TDP 16 - *Ex Situ* Soil Vapour Extraction to Remediate Chlorinated Hydrocarbons

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EXECUTIVE SUMMARY

The project site, which is situated in North-West England, supported organic chemical manufacture from the 1940s to the 1990s when the last of the various plants were demolished to slab level. A number of chemicals used in production processes at the plants were released to ground during the lifetime of the plant including carbon tetrachloride (CTC) and chloroform (an impurity of the CTC).

A volume of approximately 2,500 m^3 of soil (which included the highest concentrations of chlorinated organic compounds detected by previous investigations) was defined as requiring remediation with reference to Site Specific Target Levels (SSTLs). The area covered by this soil volume coincided with the location of the former CTC storage tanks.

The objectives of the project were as follows:

1. An assessment of the performance of *ex situ* Soil Vapour Extraction (SVE) in above ground treatment beds;

2. An assessment of the Health and Safety risks of excavation and treatment of chlorinated hydrocarbon contaminated soils along with a discussion of any associated air monitoring requirements;

3. An assessment of the feasibility and uncertainties of a mass balance on volatilisation losses during excavation and treatment.

High density polyethylene liner and vapour extraction pipe array

An *ex situ* SVE system was selected to remediate the site as it was assessed to be:

- Cost-effective remediation when compared to other options;

- Time-efficient remediation when compared to other options given the project aim which was to reduce concentrations of Volatile Organic Compounds (VOCs) in surface water drainage and remediate soils such that site specific cleanup criteria were met in a timeframe of 6 months or less;

- The most efficient way to remediate contamination in awkward areas (e.g. within redundant process drains, clay pockets, former concrete structures, etc.).

The remediation methodology included excavation of contaminated soils, validation of soil quality in excavation sides and base, construction of the treatment bed, treatment bed filling, operation of the treatment bed, SVE plant operation and continuous assessment of treatment bed performance, periodic abstraction and treatment of water in the excavation,

validation of soil treatment results and backfill of treated soils into the excavation void.

Health and Safety was treated as the number one priority at every stage of the project. Key elements included development of a pre-tender Health & Safety Plan, preparations of task specific method statements and risk assessments, management of risks arising from the release of VOCs to atmosphere and risk communication with neighbours to the site.

All treated material required validation testing prior to backfill. Concentrations in each treatment cell were below site specific cleanup criteria, with the exception of 1 treatment cell out of 40 cells, which did not meet the site specific cleanup criteria and was dispatched for off site pre-treatment and disposal. Validation sampling of the base and sides of the excavation void prior to backfill was carried out during the project - results indicated that the SSTLs were achieved.

Given that the project was completed in 6 months, the project achieved the stated contract objectives. In addition, there were no Health and Safety incidents or complaints from the public.

A VOC mass balance estimate is presented with the following parameters approximated:

- Mass of contaminants present in remediation area at outset;
- Mass of contaminants emitted to atmosphere derived from extensive boundary and personal monitoring, weather data and air dispersion modelling. Personal and vapour monitoring points were situated at distances of 0-200 m from the excavation and treatment areas. Most emissions are likely to have occurred during excavation, treatment bed filling and treatment bed turning;
- Mass of contaminants present in activated carbon after treatment;
- Mass of contaminants collected by treatment system by measuring concentration passing through total discharge air flow;
- Mass present in treatment bed after treatment.

A VOC mass balance has been attempted using data collected through execution of the remediation project. Errors associated with the initial mass present and the mass emitted to atmosphere have not been quantified but are likely to be significant. However, the contaminant mass balance equates to within 10%. The authors are not aware of previous attempts to estimate the mass of VOCs emitted to atmosphere where excavation of VOC contaminated soils (including *ex situ* remediation and 'dig and dump') has taken place. The results presented by this mass balance indicate that 60-80% of VOCs present *in situ* prior to excavation may have been emitted to atmosphere. It is recommended that this finding is taken into account during the remediation options appraisal and design in relation to *ex situ* remediation of VOC contaminated materials.

CONCLUSIONS

The remediation project achieved the stated objectives which were:

- To remediate soils in the former bulk storage area to a standard that protects environmental receptors close to the site (i.e. the surface water drainage ditch to the east and West Brook);
- To remediate soils in the former bulk storage area to a standard that protects human health receptors in the event that the site is developed for industrial /commercial end-use;
- To carry out all work to the highest safety standard;
- To complete any remedial action within a 6–12 month time frame.

