.05	<0.01	0.036 <sup>(2)*</sup>
PAH sum of 4 <sup>#</sup> (ug/l)	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	<0.15	0.10 <sup>(3)*</sup>

<sup>(1)</sup> Environmental Quality Standards (EQS) List for Freshwater (2004)

<sup>(1a)</sup> Environmental Quality Standards (EQS) List for Freshwater (50 - 100mg CaCO<sub>3</sub>/l values) (2004)

<sup>(1b)</sup> Environmental Quality Standards (EQS) List for Freshwater (200 - 250mg CaCO<sub>3</sub>/l values) (2004)

<sup>(2)</sup> Dutch RIVM report 711710 023 (2001) SRCeco values for groundwater

<sup>(3)</sup> The Water Supply (Water Quality) (Scotland) Regulations (2006)

<sup>#</sup> PAH sum of 4 includes: benzo(b,k)fluoranthene, benzo(ghi)perylene and indeno(123-cd)pyrene

\* Exceeds as Limit of Detection above Assessment Criteria.

A.C. = Assessment Criteria

River Clyde 2 location is upstream the location of the site

#### 4.4 Discussion of Results

The results obtained from the chemical testing of groundwater and surface water samples across the site have enabled a better understanding of the environmental conditions on the site. The results of the water testing indicate that neither the ponds, the ditches, the River Clyde nor the groundwater are of particularly high quality. The contaminants which exceed the relevant assessment criteria vary and some of the elevated values in the surface waters are low in the groundwater and vice versa. This correlates with the OGI report <sup>(10)</sup> which indicates that the regional groundwater flow (and hence the groundwater quality) beneath the site is in connectivity with the River Clyde via base flow.

In order to undertake the excavation works and in light of the artesian conditions present on site, widespread reduction in the groundwater levels will be required by dewatering. Discharging this water to surface water requires detailed assessment, planning and consent. The dilution effect in the surface water has been calculated (see Section 5.0) and remedial target concentrations determined to evaluate the feasibility of direct discharge into the surface waters.

The proposed development will also involve the excavation of soil containing localised heavy metals and PAH contamination. A waste classification exercise has been undertaken (Section 6.0) to determine whether the excavated soils will constitute a hazardous waste. Hazardous wastes cannot be reused on site unless a waste management license is in place. Non-hazardous materials may be reused on site if geotechnically suitable and they do not create pollutant linkages. However, an exemption from Waste Management Licensing will be required for these works.

## 5 Tier 2 Quantitative Risk Assessment

### 5.1 General

Consideration has been given to the discharge of the abstracted groundwater to the River Clyde and recharge to the local ponds. The R&D 20 methodology has been used to assess both these impacts and the results are presented below.

### 5.2 Calculation of Dilution Factors (DF) and development of Remedial Target Concentrations for groundwater discharge into the River Clyde

Hydrogeological studies by OGI indicate that groundwater must be abstracted at a rate of between 100l/s and 150l/s continuously to depress the water table to the level required. The OGI report <sup>(10)</sup> also indicates that the regional groundwater flow beneath the site is in connectivity with the River Clyde via base flow. Therefore, the relatively small abstraction of groundwater and direct discharge to the River Clyde during dewatering operations, relative to the overall base flow input, should not result in a significant change to the natural hydrogeological conditions.

To demonstrate this, the dilution occurring within the River Clyde has been calculated for each contaminant applying the R&D 20 methodology, assuming a discharge rate of 150l/s directly into the river.

A summary of Tier 2 calculations for dilution factors and remedial target concentrations is presented in Appendix 3.

### 5.3 Impact of groundwater discharge into the River Clyde

The R&D 20 assessment demonstrates that the discharge of groundwater at 150l/s at the recorded concentrations for the majority of analysed contaminants would not significantly impact the overall water quality of the River Clyde. However, the assessment has highlighted two contaminants (TPH and Aluminium) that require further consideration.

The existing, background concentrations of Aluminium within the River Clyde (0.11mg/l) already exceed the EQS for Aluminium (0.015mg/l), and therefore a significant increase to this would be unacceptable. Based on calculations using the R&D 20 methodology, it has been identified that the proposed groundwater discharge of 150 l/s containing the maximum recorded Aluminium concentration of 0.14mg/l, would increase the overall Aluminium concentration in the River Clyde by only 0.5% to 0.1106 mg/l. Furthermore, the R&D 20 calculations are based on the published "low flow" (95<sup>th</sup> percentile) value and hence the above assessment is conservative. It also assumes a long term discharge with no allowance for the relatively short term nature of the construction. Therefore, the increase in Aluminium loading in the River Clyde, due to a groundwater discharge of 150l/s is not considered to be significant.

The TPH results for the River Clyde were recorded below the laboratory limit of detection of 0.01mg/l. As a worst case approach, the limit of detection was selected as the background concentration of TPH. There is no EQS for TPH and therefore the UK Drinking Water Standard of 0.01mg/l has been adopted as a conservative assessment criterion. The maximum concentration of TPH recorded in the groundwater was 0.07mg/l, and based on the assessment using the R&D 20 methodology; it has been demonstrated that a groundwater discharge of 150 l/s, would marginally increase the overall TPH concentration in the River Clyde to 0.011 mg/l.

If the actual TPH concentrations within the River Clyde prove to be marginally less than the limit of detection for TPH (say 0.008mg/l) then a discharge of 150 l/s at 0.07mg/l would be diluted to below the adopted assessment criteria. Again, the R&D 20 calculations are based on the published “low flow” (95<sup>th</sup> percentile) value and hence the above assessment is conservative as it assumes a long term discharge with no allowance for the relatively short term nature of the construction. The mean flow in the river is significantly higher (five times) than the “low” flow rate. Therefore, the increase in TPH loading in the River Clyde, due to a groundwater discharge of 150l/s is not considered to be significant.

Consultation with SEPA has yet to take place in order to ascertain that the above conclusions meet with regulatory approval. Should SEPA disagree with the above assessment and request that the quality of groundwater discharge is improved prior to discharge then pre-treatment is an option. It is anticipated that this treatment will take the form of physical and chemical measures such as sand filtration and Granular Activated Carbon (GAC) filtration to remove dissolved and/or free phase contamination. Preliminary discussions with water treatment specialists suggest that treatment would be possible, but the general view was that treatment to such low levels would not normally be required.

#### **5.4 Calculation of Dilution Factors (DF) and development of Remedial Target Concentrations for of recharge of ponds using abstracted groundwater**

In order to proceed with the excavation works, the groundwater must be lowered during construction which might lead to a depletion of the water level in the ponds surrounding Junction 5 (Pond 1 (SSSI) and Pond 5). Accordingly, these ponds must be recharged to compensate for any such water loss.

An assessment was undertaken using the R&D 20 methodology, considering a relatively low recharge range of 1l/s with the low flow rate in the burn (ditches) and ponds set as 4.3l/s. The low flow in the burn was determined using methodology for ungauged sites outlined in Institute of Hydrology, Report 108 – Low Flow Estimation in the United Kingdom (1992).

A summary of Tier 2 calculations for dilution factors and remedial target concentrations is presented in Appendix 3.

### **5.5 Impact of recharge of ponds using abstracted groundwater**

Assessments have demonstrated that even at a low recharge rate of 1l/s, recharging the surface ponds (Pond 1 (SSSI) and Pond 5) with the abstracted groundwater does not allow sufficient dilution to take place, particularly for contaminants such as aluminium, benzo(a)pyrene, PAH (sum of 4) and TPH. In this case, water from pumping wells will require pre-treatment in the same manner as described above, prior to being reused to recharge ponds.

If actual recharge requirements during construction are found to be less than 1l/s, it might be possible to discharge the abstracted water direct to ponds without treatment, subject to further assessment at the time. Alternatively, other potential sources of water for replenishing ponds include the River Clyde, Strathclyde Loch or groundwater from another nearby location could be considered. These source options will require discussion with SEPA and possibly further chemical assessment to confirm suitability.

## 6 Waste Classification of the Excavated Soils

The construction of the underpass at M74 Junction 5, Raith will generate an estimated 170,000m<sup>3</sup> of excavated soils, which contain traces of heavy metals, PAH and TPH. To adequately manage this waste, it needs first to be classified.

The methodology for waste classification is described under the Hazardous Waste Assessment Framework for Contaminated Soils<sup>(6)</sup>. The methodology has been followed and the outcome is described as follows:

After assessment of threshold concentrations and relevant associated hazards, the excavated soils at Raith do not constitute a Hazardous Waste and therefore these materials can be re-used on site if suitable for use as defined by the conceptual site model.

A detailed explanation of the procedure followed to undertake the waste classification of the excavated soils has been included in Appendix 4. The characterisation of the excavated soils arising from works at M74 Junction 5, Raith is shown in table 6 in Appendix 4.

## 7 Conclusions and Recommendations

### 7.1 Impact to Site End Users

The completed underpass will effectively be a closed box within the ground. Thus there is no pollutant linkage between any residual source of contamination on site and end users.

### 7.2 Impact to Site Construction Workers

Construction and maintenance workers, may come into direct contact with contamination during excavation works. This risk can be mitigated by minimising exposure where possible and/ or the use of appropriate Personal Protection Equipment.

### 7.3 Impact of groundwater discharge into the River Clyde

The assessment of groundwater and surface water quality (River Clyde, ponds and ditches) has demonstrated that in both cases quality is similar and generally poor. It has been suggested (by Coal Authority consultants) that groundwater chemistry may be related to minor contact with coal measures strata but not with old coal workings.

