**SUSTAINABLE REGENERATION OF THE FORMER MACKIES COMPLEX**

**Design & Construction of Phase 2 Site Development**

This project involved the sustainable redevelopment of a brown field industrial site in west Belfast. Significant cost savings to the client were identified during design development and achieved during construction.

The main works associated with Phase 2 Site Development were:

- Provision of site access road and infrastructure.
- Breaking out, crushing and reuse of existing concrete structures.
- Excavation and reuse of the existing bituminous materials on site.
- On site treatment of contamination.
- Drainage system compliant with the principals of SUDS.
- Construction of timber crib walling to retain unstable embankments.
- Perimeter fencing.
- Provision of services for future business and industrial development.

Site investigations, a *downtaking* project and Phase 1 were undertaken prior to Phase 2 Site Development.

**Site Investigations**

From the late 1800’s to 1999 the Mackies site had been used as a brick works, for glass production, aircraft and munitions manufacture and foundries. These industrial activities had caused contamination to the site.

The contamination investigations revealed:

- Total Petroleum Hydrocarbon (TPH) soil contamination, especially around the area of oil storage
- Chlorinated solvent contamination of shallow groundwater
- Dispersed heavy metal, TPH and minor asbestos contamination of fill materials.

A remediation strategy for the site was then produced to provide a site suitable for industrial development as required by the *Industrial Development Board*. 
A detailed geotechnical investigation of the site identified that the subsoil properties comprised weathered mercia mudstone, overlain in areas by fill material from previous industrial activities on the site. The fill material varied in composition and depth across the majority of the site and comprised demolition rubble, foundry ash, soot, clay, sand, gravel and quarry aggregate. Sherwood sandstone, which is a regionally important aquifer, underlies the mudstone at depth.

![Aerial view prior to ‘downtaking’](image)

**Downtaking Project**

This involved the careful dismantling of all of the large factory buildings for reuse and recycling of the materials. Two of the buildings were carefully dismantled for re-building, steel stanchions, cladding, cranes and other heavy lifting equipment were all carefully removed for reuse.

**Phase 1 (Springfield Road Entrance)**

This involved the culverting of 150m of the Forth River upstream of the Springfield Road, infilling of the ravine to allow localised widening of the Springfield Road to accommodate a new signalised junction and construction of a new entrance road and associated infrastructure. This work was managed by the Central Procurement Directorate (CPD).

**Phase 2 Site Development**

CPD were also appointed to develop the masterplan through detailed design, planning, tender procurement and construction supervision as Phase 2 of the works. Techniques were applied to ensure the development was sustainable and the measures taken to protect and enhance the natural environment.

Construction of Phase 1 commenced in October 2003 and Phase 2 in April 2004. Invest Northern Ireland’s Scientific Services Section verified the works relating to contamination and also monitored the Forth River for contaminants during the site works.
Developing the Masterplan

During the development of the master plan through detailed design a number of changes to the site layout were considered. The extent of the site was adjusted along the western boundary to account for the unstable banks of the Forth River. A highly active main badger sett was located in the embankment on the eastern side of the site. Although, in certain circumstances, a license for the relocation of a badger sett can be obtained from the EHS, it was considered preferable to adjust the site layout to accommodate the badgers. The road layout and finished site levels were revised to balance cut / fill quantities. The client was only willing to accept the changes to the layout if the available development area was maintained, which was achieved successfully.

These changes from the original masterplan layout avoided the need to culvert the river or strengthen the banks of the ravine, reduced the quantity of imported fill and the extent of retaining structures and realised savings in excess of £750,000.
Reuse of Concrete Structures

The contract documents required that all concrete floor slabs, underground concrete structures and foundations should be excavated, crushed and reused on site. More than 10,000m$^3$ of concrete structures were crushed, with all the resulting material being reused in the development as follows:

- 25% behind the crib retaining wall as structural fill
- 20% in road construction as capping
- 10% as fill to pipe trenches
- 45% as general fill to form development plateaus

The reinforcement from the concrete structures was removed during crushing, stockpiled and taken off site for recycling. The retention of the concrete on site had both financial and environmental benefits. Cost savings are estimated in region of £125,000 in comparison to the disposal of the concrete off site and importing an equivalent quantity of stone fill. Traffic movements through a residential area were also minimised, reducing nuisance, noise, exhaust emissions and dust pollution.

