Winter 2018: Brownfield Briefing Awards Winners Guide

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SPECIAL EDITION:

Brownfield Briefing Awards Winners Guide

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2018 WINNERS

Cover and winner photographs: John Sturrock

From the editor

Several themes figure large in a substantial number of the entries to this year's *Brownfield Briefing* Awards. They include 3D mapping, digital dashboards, remote telemetry, low CO_2 and waste targets along with restrictions on lorry movements.

Some highlights include **FLI** and **Hydrock** at the Four Ashes project achieving near 100% re-use of contaminated materials; **Northern Gas Networks** demonstrating innovative use of solar power replacing generators at a Gateshead gas holder station; **Arcadis** showing innovative technology at a former oil depot, with continuous and real time monitoring, with the first use of solar-powered LNAPL monitors and use of virtual reality for presentation of findings. This was also a good example of the trend towards deployment of autonomous instrumentation in a remote site and direct uploading to the office with associated cost savings. And talking about inaccessible areas on derelict sites, **Atkins** and **National Grid Property** showed how the use of drones across three example sites certainly helps with Health & Safety issues along with reducing surveying costs.

Brownfield Project of the Year, Southall Gasworks, from **BWT, Atkins** and **CA Blackwell**, encapsulates several of the emerging themes – complex site, sophisticated community involvement, the goal of zero soils to landfill, and reduction of CO_2 with the use of the canal for materials transport. There was also use of innovative risk assessment modelling which enabled management of potential vapour pathways. Overall management of the project was facilitated by use of online real-time reporting software.

Longevity was a theme this year – when the judges decided to give a special award for only the second time since the awards began. One entry which the judges thought long and hard about was from the **City of Wolverhampton Council**. The Part 2a project took 14 years to complete and showed the complexities of dealing with contamination on a site with homes in current use involving technicalities, legalities and communications. It finished with 84 residential properties successfully remediated.

But the judges decided to give a special award to another marathon, landmark clean-up project – The Avenue Project from **Homes England, Jacobs, VSD** and **Turner & Townsend.**

This was an example of a long term, large scale, technically and logistically complex project to unlock a fenced off highly contaminated site, which has been used as an exemplar since inception involving thermal desorption, ex-situ bioremediation and waste sorting. Many lessons have been learned as it progressed and it has provided valuable practical experience for many in the industry.

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WINNER

Remediation of a former chemical factory, Four Ashes, Staffordshire

ORGANISATIONS

FLI QDS Remediation Ltd and Hydrock Consultants Ltd

QDS Remediation, together with **Hydrock Consultants**, designed and implemented an innovative and sustainable remediation strategy to enable the redevelopment of the Four Ashes chemical facility. The site was to be developed by **Bericote Properties**, the first phase including the construction of a 41,800m^2 manufacturing facility.

The challenge was to remediate a large, complex, and heavily contaminated site in a limited programme window without affecting the concurrent development works. This was successfully achieved through the use of multiple technologies to complete remediation works with a 12-month programme and resulted in >99% re-use of materials.

The 32ha Four Ashes site was used for chemical manufacture from the 1960s and was demolished in 2007. Site Investigations post-demolition identified extensive contaminant impacts to the soils and groundwater from the processing activities. The primary contaminants included high concentrations of phenol, petroleum hydrocarbons, chlorinated solvents, and BTEX. Significant volumes of fibrous asbestos were also present within the made ground. More than 40,000m^3 of heavily impacted soils were identified as requiring remediation.

The highlights of the remediation works included:

- extensive investigation and DQRA to determine clean-up criteria and demonstrate that remediation of the made ground and alluvium would provide adequate protection of the Sherwood sandstone principal aquifer
- a major delineation exercise to generate a 3D model of the contaminant hotspots excavation and ex-situ bioremediation of 25,000m^3 of contaminated soils (100% re-use on site)
- an innovative design combining chemical oxidation with soil stabilisation to treat 15,000m^3 of heavily impacted soils beneath the water table
- management and picking of 1,200 kg of asbestos from made ground to enable re-use on site
- an integrated water management system including lagoons, water treatment plant, and more than 3km of pipework to abstract and treat more than 44,000m^3 of contaminated groundwater
- and validation, demonstrating compliance with remediation criteria and 115,000kg of organic contaminants destroyed.

Remediation strategy

QDS worked with Hydrock Consultants to develop an innovative, sustainable, and cost-effective Remediation Strategy which allowed the site to be redeveloped in two phases while remediation was completed.

Below a construction thickness of made ground, the natural geology comprised glacio-fluvial superficial deposits over Sherwood sandstone group at approximately 3mbgl. The impacted shallow water table, in hydraulic continuity with the sandstone, made the principal aquifer particularly vulnerable to pollution.

A Phase 2 intrusive investigation with extensive chemical sampling provided understanding of a complex mix of organic chemical contaminants and their distribution. Subsequent DQRA work showed that remediation of contamination in the made ground and the glacial deposits were sufficient to protect the principal aquifer. The primary contaminant source area measured nearly 30,000m^3 with a further four smaller hotspots requiring remediation in two phases to fit with the build programme.

The practical considerations for the remediation design at the Four Ashes site were the major development running concurrent with the remediation phase, the limited working space, multiple contractors, and a complex programme. Technical considerations included the high water table, the range of contaminants and high concentrations in both soil and groundwater across different geological horizons.

A single approach to remediation was not considered viable. An innovative in-situ chemical oxidation and stabilisation design was combined with more traditional bioremediation to provide a rapid and robust remedial solution. Key to the design

7m deep press pit construction

Four Ashes site in development

was a delineation exercise to precisely define the extent of contamination. This included 150 trial pits with more than 300 lab samples, backed up by field readings using a photo-ionisation detector (PID). The data were combined into a detailed 3D map of the contaminant distribution.

The smaller hotspots required immediate excavation to maintain the build programme. The areas were dewatered and excavated to the top of the Sherwood Sandstone. Following validation, the bases were stabilised and backfilled with site-won material. Across the main source area, the top 1–1.5m of made ground and glacial deposits were excavated to the water table. The excavation works included the identification, classification, and removal of several underground tanks, buried waste drums, and other point sources.

A large soil treatment area was constructed for the 25,000m^3 of impacted soils to allow screening, processing, and engineering into 2km windrows. Breathable, water repellent covers were used to reduce moisture content and stimulate aerobic bioremediation. The windrows were continually turned when seasonal temperatures increased and routinely sampled to track the progress of treatment. Following six months of bioremediation, 100% of soils had achieved remedial targets and were re-used on site in accordance with the site materials management plan (MMP).

The 15,000m^3 of deeper saturated soils were very heavily impacted – visibly stained and highly odorous – with up to 3,400mg/kg of BTEX (predominantly xylene). The chemical oxidation methodology was designed specifically for this project, with application through in-situ mixing rather than the more common injection methods. This was necessary because of the high silt content that reduced permeability, preventing distribution of reagents via traditional injection methods.

JUDGES' QUOTE:

"The winner was a well-presentted entry that demonstrated effective use of an appropriate combination of remediation techniques on a complex and heavily contaminated site. They provided good evidence of burden depletion, use of bench and pilot trails, and close to 100% re-use of materials."

QDS undertook extensive laboratory trials to establish the most effective Chemox design and optimised application. After proving the concept with bench-scale tests, site trials were completed in test cells where dosing rates, mixing method, and water addition were optimised. As Chemox is primarily an aqueous reaction, optimal treatment requires the addition of water to create a slurry.

Application was undertaken over a six-week programme in 170 dedicated treatment cells, each approximately 6m X 10m in size. Water was continuously added as the excavator mixed each cell with an adapted bucket to mechanically create a slurry. The reagent was subsequently added as a liquid and mechanically mixed following the oxidant application to facilitate maximum contact between reagent and contaminants.

The use of dedicated treatment cells ensured that the precise concentration and volume of reagent could be applied to each individual cell, according to the contaminant distribution determined from site data. A total of 1,200,000l of liquid reagent was applied across the cells. A six-week validation programme was implemented post-application. QDS sampled and monitored each individual cell to identify how the soil and groundwater were reacting to the application of Chemox reagent and to identify any areas of the site that may have required further dosing. 90% reductions in both soil and groundwater concentrations were consistently achieved, meeting the validation criteria.

The final phase of treatment was a soil stabilisation process to achieve the 5% CBR geotechnical criteria. Although this did not form part of the contamination validation process (which had already been achieved), data confirmed contaminant concentrations further reduced following stabilisation.

During the course of the remediation works, QDS identified widespread asbestos pipe lagging within the made ground. QDS proposed a more cost effective and


In-situ chemical oxidation in progress

sustainable approach than off-site soil disposal through careful excavation by a licensed asbestos subcontractor under the full-time supervision of a qualified engineer. The soils were transferred to a picking station and processed to remove all visible asbestos. Following processing and validation, 100% of the soils were re-used at depth under landscaped areas in accordance with the Remediation Strategy and MMP. A total of 1,200kg of asbestos was removed from 2,000m^3 of made ground.

The high water table combined with widespread groundwater contamination presented a major difficulty for the groundworks phase. Extensive dewatering was required to allow the construction of concrete press pits more than 7m deep. With winter groundwater levels reaching the surface across much of the site (due to cut and fill requirements) and creating very difficult working conditions, a comprehensive water management system was required. QDS implemented a system comprising two lagoons, drainage channels, 3km of pipework with multiple pumps and abstraction points. Abstracted water was pumped to an automated water treatment system including oil and silt separators with sand and carbon filtration. More than 44,000m^3 of water was successfully treated and discharged into the adjacent canal under consent from **The Canal Trust** with no exceedances of the compliance limits.

Best practice

Best practice was followed throughout the remedial process. A high-quality site investigation was combined with a DQRA to establish practical and robust remediation criteria in line with CLR11. Further delineation works provided a detailed 3D model of the contaminant distribution. The consultant and contractor worked closely together to design an innovative multi-technology solution that addressed the serious contaminant issues within the constraints of the development programme and site-specific conditions. A flexible approach allowed QDS to successfully manage issues such as unexpected quantities of asbestos lagging and a cut/fill amendment that left the winter water table at surface level in the remediation area, while still delivering in programme and in full compliance with the Mobile Plant Permit and **CL:AIRE** DoWCoP.

Bench testing and site trials proved the effectiveness of the remediation methods which led to successful delivery within a short programme. The regulatory bodies were kept informed throughout the works and a detailed validation report enabled the rapid discharge of the environmental planning conditions.

Extensive vapour protection measures were implemented throughout the works. These measures included the use of atomisers to suppress odours and continuous/point source air monitoring. Vapour monitoring included the use of PID, Tenax tubes and Fourier Transform Infrared Spectroscopy.

The works were contracted at a fixed price which provided certainty of a cost-effective solution. This was possible due to the work undertaken by QDS and Hydrock Consultants to accurately define the risks and focus remediation on the key source areas. The innovative design enabled remediation to run concurrent to construction of a 41,800m^2 manufacturing facility, providing major cost and programme savings.

The remediation permanently removed a major environmental liability which had the potential to seriously impact the underlying principal aquifer. While achieving the remedial goals, the design also provided a construction platform enabling the development of a major manufacturing and employment hub.

The design was based entirely around reduction of the pollution burden. Mass balance calculations demonstrated the destruction of more than 115,000kg of hydrocarbons in soil and groundwater, primarily BTEX and phenol. Multiple technologies were applied to achieve the greatest benefit, with bioremediation of less impacted soils combined with chemical oxidation of the highly impacted saturated source zone. Re-usability was also key with 99.9% of material re-used on site and only untreatables, such as asbestos, buried drums and hydrocarbon sludges, disposed off-site.

Four Ashes was a large-scale remediation project and a high level of stakeholder engagement was required throughout. The team liaised closely with a wide range of parties including the **Environment Agency,** the local Council, Canal Trust, utility companies, and adjacent site owners.

Our ISO18001 management systems required a very high level of health and safety including detailed site inductions, toolbox talks, monthly health and safety operative meetings, regular audits by senior management, near miss reporting and analysis. No injuries or environmental incidents occurred through the 12-month operational phase.

WINNER

Sunshine on the Tyne – Redheugh Gas Holder Station Remediation

ORGANISATION

Northern Gas Networks

Remediation pumping system BHS17-04A

Northern Gas Networks (NGN) has achieved environmental betterment at a redundant gas holder station in the northeast of England through its appointment of **Sweco UK Limited** and **Geo 2 Remediation Ltd** to deliver a low-carbon, cost-effective and durable in-situ treatment solution designed and operated to the highest health and safety standards.

The remedial solution overcame several site constraints and delivered a sustainable system that had no significant impact on wider site activities or site neighbours. The project has demonstrated that a renewable energy power supply is a successful approach to deploy on sites where the physical characteristics of the dense non-aqueous phase liquid (DNAPL) being removed require a slow sustained rate of recovery, and where there are no specific remediation time constraints, such as a development programme.

NGN owns and operates a gas holder station at Redheugh, Gateshead. The site has been a gas holder station since the 1890s and originally contained four gas holders, each comprising a telescopic metal tank set within a circular masonry tank, which was constructed below ground level. Today, the site contains three decommissioned gas holders that are currently undergoing demolition. One further historical gasholder (gas holder number three) was demolished and the tank filled during the late 1980s/early 1990s so that the structure is no longer visible.

JUDGES' QUOTE:

"The winning entry was a good example of permanent, sustainable environmental betterment on a constrained site. It was neatly done, with innovative use of solar power to replace generators, providing CO_2 and neighbourhood impact reduction."

Ground investigation has identified significant hydrocarbon contamination (dissolved and non-aqueous phases) in the base of the 9m deep, 48m diameter infilled in-ground tank of former gas holder number three. Environmental risk assessment identified that the DNAPL present within the base of the tank was substantially contained and considered to be hydraulically isolated from the water within the surrounding ground.