This has resulted in release of this land for potential development. *Ex situ* operation of the treatment system enabled more certainty in meeting the stringent programme objectives. Moreover, excavating the part of the site formerly occupied by a demolished chemical works enabled segregation and appropriate treatment and disposal of the inevitable variable material encountered (e.g. former pipe tracks, underground infrastructure, etc) – this would not have been possible based on the investigation data available at the outset of the project and would have resulted in delays if an *in situ* technique had been adopted.
Although some material did require off site treatment and/or disposal, approximately 1,550 tonnes of soil was treated and backfilled under a waste management licensing exemption – this prevented approximately 80 truck movements and also prevented the corresponding volume of soil being disposed of in a landfill (although it should be noted that some form of treatment would have been requested prior to landfill disposal).

A mass balance has been attempted using data originally collected for remediation validation and Health and Safety monitoring purposes. Errors associated with the initial mass present (calculated from soil concentrations obtained from pre-remediation site investigation) and the mass emitted to atmosphere (calculated from VOC boundary monitoring data, meteorological records and atmospheric dispersion modelling) may be significant. However, the mass balance equates to within 10%. The authors are not aware of previous attempts to estimate the mass of VOCs emitted during the excavation of VOC contaminated soils. The results presented by this mass balance indicate that 60-80% of VOCs present at the start of the remediation may have been emitted to the atmosphere during excavation and emplacement within the treatment bed. This finding has implications for anyone considering *ex situ* remediation method, such as:

- Traditional excavation and disposal;
- *Ex situ* SVE;
- *Ex situ* bioremediation.

Those considering these techniques should expect a significant proportion of VOCs to be emitted when carrying out remediation of this kind, depending on soil condition and contaminant distribution. If implementing such a scheme, particular consideration should be given to:

- VOC monitoring at site boundaries;

- VOC abatement systems if risks resulting from emissions to atmosphere cannot be managed (e.g. working in a dedicated vapour tent or an air support structure);

- Use of *in situ* remediation methods.

LESSONS LEARNED

As described in Section 12, the remediation project was a success and therefore a number of issues which went well deserve emphasis, these are described below.

- Safety was the highest priority on the project and the safety arrangements resulted in the project achieving an excellent safety record. This vindicated the use of the methods employed such as early communication of safety issues, use of 'Hazcon' (construction phase hazard assessment), site induction and tool box talks, regular safety auditing, a permit to work system, extensive vapour monitoring and detailed method statements and risk assessments covering all tasks;

- Early consultation with the regulator was very useful during the project planning phase, this allowed the necessary actions (mobile plant licence, temporary consent to discharge to sewer, planning permission and waste management licensing exemption) to be implemented within the project programme. These discussions were particularly useful in the context of waste legislation. At one stage during the design phase of the project, the regulators stated that no treated soil was allowed to be backfilled regardless of the concentrations of contaminants, because it would be classified

as a waste.
It was fortunate that planning permission and a waste management licensing exemption were obtained in good time. Improved regulation in relation to the definition of waste and potential re-use of treated materials would result in wider use of on site remediation treatment technology, which would in turn reduce the volume of material disposed of to landfill.

Remediation works were located close to residential housing and a public park. The local authority imposed stringent requirements to control nuisance (odour, dust, noise, etc) during the works through planning consent conditions. These requirements were in line with the proposals for the site for heath and safety management, but could have been onerous and costly if not taken into account in the programme.

- The project team were fortunate to have good relations with a local special interest community liaison group, which included the area of the site. This proved invaluable in assisting the project team with communication of the project to local residents. No complaints were received at any stage during the project;

- The pilot test was carried out prior to detailed design of an *ex situ* SVE scheme. The results of the pilot test allowed the preferred remediation method to be amended. If an *in situ* system had been installed without a pilot test, it is considered that the project may have been unsuccessful due to soil heterogeneity and generally low soil air permeability.

In order to achieve a mass balance with quantified uncertainty, a dedicated sampling and analysis programme would be needed covering initial soil conditions and more detailed boundary sampling of VOCs in the atmosphere.

The project did not attempt to measure the mass of VOCs lost during soil sampling, however, such losses are likely to have occurred. Methods to reduce loss of volatiles during soil sampling include the use of driven, sealed sampling tubes which allow semi-undisturbed samples to be collected without excavation of boreholes or trial pits.

As described in Section 12, *ex situ* remediation of VOC contaminated soils appears likely to result in significant emission of VOCs to atmosphere. Detailed assessment of the nature and scale of these potential emissions are recommended prior to the final remediation design. If emissions need to be minimised, then either *in situ* remediation techniques should be considered, or vapour collection during excavation should be installed.

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