Hydrogeological studies by OGI indicate that groundwater must be continuously abstracted at a rate of 100 l/s to 150 l/s during the construction phase to depress the water table to the level required. An assessment has demonstrated that, even at low flow conditions, the discharge of groundwater generated by dewatering, at a rate of 150l/s can be diluted within the River Clyde without a “significant pollution” effect (as defined by Part IIA of EA 1990). However, suspended solids will need to be removed from abstracted groundwater prior to discharge and this can be achieved through settlement tanks.

A Discharge Consent and Abstraction Licence will be required from SEPA, under the Water Environment (Controlled Activities) Regulations (CAR), 2006, prior to the commencement of dewatering and discharge to the River Clyde or any surface water. Consultation has yet to take place with SEPA, particularly with reference to the conclusions drawn for the marginally elevated TPH and Aluminium. Should SEPA disagree with the above assessment and request that the quality of groundwater discharge is improved prior to discharge then pre-treatment is an option. It is anticipated that this treatment will take the form of physical and chemical measures, such as sand filtration and granular activated carbon (GAC) filtration, to remove dissolved and/or free phase contamination.

### 7.4 Impact of recharge of ponds using abstracted groundwater

Should surface water ponds be affected by lowering of the water table, a source of uncontaminated water will be required to restore water levels. Abstracted groundwater from dewatering operations may be suitable for pond recharge following

chemical and physical treatment such as sand filtration and GAC filtration, or without treatment if only very low recharge rates are required. Alternative sources of water for replenishing ponds should also be investigated and these may include the River Clyde, Strathclyde Loch or groundwater from another nearby location. Again, dialogue with SEPA is necessary to determine which options will be acceptable.

## **7.5 Waste Classification of the Excavated Soils**

Characterisation of the excavated soils has concluded that they do not constitute a hazardous waste in accordance with current waste management legislation and guidance; therefore arising soils can be re-used on site or disposed to a non-hazardous landfill.

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9. Mouchel Fairhurst JV, M74 Junction 5, Raith, Geotechnical Interpretative Report of Construction of Underpass, Issue No. 2, November 2006.
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11. White Young and Green, Raith Interchange (M74, Junction 5), Interpretation of Water Samples. August 2006.

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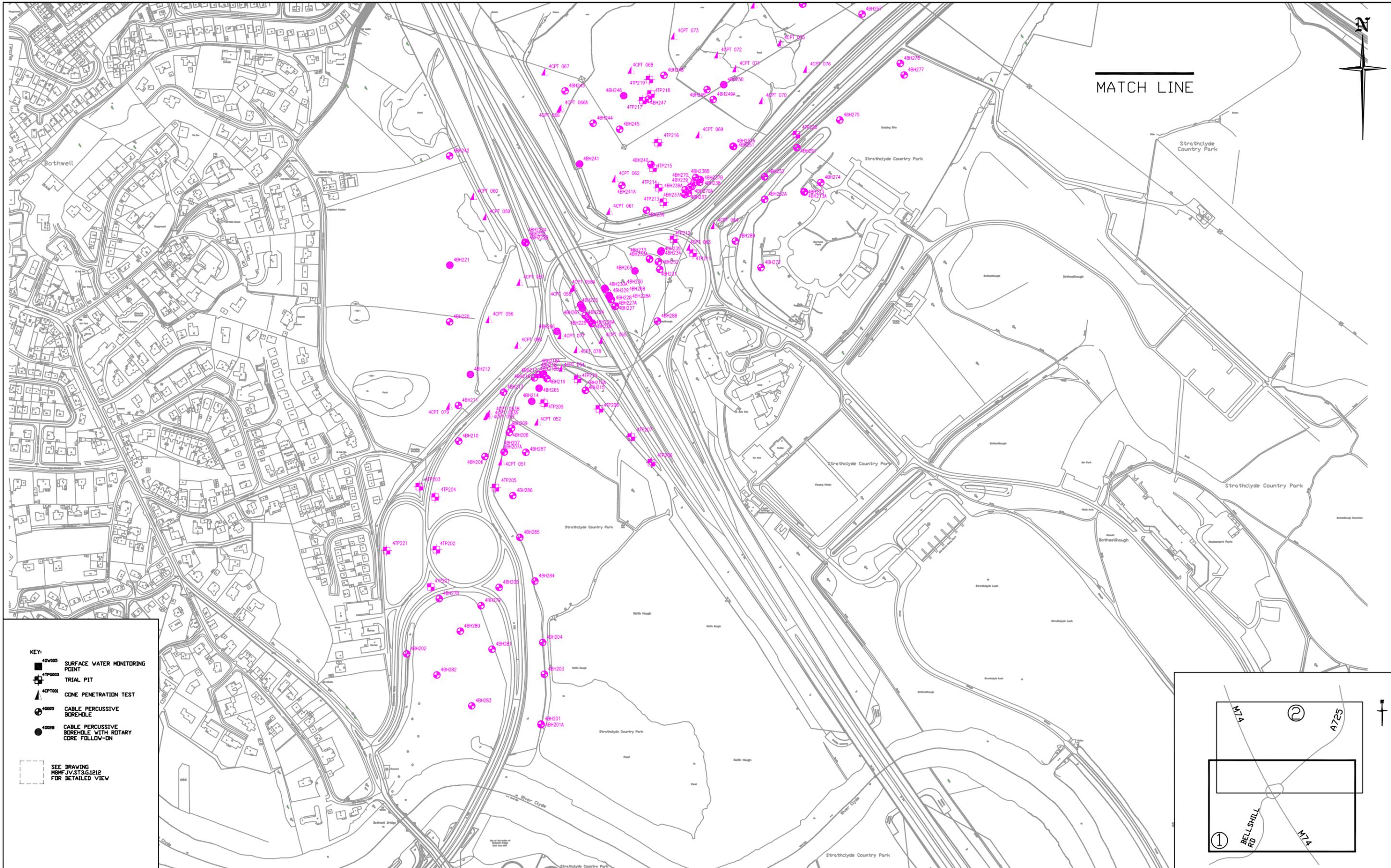
## Appendix 1 – Drawings

M8MFJV.ST3.G.1301 -1302

Exploratory Borehole locations

M8MFJV.ST3.G.1303

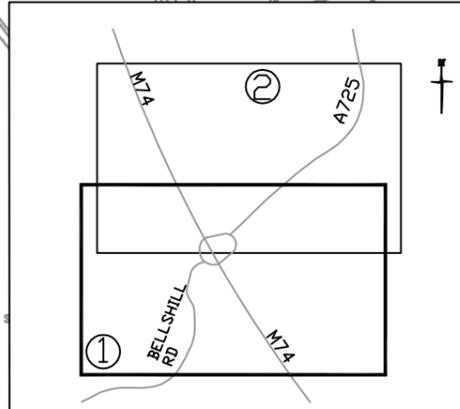
Surface water sampling locations



**KEY:**

- 4SV005 SURFACE WATER MONITORING POINT
- 4TP003 TRIAL PIT
- 4CPT001 CONE PENETRATION TEST
- 4G005 CABLE PERCUSSIVE BOREHOLE
- 43009 CABLE PERCUSSIVE BOREHOLE WITH ROTARY CORE FOLLOW-ON

