Gas Works Remediation for Mixed-Use Development

Synopsis

The remediation of Hampton Court Gas Works to a standard suitable for a mainly residential, mixed-use development was always going to be a challenging exercise. To have achieved this in the context of a very commercially driven timeframe, within a strict regulatory regime, whilst keeping to budget required a highly innovative design and an unprecedented degree of partnering between all stakeholders. This complex project resulted in successful treatment and re-use onsite of over 97% of the approximately 60,000 m^3 of soil processed. From the start of remediation to first residential sales was a period of 20 months. The project's undoubted success is the product of intensive activity by all involved and perhaps unusually leaves in its wake a real sense of pride and satisfaction, and closer relations between those who collaborated.

Introduction

The site, which extends to an area of approximately 2 hectares, encompasses the entire former Hampton Court Gas Works site, which was used for gas production from 1852 and closed in the mid 1970's (Figure 1 & 2). Historical studies showed the gas works were complex and contained up to five Gas Holders as well as range of underground and production structures. Subsequently part of the site was used as an Electricity Depot. Thereafter the majority of the site then comprised a builders merchant (approx 1.37ha), with the remaining area redeveloped with an office building and car park in the mid 1970's(approx 0.51ha), with one area of overgrown waste ground remaining in one corner (0.19ha).

Regeneration

The site was purchased by Linden Homes (South East) who were granted permission to redevelop it with 198 residential apartments incorporating communal soft landscaping, a 72 bed Nursing Home, and 800m^2 of mixed use including offices and a crèche. The development also incorporates access roads, parking (including a semi basement car park), and pedestrian access.

Community and Stakeholder Acceptance

The site is located in a highly sensitive residential area on the edge of Bushy Park and is adjoined by a busy mainline railway along the northeast boundary. Given the industrial history, from day one there were considerable objections to the development from the concerned local resident action group. The Developer and Southern Testing recognised the concerns raised, both within the local community and by the regulators, and so arranged extensive consultations with the residents, Environment Agency (EA), Environmental Health Officer (EHO), and Planning Authority (PA) from a very early stage. The Specialist Remediation Contractors were closely involved in this process. An investigation strategy was discussed upfront and submitted for approval. The regulators were consulted throughout the investigation and monitoring phases, conceptual design, pilot and laboratory trials. Once remediation works commenced, monthly progress meetings were held and attended by the EHO and EA. Monthly progress reports were issued containing the results of daily environmental control monitoring for noise, dust, and odours. The Specialist Remediation Contractor signed up to the local authorities "Considerate Contractor Scheme", achieving "very good site" status. Local residents were kept up to date with site activities and progress through consultation and information days. As the project progressed local regulators and press were also invited to activity demonstration events. This unprecedented degree of involvement was instrumental in obtaining the backing of Planning and Regulatory Authorities, alleviated concerns raised by locals, and helped to streamline the remediation, validation, and approvals process.

Site Characterisation

Southern Testing were first employed by the Linden Homes (South East) to investigate the site in 2003. Additional phases of investigation and monitoring were undertaken in 2005 and 2006, to help determine the scope of remedial works required to meet planning conditions attached to the development proposals. While the southern part of the site was vacant, the remainder was still occupied by the builder's merchants (Jewsons). This presented a number of logistical issues; Jewson's Yard was extremely busy, with a large number of daily deliveries and customers resulting in numerous vehicle movements (e.g. lorries, vans, forklifts etc). The ephemeral nature of storage on site meant that the site features and accessibility (particularly to monitoring wells) changed daily, with pallets and stockpiles constantly being delivered, moved and sold. The overall volume of data available for design was therefore limited in some areas and was a key concern during assessment of remedial options.

The site and surrounding area are generally flat and level being on the ancient former floodplains of the River Thames. The underlying geology consists of Kempton Park Terrace Gravels over London Clay. Analysis showed the site to be heavily contaminated with Arsenic, Cyanides, PAHs, TPH, BTEX compounds and SVOC's, largely correlating with the location of historic gas works structures.

