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CASE STUDY

E-Clay Permeable Reactive Barrier

River Yar Boatyard, Isle of Wight

Client

Environmental Consultants

CGL Card Geotechnics Limited
Providing Ground Solutions

Site Background & History

The site is located at Yarmouth on the Isle of Wight and is currently used as a boatyard. The site borders onto the River Yar Estuary and occupies 0.64 hectares. The high tide line bounds the site to the north and east. The Freshwater Gas Company was established on the site in 1899. The Gas Works was expanded in the 1940's with the addition of two further gas holders. It is believed that the gasworks closed in the 1960's.

The site owner is proposing to redevelop and refurbish part of the current site to improve existing facilities. The redevelopment will comprise of new hard surfaced areas, the addition of four boat sheds and a new reception building. The former dilapidated quay wall has been replaced with sheet steel piling as shown in Figure 1.

Site investigations undertaken by Card Geotechnics [Card] have identified the presence of both soil and groundwater contamination. The identified pollutants are predominantly gas works derived and include Total Petroleum Hydrocarbons (TPH), Polycyclic Aromatic Hydrocarbons (PAHs), copper, zinc and cyanide.

Figure 1 – Sheet Steel Piling Viewed at Low Tide

The prime source of contamination was in the south western corner of the site (associated with a former gas holder). The identified contamination was not considered to pose a future risk to human health as the development plans for the site incorporate the provision of significant hardstanding, thereby providing an effective 'pathway break' to protect human receptors.

The typical contamination encountered on site is shown in Figure 2.

Figure 2 – Typical Contamination

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The primary environmental concern was identified [by Card] as the potential risk to the estuary and surrounding environmentally sensitive areas (receptors). These receptors were considered to be at risk due to the presence of contaminated groundwater on the site. Card had identified the presence of elevated levels of Arsenic, Boron, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Zinc, Cyanide, Phenols, Benzo(a)Pyrene, TPH and Sulphate within the groundwater, potentially migrating offsite and impacting the sensitive receptors.

Card considered possible remediation options to address groundwater contamination on the site. Card were mindful of constraints relating to the environmental sensitivity of the area (requiring that the adopted remediation approach has minimal environmental impact) and the need to maintain existing hydrogeological conditions, as far as practically possible.

These remediation options were summarised as follows:

"Do Nothing" – this option was rejected as there was a clearly identified contamination issue on the site with the risk that future disturbance of the soils and groundwater, (particularly during the site redevelopment) or regular flooding could result in an increased and uncontrolled release of contaminants into the estuary and local environment.

"Dig and Dump" - this option was not considered to be acceptable or sustainable due to the potential environmental risks and impacts to the local area and ecology. Additionally the costs were prohibitive.

"Groundwater Extraction" – this was considered to be a possible option but was discounted due to possible impacts on the local hydrogeology, the logistical difficulties of carrying out extraction in a tidally influenced zone and potential long term rebound effects.

"Barrier System" – this was the preferred option as the impact on the local environment and groundwater regime was considered to be minimal. The proposed barrier system was designed to incorporate the recently installed sheet steel piling 'wall' - it was considered that the newly installed wall would effectively restore the groundwater regime to the former hydrogeological flow pattern (as previously exhibited by the former quay wall when integral). However there was a clear risk of migrating contaminated groundwater 'backing up' behind the impermeable wall ultimately resulting in lateral flow around the wall and / or overtopping. It was therefore considered necessary to incorporate E-Clay permeable reactive barrier 'wing' sections at the southern and northern ends of the wall.

Barrier Design

The barrier system was designed by Envirotreat including ConSim modelling, hydraulic gradient / directional flow determination and contaminant flux calculations. The final positioning of the two permeable reactive barrier wings (and the barrier scheme as a whole incorporating the sheet steel piled wall) is shown in Figure 5.

Envirotreat developed a remediation strategy for the site incorporating the barrier scheme as designed. Envirotreat subsequently obtained approval from the Environment Agency to install the permeable reactive wing sections, directly interfacing with the sheet steel piling installation to provide an integral and effective barrier system,

Methodology

The reactive barrier wing sections were installed by a local contractor under the supervision of Envirotreat. Representatives from Card were in attendance throughout overseeing the project. The works were completed within one week.

The permeable reactive barrier sections were installed by a combination of excavation / re-emplacement and *in-situ* treatment. The top 4m of each section was excavated to enable access to the deeper soils. The deeper soils were then mixed with E-Clay slurry *in–situ* (in place). The excavated soils were sorted to determine suitability for reuse – low permeability clayey material was rejected and replaced with permeable non-contaminated soils / granular material imported to site. These soils / materials were then re-emplaced in layers and mixed with E-Clay slurry to produce the shallower sections of the barrier.

The barrier was installed to the requisite depth (5.5–6.5m) keying into the underlying impermeable clay layer. The depth of the clay layer was determined by excavating trial pits to the required depth - these trial pits [trenches] were then extended to form a section of barrier. The barrier was installed in 3m to 5m sections.

The southern barrier wing section was 28.5m in length installed to a depth of 6m bgl (at the interface with the sheet steel piled wall) rising to 5m bgl. The northern barrier wing section was 10.0m in length installed to a depth of 6.5m bgl.

A number of complex problems were addressed during the barrier installation. These problems included:

- the presence of perched groundwater
- the presence of underground obstructions (particularly the former concrete quay wall which need to be removed in places)
- the presence of free product
- tidal effects

The addition of E-Clay slurry to the excavated trench for subsequent *in-situ* treatment to create the deeper reactive barrier sections is shown in Figure 3. The treatment of re-emplaced soils / materials with E-Clay slurry (to create the shallower reactive barrier sections is shown in Figure 4.

Figure 3 – Adding E-Clay Slurry to Deeper Soils

Figure 4 - Mixing Shallower Soils / Materials with E-Clay Slurry

Validation

Post remediation borehole monitoring has been undertaken by Card. The results obtained from the initial rounds of sampling and analytical testing have confirmed that the barrier system is performing satisfactorily.

Envirotreat carried out permeability testing of samples taken from the reactive barrier sections to confirm that the required permeability had been achieved.

Conclusions

The barrier system was installed in accordance with the design requirements and the remediation strategy.

Envirotreat have produced a comprehensive Validation Report to confirm the satisfactory installation of the barrier system.

The prime drivers for the remediation works were the protection of controlled waters and other sensitive receptors.

Figure 5 – Schematic Showing Barrier System (Low Permeability Section Shown in Red Colouration and Permeable Reactive 'Wing' Sections in Black Colouration)