SEE DRAWING M8MFJV.ST3.G.1212 FOR DETAILED VIEW



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PROJECT TITLE

**M74 Junction 5, Raith**

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DRAWN BY:	JS	APPROVED BY:	RI
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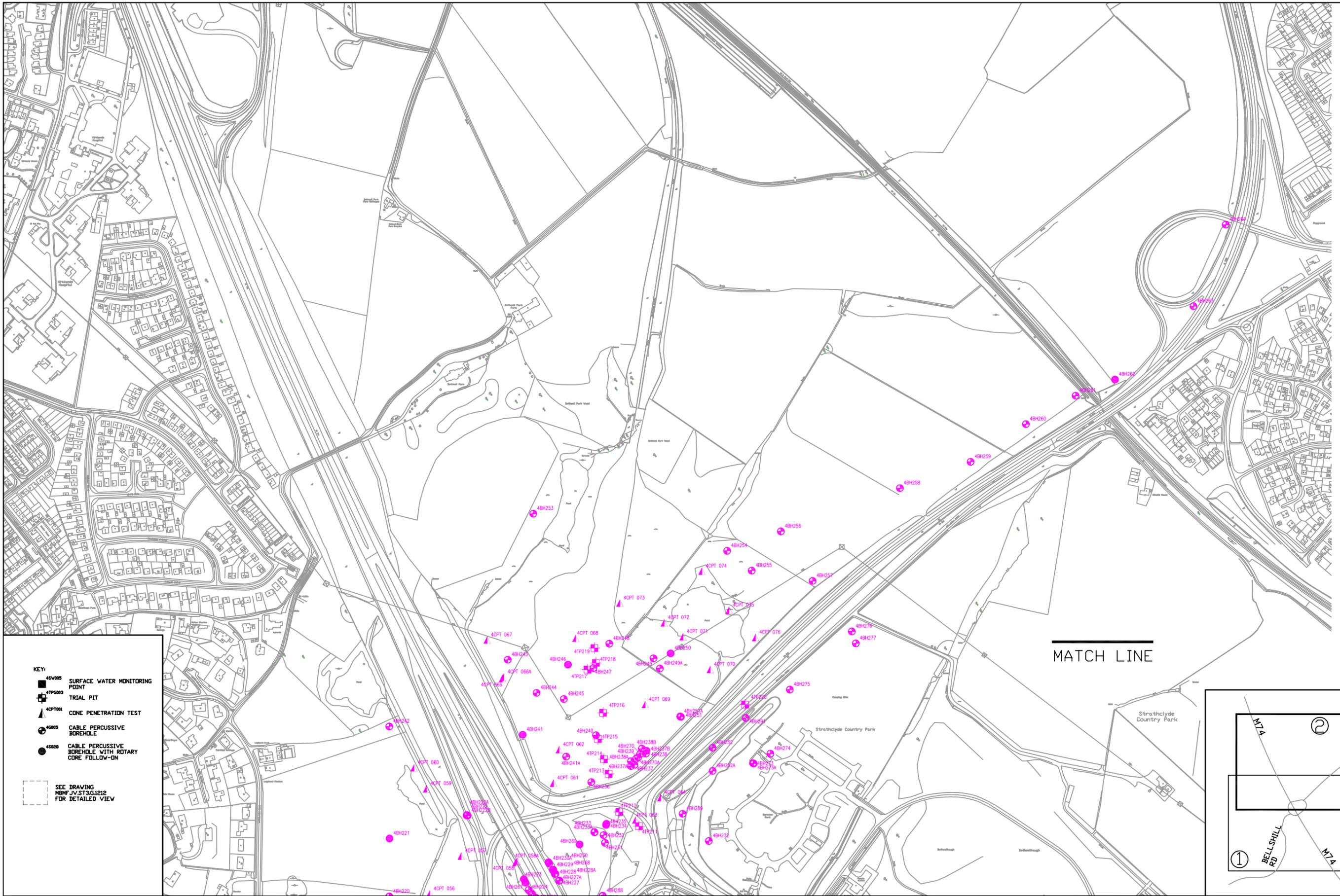
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**EXPLORATORY HOLE LOCATION PLAN**  
SHEET 1 OF 2

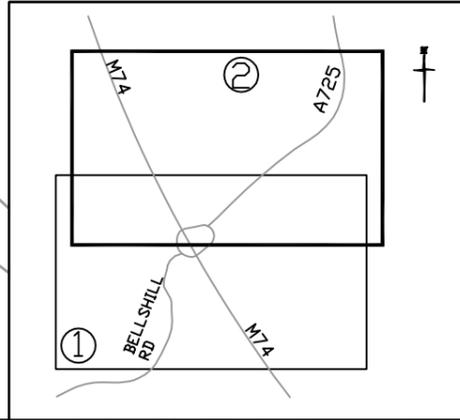
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**KEY:**

- 45V005 SURFACE WATER MONITORING POINT
- 47P0063 TRIAL PIT
- 4CPT001 CONE PENETRATION TEST
- 4C0005 CABLE PERCUSSIVE BOREHOLE
- 4C0028 CABLE PERCUSSIVE BOREHOLE WITH ROTARY CORE FOLLOW-ON

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**EXPLORATORY HOLE LOCATION PLAN  
SHEET 2 OF 2**

SCALE 1:2500 AT A1 1:5000 AT A3	DRAWING NO <b>M8MFJV.ST3.G.1302</b>	REV <b>A</b>
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DATE:	NOV 06	DATE:	NOV 06

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ENGINEER

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**SIAS** 

DRAWING TITLE

**SURFACE WATER SAMPLING LOCATIONS**

SCALE	DRAWING NO	REV
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## Appendix 2 – Principles of Environmental Risk Assessment

## Principles of Environmental Risk Assessment

The Environmental Protection Act 1990, Part II A Contaminated Land (Section 57 of the Environment Act 1995) and the Contaminated Land (Scotland) Regulations 2005 provide a basis on which to determine the risks and liabilities presented by a contaminated site. Contaminated Land is defined within Annex 3, Chapter A Part 1- Scope of Chapter and in all those Sections mentioned as:

*“Any land which appears to the local authority in whose area it is situated to be in such a condition, by reason of substances in, on or under the land that-*

- (a) Significant harm is being caused or there is significant possibility of such harm being caused; or
- (b) Significant pollution of the water environment is being caused or there is a significant possibility of such pollution being caused.”

Section 57 of the Environment Act 1995 requires that any site identified as being “contaminated” by the Local Authority will be registered by them and remediation will be required to render the site fit for use.

The presence of contamination is not the sole factor for deciding whether a site is contaminated. Relevant parties should identify site-specific risks and provide objective, cost-effective methods to manage the contamination in a manner which satisfies the proposed end-use.

A risk-based approach, which takes both technical and non-technical aspects into consideration when making decisions on contamination resulting from past, present or future human activities, is advocated. The assessment of environmental risks generally relies on the identification of three principal elements forming a ‘pollutant linkage’:

- **SOURCE:** the contaminant
- **PATHWAY:** the route through which the contaminant can migrate, and
- **RECEPTOR:** any human, animal, plant, water environment or property that may be adversely affected (harmed) by the contaminant

In the absence of any one of these elements, on any given site, there is no risk. Where all three elements are present, risk assessment is required to determine the significance of the harm or pollution that is being or may be caused. As outlined above, the terms of the Contaminated Land regime specify that remediation need only be implemented where a site is causing, or there is a significant possibility that it will cause, significant harm, or that significant pollution of the water environment is being, or there is a significant possibility of such pollution being caused.

Development of contaminated land is usually addressed through the application of planning and development legislation and guidance (i.e. Planning Guidance Note PPG23 in England and Advice Note 33 in Scotland). The suitable for use approach is seen as the most appropriate basis to deal with contaminated land, taking account of environmental, social and economic objectives. The assessment is made in the context of the proposed land use (e.g. residential, commercial, industrial and public open-space).

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## Appendix 3 – Dilution Factors (DF) and Remedial Target Concentrations (RTC)

## Tier 2 Dilution Factors and Remedial Target Concentrations Calculations

### a) Dilution factors (DF)

The calculation of dilution factors is based on the methodology described under section 5 within the R&D 20 EA publication “Methodology for the derivation of remedial targets for soil and groundwater to protect Water Resources”, which details the calculation of dilution factors on a receiving stream by using the following equations:

$$DF = \frac{(Q_c + Q_u)C_c}{Q_c C_c + Q_u C_u}$$

$$DF = \frac{C_T(Q_c + Q_u) - Q_u - C_u}{Q_c C_T}$$

Where

$Q_c$  = groundwater flow that will be discharged into receiving stream ( $m^3/d$ )

$Q_u$  = surface water low flow upstream discharge point ( $m^3/d$ )

$C_c$  = concentration of pollutant in contaminated groundwater (mg/l)

$C_u$  = background concentration of contaminant in the River Clyde (receiving stream) (mg/l)

$C_T$  = Target concentration of contaminant in the River Clyde (receiving stream) (mg/l)

In calculating dilution factors for contaminants in the river, no allowance for attenuation, bioremediation or retardation processes has been considered.

The groundwater flow that will be discharged into the River Clyde ( $Q_c$ ) has been estimated to vary between 100 to 150 l/s. After unit conversion the range of flow rates varies between 8640 and 12,960  $m^3/d$ .

The surface water low flow ( $Q_u$ ) was obtained from the report *Hydrological data UK. Hydrometric Register and Statistics published by the Centre for Ecology and Hydrology in Wallingford, 2003*<sup>(5)</sup>. The information appears under the gauging Station Register which shows that the 95 Percentile flow for the river Clyde is 7.74  $m^3/s$  (668736 $m^3/d$ ).

The concentration of pollutant in contaminated groundwater ( $C_c$ ) was obtained from the chemical results. The maximum value recorded in groundwater samples was used for each contaminant.

The background concentration of contaminant in receiving stream ( $C_u$ ), which in this case is the River Clyde, was obtained from the chemical analysis of surface water samples.

### b) Development of remedial target concentrations

The remedial target concentrations developed were obtained by multiplying the receptor target concentration by the calculated dilution factors for each contaminant.

$$RTC = DF \times TC$$

where

RTC = Remedial Target Concentration (mg/l)

DF = dilution factor

TC = Target Concentration (mg/l)

The approach used to develop the remedial target concentration (RTC) for all contaminants was based on the use of the relevant assessment criteria (i.e. EQS, DWS, etc) for each contaminant as the target concentration (TC). However, in cases where the background concentration recorded in the river Clyde was above the target concentration, then the background concentration was used as the target concentration. This was the particular case for cyanide free and aluminium.

Cyanide free concentration in both, groundwater and the River Clyde samples was recorded as <0.05mg/l (no lower limit of detection was feasible to achieve), value which is below the Drinking Water Standard of 0.05 mg/l, however it is not possible to confirm if these concentrations are below the EQS value of 0.001mg/l. Therefore, for the purpose of remedial target concentration calculations, the target concentration used was the limit of detection of 0.05 mg/l.

Since aluminium concentration in the River Clyde is recorded above the EQS value, the target concentration used to calculate the aluminium remedial target concentration was the background concentration of the contaminant in the River Clyde.