Under current site conditions, the contamination was not considered to pose a significant risk to environmental receptors. However, in recognition of the potential for degradation of the aged holder tank wall leading to leakage of DNAPL in the future, NGN commissioned a short remediation pilot trial in 2016. This confirmed that DNAPL could be freely recovered from monitoring wells installed within the former holder tank using in-situ pumping techniques.

Following this successful trial, NGN commissioned Sweco to undertake an extended DNAPL recovery trial over an initial six-month period between June to December 2017. The overall objective for NGN was to achieve environmental betterment by permanently reducing the quantity of DNAPL and the associated risks posed to environmental receptors, including surrounding groundwater and surface waters.

Remediation strategy

Sweco designed supplementary site investigation works to delineate the extent of DNAPL within the gas holder tank and installed 100mm diameter recovery wells to facilitate in-situ remediation. Baseline monitoring and pre-start pumping tests confirmed the presence of DNAPL in all wells installed within gas holder number three with thicknesses ranging between 0.12m and 1.8m.

The following constraints at the site influenced the design of the remediation solution:

- the extended DNAPL recovery works had to be undertaken concurrent with the large-scale demolition project underway across the wider site, meaning there was limited space available for remediation equipment
- there was no readily accessible electrical supply within the works area on site and limited access to drainage
- telemetry could not be used to remotely monitor remediation equipment due to NGN safety restrictions regarding mobile phone usage on "live" gas sites.
- the site has restricted vehicle access and is set within a wider mixed residential and industrial setting, which is sensitive to vehicle movements, noise, dust, and odours.

Sweco appointed specialist remediation contractor Geo 2 Remediation Limited to design, install, and operate a bespoke remediation system at the site. Bottom loading pneumatic pumps were installed in the four new 100mm diameter recovery wells alongside the existing 50mm diameter groundwater monitoring well.

An individual remediation system covering approximately 12m^2 was established around each recovery well within a fenced compound. The remediation systems comprised a pneumatic pump that recovered DNAPL and contaminated water into intermediate bulk containers stored within constructed bunded areas. The need for a small operational footprint was a key design condition due to the space requirements for the ongoing gasholder demolition works across the wider site.


Redheugh Gasworks

Each pneumatic pump was powered by an individual receiver compressor connected to a battery and a timer/controller unit. The battery was charged via a 100W photoelectric solar panel, thereby providing a solely renewable energy source. This was an important design aspect as there was no readily accessible electrical supply on the site.

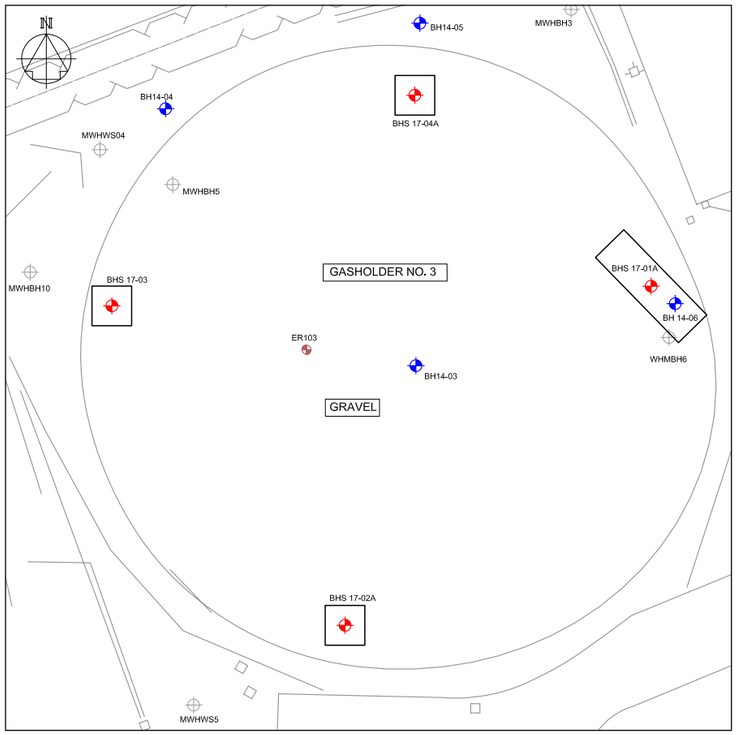
Each pumping system could be set at user defined intervals to suit the recovery characteristics of each well and the DNAPL being recovered at that location, while also balancing the power requirements from the battery.

The system was designed to be robust and durable with only minimal moving parts, allowing for easy maintenance and confidence that it could operate remotely with no requirement for full-time supervision, thereby minimising operational costs. Monthly site visits were undertaken by Sweco and Geo 2 to monitor the DNAPL thickness, undertake maintenance works, and adjust the system to optimise DNAPL recovery rates. The durability of the system has allowed for continued operation with only minimal maintenance required. The solar panels maintained power to allow optimum operation of each system throughout the works, even during the winter months. The cost of maintenance visits was minimised through the selection of a robust low maintenance remediation solution.

The lack of an available power supply was a key factor in the decision to invest in a renewable energy source. Purchase of four individual petrol-powered generators (one for each of the four remediation systems) and fuel costs during the six months of operation would have cost £5,800 more than the solar powered solution used. The in-situ treatment solution developed for the site was cost effective while also meeting the site constraints.

Optimised operation of the DNAPL recovery pumps ensured that waste generation was targeted to DNAPL and water recovery was minimised. This resulted in optimised waste disposal costs.

Over the six months of operation (June to December 2017) the system proved to be very successful with a total volume of approximately 4,370l of DNAPL removed. The targeted removal of DNAPL was a more effective method of addressing environmental liability than either bulk excavation of the backfilled gasholder or pump and treat approaches to remediating the water contained within it. In addition to the improvement in water quality within the gas holder through targeted DNAPL pumping, other environmental benefits have been delivered by this project. The use of a renewable energy source has achieved this reduction in pollution burden in a sustainable, low-carbon manner, saving approximately 18t of CO_2-e compared to the operation of four individual petrol-powered generators over the same period of time. This is the same as the emissions



Remediation system layout plan. Remediation system compounds shown surrounding the recovery wells

from driving an average car non-stop for 29 days. The original six-month operational period proved so successful that NGN extended this to a further six months.

Community acceptance and compliance

The solar-powered remediation design reduced noise and air quality impacts compared to the use of traditional petrol-powered generators, thereby delivering benefits to the local community. The durable low maintenance nature of the equipment deployed and targeted contaminant removal, reduced vehicle movements and disruption associated with site visits and waste collections, minimising noise, and traffic and air quality impacts to the local community. There were no complaints from local residents during the operation of the remediation equipment.

The remediation scheme required Sweco and Geo2 to work closely with the principal contractors of the wider gas holder demolition works and subsequent tank infilling works. Both were key stakeholders and a requirement of the remediation design was the need for the remediation system to occupy a small footprint and to cause minimal disruption to the demolition and infilling programmes. Sweco and Geo2 worked closely with the demolition contractor throughout the supplementary site investigation, remediation system installation, and operation. As a result there was no impact on the contractor's programme of works.

Compliance with health and safety procedures was paramount during the remediation works to ensure activities undertaken protected staff on site, the general public, and the environment. This was particularly important at the site at Redheugh due to wider ongoing gas holder demolition activities.

Under CDM 2015, Sweco provided services as principal designer, principal contractor, and contractor. Potential risks to all receptors during the supplementary site investigation and remediation works were considered in detail. These were captured in a designer's risk assessment. Sweco identified hazards and, where possible, these were designed out of the works - for example, choice of drilling methods, use of solar power instead of generators, reduced operational footprints, and ensuring systems were robust and easily maintained to avoid the need for attending site unnecessarily.

A detailed Construction Phase Health, Safety, and Environment Management Plan (CPP) was developed, providing key information relating to the planned works, the programme, arrangements for communication between parties on site, method statements, and risk assessments for all key activities and an emergency action plan and constraints plan. To comply with the Control of Asbestos Regulations 2012, Sweco developed a plan of works and risk assessment that was adopted during the site investigation and installation works.

During the works, NGN required a critical safe dig assessment (CSDA), adopting service clearance using CAT/Genny and ground probing radar, bespoke safe digging tools, and completion of specific CSDA form. Forward planning ensured on-site works did not conflict with wider site activities. Gas holder number three was being used as a laydown area for the wider gas holder demolition works and pre-planning of operations was essential to minimise disruption to programme.

In accordance with the British Drilling Association's Guidance Notes for the Safe Drilling of Landfills and Contaminated Land, the site was classified as a RED site. Site decontamination procedures were adopted and the site segregated into defined clean and dirty areas. Site welfare including decontamination facilities was provided throughout the works including personal protective equipment suitable for red site working.

All suppliers and sub-contractors used on the project were selected via the Sweco-approved supplier database. This system ensures sub-contractors and suppliers comply with specific Sweco requirements and values, have appropriate quality, environment, health and safety procedures, insurances and are able to supply the required services.

All personnel were trained to meet the requirements of CDM 2015 and specific NGN needs, including SHEA Gas certification as a minimum. All site operatives were provided with a health, safety and environment induction including details of hazards associated with the site, the nature and scope of the works to be undertaken, specific site safety rules, an emergency action plan, and incident reporting procedures. Compliance with the CPP was mandatory for all site personnel and regular toolbox talks were provided by Sweco staff throughout the works.

JOINT WINNER

Unlocking the redevelopment of a galligu and petroleum hydrocarbon contaminated site

ORGANISATIONS

Geotechnical and Environmental Associates (GEA) and Regenesis

The redevelopment of a site in Runcorn faced unique and complex challenges due to instability, extreme geochemistry, and contaminant egress from a low-value, derelict site. **GEA** formulated and undertook an innovative and intelligent, combined approach to successfully unlock the site.

The site is formed of a mound of industrial waste from an alkali works that used the Leblanc process to produce washing soda. The ground comprises several metres of galligu above a black ash layer, which was underlain by cohesive glacial till. Directly downgradient of the site is a steep slope down to the Bridgewater canal and the **Bridgewater Motor Boat Club.**

The site was home to a bus depot that suffered from extreme settlement, due to the poor geotechnical properties of the underlying galligu. Anecdotally, this resulted in buses being unable to drive out of garages that had settled over a weekend. The settlement also caused breakages and leaks from underground storage tanks and pipes. The leaking fuel migrated through the galligu into the underlying ash layer and impacting perched water. Immediately downgradient is a steep slope and periodically impacted water would egress from the ground and run over the patios and vegetable patches of the local boat club and into the canal.

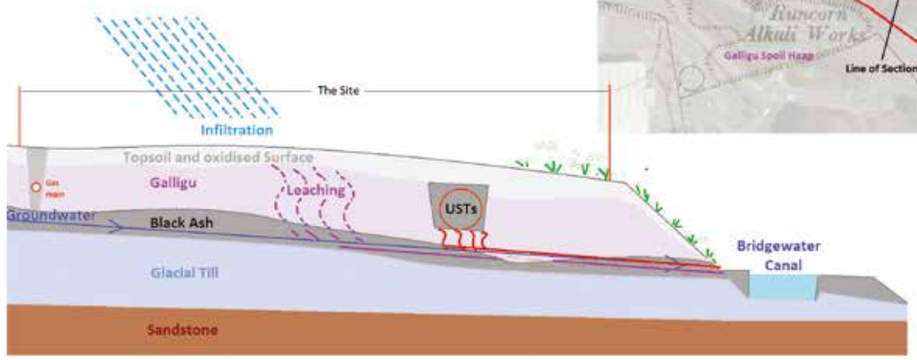
The site lay derelict for 25 years and several development proposals fell through due to the cost of remediation. Finally, a proposed joint venture development by **Marston's** and **Halton Borough Council** was progressed to create a public house, coffee shop, and public car park.

The development faced multiple challenges and GEA realised that each step in the solution process would have an effect on the next phase, so a well thought-out, integrated approach was crucial for the project's success. GEA worked with **REGENESIS** and **Deep Soil Mixing Ltd** to achieve this.

Remediation strategy

The first issue to address was the poor geotechnical properties of the galligu and the presence of a high-pressure gas main, which would limit the foundation options available. The structure of galligu varied across the site: from fused crystalline "rock" in upper areas, to a weak toothpaste consistency at depth – which was unsuitable to build on. The low value of the site prohibited expensive dig and dump. Stabilisation of the entire thickness of galligu, as had been completed locally, was not viable due to the thickness of galligu and the resultant cost of treatment. Therefore, it was determined that soil/cement mixed "panels" should be trialled, to confirm that they could support the proposed buildings and avoid unacceptable vibration of the high-pressure gas main. Several configurations and mixes were piloted and the most effective approach was determined for the site.

An installation plan was then created and it was clear that in solving the geotechnical issue, this solution would then create a new challenge: the cement stabilised columns would alter and channel the groundwater flow across the site, so altering the migration path of contaminants in the groundwater. It was crucial to understand the effect of the



Conceptual Site Model

Galligu on site

alteration to the groundwater flow so that targeted treatment could be carried out to minimise the potential for hydrocarbon contaminant egress from the site.

Modelling the groundwater flowing through variable aquifer thicknesses of anthropogenic waste at different permeabilities presented quite a challenge, particularly where abandoned buried structures provided unpredictable preferential flow paths. Commonly-used computer models are designed for more natural, homogeneous and isotropic conditions with a lesser degree of uncertainty. It was, therefore, determined that a crude but effective 2D electric resistivity model could be used to predict the redistribution of the contaminant plume. This showed that the plume would spread and then egress from the site via gaps in panel "wall" at the boundary. These gaps had been created due to the practicality of positioning the piling rig at the edge of the site and prevented the ponding of the groundwater behind the cement/soil "wall".

Now that it had been determined where the hydrocarbon plume would be located following stabilisation, a remediation method was required. The secondary source of impacted soils was to be removed through a limited excavation. However, the dissolved phase plume presented a challenge as:

- physical abstraction pipework could not be installed at the site due to the rapid construction programme immediately following the stabilisation
- chemical oxidation could not be used as it would have resulted in ground heave due to gypsum crystal growth
- enhanced biological degradation would be almost impossible due to the aggressive geochemical environment produced by the galligu i.e. pH 11-13, very low redox, and high concentrations of arsenic
- and the remediation method would have to work for a long period of time to deal with the residual dissolved phase plume, without requiring infrastructure or power.