Reuse of Bituminous Materials

Approximately 1,000m$^3$ of existing bituminous surfacing was excavated and crushed on site for reuse.

The crushed material was placed and rolled in specific areas across the site to form an impermeable capping over areas of low level contamination. This impermeable layer will reduce the potential for rainwater to percolate through the material and leach contaminants into the Forth River.

CONTAMINATION TREATMENT

Bioremediation of TPH Contaminated Soils.

Contamination of soils with Total Petroleum Hydrocarbons (TPH) was confined to the area of fill material located directly beneath the former oil storage tanks. Due to the impermeable nature of the underlying mudstone, the vertical migration of the contaminants had been restricted significantly. TPH contaminated material was excavated and placed in windrows for treatment on site.

Windrows are used to reduce the concentrations of petroleum constituents in excavated soils through the use of biodegradation. The method involved placing the contaminated soils in uniform rows and stimulating aerobic microbial activity within the soils through aeration and the addition of
nutrients. The enhanced microbial activity resulted in degradation of adsorbed petroleum-product constituents through microbial respiration. The windrows were ‘turned’ regularly to aerate the soils and to stimulate the growth and reproduction of aerobic bacteria, which in turn degraded the petroleum constituents adsorbed to the soil.

The windrows were covered with a polythene membrane to produce a controlled environment, maintain moisture content and eliminate leachate production. Frequent sampling of the windrows was carried out to monitor the rate of degradation.

Approximately 250m$^3$ of contaminated soils were treated. TPH concentrations were reduced from >9,000mg/kg to <100mg/kg over a 3 month period. After treatment the soils were considered suitable for reuse on the site. The cost of the treatment was comparable to the cost of off site disposal and proved to be a successful example of reclamation of contaminated soils while avoiding the nuisance of transportation and disposal to our fast reducing landfill sites.

Solvent Treatment

Monitored natural attenuation was considered to be a possible treatment method of the solvent contaminated groundwater. Further samples of the groundwater were taken for analysis during the site works, 8 months after previous sampling, to determine if natural degradation was occurring. The assessment concluded that only certain areas of the contaminated water had geochemical conditions amenable to the biological degradation of the chlorinated solvents.

Pumped removal and on site filtration was the method then chosen for treating the solvent contaminated groundwater. This work was sub-contracted to Geodelft Environmental, specialists in contamination treatment. The groundwater was extracted from the ground and passed through an activated carbon filter to remove the dissolved solvent.

Validation sampling of the treated water was carried out before discharge to ensure complete removal of all the solvents and the ‘spent’ filter media was disposed of to a licensed landfill.

Treatment of the groundwater took place over a number of months with minimal depletion of the water level. Excavation in the contaminated area revealed a recharging source of water from within the bedrock. The primary solvents were still being detected within the recharging water, further investigations are taking place to determine the potential source of the pollution.

Cement Stabilisation / Solidification of Contaminated Foundry Ash

During the removal of underground concrete tanks and foundations, an unexpected quantity of contaminated foundry ash was encountered. This necessitated an urgent re-assessment of treatment options.
The ash was tested and found to contain elevated concentrations of heavy metals. Cement stabilisation was chosen as a treatment method to enable the retention of the ash on site for reuse. A waste treatment exemption license was required from the EHS for this treatment process and this required rapid and intensive negotiations to approve the proposed method of stabilisation.

The excavated ash was screened to remove bricks and building rubble and the Keller Group are currently completing leaching and stability tests with the proposed cement additives. Once stabilised, the material will be suitable for use on site as general fill.

Again, this approach reduces transportation and disposal to landfill compared to the traditional “dig and dump” techniques. Significant cost savings in the region of £100,000 are anticipated from this sustainable approach to waste management.

Environment Enhancement

The retention of the badger sett on the eastern boundary of the site was agreed with the EHS during the design stage. A temporary fence was erected around the sett to identify a buffer zone into which no machinery was to travel or work take place. The sett and badger activity in the area was monitored frequently by an environmental scientist.