Table 5a. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (max. conc.) into the River Clyde

**Qu**

95 percentile low flow in the River Clyde 7.74 m3/s 668736 m3/d

Dilution Factor  $DF_1 = \frac{(Q_c + Q_u)C_c}{Q_c C_c + Q_u C_u}$   $DF_2 = \frac{C_T(Q_c + Q_u) - Q_u C_u}{Q_c C_T}$

Qc	Qc	Qu
l/s	m3/d	m3/d
150	12960	668736

Determinand	Units	Cc	Cu	Assessment Criteria (Cr)	Source	DF1	DF2	LTC1	LTC2	Final conc. In river
Aluminium	mg/l	0.14	0.11	0.11	g	1.27	1.000	0.139	0.110	0.111
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	47.440	0.050	0.237	0.005
Barium	mg/L	1.12	0.09	7.1	d	10	51.946	72.567	4.675	0.110
Boron	mg/l	0.3	0.05	2	a	5	51.310	10.958	2.566	0.055
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.005	0.005	0.005
Calcium	mg/l	205	34	250	b	6	45.582	1375.804	1549.802	37.251
Chromium	mg/l	0.031	0.002	0.01	a	12	42.280	0.122	0.085	0.003
ChromiumIV	mg/l	0.03	0.03	0.26	d	1.00	46.646	0.260	1.399	0.030
Copper	mg/l	0.011	0.002	0.01	a	5.07	42.280	0.051	0.085	0.002
Iron	mg/l	1.36	0.11	1	a	10	46.924	10.167	5.162	0.134
Lead	mg/l	0.017	0.002	0.01	a	7.44	42.280	0.074	0.085	0.002
Magnesium	mg/l	95	10	50	b	8	42.280	408.920	422.800	11.616
Manganese	mg/l	0.14	0.01	0.03	a	11	35.400	0.337	0.354	0.012
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.001	0.001	0.001
Potassium	mg/l	7	3.06	12	b	2	39.442	26.795	120.693	3.135
Nickel	mg/l	0.01	0.02	0.10	a	0.50	42.280	0.050	0.846	0.020
Sodium	mg/l	89	19	170	a	4	46.833	744.191	889.826	20.331
Selenium	mg/l	0.005	0.005	0.05	f	1.00	47.440	0.050	0.237	0.005
Zinc	mg/l	0.05	0.04	0.05	a	1.24	11.320	0.062	0.453	0.040
GRO	mg/l	0.01	0.01	0.047	f	1	41.621	0.047	0.416	0.010
DRO	mg/l	0.03	0.01	0.047	f	2.89	41.621	0.136	0.416	0.010
Methyl-tert-Butyl Ether	mg/l	0.01	0.01	0.1	e	1	47.440	0.100	0.474	0.010
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	52.591	0.030	0.0003	0.000005
Nitrate	mg/L	4.6	10.3	50	b	0.45	41.970	22.568	432.295	10.192
Ammonia as NH4	mg/l	0.48	0.05	0.5	b	8.25	47.440	4.125	2.372	0.058
Chloride	mg/l	330	25.5	250	a	11	47.337	2636.712	1207.088	31.289
Cyanide(total)	mg/l	0.05	0.05	0.05		1	1.000	0.050	0.050	0.050
Cyanide(free)	mg/l	0.05	0.05	0.05	a	1.00	1.000	0.050	0.050	0.050
pH	pH units	8.3	7.4	7.5	a	1.119	1.688	8.393	12.491	7.417
pH		7	7.4	7.5	a	0.947	1.688	7.102	12.491	7.392
Sulphate (total)	mg/l	405	39	400	a	9	47.569	3524.944	1855.191	45.958
Bicarbonate	mg/l	409	173	173	g	2	1.000	398.661	173.000	177.487
Electrical Conductivity	mg/l	1839	335	2500	b	5	45.686	12644.627	15304.676	363.593
BOD	mg/l	1	1	3	c	1.00	35.400	3.000	35.400	1.000
COD	mg/l	1	7	7	c	0.15	1.000	1.017	7.000	6.886
Acenaphthene	mg/l	0.00005	0.00001	n/a	n/a	4.65		n/a		0.00001
Acenaphthylene	mg/l	0.00005	0.00001	n/a	n/a	4.65		n/a		0.00001
Anthracene	mg/l	0.00005	0.00001	0.00002	a	4.65	26.800	0.0001	0.0003	0.00001
Benzo (a) anthracene	mg/l	0.00005	0.00001	0.001	d	4.65	52.084	0.005	0.001	0.00001
Benzo (a) pyrene	mg/l	0.00009	0.00001	0.00003	a	7.81	35.400	0.000	0.000	0.00001
Benzo (b/k) fluoranthene	mg/l	0.00009	0.00001	0.00036	d	7.81	51.167	0.003	0.001	0.00001
Benzo (ghi) perylene	mg/l	0.00011	0.00001	0.00018	d	9.24	49.733	0.002	0.000	0.00001
Chrysene	mg/l	0.00005	0.00001	0.0012	d	4.65	52.170	0.006	0.001	0.00001
Dibenzo (ah) anthracene	mg/l	0.00008	0.00001	n/a	n/a	7.06		n/a		0.00001
Fluoranthene	mg/l	0.00005	0.00001	0.00002	a	4.65	26.800	0.0001	0.0003	0.00001
Fluorene	mg/l	0.00005	0.00001	n/a	n/a	4.65		n/a		0.00001
Indeno (123-cd) pyrene	mg/l	0.00011	0.00001	0.000036	d	9.24	38.267	0.0003	0.0004	0.00001
Naphthalene	mg/l	0.00007	0.00001	0.01	a	6.28	52.548	0.063	0.001	0.00001
Phenanthrene	mg/l	0.00005	0.00001	0.03	d	4.65	52.583	0.139	0.001	0.00001
Pyrene	mg/l	0.00005	0.00001	n/a	n/a	4.65		n/a		0.00001
PAH sum of 4	mg/l	0.00031	0.00003	0.0001	b	8.78	37.120	0.001	0.001	0.00004
Cresols	mg/l	0.0005		10	d	53	52.600	526.000	0.000	0.00001
Xylenols	mg/l	0.0094		1.1	d	53	52.600	57.860	0.000	0.00018
Phenol	mg/l	0.0022	0.0005	0.03	a	4.13	51.740	0.124	0.026	0.001
Total TPH	mg/l	0.07	0.01	0.01	b	6.89	6.160	0.069	0.055	0.010

Calculation is based on 150l/s discharge of abstracted groundwater  
Cc = maximum contaminant concentration in abstracted groundwater (mg/l)  
Cu = contaminant concentration in River Clyde (background concentration) (mg/l)  
Cr = assessment criteria Concentration (mg/l)  
Qc = Groundwater Discharge Flow rate (m3/d)  
Qu = River Clyde Low Flow (Q95th) (m3/d)  
DF1 = Dilution Factor using Formula 1  
DF2 = Dilution Factor using Formula 2  
LTC1 = Remedial target concentration (mg/l) based on DF1  
LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
a = Freshwater EQS  
b = Water Supply (Water Quality) Regulations  
c = Freshwater Fisheries  
d = SRCeco RIVM report 711701 023  
e = Dutch Intervention Value  
f = Maryland Cleanup Stds.  
g = river background concentration

Table 5b. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (average conc.) into the River Clyde

**Qu**

95 percentile low flow in the River Clyde 7.74 m3/s 668736 m3/d

Dilution Factor  $DF_1 = \frac{(Q_c + Q_u)C_c}{Q_c C_c + Q_u C_u}$   $DF_2 = \frac{C_r(Q_c + Q_u) - Q_u C_u}{Q_c C_r}$