The solution was to use an innovative remedial approach that would turn the subsurface in between the stabilised panels into activated carbon filters. PlumeStop Liquid Activated Carbon is an injectable substrate that rapidly reduces dissolved phase contamination to very low concentrations for a very long period using a single injection. PlumeStop works through a combination of adsorption and accelerated biodegradation processes.

JUDGES' QUOTE:

"This entry displayed good lateral thinking to create solutions for the low-value site. There was an excellent conceptual site model, which was well presented, and included an appropriate range of remediation techniques."

The product consists of 1-2µm activated carbon colloids in water and dispersion agents, which are injected under low pressure into the subsurface. This coats the aquifer in a thin layer of activated carbon, which allows groundwater to flow through, but removes the contamination via adsorption – effectively turning the subsurface into an activated carbon filter. The activated carbon on the surface of the aquifer ('colloidal biomatrix') provides an excellent surface for microbial growth. The microbes typically degrade the contamination that has been adsorbed.

At this site, it would be expected that over time some biological degradation would occur as the source had been removed and less reduced water would begin to reach the barrier location in time. However, much of the remediation would be achieved through adsorption, with the barrier designed to be active for several decades. This barrier longevity is assisted by the removal of the source (UST and soils), resulting in the barrier-influx concentrations reducing over time, which (as shown on adsorption isotherms) will increase the efficiency of adsorption.

This application of liquid activated carbon into galligu and integrated with cement stabilised panels had never been attempted anywhere in the world. The placement of the subsurface activated carbon filter needed to be carefully considered. At the boundary gaps, groundwater flow was extremely fast and injection here would either result in partial treatment, or the need for an extremely thick barrier. It was therefore decided to move the barrier up gradient into the site, where the slower groundwater would allow a longer treatment time through the treatment zone. The barrier width was also guided by the modelling to transect the entire contaminant plume.

The barrier was injected in the "channels" between soil/cement panels, perfectly integrating with the geotechnical solution. The injection was completed from 4-5mBGL using direct push injection on a 3m spacing (in between soil/cement panels, coating the channel in between, along a 30m line). The works were completed in just one week, with no installations or equipment left on-site after

that, allowing the construction programme to continue unimpeded.

Validation sampling showed that the barrier stopped contaminant egress from the site (98% reduction to the limits of detection). Although groundwater still frequently moves over the Boat Club members' land, the water does not smell, oil sheens are absent, and there is no hydrocarbon contamination to affect the canal.

Cost effectiveness, durability, and pollution reduction

This was necessarily a complex and technical project due to cost vs benefit of revitalising this low value land. The innovative combined approach made the entire project economically viable: if dig and dump had been used, the cost would have been >£10m.

For the remediation of the petroleum hydrocarbons, the ground investigation, geo-environmental consultancy, risk assessment, design, modelling and validation, plus the PlumeStop injection amounted to approximately £80,000 of the total project cost of approximately £2m. The remedial scheme was delivered on time and budget, allowing the construction programme to continue as planned.

The barrier application brought about immediate environmental benefits, where the alternatives were either impossible to complete within the site conditions, extremely costly, or too disruptive to allow construction to continue. Designed to last for decades, the barrier will remain effective while the upgradient plume attenuates. The barrier was provided with a full warranty, with no further requirements for pumping, maintenance of use of power.

An innovative approach was taken on this unusual site

This remediation approach avoided the removal of 100,000t of galligu from the site. The only disposal completed was the tank removal and a small amount of adjacent impacted soils. The long-term passive barrier produces no waste, adsorbing the contamination to allow time for degradation and attenuation. Contaminated egress has halted, following a 98% decrease in concentrations to the limits of detection. The canal has shown a reduction in hydrocarbon loading and the groundwater break outs on Boat Club land are now devoid of hydrocarbons.

Acceptance, compliance, and success

GEA worked closely with a range of stakeholders on the project in order to balance the varying needs to provide a successful project. The development was led by a private developer (Marston's) who worked with the Runcorn Council development arm (Neptune) who subsidised the venture to allow development of the low value site. The Environment Agency and the Contaminated Land Officer were both deeply involved in the project. All the stakeholders were fully engaged and very pleased with the result of the integrated approach. The local Boat Club members are very pleased with the reduction of contamination in their canal, and prevention of contaminated water impacting their pathways, patio, and even their vegetable patches.

All work was completed on a busy construction site, with a high-pressure gas main and large easement, and there were no incidents or near misses during the works.

In situ remediation avoided 100,000t of disposal and 4,500 wagon movements. The barrier system employed produces no waste and requires no power. Remediation revitalised an eye-sore of waste ground into a useful resource for the local community and protected the Boat Club members and reduced hydrocarbon influx into the canal.

1876 over aerial with outline

JOINT WINNER

Remedial Strategy Development for Complex Fractured Bedrock DNAPL Site

ORGANISATION

ERM

ERM was commissioned to investigate and treat legacy contamination at a manufacturing facility in the UK. The site investigation activities, using high resolution site characterisation (HRSC) techniques, identified impacts from trichloroethene (TCE) within fractured bedrock, at concentrations suggesting the presence of dense non-aqueous phase liquid (DNAPL). The on-site TCE impacts relate to former degreaser locations within an operational building and the contaminant had migrated beyond the site boundary, being detected at downgradient receptors. Following site characterisation, ERM partnered with **Cornelsen** to implement the chosen remedial approach.

Due to the complex fractured bedrock geology, characterisation using traditional site investigation techniques was not feasible, so characterisation was undertaken via a complimentary suite of HRSC techniques including:

- detailed geological logging and structural frequency analysis: This involved traditional core logging to British Standards, but also logging of structure type, frequency, and orientation. The site lies directly on slate bedrock, with sporadic weathered zones
- downhole geophysics: An optical televiewer was used to visually identify fracture zones (transport pathways)
- background fluorescence analysis (BFA): This involved the analysis of groundwater samples with a fluorescence spectrometer, generating a unique fluorescence fingerprint for each sample and allowing an assessment of hydraulic connectivity
- and a discrete fracture network (CORE DFN ™): The CORE DFN™ allowed collection and on-site analysis of approximately 350 samples during a two week period, facilitating the identification of impacts in near real time and informing the drilling depth for subsequent locations, saving time, cost, and energy consumption. Rock samples were analysed from both fracture surfaces and from the intervening rock matrix via microwave extraction and GC/MS.

The integrated HRSC results allowed the creation of a fractured bedrock conceptual site model (CSM). The structural geological assessment determined that there were frequent bed-parallel fractures between 16-36m bgl, with some high angle cleavage fractures also present. The fracture locations identified correlated well with high TCE concentration data from the CORE DFN™, confirming the migration of dissolved phase TCE and allowing the installation of targeted monitoring wells. Critical information gained from the structural geological assessment indicated the absence of open fractures below 40m bgl, which corresponded to trace TCE concentrations at these depths. This allowed the depths of impacts to be determined, providing key data for remedial design.

JUDGES' QUOTE:

"This was a really good example of how fully understanding a site in difficult geology can optimise the remediation approach to solve a tricky problem on a complex operational site."

Data from the CORE DFN ™ and BFA further refined the CSM. The fluorescence fingerprints obtained via the BFA showed potential hydraulic connections between the on-site and off-site receptors, supporting the data on groundwater flow direction gained from the geological assessment. The results of the CORE DFN™ identified that significant TCE concentrations were present within both the fracture network and rock matrix.

Remedial options appraisal

Given the technical challenges of remediating DNAPL in fractured bedrock, ERM analysed the significance of matrix diffusion (contaminants may enter the rock matrix which can then 'back-diffuse' over long periods of time). Software (Matrix Diffusion Toolkit model) was used to assist with the selection of the remedial technique by generating a model curve for diffusion into the matrix from a fracture where groundwater was saturated with TCE (1,100mg/l). The results showed matrix diffusion occurring within 0.5m of fractures. However, this was of low significance, given that DNAPL mass within fractures was dominant.

A remedial options appraisal was undertaken using a holistic sustainability approach, where environmental, social and economic indicators were evaluated to determine the most sustainable option in accordance with CLR11, and the UK SuRF framework, incorporating sustainability as an integral part of the technology selection process.

The results of the ROA showed: some techniques were unsuitable due to the nature of the fractured bedrock/depths of impact (excavation); some techniques were not feasible as the source areas were located beneath operational manufacturing buildings (process based recovery techniques); and fluid-based remediation techniques were not feasible due to challenges of delivery in fractured bedrock and also the high TCE concentrations (in-situ chemical oxidation)

Given the limited options available due to technical and logistical constraints and the fact that downgradient receptors had already been affected, the remedial goal was to reduce ongoing impact to the receptors and contain the TCE. The understanding of matrix diffusion and containment distribution via the multiple HRSC techniques also suggested fracture mass should be targeted. Therefore, hydraulic containment was the chosen solution to achieve these aims and meet client and regulatory expectations in the short to medium term.

A multiple well, field scale pumping trial was undertaken by ERM with Cornelsen to confirm Hydraulic Containment System (HCS) design parameters, such as radius of influence and flow rates. The remedial system was then designed by ERM and included creation of a groundwater flow model using Modflow and Modpath codes. This system comprised six pumping wells connected to recovery equipment (DNAPL collection tank, air stripper, chiller and liquid/vapour phase discharge via Granular Activated Carbon). The system has now been installed by Cornelsen and is currently being commissioned.

Process equipment

Best Practice

Best practice was demonstrated throughout the project. The HRSC techniques used were complimentary and provided a collaborative data set, creating a robust CSM. The HRSC techniques also produced a high-quality data set in a short period of time and related sustainability/costs benefits compared to traditional techniques. The data collected informed the depth of TCE impacts and the mechanisms for contaminant migration, with the data being used to inform the ROA and subsequent design.

The innovative remedial design, including groundwater modelling and matrix diffusion assessment, also displayed best practice; and the system was innovative in a range of ways, such as:

- the installation considered long-term site operation/logistics. For example, connections between groundwater extraction wells and the remediation equipment had to be buried underground to keep the site operational
- the process system includes remote monitoring/telemetry/high level of control and monitoring from off-site
- the process equipment includes innovative security, such as finger print log in, passwords, and different access rights
- high quality of plant, such as stainless steel high quality welds, efficient air stripper
- solenoid pump controls to allow pumps to operate lower than their normal operating rates
- multi-mode groundwater pump control
- in-line PID to measure solvent vapours, enabling system optimisation in conjunction with the remote access
- plant built into a container to allow full off-site construction and test running of the plant, which reduced installation time on-site.

ERM has also created a Power BI dashboard to allow real-time data visualisation and interpretation. Data collected from the process equipment will be uploaded into the system via an EQuIS database, together with any manual data collection (using the EDGE field tool). This approach will significantly reduce data processing time and enable the system to be rapidly optimised.

It has collaborated with Cornelsen to implement its conceptual design. However, unlike many traditional engineering design-and-build contracts, this relationship has been leveraged to allow both parties to input into the detailed design from both an innovation and safety perspective, which ultimately has produced a higher quality product.

Furthermore, a trusted advisor relationship has been built between the ERM/Cornelsen team and the Environment Agency (EA), with multiple discussions held and a remediation training session to be scheduled for EA staff in the future.

In terms of health and safety, a HAZOP/process safety review was undertaken at the design stage with any mitigation measures being verified during system commissioning. This process will reduce operational risks significantly and included liaison with site management on issues such as fire protection in the context of wider site activities.

Project successes

The HRSC approach adopted minimised the duration of the site investigation and finalised the CSM without the need for multiple phases of investigation that are typical with conventional drilling approaches. As the duration was shorter, ERM estimates the cost of the investigation was 30-50% cheaper than using traditional techniques. The accurate delineation of the identified impact enabled the remedial strategy and design to be robustly assessed, thereby increasing the likelihood of achieving the remedial objectives. The remote system control and data management systems also mean site attendance can be reduced, saving cost. The innovative system design and data management protocols will also reduce downtime.

Regarding reducing the pollution burden, the HCS system is expected to reduce impacts to the off-site receptors by breaking the pollutant linkage. This approach has been selected due to the inaccessibility of the source zones and majority of the mass being in the relatively high permeability fractures, although some mass removal during the containment is still anticipated and will be assessed via monitoring to confirm the suitability of the strategy in the longer term.

With respect to community and stakeholder acceptance, all project stakeholders were consulted throughout the project. ERM kept the EA informed throughout the project and has received positive feedback from the regulator, who noted that the HRSC assessment had been completed to a level beyond that typically seen in the UK. The carefully designed remedial approach enabled endpoints to be agreed quickly with the regulators. ERM also held regular meetings with the client to discuss a wide range of issues, including health and safety and integration of remedial activities with site activities. The works were completed safely, on schedule, on budget and to the satisfaction of all stakeholders.

ERM and Cornelsen instigated a proactive, sustainable approach to health and safety that frequently considered the risks in the context of an operational site. The work also fell under the CDM Regulations (2015), therefore the roles and responsibilities were clearly defined. In addition to typical risks considered for any in-situ remediation project, the following was also undertaken:

- process safety was considered at the design stage with several reviews undertaken, the outcome of which added process safety features to the remedial equipment
- a strong safety culture was embedded within the project team
- mentoring of junior staff throughout the works
- three project audits were undertaken in accordance with ERM's global Active Safety Management approach
- use of the HRSC approach significantly reduced Health and Safety risks, given that accurate site characterisation can be undertaken more rapidly and with fewer intrusive locations.

Sustainability has also been a key consideration throughout the project lifecycle. The use of innovative HRSC techniques has resulted in a lower carbon footprint than if multiple phases of traditional investigation had been undertaken. The remedial approach focused on carbon footprint reduction.

