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CASE STUDY

E-Clay Stabilisation
Reactive Barrier Installation

Remediation of Former Landfill Site, Barking Riverside

Client

BARKINGRIVERSIDE

Environmental Consultants

CGL
Card Geotechnics Limited
Providing Ground Solutions

Site Background & History

Barking Riverside is one of the largest development sites in London occupying 185 hectares in total and is the largest housing development in the Thames Gateway.

The vision is for Barking Riverside to provide a model for sustainable living in the 21st century. Over the next 20 years it is planned to build 10,800 new homes to house 26,000 people. The development will benefit from new transport links including the East London Transit and the Docklands Light Railway. New primary and secondary schools will also be constructed. The proposed site development is shown in Figure 1 below.

Figure 1 – Proposed Future Site Development

The specific development site described in this case study is the former Renwick Road Landfill (referred to as Area 9 by Barking Riverside). In addition remediation works were carried out on a contamination hot-spot in Area 7 to the west of Area 9.

The Renwick Road Landfill [Area 9] occupies an approximate area of 2.1km^2. The site is bounded to the north by Choats Road which divides the portion of the landfill currently undergoing development from another slightly smaller portion of the landfill to the north. The eastern boundary is formed by a leachate ditch and the south flowing Gores Brook. The southern boundary is delineated by flood defences and the River Thames.

A large area of stockpiled surcharge material is located to the west of Area 9. This material will be utilised for surcharging Area 9.

The landfill is understood to have operated as a local authority waste disposal site accepting domestic waste, asbestos waste, inert wastes, gasworks waste and contaminated soils between the 1950's and 1993.

The landfilled wastes were a highly variable mix of domestic and commercial wastes including soils with strong hydrocarbon odours. An area of shallow suspected gas works wastes in the south-eastern corner of site recorded particularly high cyanide concentrations.

The base of the landfill was identified to be between 10m and 14mbgl - no membrane or engineered clay liner was identified suggesting the wastes lie directly on the natural alluvium.

The contamination 'hot-spot' in Area 7 (to the west of Area 9) was identified as gasworks waste and specifically spent oxide waste. This material is assumed to have been tipped historically and is currently present within a hollow surrounded by surcharged material on Area 7 as a whole.

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The site as a whole including Area 7 is shown in Figure 2 below.

Figure 2 – Site Overview

Site Contamination

The contaminants in Area 9 reflect the historical usage of the site as a landfill. Concentrations of arsenic, total chromium, lead, total petroleum hydrocarbons [TPH] and polycyclic aromatic hydrocarbons [PAHs] were recorded above assessment criteria in the underlying shallow landfill materials. Whilst contaminants were generally found in the landfill waste materials across the site, the prime contamination source was identified in the south eastern corner of landfill site i.e. a significant quantity of gas works / spent oxide waste historically deposited in this area of the landfill.

Leachability testing identified a number of leachable contaminants including heavy metals, phenols, cyanide, sulphate, ammonia, and TPH exceeding the assessment criteria, (particularly in the south eastern part of the site associated with the gas works /spent oxide waste). All of these contaminants had the potential to pollute the Gores Brook and the River Thames.

Surface water sampling of the adjacent leachate ditches and Gores Brook indicated elevated concentrations of arsenic, boron, phenols, cyanide and sulphate. Elevated cyanide concentrations were identified in surface water samples taken in close proximity to the area of gas works waste located on the south-eastern boundary of the site – this indicated that a migration pathway existed from the landfill into the surface water receptors.

The intention is to surcharge the landfill materials with 250,000m^3 of soils to improve the geotechnical properties of the landfill by compaction. The surcharging will promote 100mm - 200mm of mechanical consolidation of the underlying landfill material – this has the potential to create a detrimental impact on surrounding surface water receptors (due to compaction effects which are likely to 'squeeze out' perched water over time).

To achieve the site development objectives the former landfill site required remediation to minimise future impact to water receptors. Additionally it was considered necessary to remediate the contaminated 'hot-spot' in Area 7.

Remediation Strategy

Following a remediation options appraisal by the appointed consultant Card Geotechnics Limited [CGL], it was agreed to implement an *integrated remediation approach* comprising the installation of a reactive barrier system and source treatment of contamination 'hot-spots'.

The integrated remediation strategy comprised of the following key elements:

- The installation of a reactive barrier system along the eastern and southern boundaries of the landfill (Area 9)
- Source treatment of identified spent oxide / gas works waste contamination in the south eastern corner of the landfill (Area 9)

- Source treatment of identified contamination 'hot-spots' located in close proximity to the permeable reactive barrier sections on the southern / south eastern boundaries of landfill site (Area 9)
- Source treatment of identified spent oxide contamination in the adjoining site (Area 7)

The reactive barrier system was designed to treat perched groundwater which is expected to migrate from the site in the direction of the Gores Brook and the River Thames. The barrier was installed utilising pillared E-Clay technology.

The source treatment [stabilisation] process was designed to chemically treat the contaminated materials (and associated groundwater) using a combination of cementitious materials, E-Clays and specialist additives. Treatability trials were undertaken to demonstrate the suitability of the stabilisation process for the treatment of the gas works / spent oxide wastes in both Areas 7 and 9.

Methodology

Envirotreat were employed by Barking Riverside to undertake the proposed remediation works over an eight week programme.

