CASE STUDY

Ex-Situ / In-Situ E-Clay Stabilisation

Remediation of Former Gas Works
Dalmarnock, Glasgow

Client

Clyde Gateway

Main Contractor

I & H BROWN LIMITED

Environmental Consultants

Grontmij

Site Background & History

The Dalmarnock Gas Works was opened in 1843 and later extended in 1856 and 1871. The works closed in 1904 but later reopened again in 1911. The works were finally closed in 1956 and most of the above ground structures were demolished in the 1970's. The historical gas works in shown in Figure 1 below.

The former gas works occupied two distinct sites separated by Poplin Street. The Bartholomew Street Site occupied an area of land enclosed by Dunn Street (to the west), Dalmarnock Road (to the north), Bartholomew Street (to the east) and Poplin Street (to the south). The Poplin Street Site occupied an area of land enclosed by Dora Street (to the west), Poplin Street (to the north), Sawnston Street (to the east) and French Street (to the south).

I&H Brown [IHB] were instructed by Clyde Gateway to undertake remediation of two parcels of land associated with the former gas works site. IHB's scope of works initially included the excavation, processing, bioremediation and soil washing of contaminated material which was predominantly located in the below ground gas holder bases (as infilled material).

Figure 1 – Historical Aerial View of the Former Dalmarnock Gas Works

Grontmij UK were commissioned by Clyde Gateway as the Client's Representative. Grontmij were primarily engaged as environmental consultants – the remediation strategy was developed by Grontmij and the remediation works were overseen by Grontmij.

The soil washing operation was terminated towards the end of 2012 and an alternative remediation solution was sought. The alternative remediation solution was required to address the stockpiled filter cake material and the remaining untreated materials on both sites. The requirement was to comply with the remediation target criteria [RTC] derived by Grontmij and to remediate the contaminated materials within a very short timescale to achieve the contractual obligations.

At the end of 2012 Envirotreat was invited by IHB to develop a remediation [E-Clay Stabilisation] solution based on an estimated overall treatment volume of circa 15,000m^3. Envirotreat was subsequently engaged by IHB in early 2013 to achieve the remediation objectives within a very short timescale of 2 - 3 months.

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The revised remediation strategy combined both *ex-situ* treatment of stockpiled material and *in-situ* remediation of gas holder contents which could not be excavated for practical / structural reasons.

The remediation works comprised the following elements:

- *Ex-Situ* E-Clay Stabilisation of Stockpiled Filter Cake (resulting from the on-site soil washing process – see Figure 2 below)
- *Ex-Situ* E-Clay Stabilisation of Excavated General Gas Works Waste
- *Ex-Situ* E-Clay Stabilisation of Spent Oxide Waste – see Figure 3 below
- *In-Situ* E-Clay Stabilisation of General Gas Works Waste (within an onsite gas holder)

The identified contamination issues were diverse and complex. The contaminants of concern (CoCs) were wide ranging and essentially unique for each waste stream - the CoCs predominantly comprised of total and free cyanides, thiocyanates, polycyclic aromatic hydrocarbons (PAH), total petroleum hydrocarbons, phenols and metallic pollutants.

Prior to commencement of the on-site remediation works Envirotreat carried out a series of treatability trials to demonstrate / confirm the efficacy of the proposed remediation process in addressing the respective waste streams and their associated contamination issues.

Figure 2 – Filter Cake Material (showing hydrocarbon contamination associated with the filter cake material)

Figure 3 – Spent Oxide Material (showing complex cyanide ['Prussian Blue'] contamination associated with the spent oxide material)

Technical Rationale

Filter Cake (2,671m^3):

The previously employed soil washing process produced a concentrated contaminated filter cake comprising of 'fines', typically less than 0.06mm in diameter – these contaminated fines are typically hazardous in nature with associated high disposal costs. It was therefore necessary to implement a cost-effective and technically acceptable on-site remediation stabilisation solution.

The soil washing process had been applied to a number of waste streams and henceforth the filter cake contained a wide range of CoCs which were concentrated in the filter cake material.