The Kempton Park Gravels that underlie the site are classified as a major aquifer and, therefore, sensitive to potential groundwater contamination. Characterisation of the groundwater contamination beneath the site formed an important part of the investigation and risk assessment process. BTEX compounds, Naphthalene and BaP were identified as critical contaminants. Elevated concentrations of these contaminants were found at the northern end of the site, associated with the below ground gas holders, with a lesser degree of contamination at the location of a sunk liquor-tank. Monitoring showed that significant concentrations were not present at the downgradient site boundary. Modelling of the contaminants was in good agreement with the measured distribution and showed no significant off-site migration. Therefore, no specific groundwater remediation was required. Post-remediation monitoring is continuing. Groundwater was the most sensitive receptor in elements of the risk assessment and was the controlling factor in setting a number of key remedial targets for the soils remediation.

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Assessment of Remedial Options

Investigations identified contaminated soils largely correlating with the location of works structures, together with two backfilled gasholders. A dig and dump solution was considered to be unsustainable, excessively expensive, and unacceptable given the sensitive surroundings. Both in-situ and ex-situ techniques were considered. After extensive consultation with the regulators and various remediation specialists, an innovative and sustainable treatment system was designed incorporating elements of insitu & ex-situ bioremediation, stabilisation to aid excavation for treatment (figure 4), and a multi-phased insitu approach to DNAPL recovery within the gasholders. Treatability trials were carried out for bioremediation and stabilisation. Overall it was felt that bioremediation offered benefits on a site of this nature, given the generally granular nature of the soils and the heterogeneous distribution of the contamination. Excavation to place the material in treatment would also deal with physical obstructions, thereby facilitating development, and improve the overall validation process. The other in-situ techniques offered additional benefits in that they minimised the visual impact in a sensitive residential environment, reduced the need for prolonged open excavations or stockpiles, and so allowed odours to be more effectively controlled.

Technical Innovation (Best Practice)

Linden Homes wished to incorporate a variety of sustainable and innovative techniques that were designed to meet the planning, environmental and geotechnical requirements of the site while managing the longer term environmental liabilities. The combined treatment system proposed by Southern Testing provided a flexible solution and allowed for variations to cope with unknown ground conditions, site access restrictions, environmental risks and phased site hand-back and construction deadlines imposed by the Client.

Remediation started at the southern end of the site, while the builder's merchants remained, and progressed north as access became available. Soil treatment was undertaken by Specialist Remediation Contractor Biogenie, who utilised a multi component scheme that took into account the level, and type of contamination, the environmental risk and site circumstances. Initially, due to restricted working space and environmental concerns, bioremediation comprised below ground (in-situ) biopiles. The flexible remediation strategy allowed for these to be replaced by more traditional (ex-situ) above ground biopiles during the later phases, or "double-decker" biopiles if necessary.

The approach for the general site area entailed a "blanket" excavation, sorting and onsite treatment of all materials within the upper 3m. In-situ treatment work stages comprised the installation of treatment process pipes within excavation strips, prior to replacing soils for treatment (Figure 9). These are connected to the containerised treatment plant (Figure 10). Amendments are added with the soils to allow optimal conditions to be created for degradation of contaminants. During the 20 week treatment the soil is occasionally decompacted to aid the transfer of air through the soil. Biogenie also provided a system for collection and treatment of waters encountered in excavation, prior to discharge under consent to foul sewer. At the time of writing preparations are being made for treatment of pile arising from across the northern part of site (gas holders) using ex-situ bioremediation located on-top of the former in-situ biopiles.

As noted previously, two gas holders where located on the northern half of the site within the existing Jewson's Yard. Full access to this part of the site was not available until January 2007 when the tenancy ended. However, the treatment approach allowed for remediation works to commence much earlier while still allowing continued use of the builders yard. Specialist Remediation Contractor QDS undertook remediation work within the gasholders with the objective to remove as much DNAPL (coal tar) as possible and improve the water quality using a combination of best available conventional and innovative technologies. It is thought to be the first time this combination of techniques has been used in the UK for this purpose. Techniques included – Tar Pumping; Flow Path Management (FPM) (Figure 5); In-situ Conductive Heating (ISCH); Soil Vapour Extraction (SVE); and Surfactant Flushing, with a final phase of In situ Chemical Oxidation.