Qc l/s	Qc m3/d	Qu m3/d
150	12960	668736

Determinand	Units	Cc	Cu	Assessment Criteria (Cr)	Source	DF1	DF2	LTC1	LTC2	Final conc. In river
Aluminium	mg/l	0.058	0.11	0.11	g	0.54	1.000	0.0589	0.1100	0.1090
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	47.440	0.0500	0.2372	0.0050
Barium	mg/L	0.000	0.09	7.1	d	0	51.946	0.0000	4.6751	0.0883
Boron	mg/l	0.176	0.05	2	a	3	51.310	6.7181	2.5655	0.0524
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.0050	0.0050	0.0050
Calcium	mg/l	155.000	34	250	b	4	45.582	1067.4819	1549.8016	36.3004
Chromium	mg/l	0.014	0.002	0.01	a	6	42.280	0.0622	0.0846	0.0022
ChromiumIV	mg/l	0.027	0.03	0.26	d	0.89	46.646	0.2316	1.3994	0.0299
Copper	mg/l	0.013	0.002	0.01	a	5.75	42.280	0.0575	0.0846	0.0022
Iron	mg/l	0.513	0.11	1	a	4	46.924	4.3626	5.1616	0.1177
Lead	mg/l	0.014	0.002	0.01	a	6.22	42.280	0.0622	0.0846	0.0022
Magnesium	mg/l	63.125	10	50	b	6	42.280	286.6717	422.8000	11.0100
Manganese	mg/l	0.113	0.01	0.03	a	9	35.400	0.2842	0.3540	0.0120
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.0010	0.0010	0.0010
Potassium	mg/l	5.125	3.06	12	b	2	39.442	19.8435	120.6925	3.0993
Nickel	mg/l	0.010	0.02	0.10	a	0.50	42.280	0.0505	0.8456	0.0198
Sodium	mg/l	50.250	19	170	a	3	46.833	435.9729	889.8259	19.5941
Selenium	mg/l	0.005	0.005	0.05	f	1.00	47.440	0.0500	0.2372	0.0050
Zinc	mg/l	0.023	0.04	0.05	a	0.57	11.320	0.0286	0.4528	0.0397
GRO	mg/l	0.016	0.01	0.047	f	2	41.621	0.0755	0.4162	0.0101
DRO	mg/l	0.010	0.01	0.047	f	1.00	41.621	0.0470	0.4162	0.0100
Methyl-tert-Butyl Ether	mg/l	0.010	0.01	0.1	e	1	47.440	0.1000	0.4744	0.0100
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	52.591	0.0300	0.0003	0.000005
Nitrate	mg/L	0.750	10.3	50	b	0.07	41.970	3.7061	432.2951	10.1184
Ammonia as NH4	mg/l	0.293	0.05	0.5	b	5.37	47.440	2.6849	2.3720	0.0546
Chloride	mg/l	121.750	25.5	250	a	4	47.337	1113.7091	1207.0884	27.3298
Cyanide(total)	mg/l	0.050	0.05	0.05	1	1.000	1.000	0.0500	0.0500	0.0500
Cyanide(free)	mg/l	0.050	0.05	0.05	a	1.00	1.000	0.0500	0.0500	0.0500
pH	pH units	7.291	7.4	7.5	a	0.986	1.688	7.3915	12.4912	7.3979
pH		7.000	7.4	7.5	a	0.947	1.688	7.1019	12.4912	7.3924
Sulphate (total)	mg/l	247.364	39	400	a	6	47.569	2303.1307	1855.1910	42.9613
Bicarbonate	mg/l	476.667	173	173	g	3	1.000	461.2736	173.0000	178.7731
Electrical Conductivity	mg/l	1407.400	335	2500	b	4	45.686	9900.4515	15304.6760	355.3878
BOD	mg/l	1	1	3	c	1.00	35.400	3.0000	35.4000	1.0000
COD	mg/l	1	7	7	c	0.15	1.000	1.0166	7.0000	6.8859
Acenaphthene	mg/l	0.00002	0.00001	n/a	n/a	1.49		n/a		0.000010
Acenaphthylene	mg/l	0.00002	0.00001	n/a	n/a	1.49		n/a		0.000010
Anthracene	mg/l	0.00002	0.00001	0.00002	a	1.49	26.800	0.0000	0.0003	0.000010
Benzo (a) anthracene	mg/l	0.00002	0.00001	0.001	d	1.61	52.084	0.0016	0.0005	0.000010
Benzo (a) pyrene	mg/l	0.00004	0.00001	0.00003	a	4.00	35.400	0.0001	0.0004	0.000011
Benzo (b/k) fluoranthene	mg/l	0.00004	0.00001	0.00036	d	3.89	51.167	0.0014	0.0005	0.000011
Benzo (ghi) perylene	mg/l	0.00005	0.00001	0.00018	d	4.96	49.733	0.0009	0.0005	0.000011
Chrysene	mg/l	0.00002	0.00001	0.0012	d	1.61	52.170	0.0019	0.0005	0.000010
Dibenzo (ah) anthracene	mg/l	0.00004	0.00001	n/a	n/a	3.89		n/a		0.000011
Fluoranthene	mg/l	0.00002	0.00001	0.00002	a	1.96	26.800	0.0000	0.0003	0.000010
Fluorene	mg/l	0.00002	0.00001	n/a	n/a	1.49		n/a		0.000010
Indeno (123-cd) pyrene	mg/l	0.00005	0.00001	0.000036	d	4.96	38.267	0.0002	0.0004	0.000011
Naphthalene	mg/l	0.00005	0.00001	0.01	a	4.33	52.548	0.0433	0.0005	0.000011
Phenanthrene	mg/l	0.00002	0.00001	0.03	d	2.31	52.583	0.0694	0.0005	0.000010
Pyrene	mg/l	0.00002	0.00001	n/a	n/a	1.73		n/a		0.000010
PAH sum of 4	mg/l	0.00015	0.00003	0.0001	b	4.61	37.120	0.0005	0.0011	0.000032
Cresols	mg/l	0.0005		10	d	53	52.600	526.0000	0.0000	0.000010
Xylenols	mg/l	0.0005		1.1	d	53	52.600	57.8600	0.0000	0.000010
Phenol	mg/l	0.0004	0.0005	0.03	a	0.79	51.740	0.0236	0.0259	0.000498
Total TPH	mg/l	0.04	0.01	0.01	b	4.17	6.160	0.0417	0.0554	0.009589

Calculation is based on 150l/s discharge of abstracted groundwater  
Cc = average contaminant concentration in abstracted groundwater (mg/l)  
Cu = contaminant concentration in River Clyde (background concentration) (mg/l)  
Cr = assessment criteria Concentration (mg/l)  
Qc = Groundwater Discharge Flow rate (m3/d)  
Qu = River Clyde Low Flow (Q95th) (m3/d)  
DF1 = Dilution Factor using Formula 1  
DF2 = Dilution Factor using Formula 2  
LTC1 = Remedial target concentration (mg/l) based on DF1  
LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
a = Freshwater EQS  
b = Water Supply (Water Quality) Regulations  
c = Freshwater Fisheries  
d = SRCeco RIVM report 711701 023  
e = Dutch Intervention Value  
f = Maryland Cleanup Stds.  
g = river background concentration

Table 5c. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (max. conc.) into Pond 1 (SSSI)

**Qu calculation**

Burn Low Flow (Q95th) 4.3 l/s 0.0043 m3/s 371.52 m3/d

$$DF_1 = \frac{(Q_c + Q_u)C_c}{Q_c C_c + Q_u C_u} \quad DF_2 = \frac{C_r(Q_c + Q_u) - Q_u C_u}{Q_c C_r}$$

Qc	Qc	Qu
l/s	m3/d	m3/d
1	86	371.52

Determinand	Units	Cc	Cu	Assessment Criteria (Cr)	Source	DF1	DF2	LTC1	LTC2	Final conc. In Pond 1
Aluminium	mg/l	0.14	0.08	0.08	g	1.53	1.000	0.123	0.080	0.091
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	4.870	0.050	0.024	0.005
Barium	mg/L	1.12	0.08	7.1	d	4	5.252	28.788	0.420	0.276
Boron	mg/l	0.3	0.20	2	a	1	4.870	2.741	0.974	0.219
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.005	0.005	0.005
Calcium	mg/l	205	120	250	b	2	3.236	376.734	388.320	136.038
Chromium	mg/l	0.031	0.003333333	0.05	a	4	5.013	0.181	0.017	0.009
ChromiumIV	mg/l	0.03		0.26	d	5.30	5.300	1.378	0.000	0.006
Copper	mg/l	0.011	0.002333333	0.028	a	2.77	4.942	0.078	0.012	0.004
Iron	mg/l	1.36	0.073333333	1	a	4	4.985	4.302	0.366	0.316
Lead	mg/l	0.017	0.002666667	0.02	a	3.17	4.727	0.063	0.013	0.005
Magnesium	mg/l	95	35	50	b	2	2.290	102.546	80.150	46.321
Manganese	mg/l	0.14	0.303333333	0.303333333	g	1	1.000	0.156	0.303	0.273
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.001	0.001	0.001
Potassium	mg/l	7	6.17	12	b	1	3.089	13.277	19.060	6.327
Nickel	mg/l	0.01	0.01	0.20	a	1.00	5.085	0.200	0.051	0.010
Sodium	mg/l	89	90	170	a	1	3.024	168.464	272.118	89.811
Selenium	mg/l	0.005	0.005	0.05	f	1.00	4.870	0.050	0.024	0.005
Zinc	mg/l	0.05	0.04	0.125	a	1.19	3.924	0.149	0.157	0.042
GRO	mg/l	0.01	0.01	0.047	f	1	4.385	0.047	0.044	0.010
DRO	mg/l	0.03	0.01	0.047	f	2.18	4.385	0.102	0.044	0.014
Methyl-tert-Butyl Ether	mg/l	0.01		0.1	e	5	5.300	0.530	0.0000	0.002
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	5.299	0.030	0.00003	0.000005
Nitrate	mg/L	4.6	7.4	50	b	0.67	4.664	33.471	34.511	6.872
Ammonia as NH4	mg/l	0.48	0.263333333	0.5	b	1.58	3.035	0.789	0.799	0.304
Chloride	mg/l	330	97.2	250	a	2	3.628	584.590	352.657	141.125
Cyanide(total)	mg/l	0.05		0.05	b	5	5.300	0.265	0.000	0.009
Cyanide(free)	mg/l	0.05	0.05	0.05	g	1.00	1.000	0.050	0.050	0.050
pH	pH units	8.3	7.5	7.5	a	1.085	1.000	8.136	7.500	7.651
pH		7	7.5	7.5	a	0.945	1.000	7.089	7.500	7.406
Sulphate (total)	mg/l	405	196	400	a	2	3.193	688.091	625.828	235.434
Bicarbonate	mg/l	409	362.3333333	362.3333333	g	1	1.000	399.297	362.333	371.138
Electrical Conductivity	mg/l	1839	1167	2500	b	1	3.293	3553.507	3842.651	1293.792
BOD	mg/l	1		3	c	5.30	5.300	15.900	0.000	0.189
COD	mg/l	1	20	20	g	0.06	1.000	1.218	20.000	16.415
Acenaphthene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Acenaphthylene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Anthracene	mg/l	0.00005	0.00005	0.00005	g	1.00	1.000	0.000	0.0001	0.00005
Benzo (a) anthracene	mg/l	0.00005	0.00005	0.001	d	1.00	5.085	0.001	0.0003	0.00005
Benzo (a) pyrene	mg/l	0.00009	0.00005	0.00005	g	1.56	1.000	0.000	0.0001	0.00006
Benzo (b/k) fluoranthene	mg/l	0.00009	0.00005	0.00036	d	1.56	4.703	0.001	0.0002	0.00006
Benzo (ghi) perylene	mg/l	0.00011	0.00005	0.00018	d	1.79	4.106	0.000	0.0002	0.00006
Chrysene	mg/l	0.00005	0.00005	0.0012	d	1.00	5.121	0.001	0.0003	0.00005
Dibenzo (ah) anthracene	mg/l	0.00008	0.00005	n/a	n/a	1.44		n/a		0.00006
Fluoranthene	mg/l	0.00005	0.00005	0.00005	g	1.00	1.000	0.000	0.0001	0.00005
Fluorene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Indeno (123-cd) pyrene	mg/l	0.00011	0.00005	0.00005	g	1.79	1.000	0.000	0.0001	0.00006
Naphthalene	mg/l	0.00007	0.00005	0.01	a	1.30	5.279	0.013	0.0003	0.00005
Phenanthrene	mg/l	0.00005	0.00005	0.03	d	1.00	5.293	0.030	0.0003	0.00005
Pyrene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
PAH sum of 4	mg/l	0.00031	0.00015	0.00015	b	1.72	1.000	0.000	0.0002	0.0002
Cresols	mg/l	0.0005		10	d	5	5.300	53.000	0.0000	0.00009
Xylenols	mg/l	0.0094		1.1	d	5	5.300	5.830	0.0000	0.002
Phenol	mg/l	0.0022	0.0005	0.03	a	2.68	5.228	0.080	0.003	0.001
Total TPH	mg/l	0.07	0.01	0.01	b	3.41	1.430	0.034	0.013	0.021