Barrier Installation:

The Barrier was installed in accordance with the Barrier Design Statement. The actual barrier alignment was dictated by local conditions (flatness of ground, obstructions, etc.). The barrier was constructed by soil mixing techniques incorporating a purpose designed pillared E-Clay formulation reflecting to barrier design requirements.

A series of trial pits were excavated along the alignment of the barrier to ascertain the depth of the underlying low permeability material. The mode of barrier installation was dependent on the required barrier depth and stability of the made ground.

In general the barrier depth varied between 3.5m - 7.0m bgl. The barrier was keyed into the underlying low permeability layer.

The barrier installation is shown in Figures 3 and 4 below. The barrier system comprised of permeable reactive sections on the eastern and southern boundaries (designed to intercept and treat contaminated groundwater migrating from the site in the direction of the Gores Brook and the River Thames) and a low permeability section on the south-western boundary of the site designed to channel contaminated groundwater in the direction of the southern reactive barrier section.

Figure 3 – Barrier Installation

Figure 4 – Barrier Installation – Soil Mixing Process

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Gas Works / Spent Oxide Waste Remediation:

The proposed remediation strategy was designed to address the concern that highly mobile and toxic free cyanides and unstable iron cyanide species ($Fe(CN)_6$) would be 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 with the prime objective to 'drive' the equilibrium towards the formation of low solubility and relatively immobile complexed ferri-ferrocyanides.

The gas works / spent oxide waste identified in the south-eastern corner of the landfill site (Area 9) was delineated and excavated as far as practically possible. The subsequent stockpiled spent oxide waste was treated *ex-situ* utilising the designated stabilisation medium incorporating cementitious materials, the appropriate E-Clay formulation and specialist additives. Following successful validation (by leachate testing) the treated material was reused as part of the surcharging material requirement in accordance with the material management plan [MMP] for the site.

The excavation of the gas works /spent oxide waste in Area 9 is shown in Figure 5 below. The *ex-situ* treatment process is shown in Figure 6 below.

Figure 5 – Excavation of Identified Gas Works / Spent Oxide Waste

Figure 6 – *Ex-Situ* Treatment of Gas Works / Spent Oxide Waste in Area 9

The spent oxide waste on the adjoining site (Area 7) was delineated by the excavation of a number of trial pits. The identified area was treated *in-situ* treatment utilising the designated stabilisation medium incorporating cementitious materials, the appropriate E-Clay formulation and specialist additives. The contaminated material in Area 7 was predominantly spent oxide waste with an associated very low pH necessitating a different stabilisation medium to that employed in Area 9.

The treated material was validated by leachate testing to demonstrate the effectiveness of the treatment process.

The *in-situ* treatment of the spent oxide waste is shown in Figure 7 below.

Figure 7 – *In-Situ* Treatment of Spent Oxide Waste in Area 7

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Identified "Hotspot" Remediation:

Previous site investigations had identified a number of highly contaminated areas (predominantly hydrocarbon contamination) within the landfill waste.

The close proximity of highly elevated source and groundwater hydrocarbon contamination was considered to be potentially detrimental to the reactive barrier installation. It was therefore decided to remediate these 'hot-spot' areas as a key element of the integrated remediation strategy for the landfill site.

Three 'hot-spot' areas were identified as requiring remediation. It was decided to carry out *in-situ* remediation due to the significant depth of the 'hot-spots'.

The 'hot-spots' were delineated by the excavation of a number of trial pits. The identified areas were treated in-*situ* utilising the designated stabilisation medium incorporating cementitious materials and the appropriate E-Clay formulation.

The treated materials were validated by leachate testing to demonstrate the effectiveness of the treatment process.

The in-situ treatment of the identified 'hot-spots' is shown in Figure 8 below.

Figure 8 – *In-Situ* Treatment of Identified Hydrocarbon Contaminated 'Hot-Spots'

Environmental Monitoring

A comprehensive environmental monitoring programme was implemented due to the close proximity of several sensitive receptors. Dust, odours, noise and VOCs were monitored around the site during the remediation works. Additionally the water quality of the Gores Brook was monitored during the remediation works.

Validation

Representative samples were taken from the treated soils for validation purposes (representative of one sample for every 250m^3 treated). Following a suitable period of "curing" the composite samples were leach tested and compared with the designated leachate target criteria.

All leachate values were compliant with the designated leachate remediation target criteria. The treated material was therefore considered suitable for reuse on site as a substitute for imported fill.

A series of boreholes were installed along the length of the barrier with the purpose of monitoring groundwater quality over the next five years.

Summary of Remediation Works

The overall barrier installation was 925m in length comprising 750m of permeable reactive barrier sections and 175m of a low permeability barrier as shown in Figure 3 above.

Approximately 1,250m^3 of gas works / spent oxide waste was excavated and treated on the landfill site and approximately 2,650m^3 of predominantly hydrocarbon waste was treated *in-situ*.

A further 3,000m^3 of spent oxide was treated *in-situ* in Area 7.

These weeks were completed within the agreed 8 week programme.

Conclusions

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

The prime driver for the remediation works was the protection of controlled waters.

Figure 9 shows the location of the installed barrier system on the landfill site (Area 9) and the locations of the gas works / spent oxide and hydrocarbon contamination hotspots. The location of the 'hot-spot' in Area 7 is also shown.

Figure 9 – Barking Riverside - Integrated Remediation Scheme (Areas 7 and 9)