In addition to the concentrating effect of the soil washing process there was the additional concern that highly mobile and toxic free cyanides and unstable iron cyanide species ($Fe(CN)_6$) would have been liberated through dissociation of relatively stable 'Prussian Blue' complexed cyanide compounds. It was therefore essential to implement effective pH control in combination with the E-Clay Stabilisation Process – the objective was to drive the equilibrium towards the formation of low solubility and relatively immobile complexed ferri-ferrocyanides (which also necessited the addition of iron compounds within the stabilisation media).

Treatability trials carried out on the filter cake demonstrated that the material could be effectively treated with E-Clay Stabilisation in compliance with the RTC.

General Gas Works Waste (8,717m^3):

The general gas works wastes contained a wide range of CoCs of varying composition and concentration. As with the filter cake material it was necessary to implement a strictly controlled remediation strategy comprising E-Clay Stabilisation and effective pH control.

Treatability trials carried out on the general gas works waste demonstrated that the material could be effectively treated with E-Clay Stabilisation in compliance with the RTC.

Spent Oxide Waste (2,292m^3):

These waste streams were segregated by IHB on the basis that the material was clearly contaminated with spent oxide (cyanide bearing waste typically associated with the gas purification stage of the historical gas works operation). The spent oxide materials exhibited significantly elevated levels of total cyanides (circa 15,000mg/kg) in addition to other typical gas works pollutants.

Treatability trials carried out on the spent oxide waste demonstrated that the material could be effectively treated with E-Clay Stabilisation in compliance with the RTC.

Remediation Objectives

Envirotreat were commissioned by IHB to undertake the following scope of works:

1. Formulation and approval of a remediation strategy to satisfy regulatory requirements

2. Management and implementation of the agreed remediation strategy for the treatment of contaminated materials utilising E-Clay Stabilisation

3. Preparation and submission of a comprehensive validation report to satisfy the requirements of Glasgow City Council [GCC] and SEPA

Methodology

The leachate RTC had previously been agreed with GCC and SEPA – the RTC were utilised as compliance criteria enabling reuse of treated materials on site (as a substitute for imported fill). The RTC are summarised in Table 1 below.

Envirotreat produced a Site Specific Working Plan outlining the site history, identified contamination issues, proposed remediation strategy & technical rationale, environmental protection measures required during the remediation works and validation protocols for the treatment element of the works. Following liaison with GCC and SEPA, approval was gained to undertake the treatment element of the works.

Ex-Situ Remediation

The majority of the contaminated soils (13,680m^3) were treated *ex-situ* employing a remediation strategy developed through laboratory based treatability trials to determine the most effective E-Clay Stabilisation medium. The treatment process was further refined on-site to reflect the variable nature of the respective waste streams.

The *ex-situ* remediation works involved the treatment of contaminated materials in 15m^3 batches utilising a mixing bin (see Figure 4 below). The treatment process involved mixing the wastes with the designated E-Clay in slurry form and cementitious materials in dry form. The wastes were mixed with the treatment materials to produce a homogeneous mass. Representative samples were taken throughout the treatment process – these samples were combined to produce composite samples for validation purposes.

Figure 4 – Ex-Situ Stabilisation of Contaminated Materials

Figure 5 – In-Situ Remediation of Gas Holder A8

In-Situ Remediation

It was not feasible to excavate contaminated materials from Gas Holder A8 (as the gas holder was partially located under the adjoining roadway and there was a potential risk of structural collapse if the material was excavated). As a consequence it was decided to implement an *in-situ* remediation approach treating the contaminated gas works material 'in-place'.

The *in-situ* treatment (1,340m^3) was carried out utilising an Allu soil cutter / mixer to achieve effective in place mixing of the treatment reagents with the gas holder materials.

The treatment process involved mixing the wastes with the designated E-Clay in slurry form and cementitious / bentonitic materials in dry form. The wastes were mixed with the treatment materials to produce a homogeneous mass. Representative samples were taken throughout the treatment process – these samples were combined to produce composite samples for validation purposes.