Pumping trial and groundwater modelling during the design stage identified the optimum pumping parameters to achieve capture and increase the overall efficiency for the commissioning and operations stage. Completing the system build largely off-site reduced travel to the facility. Condensing the vapour stream using heat exchangers to dry vapour minimised granular activated carbon use. Remote monitoring technology made the system operation more efficient and reduced site attendance, and changeable pumping modes to maximised and targeted recovery with minimal power input.

Equipment container

WINNER

Detailed characterisation of a former oil depot

ORGANISATION

Arcadis

The site is a former oil depot in the south of England. It is located on a tidal waterway and previously received products for storage by ship with distribution from the site via road and rail. The site was disused with above ground tanks and below ground infrastructure removed. Light non-aqueous phase liquid (LNAPL) was known to be present, with a concern about potential risks to future site users, neighbouring land users, and the wider environment from LNAPL migration.

The client was keen to sponsor and implement an R&D-led assessment strategy, and worked closely with **Arcadis** to develop an innovative solution to further characterise the site conditions and enable a sustainable remediation strategy to be developed.

Best practice techniques were applied including a range of market-leading innovative approaches. These approaches included the following:

- development of a detailed conceptual site model (CSM) including use of an innovative remote telemetry LNAPL monitoring system to understand the influence of tidal changes on the LNAPL
- forensic testing of LNAPL samples and transmissivity testing to evaluate LNAPL mobility and recoverability
- increased data quantity and quality through remote telemetry permanent ground gas monitoring to aid understanding of natural source zone degradation (NSZD) rates associated with volatilisation and degradation in the unsaturated zone
- saturated and unsaturated zone temperature monitoring using data loggers
- collection of groundwater samples for laboratory analysis to further aid the NSZD assessment
- development of reporting dashboards, summarising the CSM in real time
- and creation of a 3D model for the site to aid stakeholder engagement, embedded within the dashboard.

The site had a long history of use as a depot, and primarily stored diesel range oils, including kerosene. Storage consisted of above ground storage tanks (ASTs) with lower volumes of product stored in barrels close to the waterfront. The site elevations are variable, with the former location of the ASTs some metres higher than the former storage location of the barrels. Previous investigations confirmed the presence of LNAPL in wells in the vicinity of the former barrel storage area.

The geology beneath the site comprises a limited thickness of made ground beneath the former barrel storage area, underlain by a thick sequence of fine to medium sands. Groundwater rests at 1.7m to 2m below ground level, and is tidally influenced. The tidal range in the adjacent watercourse is up to 1m, resulting in a change in groundwater of up to 0.3m in wells on the site, to around 30m within the site, clearly reflecting the tidal cycle.

A programme of borehole drilling, soil gas sampling, and multiple groundwater sampling visits had provided data to inform a detailed quantitative risk assessment (DQRA). The DQRA modelled the fate, transport, and associated exposure of petroleum hydrocarbons in soil, soil gas, and groundwater by future on-site users, neighbouring land users, the aquifer, and the adjacent watercourse. The modelling results found no significant risks present to the receptors.

Use of laser induced fluorescence (LIF) probing to map the presence, extent, and composition of the LNAPL had been undertaken during a previous phase of investigation, providing a strong evidence base to inform the development of the LNAPL CSM. Discrete monitoring events, including throughout the day, had confirmed the presence of a dynamic system with LNAPL presence up to 0.5m with variable thickness dependent on time measured. However, there remained a number of data gaps relating to the LNAPL which had not been possible to address using traditional investigation techniques, leading to uncertainty regarding the LNAPL. This prevented the development of a sustainable risk management strategy.

Data gaps existed regarding: the influence of tidal fluctuation on LNAPL thickness in the monitoring wells; the mobility of the LNAPL; the transmissivity and therefore predicted recoverability of the LNAPL; the rate of NSZD of the LNAPL; and uncertainty as to whether the LNAPL plume was expanding.

Remediation strategy

The investigation strategy was informed not only by the technical objectives, but also consideration of sustainability including health and safety. The site is located in an area of the country that can only be accessed for monitoring by road – a four hour minimum round trip – and which has no power supply or water disposal routes. While the site wasn't identified as a high risk area for our workers, with the well secured, the team recognised that the fewer trips to site, the lower the project health and safety risks would be, given driving is one of the most dangerous activities undertaken by site engineers.

A scope of site works was developed in close collaboration with the client to provide a high resolution dataset while minimising travel time through use of remote telemetry devices and using renewable power supplies. Three autonomous, real-time, continuous LNAPL monitoring devices were installed within existing groundwater wells (supplied by GeoStream). These were powered by a solar panel installed onto a small shipping container which hosted the above ground telemetry unit.

LNAPL samples were collected for forensic testing and LNAPL baildown testing was used to assess LNAPL transmissivity. Temperature data loggers were installed and three GasFlux TM devices were put in place within two groundwater monitoring wells and an adjacent soil gas well. These were powered by solar panels installed into an innovative headworks (all supplied by AmbiSense), and other measures included groundwater sampling and analysis for petroleum hydrocarbons as well as a monitored natural attenuation (MNA) suite.

The majority of the works were undertaken between November and December 2017, with all site works complete by the end of 2017. The key findings of the works were:

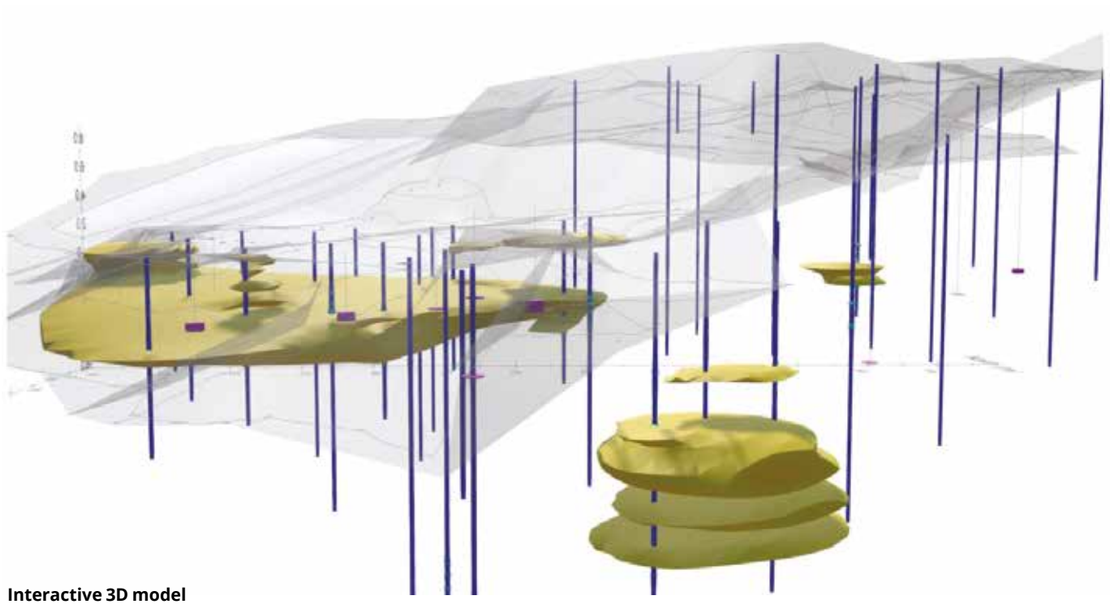
- LNAPL thickness in monitoring wells was confirmed as having a strong tidal influence, with a decrease in depth to groundwater leading to a temporary increase in LNAPL thickness with limited lag time – the results were validated against existing discrete LNAPL thickness measurements
- the maximum LNAPL transmissivity was 9.2cm^2 a day, well below the ITRC threshold range for hydraulically recoverable LNAPL and validating an ongoing strategy of product bailing
- the LNAPL comprised a weathered kerosene and/or diesel mixture, concurring with the results of the LIF probing
- there was a clear influence on unsaturated temperature from ambient condition, but no observable influence on groundwater temperature (limited tidal influence)
- there was a limited tidal influence apparent for the ground gas data from the groundwater wells (with tidal influence apparently buffered) but a strong tidal influence ("pumping") apparent for the ground gas data from the unsaturated zone (narrow diameter) well.

Best practice

High resolution datasets were generated using innovative toolkits. A robust CSM, needed to inform quantitative risk assessment, was developed through the collection of high resolution datasets – both providing context for the changing LNAPL thicknesses previously observed in wells and to understand the complexities of the ground gas regime. This was used to inform both the LNAPL mobility assessment and the NSZD evaluation.

The team quantified data on LNAPL behaviour. The forensic testing and LNAPL transmissivity testing were used to inform the quantitative risk assessment on LNAPL mobility and recoverability. The assessment concluded that the LNAPL was functionally immobile.

Time series data were also gathered on the gas regime. The quantified gas data, collected over time, enabled the calculation



Interactive 3D model

of NSZD rate as a result of unsaturated zone processes with confidence – something which would not have been possible using discrete carbon dioxide measurements given the dynamic nature of the site. The NSZD estimate was around 11,000l a HA/YR, equating to around 11m^3 of NAPL a year for this site.

Regarding the collection of hydrocarbon and MNA groundwater data, the laboratory analysis of groundwater samples provided a good evidence base for calculation of NSZD rate as a result of saturated zone processes. The rate of NSZD was at least one order of magnitude lower than the unsaturated zone processes.

A key component of the investigation was data management and data presentation. The data presentation requirements took two forms: monitoring the high-resolution dataset as it was received and presenting the findings in an online CSM in a dashboard format including a 3D model of the site that can be viewed in Augmented Reality.

LNAPL thickness and gas data were transmitted remotely, with the gas and weather dataset accessible to the project team through a secure online portal provided by AmbiSense and the LNAPL data provided daily via email. The LNAPL transmissivity datasets and LNAPL distribution data were shared with the neighbouring land users to provide confidence that LNAPL migration was not occurring, and that LNAPL was not readily recoverable.

A 3D model of the site was developed in EVS and embedded into the CSM interactive dashboard developed for the site by Arcadis, drawing upon new and historical datasets stored within a structured database.

In terms of the project's cost effectiveness and the viability of other investigation approaches, the only alternative for the site would have been continual site presence for one month of at least two consultants, collecting multiple discrete measurements, and using flux boxes to record CO_2 emissions. The cost of the team's approach was comparable with the alternative. However, it included purchase of three LNAPL monitoring devices – which are still monitoring the site – and the resolution of the dataset far exceeded the resolution that would have been achieved through discrete measurements. The use of solar panels significantly reduced costs compared to connecting the site to the local grid. Now developed, this approach can be applied to other sites with lower variable costs.

Concerning health and safety compliance, Arcadis carried out both principal designer and principal contractor duties under the CDM Regulations 2015. The main hazards specific to the site were identified via a health and safety plan. Arcadis developed a methodology known as Track to 0, based on HSE best practice guidelines, to ensure safe work practices for the health and safety of Arcadis operatives, subcontractors, port employees and the general public. The system comprises five stages to identify, assess and control H&S risks and is a key part of the site-specific Health and Safety Plan. All visitors to site underwent a full health and safety induction, which included a toolbox talk to highlight previous integrated observations and near misses recorded for the site.

The most notable health and safety risk for the works on-site comprised travel to and from site. However, the use of remote telemetry systems to capture high resolution datasets reduced the need for site engineers to visit site routinely, resulting in a significant reduction in carbon footprint and car/van travel. In total, there was an estimated 60% reduction in miles travelled over a one-month assessment period, which would increase with length of deployment of the remote telemetry technologies.

JUDGES' QUOTE:

"The winning project was an exemplary use of innovative technology, with the first use of solar-powered LNAPL monitors and use of virtual reality to present their findings. This is a good example of the deployment of autonomous instrumentation at a remote site and direct uploading to the office with associated cost savings and health and safety benefits."

WINNER

Sandford Farm landfill remediation

ORGANISATION

Vertase FLI

Loddon Park in the east of Reading is a **Taylor Wimpey West London** housing scheme on a former landfill site. The 20ha site, previously known as the Sandford Farm landfill, was a former sand and gravel quarry. It was later used as a ready mix concrete batching site before operating as a licensed landfill, receiving industrial and commercial waste between 1981 and 1991. The site is located within the residential setting of Woodley, with residential housing constructed up to the western site boundary in the 1980s.

The proposed remediation of the Sandford Farm landfill site to make the land suitable for residential development proved very controversial. It was locked in the planning system for many years with multiple planning applications from several potential developers rejected. The main objections to the remediation and redevelopment came from the local residents and centered on the perceived health effects from disturbance of the landfill waste. Indeed, there was the potential for >60,000 lorry movements on local roads to relocate the waste to a suitable landfill site and the void would have been reinstated with inert material if a traditional "dig and dump" remedial strategy had been adopted.

Key to paving the way for the successful remediation of Sandford Farm was a pilot trial undertaken by **RSK** in 2008 as part of a planning appeal process, which demonstrated that a majority of the landfill material could be safely processed and re-used on site, thus providing an alternative to dig and dump. This created an opportunity to explore a more innovative process-based remediation strategy that was in keeping with the principles of sustainability and would cause significantly less disruption to local residents. As a commitment to this sustainable approach, the project team agreed that only 10 lorry movements per day, in and out of site, would form part of the planning requirements.

Gas generation (drum) tests to monitor ground gas generation from recovered materials intended for re-use

Segregated sample of recovered material from landfill waste undertaken as part of the forensic description methodology in RB17

Outline planning approval was granted in March 2010. Taylor Wimpey purchased the site later that year with full planning permission granted in 2011 for the development, which is currently in the latter phase of the house building scheme. Building on the RSK pilot trial information, Vertase FLI successfully completed the remediation of Sandford Farm landfill. Importantly, the majority (~95% by mass) of the landfill material has been re-used on site.