The proposed landscaping within the site is to include native planting to encourage and enhance wildlife habitats. Wildlife corridors within the development have been maintained and access for small animals through new fencing is provided.

Storm Water Management System

Urban drainage can increase flood risk in rivers by altering the natural flow patterns. Rainwater runoff from large areas of hard standing can produce sudden peak flows to the receiving watercourse. During storm conditions the accumulation of these discharges can cause downstream flooding if the drainage system is unable to handle the excess demand. Global warming is also adding to the problem with increased rain fall and storm intensity.

Urban discharges are a major cause of surface water pollution. Surface drainage from roads, car parking and industrial sites is often contaminated with oils, sediments, rubber, chemicals and organic matter.

A Sustainable Urban Drainage Systems (SUDS) concept has been adopted within this development. Additional retention has been created within the storm sewers with the use of oversized pipework and a ‘throttled’ discharge. Storm water is also passed through an interceptor for the removal of oils and sediments before discharge to the Forth River. The inclusion of a retention pond, which would also act as an amenity and wildlife habitat was considered during the design stage, but due to the high demand for development land and the limited space available it was not considered viable. Future investors on the site will also be encouraged to include SUDS in their development. eg. collection of rainwater from roofs for reuse.

Japanese Knotweed

Japanese Knotweed was discovered on the western boundary of the site along the top of the Forth River ravine during the start of the site works. A detailed investigation of the site confirmed that the Knotweed was present in large clumps along the Forth River valley and on adjacent lands.
Advice on the treatment and management of the knotweed was given by the Department of Agriculture and Rural Development, Applied Plant Science Division. Dig and dump was not considered a viable option due to the extensive spread of the knotweed throughout the Forth River ravine. A management programme, which included the periodic spraying with herbicides and monitoring was recommended.

The location of the new fence along this boundary was also amended to create a sterile buffer zone between the Knotweed and the site boundary. The presence of knotweed on a site can devalue a development significantly.

It was fortunate that there was a substantial landscaping buffer zone that could be utilised to contain and treat the Knotweed as off site disposal or burial and containment on site would have cost in excess of £100,000. This highlights the importance of identifying this troublesome plant at an early stage.

Waste Management

The policies of on site reuse, remediation and stabilisation adopted on this project have dramatically reduced the amount of waste produced. Only small quantities of special waste such as asbestos sheeting and the carbon filters from the solvent treatment have had to be taken offsite for disposal.

Contaminated Land Management

Since 2002, the Environmental and Heritage Service (EHS) has adopted a site specific quantitative risk assessment approach to determine the potential impact contaminated land is having on the environment and human health. Previously used qualitative assessments and the comparison of contaminant concentrations with generic lists of contaminant trigger levels (ICRCL or Dutch Intervention) are no longer acceptable.

The initial contaminated land assessment for this development was produced before 2002 and used the qualitative approach. The EHS have now requested a site specific risk assessment is carried out for the development. This work is currently taking place to comply with the current legislation and best practice in validating the contamination treatment on the site.

Conclusions

This project provides confirmation that with a sustainable approach to design and construction of civil engineering projects, significant cost savings to the client can be achieved. The methods adopted during this project achieved real cost savings in the region of £225,000 through the on site reuse of existing concrete structures and the treatment and stabilisation of contaminated soils, almost 10% of the contract value.

Treatment of contaminated land, inclusion of sustainable drainage, provision of wildlife habitats and minimising traffic disruption through a residential area during construction all contributed to the enhancement of the natural environment.

Integration of the supply chain through the inclusion of professional advice during the design and the use of specialist environmental sub-contractors during the construction phase added to the delivery of a ‘value for money’ project.

Contrary to what many people would have expected, the adoption of onsite recycling and remediation on this project has produced considerable cost savings, reduced traffic noise and
pollution during construction and has required the minimum of landfill disposal. Specifications already allow the use of recycled aggregates in most construction materials and the more widespread understanding of the potential benefits and cost saving should give a boost to the recycling industry and take some pressure off our overburdened landfill sites.