Calculation is based on 1l/s discharge of abstracted groundwater  
Cc = maximum contaminant concentration in abstracted groundwater (mg/l)  
Cu = contaminant concentration in Pond 1 (background concentration) (mg/l)  
Cr = assessment criteria Concentration (mg/l)  
Qc = Groundwater Discharge Flow rate (m3/d)  
Qu = Burn Low Flow (m3/d)  
DF1 = Dilution Factor using Formula 1  
DF2 = Dilution Factor using Formula 2  
LTC1 = Remedial target concentration (mg/l) based on DF1  
LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
a = Freshwater EQS  
b = Water Supply (Water Quality) Regulations  
c = Freshwater Fisheries  
d = SRCeco RIVM report 711701 023  
e = Dutch Intervention Value  
f = Maryland Cleanup Stds.  
g = Pond 1 (SSSI) background concentration

Table 5d. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (average conc.) into Pond 1 (SSSI)

**Qu**

Burn Low Flow (Q95th) 4.3 l/s 0.0043 m3/s 371.52 m3/d

$$DF_1 = \frac{(Q_c + Q_u) C_c}{Q_c C_c + Q_u C_u} \quad DF_2 = \frac{C_r(Q_c + Q_u) - Q_u C_u}{Q_c C_r}$$

Qc	Qc	Qu
l/s	m3/d	m3/d
1	86	371.52

Determinand	Units	Cc	Cu	Assessment Criteria (Cr)	Source	DF1	DF2	LTC1	LTC2	Final conc. In Pond 1
Aluminium	mg/l	0.058	0.08	0.08	g	0.77	1.000	0.061	0.080	0.076
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	4.870	0.050	0.024	0.005
Barium	mg/L	0.000	0.08	7.1	d	0	5.252	0.000	0.420	0.065
Boron	mg/l	0.176	0.20	2	a	1	4.870	1.801	0.974	0.195
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.005	0.005	0.005
Calcium	mg/l	155.000	120	250	b	1	3.236	306.073	388.320	126.604
Chromium	mg/l	0.014	0.003333333	0.05	a	3	5.013	0.130	0.017	0.005
ChromiumIV	mg/l	0.027		0.26	d	5.30	5.300	1.378	0.000	0.005
Copper	mg/l	0.013	0.002333333	0.028	a	2.96	4.942	0.083	0.012	0.004
Iron	mg/l	0.513	0.073333333	1	a	3	4.985	3.283	0.366	0.156
Lead	mg/l	0.014	0.002666667	0.02	a	2.90	4.727	0.058	0.013	0.005
Magnesium	mg/l	63.125	35	50	b	2	2.290	78.306	80.150	40.307
Manganese	mg/l	0.113	0.303333333	0.303333333	g	0	1.000	0.129	0.303	0.267
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.001	0.001	0.001
Potassium	mg/l	5.125	6.17	12	b	1	3.089	10.297	19.060	5.973
Nickel	mg/l	0.010	0.01	0.20	a	1.00	5.085	0.200	0.051	0.010
Sodium	mg/l	50.250	90	170	a	1	3.024	103.545	272.118	82.500
Selenium	mg/l	0.005	0.005	0.05	f	1.00	4.870	0.050	0.024	0.005
Zinc	mg/l	0.023	0.04	0.125	a	0.62	3.924	0.077	0.157	0.037
GRO	mg/l	0.016	0.01	0.047	f	1	4.385	0.068	0.044	0.011
DRO	mg/l	0.010	0.01	0.047	f	1.00	4.385	0.047	0.044	0.010
Methyl-tert-Butyl Ether	mg/l	0.010		0.1	e	5	5.300	0.530	0.000	0.002
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	5.299	0.030	0.00003	0.000005
Nitrate	mg/L	0.750	7.4	50	b	0.12	4.664	6.102	34.511	6.145
Ammonia as NH4	mg/l	0.293	0.263333333	0.5	b	1.09	3.035	0.545	0.799	0.269
Chloride	mg/l	121.750	97.2	250	a	1	3.628	298.899	352.657	101.832
Cyanide(total)	mg/l	0.050		0.05	b	5	5.300	0.265	0.000	0.009
Cyanide(free)	mg/l	0.050	0.05	0.05	g	1.00	1.000	0.050	0.050	0.050
pH	pH units	7.291	7.5	7.5	a	0.977	1.000	7.329	7.500	7.461
pH		7.000	7.5	7.5	a	0.945	1.000	7.089	7.500	7.406
Sulphate (total)	mg/l	247.364	196	400	a	1	3.193	481.039	625.828	205.691
Bicarbonate	mg/l	476.667	362.3333333	362.3333333	g	1	1.000	449.882	362.333	383.906
Electrical Conductivity	mg/l	1407.400	1167	2500	b	1	3.293	2902.194	3842.651	1212.358
BOD	mg/l	1		3	c	5.30	5.300	15.900	0.000	0.189
COD	mg/l	1	20	20	g	0.06	1.000	1.218	20.000	16.415
Acenaphthene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Acenaphthylene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Anthracene	mg/l	0.00002	0.00005	0.00005	g	0.35	1.000	0.000	0.0001	0.00004
Benzo (a) anthracene	mg/l	0.00002	0.00005	0.001	d	0.37	5.085	0.000	0.0003	0.00004
Benzo (a) pyrene	mg/l	0.00004	0.00005	0.00005	g	0.87	1.000	0.000	0.0001	0.00005
Benzo (b/k) fluoranthene	mg/l	0.00004	0.00005	0.00036	d	0.85	4.703	0.000	0.0002	0.00005
Benzo (ghi) perylene	mg/l	0.00005	0.00005	0.00018	d	1.06	4.106	0.000	0.0002	0.00005
Chrysene	mg/l	0.00002	0.00005	0.0012	d	0.37	5.121	0.000	0.0003	0.00004
Dibenzo (ah) anthracene	mg/l	0.00004	0.00005	n/a	n/a	0.85		n/a		0.00005
Fluoranthene	mg/l	0.00002	0.00005	0.00005	g	0.45	1.000	0.000	0.0001	0.00004
Fluorene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Indeno (123-cd) pyrene	mg/l	0.00005	0.00005	0.00005	g	1.06	1.000	0.000	0.0001	0.00005
Naphthalene	mg/l	0.00005	0.00005	0.01	a	0.94	5.279	0.009	0.0003	0.00005
Phenanthrene	mg/l	0.00002	0.00005	0.03	d	0.53	5.293	0.016	0.0003	0.00005
Pyrene	mg/l	0.00002	0.00005	n/a	n/a	0.40		n/a		0.00004
PAH sum of 4	mg/l	0.00015	0.00015	0.00015	b	0.99	1.000	0.000	0.0002	0.0001
Cresols	mg/l	0.0005		10	d	5	5.300	53.000	0.0000	0.00009
Xylenols	mg/l	0.0005		1.1	d	5	5.300	5.830	0.0000	0.00009
Phenol	mg/l	0.0004	0.0005	0.03	a	0.82	5.228	0.024	0.003	0.0005
Total TPH	mg/l	0.04	0.01	0.01	b	2.69	1.430	0.027	0.013	0.015

Calculation is based on 1l/s discharge of abstracted groundwater  
 Cc = average contaminant concentration in abstracted groundwater (mg/l)  
 Cu = contaminant concentration in Pond 1 (background concentration) (mg/l)  
 Cr = assessment criteria Concentration (mg/l)  
 Qc = Groundwater Discharge Flow rate (m3/d)  
 Qu = Burn Low Flow (m3/d)  
 DF1 = Dilution Factor using Formula 1  
 DF2 = Dilution Factor using Formula 2  
 LTC1 = Remedial target concentration (mg/l) based on DF1  
 LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
 a = Freshwater EQS  
 b = Water Supply (Water Quality) Regulations  
 c = Freshwater Fisheries  
 d = SRCeco RIVM report 711701 023  
 e = Dutch Intervention Value  
 f = Maryland Cleanup Stds.  
 g = Pond 1 (SSSI) background concentration