Best practice

The remediation of Sandford Farm landfill represents a significant achievement in the context of sustainable remediation and project closure. It was made possible by the project team's commitment to adopting and working in accordance with best practice guidance throughout the project. Evidence of this is best demonstrated through the partnership with the **Environmental Protection Group Ltd** (EPG), who acted as sub-consultant to VertaseFLI throughout the project with regard to ground gas remediation and management. As a contributing author to best practice guidance in ground gas risk assessment, the input from EPG was critical to demonstrating the suitability for re-use of materials recovered from landfill waste to construct a development platform. Furthermore, the extensive datasets obtained during verification of the project are being used to develop new best practice approaches to ground gas monitoring and risk assessment.

Remedial objectives and community acceptance

The original remediation objectives and remediation strategy for the site were enshrined within an options appraisal undertaken by RSK several years before planning consent for the remediation works was provided. The core remedial objectives at this stage of the project were to: ensure that identified pollutant linkages were not present post-development; re-use as much of the site soils as possible; and reinstate development platforms using materials that would not generate ground gas flow rates in excess of those corresponding with Amber 2 under the **NHBC** guidance.

Outline of the site located in Woodley, Reading

RSK also identified development objectives to inform selection of the most sustainable remediation strategy:

1. minimise the carbon footprint of the remediation
2. maximise recycling of materials from the landfill waste
3. minimise waste removed from site
4. maximise use of the proposed development layout
5. eliminate the need for long-term maintenance and waste licencing
6. minimise nuisance to site neighbours
7. and enable a phased build programme to commence concurrently with remediation.

Vertase FLI met all of the remediation and development objectives identified by RSK.

The remediation and redevelopment plans attracted significant opposition from local residents. This opposition was given additional momentum by **Loddon Valley Action Group** (LVAG), which was formed by members of the local community to raise funding for legal representation to oppose the development plans. When planning consent was finally granted, LVAG restructured to act as a liaison committee for monitoring the remediation and development of the site. The importance of community liaison during the remediation works was enhanced by a planning condition imposed to ensure that a Communications Plan was in place to specify methods of communication with local residents, including creation of a liaison group to meet at regular intervals.

VertaseFLI, in collaboration with RSK and Taylor Wimpey, developed the Communications Plan which set out plans to disseminate information associated with the remediation works via numerous mechanisms including letter drops, site perimeter notice boards, a project website, resident liaison group meetings, and resident site visits where residents were given a tour of the site accompanied by members of the project team to answer queries and describe activities.

The liaison group meetings were effective in achieving community acceptance of the remediation works. Typically attended by representatives of Taylor Wimpey, RSK, VertaseFLI and **Wokingham Borough Council**, they provided an open forum for residents to raise concerns or queries about the remediation works. Importantly, the meetings were minuted so that actions could be assigned to the project team, thus providing a direct mechanism for the residents to influence the works. This mechanism of empowering the residents provided all stakeholders with the comfort required.

Over the four-year course of the project, there were relatively few complaints relating to the remediation works from local residents, the majority of which were minor and could be dealt with on the day of receipt. This reflects the community acceptance achieved at the outset.

Monitoring and risk management

Significant testing and monitoring were undertaken during and after completion of the remediation works to provide evidence to stakeholders that remediation objectives were met. All monitoring techniques were undertaken in accordance with best practice guidance and available standards.

Testing of the total organic carbon (TOC) content within reinstated materials recovered from the landfill waste was undertaken using a pioneering "forensic description" methodology which had been developed shortly before the commencement of this project and published by **CL:AIRE** in *Research Bulletin 17*. VertaseFLI was the first remediation contractor to apply this method at the commercial scale to material recovered from landfill waste as a line of evidence to demonstrate its suitability for re-use.

Furthermore, to provide an initial characterisation of the gas generation potential of materials recovered from the landfill waste, VertaseFLI, under the guidance of EPG, constructed state of-the-art gas generation tests within sealed steel drums. Designed to mimic the conditions of the material following reinstatement as closely as possible, gas concentrations, flows and other parameters were measured within the steel drums to model the likely ground gas regime upon site-scale reinstatement. Validation of this remediation project to the satisfaction of all stakeholders would not have been possible without adopting wide ranging and advanced monitoring techniques as well as comprehensive materials management planning and recording so that the gas generation potential of every individual layer of placed material is known.

Furthermore, the monitoring undertaken has set a precedent for the level of detailed data collection that is required on future similar projects, raising standards of remediation verification within the industry.

Upon completion of the physical remediation works, there remained residual risk from: contaminants present in reinstated materials; ground gas present within reinstated materials; and ground settlement. It was the responsibility of VertaseFLI to demonstrate to RSK and regulators that this residual risk was in

keeping with the remediation strategy, which was achieved with the help of EPG through presentation of the monitoring data collected during reinstatement within comprehensive factual validation reports.

Demonstrating that the residual long-term risk posed by ground gas was acceptable presented a significant challenge from a risk communication perspective. Early gas generation (drum) testing confirmed that initial post-remediation ground gas concentrations and flows were likely to be elevated by virtue of the stimulated biological activity within the reinstated materials. However, it was found that this anticipated trend of elevated ground gas concentrations and flows was exacerbated by limitations associated with the conventional borehole installation method of monitoring ground gases and flow where significant depths of engineered fill are present.

Specifically, the limitations identified were: that boreholes acted as preferential flow paths for the dissipation of pore-water during primary consolidation of the fill; and the presence of relic dissolved methane in the pore water of materials recovered from the landfill waste that partitioned into, and concentrated within, the air space of the borehole installations.

JUDGES' QUOTE:

"This winning entry demonstrated a very complex but well managed verification process. Datasets were used to develop new best practice approaches to ground gas monitoring and risk assessment. There was an interesting use of forensic methodology on a whole-site scale. Out of the entries in this category, this has the greatest potential impact across the industry."

Both of these factors contributed to the apparent trend of elevated flow and gas concentrations recorded in the boreholes during the six-month post-remediation monitoring period, thus lending weight to a false interpretation that risk from ground gas remained unacceptable upon completion of the works.

To more accurately assess the residual risk posed by ground gas, it was necessary to draw upon additional lines of evidence including the organic carbon content of the fill, dissolved methane content of pore water, surface emission monitoring data and subfloor void monitoring data. In direct contrast to the borehole installation data, all of the additional lines of evidence confirmed that the reinstated materials had a gas generation potential that was in keeping with the remediation objectives (not exceeding that associated with Amber 2). When presented holistically within a technical validation report, coupled with face-to-face meetings with regulators to communicate its contents, VertaseFLI and EPG were able to demonstrate that the residual risk posed by ground gases was acceptable and in keeping with the remediation strategy. This work culminated in successful discharge of the planning condition relating to the remediation works by the Local Planning Authority.

During the construction phase, RSK verified that Amber 2 gas protection measures were correctly installed in the properties, that the cover system thicknesses in gardens were appropriate, and that the chemical concentrations in topsoil and subsoil were compliant. This work culminated in the phased discharge of the planning condition relating to this aspect of the construction phase, which was ongoing during 2017/2018.

WINNER

Purfleet Centre

ORGANISATIONS

Thurrock Council and Purfleet Centre Regeneration Limited (PCRL)

Thurrock has seen a significant amount of house building over the past 20 years. While these developments have delivered much-needed housing, many of them have been delivered in isolation from each other and have not secured the delivery of local services and wider ambitions such as river access, sports provision, and green space.

Purfleet is a strategically important location, being the gateway to Thurrock to those travelling from London and the west as well as to the wider London area for those travelling from Essex.

The existing community of Purfleet had been subject to piecemeal development for decades. Medium to high density residential development now sits alongside active industrial areas and the town has suffered from a deficiency of public and social amenities.

Having seen the last immediately available riverside sites developed for low density, low aspiration housing with little thought to placemaking or river access through the early 2000s, the Council intervened directly in Purfleet to drive forward proposals to develop a new town centre fronting on to the River Thames, thus the Purfleet Centre project was born. The Council has since worked with its developer partner, Purfleet Centre Regeneration Ltd (PCRL), to develop ambitious plans to transform 147a of predominately industrial and manufacturing brownfield land into a thriving community.

Redeveloping this existing brownfield site in such a comprehensive manner offered a clear opportunity to improve the urban environment and limit urban sprawl, reducing the need to find rural land to deliver sites for Thurrock's housing targets.

Our Purfleet – building community support

Thurrock Council and **PCRL** have maintained a fantastic relationship throughout the consultation process with both parties recognising that, by working together as strong partners, they will achieve successful outcomes over the months and years to come.

The sole aim of the partnership is to create a Purfleet "for the people by the people" – the mantra that has been pursued throughout. This aim is also in keeping with the active Purfleet Community Forum whose vision is "striving to make Purfleet a better place to live and work". All parties involved in the regeneration of Purfleet have the community at their heart and recognise the importance of the voice of the people.

John Rowles, chair of the **Purfleet Community Forum**, has become one of the scheme's biggest advocates. He said: "Purfleet has been promised a 'sustainable community' for many years, but it never happened". The community can now see that this is happening and John describes it as "inspirational".

Engagement principles were developed from the very first moment the project was established. It is clear that the success of Purfleet's development requires the involvement of the local community and comprehensive stakeholder engagement and these have been used throughout. These principles are to:

- establish a genuine dialogue with the local community
- ensure effective consultation and engagement to include the local community at every stage of the development
- help local people and businesses engage with the opportunities created by the development
- be an active member of the local community.

The engagement principles have been brought to life from day one and the project has been sensitive to any community concerns. Digital engagement and consultation played a huge part in liaising with the community to recognise the important role that technology plays in reaching a vast audience who cannot always partake in face-to-face activities.

A dedicated website (www.ourpurfleet.com) was set up from the outset to publish any new information and to encourage the sharing of ideas. Social media was also used for the consultation to reach a wide audience by using the simple hashtag #OurPurfleet across all platforms. This allowed the existing community to share images or information that may have been a suggestion, an inspiration or something to celebrate within Purfleet – this formed the collective inspiration board and meant that all ideas were in one place. It is a tangible and evolving board, meaning that it is constantly being updated as the project progresses.

So far, 124 visual ideas have been shared to PCRL via this board, showing the clear impact social media can have as well as how quickly these can be pulled upon by both parties for use.

Other innovative approaches to community engagement included the establishment of a Community Design Panel. Twenty five volunteers met regularly with PCRL during the design process to identify opportunities and issues that should be addressed in the development and to input into the design process. The panel last met in January 2018 prior to the submission of the outline planning application.

The chair of the panel is a local resident, which demonstrates a clear commitment to a resident-led process. Also, seven open Community Consultation Workshops were held between April 2016 and February 2018 in various, accessible locations in Purfleet, allowing the broader community an opportunity to feed into and comment on the masterplan development in an informal setting. These were all well promoted and were therefore very well attended.

The wider audience

This brownfield redevelopment has been brought to the attention of those at an international level. MIPIM 2018 was the leading event that showcased the project. Thurrock Council, alongside PCRL and **Swan Housing Association**, (who acted as construction managers for the project), presented the concept to an audience consisting of internationally influential developers and investors. It showed people that Thurrock is a place you can do business with and highlighted the ambitious plans that have been developed. (The presentation can be found here: www.ourpurfleet.com/Videos/). This has since resulted in meetings being set up with key players in the property industry who otherwise may not have known about Purfleet at all, let alone the plans for the Purfleet Centre.

JUDGES' QUOTE:

"The winning entry demonstrated an interesting multi-strand approach to get the public involved in the design side of a big regeneration project. Importantly, evidence of feedback has been acted upon, resulting in community-led changes to the development masterplan."

Schematic of the development

Artist's impression of the scheme

The project has recently acted as a case study in a **Town and Country Planning Association** (TCPA) project detailing exemplar projects that aim to ensure new developments provide healthy environments. This work included the chair of PCRL presenting the Purfleet plans to a Thurrock Council-led Developer Forum and highlighting the efforts that PCRL has made to ensure that the new development encourages activity and healthy lifestyles. The project was featured in the TCPA report *Leveraging Public-Private Sector Consensus for Healthy Development* and the Chair of PCRL spoke at the Westminster Parliamentary Launch at Portcullis House. This has further been supplemented by the project becoming part of the **NHS** Healthy New Town programme.

Sir Tim Laurence is the chair of PCRL, which in itself shows the gravitas of this redevelopment. Since his retirement from the Navy, Laurence has pursued interests that are mainly around the regeneration and property portfolios, so it was with great regard that he chose one of those focuses to be on Purfleet. He has been a fantastic advocate for the project by regularly meeting with Thurrock Council and speaking at various events/meetings to drive forward this brownfield site reclamation. This again shows the seriousness of this project to the wider audience, which has engaged stakeholders and encouraged investment.

Ultimately, this partnership is about creating a desirable place to live and work that capitalises on Purfleet's natural advantages and can be a flagship for the unrivalled growth story that is Thurrock: the Place. Purfleet is one of the six Growth Hubs in the borough as identified within the Council's Economic Development and Regeneration Strategies and the Local Development Framework. While the majority of the borough's growth is private sector led, the Purfleet Centre Project is the largest regeneration programme that the Council is directly involved with, owing to the use of its significant land holding in the area and the desire to regenerate brownfield sites.

Has public feedback actually been used?

The simple answer is yes. One hundred and forty two unique community ideas were shared as part of Community Consultation Workshops and Design Panels; these spanned 11 main themes heard by PCRL for inclusion in the masterplan. From these ideas a number of changes have been made to the Concept Scheme, including:

- increasing the size of Phase 1 enabling significant infrastructure (such as replacing the level crossing at Purfleet Station with a vehicle and pedestrian bridge, upgraded station facilities, developing the town centre, and providing a new, Integrated Medical Centre) to be delivered earlier in the development programme than was originally anticipated
- identifying a site for the Integrated Medical Centre to be delivered in line with the Council and Thurrock Clinical Commissioning Group's aspirations for an operational facility in 2020
- including provision of 30% of the residential units in the first phase of the project to be delivered as Shared Ownership properties.