In summary, in its basic form Flow Path Management entails the abstraction of groundwater and contaminants from within the holder bases via a series of abstraction wells (Figure 6). The groundwater is treated and re-injected via injection wells to aid the recovery process by maintaining DNAPL flow. All pipe work and wells are installed below the surface, and recovery plant is contained within fully instrumented containerised units so allowing the continued operation of the site. Heating (ISCH) was used to reduce tar viscosity and accelerate recovery rates. During the second phase of treatment, a surfactant was injected within the holder, to reduce DNAPL surface tension and increase contaminant mobilisation. This allowed the flow of residual DNAPL towards recovery wells. This process was based on laboratory trials to determine optimum conditions and surfactant concentrations for maximum DNAPL recovery.

Figure 1 – Gas Works Early

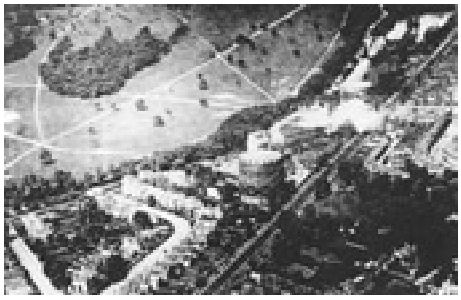
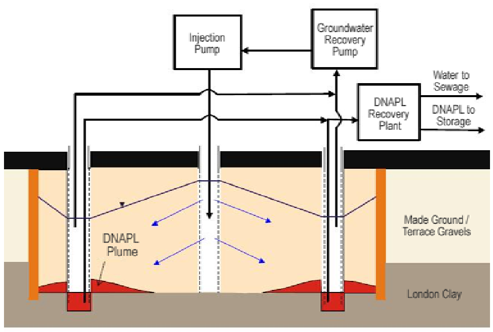


Figure 2 – Gas Works Layout

Figure 3 – Excavation of Tar Tank Structure

Figure 4 – Stabilisation to aid Excavation

Figure 5 – Flow Path Management



The third phase of treatment comprised In Situ Oxidation using Fenton's reagent. Chemicals are injected which oxidise contaminants to carbon dioxide and water or less toxic / more biodegradable compounds. It is a rapid and powerful technology and as such has certain Health and Safety issues that must be addressed. Throughout the full process the upper parts of the wells were used to collect and control vapours. Following in-situ treatment, the gas holder walls were broken down to 2m below ground level and the top of the structures sealed with a compacted clay cap.

Throughout the remediation the Specialist Remediation Contractors were responsible for ensuring that proper environmental controls were implemented. These included visual assessments and regular monitoring of dust, VOC and noise onsite and in the surrounding area. Controls were implemented in the form of damping down of excavations, minimising the size of open excavations and covering stockpiles. An odour control spray system was operated on the site boundary and locally at excavations. A foam blanket was used overnight in some excavations to minimise odours. The biopiles were also capped with a biofilter material. Wellheads were sealed to control vapours.