Table 5e. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (max. conc.) into Pond 5

**Qu calculation**

Burn Low Flow (Q95th) 4.3 l/s 0.0043 m3/s 371.52 m3/d

$$DF_1 = \frac{(Q_c + Q_u)C_c}{Q_c C_c + Q_u C_u} \quad DF_2 = \frac{C_T(Q_c + Q_u) - Q_u C_u}{Q_c C_T}$$

Qc l/s	Qc m3/d	Qu m3/d
1	86	371.52

Determinand	Units	Cc	Cu	Assessment Criteria (C <sub>T</sub> )	Source	DF1	DF2	LTC1	LTC2	Final conc. In Pond 5
Aluminium	mg/l	0.14	0.09	0.09	g	1.41	1.000	0.127	0.090	0.099
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	4.870	0.050	0.024	0.005
Barium	mg/L	1.12	0.07	7.1	d	4	5.258	29.659	0.368	0.268
Boron	mg/l	0.3	0.10	2	a	2	5.085	4.356	0.509	0.138
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.005	0.005	0.005
Calcium	mg/l	205	96	250	b	2	3.649	439.665	350.285	116.566
Chromium	mg/l	0.031	0.005	0.05	a	3	4.870	0.156	0.024	0.010
ChromiumIV	mg/l	0.03		0.26	d	5.30	5.300	1.378	0.000	0.006
Copper	mg/l	0.011	0.001	0.028	a	3.81	5.146	0.107	0.005	0.003
Iron	mg/l	1.36	0.18	1	a	3	4.526	3.378	0.815	0.403
Lead	mg/l	0.017	0.004	0.02	a	2.63	4.440	0.053	0.018	0.006
Magnesium	mg/l	95	35	50	b	2	2.290	102.546	80.150	46.321
Manganese	mg/l	0.14	0.04	0.04	g	2	1.000	0.095	0.040	0.059
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.001	0.001	0.001
Potassium	mg/l	7	3.91	12	b	2	3.899	18.696	15.245	4.493
Nickel	mg/l	0.01	0.01	0.20	a	1.00	5.085	0.200	0.051	0.010
Sodium	mg/l	89	30	170	a	2	4.541	367.839	136.235	41.132
Selenium	mg/l	0.005		0.05	f	5.30	5.300	0.265	0.000	0.001
Zinc	mg/l	0.05	0.03	0.075	a	1.48	3.580	0.111	0.107	0.034
GRO	mg/l	0.01	0.01	0.047	f	1	4.385	0.047	0.044	0.010
DRO	mg/l	0.03	0.01	0.047	f	2.18	4.385	0.102	0.044	0.014
Methyl-tert-Butyl Ether	mg/l	0.01		0.1	e	5	5.300	0.530	0.000	0.002
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	5.299	0.030	0.00003	0.000005
Nitrate	mg/L	4.6	0.1	50	b	4.85	5.291	242.346	0.529	0.949
Ammonia as NH4	mg/l	0.48	0.31	0.5	b	1.40	2.634	0.702	0.817	0.342
Chloride	mg/l	330	46.5	250	a	3	4.500	825.078	209.259	99.991
Cyanide(total)	mg/l	0.05		0.05	b	5	5.300	0.265	0.000	0.009
Cyanide(free)	mg/l	0.05	0.05	0.05	g	1.00	1.000	0.050	0.050	0.050
pH	pH units	8.3	7.8	7.5	a	1.051	0.828	7.885	6.458	7.894
pH		7	7.8	7.5	a	0.915	0.828	6.864	6.458	7.649
Sulphate (total)	mg/l	405	150	400	a	2	3.688	817.714	553.125	198.113
Bicarbonate	mg/l	409	238	238	g	2	1.000	360.174	238.000	270.264
Electrical Conductivity	mg/l	1839	795	2500	b	2	3.933	4634.665	3126.417	991.981
BOD	mg/l	1		3	c	5.30	5.300	15.900	0.000	0.189
COD	mg/l	1		7	c	5.30	5.300	37.100	0.000	0.189
Acenaphthene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Acenaphthylene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Anthracene	mg/l	0.00005	0.00005	0.00005	g	1.00	1.000	0.0001	0.0001	0.00005
Benzo (a) anthracene	mg/l	0.00005	0.00005	0.001	d	1.00	5.085	0.001	0.0003	0.00005
Benzo (a) pyrene	mg/l	0.00009	0.00005	0.00005	g	1.56	1.000	0.0001	0.0001	0.00006
Benzo (b/k) fluoranthene	mg/l	0.00009	0.00005	0.00036	d	1.56	4.703	0.001	0.0002	0.00006
Benzo (ghi) perylene	mg/l	0.00011	0.00005	0.00018	d	1.79	4.106	0.0003	0.0002	0.00006
Chrysene	mg/l	0.00005	0.00005	0.0012	d	1.00	5.121	0.001	0.0003	0.00005
Dibenzo (ah) anthracene	mg/l	0.00008	0.00005	n/a	n/a	1.44		n/a		0.00006
Fluoranthene	mg/l	0.00005	0.00005	0.00005	g	1.00	1.000	0.0001	0.0001	0.00005
Fluorene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
Indeno (123-cd) pyrene	mg/l	0.00011	0.00005	0.00005	g	1.79	1.000	0.000	0.0001	0.00006
Naphthalene	mg/l	0.00007	0.00005	0.01	a	1.30	5.279	0.013	0.0003	0.00005
Phenanthrene	mg/l	0.00005	0.00005	0.03	d	1.00	5.293	0.030	0.0003	0.00005
Pyrene	mg/l	0.00005	0.00005	n/a	n/a	1.00		n/a		0.00005
PAH sum of 4	mg/l	0.00031	0.00015	0.00015	g	1.72	1.000	0.000	0.0002	0.0002
Cresols	mg/l	0.0005		10	d	5	5.300	53.000	0.000	0.00009
Xylenols	mg/l	0.0094		1.1	d	5	5.300	5.830	0.000	0.002
Phenol	mg/l	0.0022		0.03	a	5.30	5.300	0.159	0.000	0.0004
Total TPH	mg/l	0.07	0.01	0.01	b	3.41	1.430	0.034	0.013	0.021

Calculation is based on 1l/s discharge of abstracted groundwater  
 Cc = maximum contaminant concentration in abstracted groundwater (mg/l)  
 Cu = contaminant concentration in Pond 5 (background concentration) (mg/l)  
 C<sub>T</sub> = assessment criteria Concentration (mg/l)  
 Qc = Groundwater Discharge Flow rate (m3/d)  
 Qu = Burn Low Flow (m3/d)  
 DF1 = Dilution Factor using Formula 1  
 DF2 = Dilution Factor using Formula 2  
 LTC1 = Remedial target concentration (mg/l) based on DF1  
 LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
 a = Freshwater EQS  
 b = Water Supply (Water Quality) Regulations  
 c = Freshwater Fisheries  
 d = SRCeco RIVM report 711701 023  
 e = Dutch Intervention Value  
 f = Maryland Cleanup Stds.  
 g = Pond 5 background concentration

Table 5f. Dilution Factor and Remedial Target Concentration Calculations to discharge abstracted groundwater (average conc.) into Pond 5

**Qu**

Burn Low Flow (Q95th) 4.3 l/s 0.0043 m3/s 371.52 m3/d

$$DF_1 = \frac{(Q_c + Q_u) C_c}{Q_c C_c + Q_u C_u} \quad DF_2 = \frac{C_r(Q_c + Q_u) - Q_u C_u}{Q_c C_r}$$