This clearly shows the power of the community in that the changes are all people-led and will benefit those in the area. The local community is keen to use the new development as a way of further enhancing the status of Purfleet in the borough.

The Community Forum has recently proposed changing the name of Purfleet to Purfleet-on-Thames to recognise the enviable position that the town has on the riverfront. This proposal has the support of ward Councillors, PCRL, and the regeneration team and a wider community consultation is due to be carried out later this year as a first step to formally changing the name. This proposal will be community led but Swan Housing Association has offered financial support to the marketing effort to promote the Forum-led consultation and start this process. This shows that the Purfleet Centre scheme is changing the face of Purfleet even before spades have hit the ground.

An outline planning application and the first full detailed planning application has now been submitted for the Purfleet scheme. Both of these have been heavily influenced by the community engagement undertaken with local residents over many years.

WINNER

Sandford Farm Landfill Remediation

ORGANISATIONS

Vertase FLI Ltd, RSK Environment Ltd, and Taylor Wimpey UK Ltd

Loddon Park in the east of Reading is a **Taylor Wimpey West London** housing scheme on a former landfill site. The 20ha site, previously known as the Sandford Farm landfill, was a former sand and gravel quarry. It was later used as a ready mix concrete batching site before operating as a licensed landfill, receiving industrial and commercial waste between 1981 and 1991. The site is located within the residential setting of Woodley, with residential housing constructed up to the western site boundary in the 1980s.

The proposed remediation of the Sandford Farm landfill site to make the land suitable for residential development proved very controversial. It was locked in the planning system for many years with multiple planning applications from a number of potential developers rejected. The main objections to the remediation and redevelopment came from the local residents and centred on the perceived health effects from disturbance of the landfill waste Indeed, there was the potential for >60,000 lorry movements on local roads to relocate the waste to a suitable landfill site and the void would have been reinstated with inert material if a traditional "dig and dump" remedial strategy had been adopted.

Key to paving the way for the successful remediation of Sandford Farm was a pilot trial undertaken by **RSK** in 2008 as part of a planning appeal process, which demonstrated that a majority of the landfill material could be safely processed and re-used on site, thus providing an alternative to dig and dump. This created an opportunity to explore a more innovative process-based remediation strategy that was in keeping with the principles of sustainability and would cause significantly less disruption to local residents. As a commitment to this sustainable approach, the project team agreed that only 10 lorry movements per day, in and out of site, would form part of the planning requirements.

Outline planning approval was granted in March 2010. Taylor Wimpey purchased the site later that year, with full planning permission granted in 2011 for the development, which is currently in the latter phase of the housebuilding scheme. Building on the RSK pilot trial information, Vertase FLI successfully completed the remediation of Sandford Farm landfill. Importantly, the majority (~95% by mass) of the landfill material has been re-used on site.

Innovative material re-use

To maximise the re-use of materials recovered from the landfill waste in place of proprietary materials, significant effort was made to: separate the waste fractions; process the separated fractions where necessary (by crushing and/or shredding); blend the recovered fraction where necessary; and identify end uses for which the recovered materials would form an appropriate substitute.

Several technologies were trialled to separate the waste materials including vibratory screeners (size separation), rotational trommel screeners (size separation), air knife (density separation), manual sorting (hand picking), and soil washing. As the waste characteristics changed within the landfill during excavation, it was necessary to adapt the separation process to maximise production and quality. It was found that soil washing was the least productive technology for the waste due to the high clay/fines content, whereas combinations of vibratory screening (size separation), density separation, and manual sorting were more effective.

JUDGES' QUOTE:

"This was a well-presented entry, with good evidence of the benefits achieved from the effective reclamation of a former landfill for development in a high-value residential area, and demonstrated how the technique used could be applied to other sites. The reclamation involved extensive excavation works, creatively re-using much of the material, with effective and appropriate use of The Definition of Waste: Development Industry Code of Practice."

Engineering of the recovered material to construct development platforms and public open space (POS) areas with tolerable long-term settlement potential also required significant characterisation and innovation. Methods of compaction specified in the **Department for Transport** Specification for Highway Works provided a useful starting point for applying compaction and controlling the earthworks. These methods were refined by **VertaseFLI** and supplemented with other ground improvement techniques where necessary (e.g. surcharging with pore water recovery) to ensure the effective re-use of materials from a geotechnical perspective.

Replication of the technique

The remediation methodology applied to Sandford Farm (involving recovery of materials for re-use from landfill waste, thus minimising off-site disposal) has the potential to be cost-effectively applied to other landfill sites intended for redevelopment for residential housing (or indeed other land uses). To replicate the technique for maximum material re-use, several assumptions must hold true.

Firstly, the planning layout for the proposed development must provide a balance of POS and development platform. This reflects the importance of the POS areas for providing a sufficient volume to reinstate materials that have a relatively higher gas generation potential and would be unsuitable directly beneath residential properties. Using the planning layout to the advantage of the material re-use is key to the overall concept.

Secondly, soil and aggregate must be present within the as-dug landfill waste. Historically, landfill operators used soils and aggregate/demolition rubble as a daily cover to minimise disturbance of the waste by scavengers and to prevent lighter materials in the waste becoming airborne. This assumption has held true in the majority of landfill wastes observed and investigated by VertaseFLI.

Thirdly, ground gas protection measures shall be required within properties built on development platforms constructed using materials recovered from landfill waste to manage long-term risks from ground gas. This reflects the residual (albeit potentially low level) organic carbon content within the reinstated materials. The processing methodology for separating landfill waste to recover re-useable materials that was developed during the remediation of Sandford Farm, while optimised for the waste type at Sandford, is applicable in principle to future sites (subject to further material specific refinement). Opportunities to re-use all recovered materials on future sites will depend largely upon the proposed development layout and the surrounding land use. It is not unrealistic (as demonstrated by this project) that up to 95% by mass of materials could be re-used on-site.

Combinations of screening, density separation, and manual sorting were used to separate re-useable materials from landfill waste

Sustainable re-use of materials

The Sandford Farm project provides a clear example of the sustainable re-use of materials. From an economic perspective, off-site disposal of all the landfill waste would have cost circa £51m. Import of inert fill to reinstate the void could have cost in the region of £5m in materials alone, excluding the plant costs to engineer the materials to a suitable specification to minimise settlement. In contrast, remediation of Sandford Farm landfill via the innovative RSK-VertaseFLI approach that was adopted cost approximately £12m – saving about 80% of the cost of a traditional approach. Furthermore, efforts were made to employ local labour during the remediation works where possible, thus maximising the financial benefits for the local economy and community.

From an environmental perspective, the remediation works have broken the pollutant linkage between contaminants present within the waste and surrounding controlled waters (groundwater and surface water). Furthermore, risk posed to human health and property (both on the proposed development and neighbouring properties) has also been managed. Due to the significantly reduced number of lorry movements relative to a dig and dump remediation approach, it is undoubted that the approach to maximise re-use of materials has minimised the carbon footprint of the project. The re-use of the materials on-site has also negated the requirement for relocation of significant quantities of material to alternative landfill space, which is in keeping with wider Government policy on the reduction of materials being sent to landfill by virtue of their finite capacity.

From a social perspective, while the remediation and development proposals have undoubtedly caused some concerns to local residents (as evidenced by the opposition at the planning stage), the remediation works have facilitated the transformation of a former restored landfill site with limited amenity value and potential hazards into land suitable for the development of 541 dwellings including

Soil washing plant used to recover soil and aggregate from landfill waste

social housing, shops, and a modern development with a significantly higher proportion of POS areas than would be normal.

Material management

In the context of the **CL:AIRE** Definition of Waste: Development Industry CoP, the Sandford Farm remediation project was set up as a Cluster Project whereby Sandford Farm acted as both the hub site (on which the decontamination/treatment facility was located) and the receiver site. The treatment process operated on the site was regulated under the Environmental Permitting regime.

Soils recovered from the landfill cap, and indeed soils and aggregates recovered from the landfill waste itself, were re-used in accordance with the requirements of the CoP. An extensive regime of laboratory chemical testing was obtained in demonstrating suitability for proposed re-use.

Soils were also imported from local development sites ("donor sites") to account for a reinstatement volume deficit resulting from the necessary off-site disposal of some materials that were not suitable for re-use (i.e. textiles, some wood, tyres and metal), and the increased density of the reinstated materials by virtue of the earthworks specification to construct development platforms with minimal future settlement potential.

The project team made a significant effort to reduce the identified deficit through revision of the remediation restoration levels across the site. This was achieved by working closely with Taylor Wimpey to understand the volume of construction arisings that would result from the development and require management during the construction phase. By accurately estimating this volume and reducing the remediation restoration levels accordingly, there was scope to re-use the arisings within the agreed finished planning levels, thus further reducing disposal costs and associated vehicle movements during the construction phase. As a result, the volume deficit was reduced from 40,000m^3 to 24,000m^3, thus reducing the import volume by 16,000m^3 (equivalent to >1,600 vehicle movements).

About 95% of the landfill material (by mass) has been reused on site

As-dug waste recovered from Sandford Farm gradual decline

A comprehensive material tracking system was maintained throughout the project to track materials from their origin through to reinstatement, including their treatment and testing/characterisation to demonstrate their suitability for re-use. This tracking system was key to both demonstrating compliance with the CoP and indeed satisfying regulators and the **National House Building Council.**

WINNER

The Development of Magnetic Molecules for the Selective Removal of Metal Contaminants from Soil and Groundwater

ORGANISATIONS

Rodgers Leask Ltd

ProNu-Dec Ltd

There are many techniques for removing dissolved impurities from water. Existing water purification techniques include evaporation, ion exchange and reverse osmosis. Although these techniques produce pure water, they are not capable of selectively removing certain target impurities while leaving all other dissolved constituents in the solution.

This "one size fits all" approach can result in the removal of good as well as bad (target) constituents, giving an environmentally poorer quality discharge water. It also can mean higher operational and treatment costs as filters have to be backwashed more frequently or excess chemicals added during the treatment process.

Given the above, it was thought that the brownfield and water treatment industry could benefit from the development of a new approach, where a selected target ion could be easily removed from solution in conditions of high particulate burdens which would prohibit the use of fine filtration or ion exchange. This led to the design of magnetic molecules.

A PhD study being undertaken at the **University of Reading** is supported by **Rodgers Leask** to look at a new method for the clean-up of ground water and solutions used for soil washing. The new approach was originally considered for application to radioactive contaminated areas but the same method is being adapted for industrial pollutants such as heavy metals. The technique being considered is used as a polishing step to remove low levels of pollutants to below regulatory requirements.

Technique

The technique uses the property of "chelation" exhibited by some organic molecules when they interact with metal ions in solution. By having the correct 3-dimensional construct and accompanying ionic charges the chelate (derived from the Greek "khele" meaning "claw") interacts with the metal ion to neutralise the ionic charges and keep the metal in solution as part of a metal complex. This technique is used to maintain the solubility of metals or to obstruct certain ionic species taking part in a chemical reaction sequence 'masking' or in effect isolating the metal ion. However, it also makes the metal species very difficult to remove from solution due to the properties of the inactive complex.

To overcome this, the chelating molecule is bonded to a small magnetic core with an outer shell (magnetic moiety) that allows the metal complex to be extracted onto a magnetic filter (Figure 1).

Innovative thinking and laboratory techniques are being used to create a suite of magnetic molecules to target specific contaminants. The design parameters and laboratory studies are summarised in the following sections.

Figure 1- Magnetic moieties attracted to rare earth magnet

Magnetic Molecules Design Parameters

The operational parameters required for the new separation technology were listed as follows:

1. High selectivity for the target contaminant
2. Fast reaction kinetics
3. Satisfactory absorption capacity for the contaminant
4. Easily separated from the treated liquid
5. Minimum waste volume
6. Reliable technology and application.

Laboratory Study

The magnetic molecule is made up of several main parts:

1. A magnetite core
2. A silicon shell to protect the core from chemical attack and to provide sites to attach connecting ligands
3. The connecting link
4. The active chelating group, selective for target metal ions.

An illustration of a magnetic molecule is given in Figure 2 but the details of the construction follow.

Figure 2 – Illustration of the four parts of the magnetic molecule.(diag after D' Agata et al, Dec 2017)

Broad Spectrum Chelator

Diethylenetriaminepentaacetate (DTPA) is a broad spectrum chelating agent that lacks the specificity to effect efficient separations of many cations in solution but it is a very useful molecule with which to investigate binding of a complexant to the surface of a magnetic molecule. This is because DTPA is readily available in pure form and is economic. The molecule has five end groups, one of which can be used for binding to the magnetic molecule.

The molecule is functionalised at one of its carboxylate residues, e.g. via position 1 as shown (Figure 3), so that it can be attached to the magnetic molecule surface; in the process one coordination site is lost.

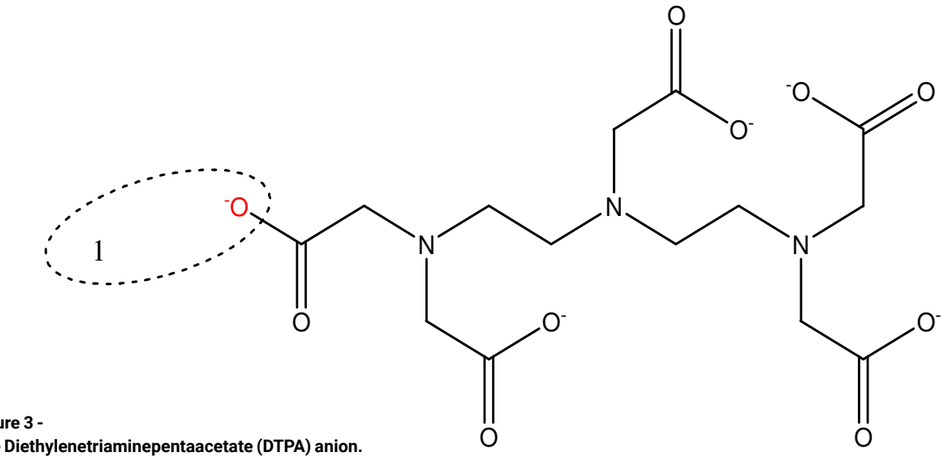


Figure 3 -
The Diethylenetriaminepentaacetate (DTPA) anion.