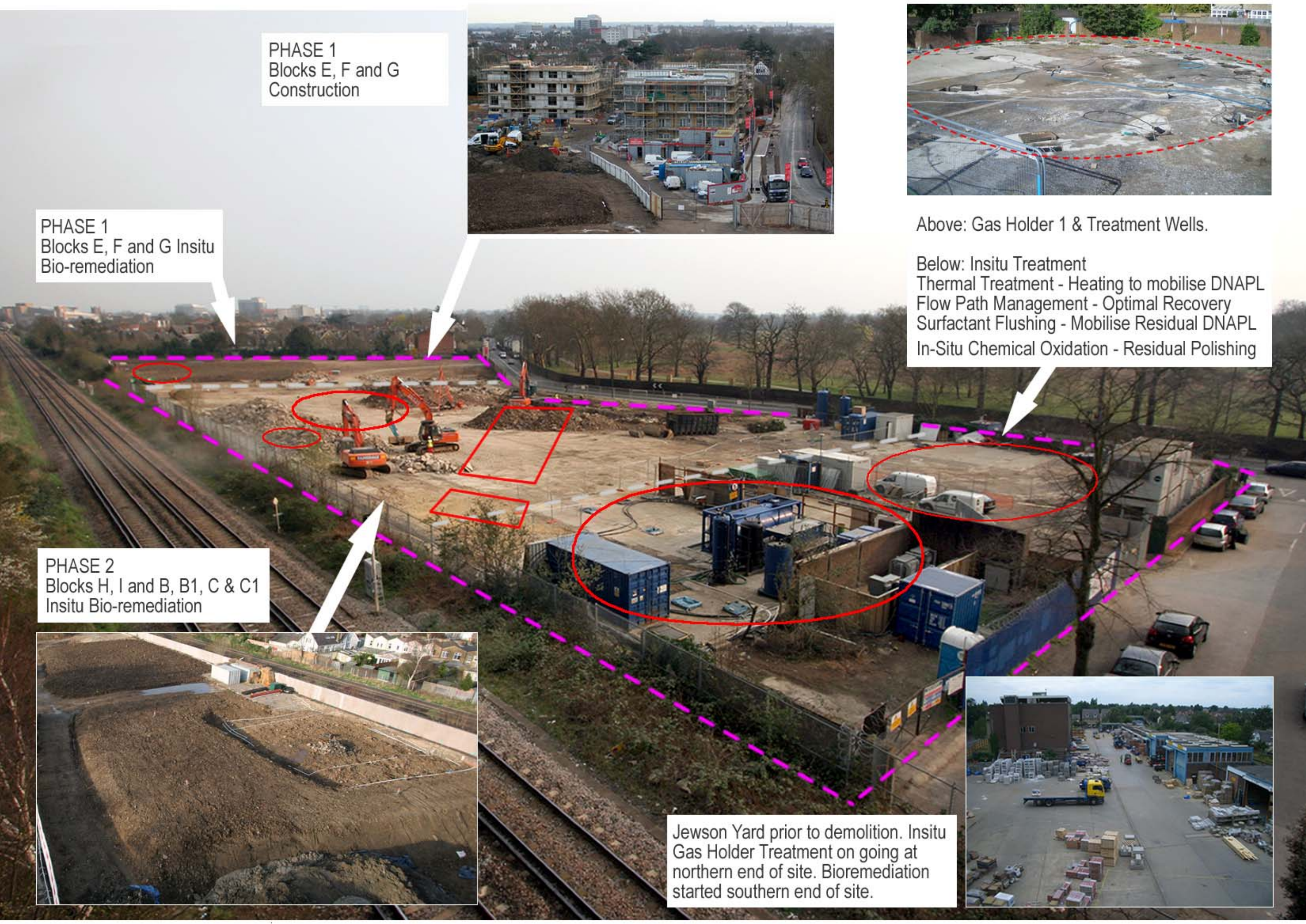


Figure 6 - Remediation in Summer 2007

Construction precautions within the properties include; hydrocarbon vapour membranes within the floor slab construction, with well-ventilated sub floor voids; and selection of suitably resistant pipes with respect to utility services and drainage. Soft landscaped areas are finished with an engineered clean cover, comprising a capillary break layer and topsoil.

Cost Effectiveness and Durability

Specialist remediation had the benefit that it was around one third of the cost of a dig and dump remediation scheme, in addition to significant environmental benefits previously mentioned. The contract was let to Biogenie as Principal Contractor, on a lump sum basis to provide cost certainty and keep tight control on the budget. QDS acted as sub-contractor to Biogenie. The accuracy of the site characterisation was confirmed by the fact that the finished scheme fell within the original budget. Substantial water treatment infrastructure was established by Biogenie to deal with groundwater in excavations and surface run off. This treatment plant was also able to be used by the Developer during construction work in dewatering deeper excavations.

The durability of the scheme comes from the massive reduction in the contamination loading below the site, which provides a permanent solution as apposed to a containment approach, which would have a limited life span.