River		
Qc	Qc	Qu
l/s	m3/d	m3/d
1	86	371.52

Groundwater Pond 5

Determinand	Units	Cc	Cu	Assessment Criteria (Cr)	Source	DF1	DF2	LTC2-1	LTC2-2	Final conc. In Pond 5
Aluminium	mg/l	0.058	0.09	0.09	g	0.69	1.000	0.062	0.090	0.084
Arsenic	mg/l	0.005	0.005	0.05	a	1.00	4.870	0.050	0.024	0.005
Barium	mg/L	0.000	0.07	7.1	d	0	5.258	0.000	0.368	0.057
Boron	mg/l	0.176	0.10	2	a	2	5.085	3.079	0.509	0.114
Cadmium	mg/l	0.005	0.005	0.005	a	1.00	1.000	0.005	0.005	0.005
Calcium	mg/L	155.000	96	250	b	1	3.649	361.703	350.285	107.132
Chromium	mg/l	0.014	0.005	0.05	a	2	4.870	0.104	0.024	0.007
ChromiumIV	mg/l	0.027	0.26	0.26	d	5.30	5.300	1.378	0.000	0.005
Copper	mg/l	0.013	0.001	0.028	a	3.96	5.146	0.111	0.005	0.003
Iron	mg/l	0.513	0.18	1	a	2	4.526	2.113	0.815	0.243
Lead	mg/l	0.014	0.004	0.02	a	2.36	4.440	0.047	0.018	0.006
Magnesium	mg/l	63.125	35	50	b	2	2.290	78.306	80.150	40.307
Manganese	mg/l	0.113	0.04	0.04	g	2	1.000	0.084	0.040	0.054
Mercury	mg/l	0.001	0.001	0.001	a	1.00	1.000	0.001	0.001	0.001
Potassium	mg/l	5.125	3.91	12	b	1	3.899	14.858	15.245	4.139
Nickel	mg/l	0.010	0.01	0.20	a	1.00	5.085	0.200	0.051	0.010
Sodium	mg/l	50.250	30	170	a	1	4.541	252.582	136.235	33.821
Selenium	mg/l	0.005	0.05	0.05	f	5.30	5.300	0.265	0.000	0.001
Zinc	mg/l	0.023	0.03	0.075	a	0.79	3.580	0.060	0.107	0.029
GRO	mg/l	0.016	0.01	0.047	f	1	4.385	0.068	0.044	0.011
DRO	mg/l	0.010	0.01	0.047	f	1.00	4.385	0.047	0.044	0.010
Methyl-tert-Butyl Ether	mg/l	0.010	0.1	0.1	e	5	5.300	0.530	0.000	0.002
PCB (total)	mg/l	0.000005	0.000005	0.03	a	1.00	5.299	0.030	0.00003	0.000005
Nitrate	mg/L	0.750	0.1	50	b	3.37	5.291	168.432	0.529	0.223
Ammonia as NH4	mg/l	0.293	0.31	0.5	b	0.96	2.634	0.478	0.817	0.307
Chloride	mg/l	121.750	46.5	250	a	2	4.500	501.457	209.259	60.698
Cyanide(total)	mg/l	0.050	0.05	0.05	b	5	5.300	0.265	0.000	0.009
Cyanide(free)	mg/l	0.050	0.05	0.05	g	1.00	1.000	0.050	0.050	0.050
pH	pH units	7.291	7.8	7.5	a	0.946	0.828	7.098	6.458	7.704
pH		7.000	7.8	7.5	a	0.915	0.828	6.864	6.458	7.649
Sulphate (total)	mg/l	247.364	150	400	a	1	3.688	587.665	553.125	168.370
Bicarbonate	mg/l	476.667	238	238	g	2	1.000	400.827	238.000	283.031
Electrical Conductivity	mg/l	1407.400	795	2500	b	2	3.933	3864.160	3126.417	910.547
BOD	mg/l	1		3	c	5.30	5.300	15.900	0.000	0.189
COD	mg/l	1		7	c	5.30	5.300	37.100	0.000	0.189
Acenaphthene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Acenaphthylene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Anthracene	mg/l	0.00002	0.00005	0.00005	g	0.35	1.000	0.00002	0.0001	0.00004
Benzo (a) anthracene	mg/l	0.00002	0.00005	0.001	d	0.37	5.085	0.0004	0.0003	0.00004
Benzo (a) pyrene	mg/l	0.00004	0.00005	0.00005	g	0.87	1.000	0.00004	0.0001	0.00005
Benzo (b/k) fluoranthene	mg/l	0.00004	0.00005	0.00036	d	0.85	4.703	0.0003	0.0002	0.00005
Benzo (ghi) perylene	mg/l	0.00005	0.00005	0.00018	d	1.06	4.106	0.0002	0.0002	0.00005
Chrysene	mg/l	0.00002	0.00005	0.0012	d	0.37	5.121	0.0004	0.0003	0.00004
Dibenzo (ah) anthracene	mg/l	0.00004	0.00005	n/a	n/a	0.85		n/a		0.00005
Fluoranthene	mg/l	0.00002	0.00005	0.00005	g	0.45	1.000	0.00002	0.0001	0.00004
Fluorene	mg/l	0.00002	0.00005	n/a	n/a	0.35		n/a		0.00004
Indeno (123-cd) pyrene	mg/l	0.00005	0.00005	0.00005	g	1.06	1.000	0.0001	0.0001	0.00005
Naphthalene	mg/l	0.00005	0.00005	0.01	a	0.94	5.279	0.009	0.0003	0.00005
Phenanthrene	mg/l	0.00002	0.00005	0.03	d	0.53	5.293	0.016	0.0003	0.00005
Pyrene	mg/l	0.00002	0.00005	n/a	n/a	0.40		n/a		0.00004
PAH sum of 4	mg/l	0.00015	0.00015	0.00015	g	0.99	1.000	0.0001	0.0002	0.0001
Cresols	mg/l	0.0005		10	d	5	5.300	53.000	0.000	0.00009
Xylenols	mg/l	0.0005		1.1	d	5	5.300	5.830	0.000	0.00009
Phenol	mg/l	0.0004		0.03	a	5.30	5.300	0.159	0.000	0.00007
Total TPH	mg/l	0.04	0.01	0.01	b	2.69	1.430	0.027	0.013	0.015

Calculation is based on 1l/s discharge of abstracted groundwater  
Cc = average contaminant concentration in abstracted groundwater (mg/l)  
Cu = contaminant concentration in Pond 5 (background concentration) (mg/l)  
Cr = assessment criteria Concentration (mg/l)  
Qc = Groundwater Discharge Flow rate (m3/d)  
Qu = Burn Low Flow (m3/d)  
DF1 = Dilution Factor using Formula 1  
DF2 = Dilution Factor using Formula 2  
LTC1 = Remedial target concentration (mg/l) based on DF1  
LTC2 = Remedial target concentration (mg/l) based on DF2

Source  
a = Freshwater EQS  
b = Water Supply (Water Quality) Regulations  
c = Freshwater Fisheries  
d = SRCeco RIVM report 711701 023  
e = Dutch Intervention Value  
f = Maryland Cleanup Stds.  
g = Pond 5 background concentration

## Appendix 4 – Hazardous Waste Classification procedure

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## Hazardous Waste Classification

The methodology for waste classification is described under the Hazardous Waste Assessment Framework for Contaminated Soils<sup>(6)</sup>. The methodology has been followed and the outcome is described as follows:

The excavated soils represent a Directive waste under the Waste Framework Directive and a Controlled Waste under the UK Waste Management legislation for household, commercial and industrial waste, as a result the excavated soils represent a potential hazardous waste.

Under the European Waste catalogue (EWC)<sup>(7)</sup> the arising soils from the underpass excavation fit within the 17 05 03 category (soil including excavated soil from contaminated sites - containing dangerous substances), however this waste is considered a "Mirror" entry, so it is regarded as a hazardous waste only if the dangerous substances are present above threshold concentrations.

In order to identify the composition of the excavated soil (waste), references to information such as desk studies or historical data has to be checked in order to identify the possible sources of contamination on site. It is important to mention that when undertaking a hazardous waste classification all the contaminants have to be evaluated regardless of their potential risk, since a hazardous waste classification is based on hazard and not on risk. In order to identify the associated risk phrases to each contaminant present in the excavated soils the Approved Supply List (ASL)<sup>(8)</sup> has been consulted

Based on the characterisation of the waste, the hazardous properties were identified as H1 to H14.

## Hazardous Waste Assessment Methodology

There is a series of steps involved in determining if contaminated soil and other wastes arising from the remediation of contaminated land, is hazardous or non-hazardous waste, which is common to all wastes and described in more detail in TG WM2(1). The steps are as follows:

- Step 1            Decide if it is controlled or Directive waste
- Step 2            Decide if it is a domestic waste
- Step 3            Identify wastes in the EWC catalogue
- Step 4            Identify the composition of waste
- Step 5a           Identify the risks phrases that apply to each contaminant in the waste. The Approved Supply List (ASL) should be used to give all the risk phrases for substances in the waste. If the substance is not in the ASL, then Safety Data Sheets (SDS) or other peer reviewed data using the Approved Classification and Labelling Guide (12) should be used to determine the risk phrases. If there is no data available then there is likely to be a requirement for testing (see Step 5b).  
  
                      Identify the hazardous properties and relevant threshold concentrations for each contaminant
- Step5b           Test the waste to determine if it possesses any hazardous properties in cases where substances identified in Step 4 are not on ASL or where SDS are not available.  
  
                      Test for flash point (flammable) and pH (irritant/corrosive), where appropriate
- Step 6            Record the threshold concentrations and relevant hazards concentrations for each component

The methodology has been followed and the outcome is described as follows:

The excavated soils represent a Directive waste under the Waste Framework Directive and a Controlled Waste under the UK Waste Management legislation for household, commercial and industrial waste; as a result the excavated soils represent a potential hazardous waste.

Under the European Waste catalogue (EWC) the arising soils from the hospice excavation fit within the 17 05 03 category (soil including excavated soil from contaminated sites - containing dangerous substances), however this waste is considered a "Mirror" entry, in which case it is regarded as a hazardous waste only if the dangerous substances are present above threshold concentrations.

In order to identify the composition of the excavated soil (waste) reference to information such as desk studies, historical data and ground investigations has to be checked in order to identify the possible sources of contamination on site. It is

important to mention that when undertaking a hazardous waste classification all the contaminants have to be evaluated regardless of their potential risk, since a hazardous waste classification is based on hazard and not on risk. In order to identify the associated risk phrases to each contaminant present in the excavated soils the Approved Supply List (ASL) has been consulted

Based on the characterisation of the waste the hazardous properties were identified as H1 to H14. After assessment of threshold concentrations and relevant associated hazards it can be stated that the excavated soils at St. Margaret's Hospice fall within the H14 and H5 hazardous properties.