When successfully attached to a magnetic molecule, the bound DTPA has a similar chelating behaviour to EDTA, a popular and useful chelation agent. Although not a specific chelation agent it can be used to separate single positive valent (charged) ions from multivalent positive ions. This can exploit the difference between caesium (1+) and cobalt (2+). In proving tests, DTPA was used to separate these two ions. It can also be used to separate copper and nickel from sodium and potassium.

Laboratory tests using a magnetic filter in conjunction with the magnetic molecules successfully demonstrated the feasibility of the method to separate the two radionuclides caesium and strontium.

The next phase of development required the identification and addition of specific chelation groups to achieve the necessary separations desired. It was possible that this could involve many and various types of molecules and a disproportionate work effort to design suitable reaction conditions for attaching the different molecules to the ferritin.

Molecular Approach

A previous literature study indicated that the use of a modified calixarene molecule for the selective chelation of caesium had been demonstrated by a number of research groups. The calix[4]arenes are most often used due to ease of preparation and functionalisation (Figure 4).

Modification of the calixarene molecule structure allows different selectivity to be created for radionuclides such as caesium, strontium and plutonium. This in effect a modular approach to the synthesis.

For example the 1,3-Calix[4]arene crown-5 is selective for potassium over caesium whereas the crown-6 provides high selectivity for caesium over potassium[6]. The crown-6 form can be further enhanced by the use of two crowns (bis-crown-6) and substitution within the crown, as shown in Figure 5:

More elaborate crowns have been synthesized using aromatic groups at the three positions furthest from the calixarene ring. It is also considered that further structural changes interact with the metal cation to assist stabilisation.

For the purpose of demonstrating selection of caesium – Calix[4]arene-bis--[(4-ethoxycarbonyl-1,2-phenylene) crown-6 was chosen as the best candidate (Figure 6).

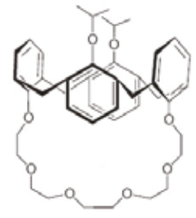


Figure 4 - 1,3-Calix[4]arene crown-6

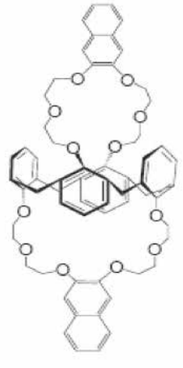


Figure 5 -
1,3 Calix[4]biscrown-6 1,3 Calix[4] bis-o-naptho-crown-6

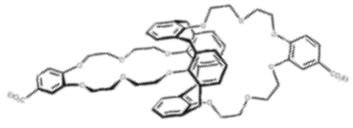


Figure 6 – Calix[4]arene-bis-[(4-ethoxycarbonyl-1,2-phenylene)crown-6

In laboratory testing this molecule removes 99% of caesium from test solutions. A second molecule chosen for application with multivalent metal ion was BTBP. This is can be applied to the removal of ions such iron, nickel, copper, lead, cadmium, zinc, manganese and others which may be found in brownfield waste and leachates. (Figure 7)

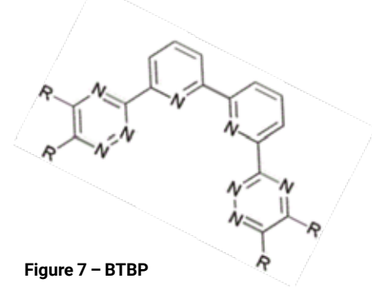


Figure 7 – BTBP

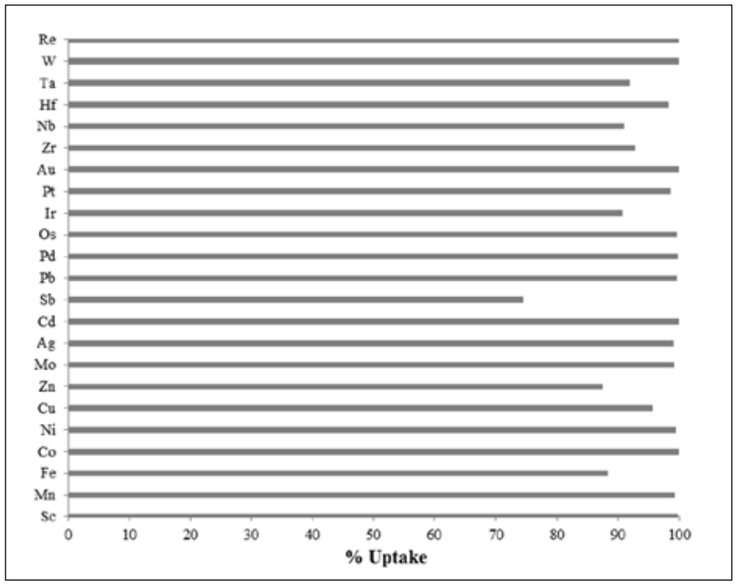


Figure 8 – BTBP uptake of metals from a laboratory test solution

BTBP does not affect ions of sodium, potassium, magnesium, calcium or aluminum. Laboratory testing has shown the applicability of BTBP for the extraction of a number of metals (see Figure 8):

Metal extraction of between 70% - 100% has been achieved depending on the metal species. For cadmium and manganese the extraction has been 100% for both, indicating potentially how well this technology has been adapted and transferred from nuclear to more conventional contaminants.

The test programme is now being extended to real samples to produce data for both an application design and process design.

Application Design (Size of Molecules)

A key factor in the application design will be the physical size of the molecules. This is in the order of 50 to 100 nanometres diameter. The size can be altered in production but if made too small the magnetic susceptibility is too low to be removed from a process stream. Images showing the molecules from the the transmission electron microscope (TEM) are shown in Figure 9.

Process Design

The technology is designed to remove dissolved ionic species from aqueous solutions in a manner that targets a specific contaminant or contaminants (Figure 10). The basic concept of the technology application is:

1. Addition of magnetic molecules
2. Mixing of the solution
3. Pump liquid through magnetic filters
4. Extraction on to a magnetic filter
5. Liquid recycled to tank
6. Magnetic filter degaussed for next cycle.

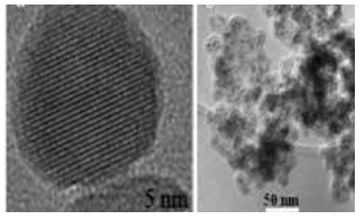


Figure 9 – TEM pictures showing the dark iron core of the molecule a) surrounded by silicate shell and b) chelate molecules.

The cycle from 1 to 6 can be repeated with different molecules to remove targeted contaminants. In this way, mixtures of contaminants can be segregated into different waste streams.

The process depends on the physical agitation or stirring of the solution to ensure mixing and absorption of the contaminants on to the functionalised molecules. This may be done in a pipeline or a tank. To ensure good contact, one component (the molecules) can be in solution in large excess, making it possible for the other component to react quickly even when in very low concentration. This makes it advantageous to add an excess of magnetic molecules during an application, with the condition that the excess is not so great as to render the process impracticable.

Further work is currently being undertaken to determine the optimal disposal options for the small volume of waste concentrates produced by the process, based upon waste classification and optimal decay time.

High gradient magnetic filters (HGMF) are used commercially in the mining and china clay industries and can remove small particles of iron oxide from 20% slurries of clay to whiten the clay before processing.

An alternative approach to mixing the molecules then extracting onto a filter is to hold unused magnetic molecules on the surfaces of filter media and allow the liquid waste to pass over them. This is a similar approach to pre-coating filter surfaces. A very small amount of molecules could treat a large volume of waste because only the selected contaminant would react with the molecules. The contact time and surface area could be chosen for best advantage. Once finished the molecules would be regenerated from the filter in the normal fashion.

Potential Areas of Application

The team is currently exploring potential applications for this technology in the brownfield, water treatment and manufacturing industries. For example in:

- Acid Mine drainage
- Run off water from brownfield sites
- And groundwater from contaminated sites.

As well as the ex-situ application described above, the magnetic molecules technology could also be considered for use in in-situ groundwater clean up, such as a reactive barrier or funnel and gate system.

JUDGES' QUOTE:

"This project demonstrates original scientific research to create tailored molecules for more effective treatment of metals in water. It is a useful broadening of existing research to include brownfield and could be very exciting if it can be scaled up."

ea development+infrastructure

WINNER

Digital Surveying using UAVs across a Portfolio of Former Gasworks Sites

ORGANISATIONS

Atkins and National Grid Property

Drone survey at below ground gasholder site

National Grid Property (NGP) owns a portfolio of approximately 300 sites, ` from tenanted residential commercial sites to disused gasholders. Surveying of land and assets is undertaken routinely, estimated at 250+ person days per year, ranging from topographic surveys to heritage surveys of listed structures. As a long-standing provider of surveying services to NGP, **Atkins** wanted to find ways to deliver these activities more safely, efficiently, cost effectively and sustainably.

Atkins has an established surveying and geomatics information systems (GIS) capability and has taken this expertise and pioneered the use of unmanned autonomous vehicles (UAVs) such as drones in digital surveying. Over the last two years, Atkins has deployed UAVs at 15 National Grid Property owned sites, for varied digital survey purposes. Advantages of UAVs include:

- **Reduction of SHE risks**: 600,000 reported workplace injuries in the UK in 2017, of which 137 were fatal. Using UAVs for tasks previously performed by people significantly reduces these risks
- **Surveying of inaccessible locations**, e.g. rough terrain, dangerous structures etc
- **Faster data acquisition** – UAVs can perform surveys or inspections in a shorter timespan and,
- **Improved image resolution/ detail** – UAVs can get closer to the survey object, resulting in better data density/survey quality.

This submission provides examples of three key surveying types:

- **Black Rock, Brighton**: Topographic surveying/volumetric calculations relating to stockpiled materials
- **Twelve disused gas holder sites, UK-wide:** Topographic/video surveying undertaken as part of pre-demolition assessment works, informing tendering/ stakeholder consultations; and,
- **Heritage Survey, Norwich**: High-resolution still photography/video surveying, undertaken as part of Level 2 heritage recording at a disused gasholder site.

The Challenge

The examples included required the collection of topographic and aerial video/high-resolution photography survey data. Key challenges associated with obtaining these data via traditional methods are:

- Ground-based survey team required for topographic survey, with associated H&S risks due to uneven, vegetated ground and trip hazards. This was compounded at Brighton, where the stockpiles could not be safely accessed, meaning a ground-based survey would be of limited accuracy
- Topographic surveying of tall structures, such as gasholders, would traditionally be undertaken from ground-level. Inaccessible areas (e.g. top of gasholder crown and columns) are surveyed remotely from the ground, however, accuracy decreases with elevation
- Detailed heritage recording of gasholder structures undergoing demolition typically requires the removal of items of importance by the demolition contractor, which are sketched/ photographed at ground-level by a heritage consultant. Consequently, features are not recorded in their original context as part of the gasholder structure. Multiple visits to site may be required by the heritage consultant, resulting in additional costs
- Many gasholders are more than 100 years old, are at the end of their serviceable life and may be extensively corroded. The condition of a structure affects demolition methodology, and can result in additional cost, lengthening of programme, and increased H&S risks. Obtaining a detailed video/photography survey of a gasholder structure via traditional methods is difficult and time consuming, due to safety requirements associated with working at height, and may be cost prohibitive
- Aerial video and photography would traditionally be obtained using manned aerial vehicles. This approach is relatively costly if applied to a single site, and footage may not be sufficiently detailed. Manned vehicles are typically powered by fossil fuels, and are correspondingly less sustainable than electric powered drones and,
- Obtaining topographic, aerial video and detailed heritage photographic data would traditionally require mobilisation of three different survey teams, at substantial financial and programme cost to the client, with associated environmental/ sustainability impacts.

Faced with these challenges across NGPH's land portfolio, Atkins have pioneered the use of UAVs, reducing H&S risks throughout the project lifecycle, reducing costs by reducing the number of person days to undertake the works, and reducing programme length and uncertainty by providing high quality video/photographic imagery to contractors.

The Solution

The following examples illustrate the range of UAV digital survey services provided across the NGPH portfolio:

Digital UAV Topographic Stockpile Survey at Black Rock, Brighton

Several large stockpiles of waste soil and other materials were present on this tenanted site. The stockpiles were impacted with asbestos, and were uneven and difficult to access due to their location near retaining walls. Atkins used cutting-edge drone technology to remotely measure the stockpiles, operating at 100m above ground level, capturing data points at 2cm resolution. The survey took <20 minutes, and resulted in volumetric calculations of equal accuracy to ground-based laser scanning.

Digital UAV Pre-Demolition Assessment Surveys at 12 UK-wide Gasholder Sites

Atkins undertook site wide topographic and video surveying at twelve disused gasholder sites scheduled for demolition. The survey information was provided to demolition contractors as part of pre-demolition assessments, to inform costing, methodology and programme decisions. In total, >10 ha of land and >20 gasholders were surveyed across 12 sites in just six days, averaging two sites per day.

Heritage Survey at Gasholder Site, Norwich

The Norwich gasholders are of local historical interest, and include several interesting features considered to have heritage value. Atkins' drone survey comprised a combination of video and high-resolution still photography, allowing features to be captured while in situ and in their original historical context. A heritage consultant provided guidance on features which required capturing, with works directed on-site by an Atkins Geomatics photogrammetry expert.

Shows innovative thinking

The client and consultant team used innovative methods to deliver excellent quality digital survey deliverables across a range of projects, each with its own challenges.

The Brighton project represented the first occasion which UAVs had been used to undertake topographical survey work at an NGP-owned site. The survey accuracy was equivalent to traditional methods, and was completed in <20 minutes, with no person-access to the stockpiles required. This minimised disruption on a busy car parking site, and eliminated H&S risks associated with physically accessing the stockpiles.