Sustainability

A total of 60,000m^3 of soils have been excavated from across the site by Biogenie and carefully segregated. Biogenie successfully treated approximately 40,000m^3 of soil to meet strict validation criteria agreed with the EA and EHO for reuse onsite. Most of the remainder met re-use criteria and did not require treatment. The alternative to this scheme would have resulted in significant and unjustified additional loading on landfill and some 8,000 unnecessary lorry movements through the local area and beyond to remove and reinstate soils. Only 3,000 tonnes of contaminated soil, which was mainly cyanide-impacted and not treatable, was segregated. 2,200 tonnes was pre-treated to Non-Hazardous levels and the remainder sent of-site for soil washing.

QDS successfully removed 114,420 litres of coal tar from both the gasholders. This recovery represents a significant improvement on the initial estimated product recovery volumes. Based on the residual free product dips, undertaken once no more free product could be recovered, it is estimated that 99.7% of all recoverable tar was removed at the end of tar recovery prior to chemical oxidation.

Reduction of Pollution

An exceptionally contaminated site, which was a blight to the surrounding area, was successfully remediated using sustainable methods to provide an aesthetically pleasing addition to the local community. To date the completed phases have been carried out within a very commercially driven timeframe, with the bio treatment times being on average of 20 weeks. The treatment achieved significant pollution reduction with for example PAH contamination reduced by 90% and TPH by more than 80%, as well as the near total elimination of BTEX.

When each of the innovative technologies were applied within the gas holders following tar pumping, a significant improvement in the tar recovery rate was seen as the sequential application squeezed more residual tar from the bases. Heating (ISCH) was identified to increase tar recovery rate by as much as 157%. Holder base water samples were taken and analysed throughout the project. Final results indicated 78%, 69% and 92% reductions for EPH, BTEX and PAH dissolved phase respectively compared to initial concentrations.

Health and Safety

There were significant Health and Safety benefits to the scheme (such as reduced lorry movements, controlled excavations, multidisciplinary contractors, highly trained site staff etc) There were also however significant complications presented by the build programme (not least in the number of simultaneous operations on site). These were very competently addressed at the design stage and any issues solved by the very close working relationship of those involved.

Further complications were represented by the presence of several live gas and electric mains along the site boundary and in close proximity to the railway line. These issues were overcome in close consultation with Transco and Network Rail. In some areas these negotiations have enabled the works to be within 1.5m of live mains and the railway for example. Biogenie was present onsite throughout and was Principal Contractor during the remediation simplifying H & S management.

Validation and Monitoring

Biogenie were responsible for monitoring of the biopiles during treatment to ensure that optimum conditions were maintained and for validation sampling of all treated materials to meet agreed criteria for reuse on site. Southern Testing undertook an extensive sampling and validation exercise to demonstrate that the identified zones were appropriately excavated for treatment. All target criteria were successfully achieved.

Technology employed by QDS showed a significant improvement on the initial estimated product recovery volumes. Validation water samples indicated significant reductions in contaminants compared to initial concentrations allowing signoff from the regulators.

Key Remediation Techniques

Treatability Trials, Segregation, Insitu Bioremediation, Exsitu Bioremediation, Stabilisation, Soil Washing, Tar Pumping, Flow Path Management (FPM), In-situ Conductive Heating (ISCH), Soil Vapour Extraction (SVE), Surfactant Flushing, In situ Chemical Oxidation, Groundwater Collection and Treatment System.

Figure 7 – Schematic In-situ Biopile

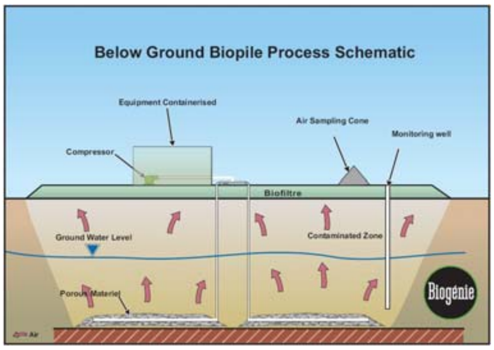


Figure 8 –In Situ Biopile Collector Pipework

Figure 9 – Below ground (In-situ) Biopile

Figure 10 – Insitu Treatment Gasholders

Figure 11 – Phase 1 Complete.

Linden Homes Biogénie QDS

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