The *in-situ* treatment process is shown in Figure 5 below.

The remediation works were undertaken within a twelve week timescale.

The E-Clay Stabilisation Process is licensed as a waste recovery process enabling reuse of the treated material on-site. The remediation works were undertaken under the auspices of a Mobile Plant Licence authorised by SEPA.

The *ex-situ* and *in-situ* treated materials were seen as a necessary part of the works – the treated materials were intended to replace the requirement to utilise imported fill to return the site to pre-remediation formation levels. The material was identified as having a specific purpose with any deficit of material resulting in the necessity to import fill.

The works were undertaken in accordance with the approved Site Specific Working Plan. It was agreed that the suitability of treated material for reuse on site would be determined by compliance with designated leachate target values.

Validation

Due to project time constraints the validation process ("curing" period) was significantly reduced to the minimum required for effective treatment - an accelerated curing process was utilised for validation purposes.

Representative composite samples (equivalent to a minimum of one sample per 250m^3 of treated material) of treated material were leach tested and compared with the RTC.

A total of 83 samples were tested and all leachate values were compliant with the RTC.

The treated material was therefore considered suitable for reuse onsite and re-emplaced in the void spaces created by the excavations as a substitute for imported fill.

The majority of the contaminated material was re-emplaced in the former Poplin Street Gas Holder as shown in Figure 6 below. The site prior to remediation showing the excavated Poplin Gas Holder and stockpiled material is shown in Figure 7 below.

Figure 6 – Re-emplacement of Treated / Validated Material within the Former Poplin Street Gas Holder

Conclusions

Envirotreat were able to demonstrate through a comprehensive Validation Report that the overall remediation strategy had been successfully implemented.

The prime driver for the remediation works was the protection of the water environment.

Table 1 – Summary of Remediation [Leachate] Target Criteria

Metals and Inorganics (ug/l)	Leachate RTC	Total Petroleum Hydrocarbons (ug/l)	Leachate RTC	Polyaromatic Hydrocarbons (ug/l)	Leachate RTC
Arsenic	185	Aliphatic C_5-C_6	88,500	Acenaphthene	0.383
Cadmium	93.2	Aliphatic C_6-C_8	10,700	Acenaphthylene	0.606
Total Chromium	923	Aliphatic C_8-C_{10}	1,640	Anthracene	0.219
Copper	1,850	Aliphatic C_{10}-C_{12}	731	Benzo(a)anthracene	0.207
Iron	3,690	Aliphatic C_{12}-C_{16}	143	Benzo(a)pyrene	0.214
Lead	185	Aliphatic C_{16}-C_{21}	247	Benzo(b)fluoranthene	0.21
Mercury	9.95	Aliphatic C_{21}-C_{35}	274	Benzo(k)fluoranthene	0.192
Nickel	199	Aromatic C_6-C_7	88,500	Benzo(g,h,i)perylene	0.208
Selenium	61.1	Aromatic C_7-C_8	53,400	Chrysene	0.2
Vanadium	2,140	Aromatic C_8-C_{10}	3,280	Dibenzo(a,h) anthracene	0.201
Zinc	15,400	Aromatic C_{10}-C_{12}	895	Fluoranthene	0.221
Thiocyanate	554	Aromatic C_{12}-C_{16}	285	Fluorene	0.606
Cyanide (Total)	970	Aromatic C_{16}-C_{21}	495	Indeno(1,2,3-c,d)pyrene	0.206
Cyanide (Free)	207	Aromatic C_{21}-C_{35}	457	Naphthalene	95.3
Phenols (ug/l)		**BTEX (ug/l)**		Phenanthrene	0.271
Total Phenols	506,000	Ethylbenzene	3,170	Pyrene	0.192

Figure 7 – Former Dalmarnock Gas Works – Aerial Photograph Showing the Excavation of the Former Gas Holder on the Poplin Street Site and the Stockpiling of Soils in Preparation for the Remediation Works