A key objective for NGPH in undertaking gasholder demolition is ensuring the highest standards of H&S performance. Atkins drone survey works across 12 sites represents innovation in supporting this objective. While obtaining standard topographic survey information, video and photographic survey data were also gathered, at limited additional cost. These data provide vital information to demolition contractors, informing their assessment of the gasholders' structural integrity and construction, and allowing design of a safe demolition methodology.

The use of drones for gasholder heritage recording purposes is genuinely innovative, and has resulted in imagery that could not be obtained by traditional methods. The 24MP camera creates richly detailed images, capturing gasholder features in the context of the surrounding environment and providing an unmatched level of historical recording. Images have been provided to local history groups, forming a historical resource for the community.

Useful transfer of technology from other areas

As demonstrated by:

- Drones have been used for several years for digital surveying within construction. This submission is unique in demonstrating the use of drone surveying for multiple survey types (e.g. pre-demolition, heritage), gathering the required data in a single visit; and,
- Use of state of the art camera technology, commonly used for professional photography, comprising 24MP Sony RX1R mirrorless camera, with Zeiss™ optics and full frame sensor, allowing capture of highly detailed imagery.

JUDGES' QUOTE:

"The use of drones across sites certainly helps with Health and Safety and inaccessible. Effectively seeing at eye level and from above reduces uncertainties. The information was captured for multiple purposes and represents a significant development of existing technology, bringing discipline to the area."

Potential for widespread use

There is clear scope to increase the use of UAV digital surveying both within the NGPH portfolio and beyond:

- Across NGPH and other Gas Distribution Networks (GDNs), there are more than 150 gasholders requiring demolition; examples within this submission demonstrate the value of UAV surveying from H&S through to heritage
- UAV surveying is particularly well

suited to larger sites, or multiple sites within a portfolio, whereby economies of scale quickly come into play

- Clear widespread applicability of UAV-surveys for heritage recording of structures – reduces the number of person days on-site, allows high-fidelity recording, and eliminates H&S risks when recording either concurrently with demolition works, or in difficult to access locations and,
- UAVs allow multiple data sets to be obtained during the same survey. Additional data can be obtained for relatively low cost, and used for other purposes than originally anticipated, e.g. video and photo survey works allow recording of a 3D point cloud, which can be used to create 3D visualisations.

Demonstrable achievement of time or cost efficiencies

Time and cost efficiencies within these examples include:

- The Brighton stockpile survey was completed in an approximate 20-minute drone flight, compared with an estimated 4-6 hours for traditional survey works. Costs were similar, but would become cheaper if deployed for multiple or large sites
- Pre-demolition topographic/video survey works were undertaken at 12 gasholder sites at an average rate of two per day, including travelling between UK-wide sites. A traditional survey team would take 2-3 days per site, reflecting a time saving of up to 600%; and,
- Drone heritage survey work at Norwich was completed in around four hours on-site. Input from a heritage consultant was obtained before mobilisation, whereas traditionally, a heritage consultant would attend site throughout the demolition works to record features as they are removed. Atkins novel approach resulted in a saving of five days of a heritage consultant's time, equating to a 50% reduction in costs, potentially delivering a £100-150k saving across the entire NGPH portfolio.

Enhanced data capture, storage and accessibility

The survey works were designed in accordance with the general principle of "capture once, use many times". For example, topographic surveys created a high-resolution point cloud of sites (2cm point-to-point resolution). This point cloud can be used for a variety of purposes in future, such as 3D or virtual reality visualisations, which NGPH is exploring using at higher profile sites as part of stakeholder engagement. An example of a 3D point cloud is included below.

Data capture was undertaken using a Sony RX1R mirrorless camera, permitting data capture at very high resolutions. The full frame sensor permitted excellent dynamic range, allowing greater detail to be extracted from dark and shadowy areas in comparison to smaller framed cameras, thereby mitigating the effect of shadowing. The high-resolution and enhanced clarity in the images enabled maximum detail to be mapped from the imagery, enhancing the accuracy of the mapping.

All drone survey works and data capture were undertaken in accordance with current UK best practice/legislation, using a drone subcontractor with full **Civil Aviation Authority** (CAA) permissions for commercial operations and professionally qualified pilots.

Significant contribution to QA/QC

The use of UAVs has resulted in significant contributions to QA/QC compared with traditional methods of obtaining similar data, namely:

- Highest quality survey deliverables, through use of state of the art Zeiss™ optics and 24MP full frame camera sensor, followed by processing via experienced geomatics specialists
- Best possible heritage recording of historical features, ensuring they are captured in situ and in their original context; a typical survey can capture 200+ high-resolution images and,
- Reducing H&S and contractual risks associated with gasholder demolition, allowing provision of detailed imagery at tender stage, informing early demolition design and programming decisions.

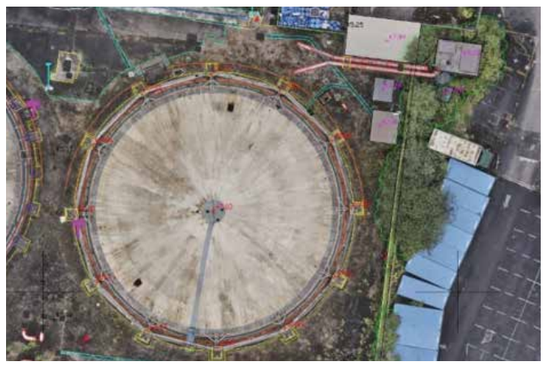
A genuine breakthrough of real value to the sector

Deploying UAVs in surveying is a rapidly emerging industry, however, the pace of technological innovation has brought issues such as poorly trained operators or use of automated "cloud based" data processing services, resulting in poor outcomes for clients. Atkins has coupled the technical excellence of our established Geomatics survey personnel with an industry leading drone survey contractor, to successfully deliver a range of best-in-class survey works across a varied property portfolio.

The examples included in this submission have demonstrated clear benefits in:

- Cost – delivered up to 50% cost savings for heritage survey works compared with a traditional approach requiring multiple site visits to record data
- Programme – use of drone survey works resulted in an estimated 600% reduction in programme when undertaking topographic survey works across multiple gasholder sites;
- Health and Safety – elimination of risks associated with traditional surveying, and,
- Increased sustainability – achieved via reducing programme and visits to site/ corresponding carbon emissions required to complete the works.

3D Point Cloud of gasholder Site



CAD Drawing with Ortho-Photo Overlay

WINNER

Southall Waterside

ORGANISATIONS

Berkeley West Thames , Atkins (Designer), CA Blackwell (Contractor)

Southall Waterside is one of London's largest and most significant regeneration projects and the Mayor of London's first Strategic Housing Zone. Inaccessible, underused and with a legacy of industrial activity, the 45ha former Southall Gasworks provides a significant opportunity to capitalise on the **Crossrail** project and transform the local area.

The historical land uses presented complex brownfield constraints across the site, which had left a void in the urban fabric of Southall for many decades. The regeneration of the site will allow the land to be revitalised in line with the Government's agenda of regenerating former industrial sites to help create sustainable communities.

The masterplan for the site includes: 320,000m^2 residential development (3,750 homes); 74,000m^2 commercial/community space (including hotel, cinema, leisure, restaurants, bars, cafes and office/studio units); healthcare and education facilities (including a primary school and health centre within a community hub); and 100,000m^2 high quality public realm

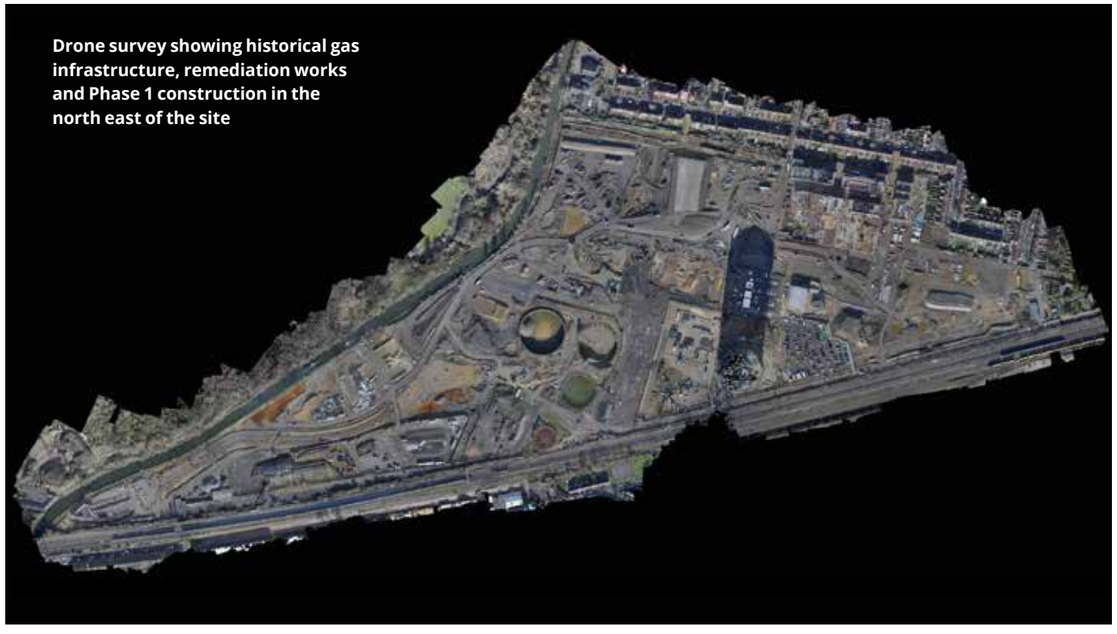
Represents best rather than good or average practice

The client and consultant team used innovative and technically excellent risk assessment practices to develop a remediation design to address environmental liabilities. This involved developing remediation criteria within the design which were suitably protective of a surface water receptor to the west of the site, while justifying less stringent criteria for other areas where no critical receptors were present.

This approach avoided disproportionate remediation works relative to the actual risks, with associated sustainability, logistical and cost implications. This design was accepted by the regulators and the resulting DQRA and Remediation Strategy were approved.

Implementation of the remediation design supports the ethos of maximising the reuse of site won materials. Soils are pre-classified using site investigation data, further segregated at source and scheduled for direct reuse, temporary stockpiling or treatment within the 1.3ha on-site soil hospital. This provides sufficient treatment area for technologies including soil stabilisation, bioremediation and gravel washing on a scale to match the project's ambitious programme, as well as water treatment and storage for reuse within the facility. Best practice risk assessment to support decision making has continued throughout the earthworks, remediation and construction phases. Complex modelling was undertaken to assess potential risks to human health from vapour intrusion into buildings from the soil and groundwater.

Working closely with **LB Ealing** and **NHBC**, the assessment concluded that vapour membranes were required in ground-level structures. Apartment buildings located above large basements only required vapour membranes within stair and lift cores to mitigate the impacts of stack effects within the building. Impacts of vapours elsewhere in the basement were addressed using the mechanical ventilation already incorporated into the structure to provide air exchange to the basement car park. Day to day management of the



Drone survey showing historical gas infrastructure, remediation works and Phase 1 construction in the north east of the site

Approved masterplan for the project, showing the extent of green space, transport links and the surrounding communities

site is carried out via online real-time reporting software FieldView. The system incorporates more than 100 proformas including quality assurance processes, health and safety inspections, site management, logistics and daily diaries, with all BWT site managers using field-based tablets on-site. The earthworks and remediation contractor also operates drone surveys equipped with LiDAR laser scanning to assist with stockpile management and progress reporting, as well as producing hi-resolution imagery for the site.

Demonstrates economic, social and community benefits over the wider area

The Southall Waterside team has been highly proactive in engaging with local residents' groups, schools and colleges and stakeholders including the **GLA**, LB Ealing, the **Environment Agency** and NHBC. Community engagement events commenced early in the planning stages and have continued at regular intervals. The project welcomed local residents, children and A-level students to site during an "Open Doors" event, allowing Southall's engineers of tomorrow the opportunity to discuss work experience and the variety of career routes available in construction.

A dedicated public relations company (Local Dialogue) is employed by the project to provide 24-hour support to local residents – their feedback survey for these events identified that 94% of attendees rated the visit "Very Good". A-level students from **Greenford High School** in Southall visited Southall Waterside to learn more about the remediation works. Following a presentation and site tour centred around the site's historical industrial heritage, the earthworks and remediation contractor, **CA Blackwell**, provided an in-depth tour of the soil hospital and an interactive workshop to allow the students to learn more about the remediation techniques operating on the site.

The team includes dedicated neighbourhood officers to meet residents in the 1,500 properties that border the site, building relationships with key individuals and providing a friendly face for any queries. This is supported by a quarterly newsletter issued to 5,000 homes in the wider Southall area (*SouthAll Community News*), press releases and a 22-page quarterly booklet circulated via local community groups. The project also established LB Ealing's first "Incredible Edible" garden, which was opened by Councillor **Simon Woodroofe**, the Mayor of Ealing and **Virendra Sharma,** MP for Ealing Southall. The team has also delivered road safety days at three local primary schools, engaging with 800 children over three days; and ran a "Name the Crane" Competition for pupils from **Blair Peach Primary School**, with the winning entry ("Colossus") displayed on the first crane erected on site. Runners up entries were also displayed on the exterior hoarding for the community to see. As well as dedicating interim uses of the site to train young people and supporting local careers events such as the LB Ealing "In Focus" event, 11 apprentices and 73 local residents are currently working on the development.

More than 30 staff are currently working towards further qualifications including NVQs, RICS and ICE. With a build programme of 25 years, Southall Waterside presents a unique opportunity to promote careers in the construction industry and provide training and job opportunities for the local community, while addressing the shortfall in apprenticeships within the construction industry.

BWT has partnered with **West London College** to build a 1,858m^2 Construction Academy to train apprentices in: groundworks, plant and machinery, bricklaying, plastering, internal fitting and upskilling of supervisors and management, which is currently under construction. The land provided for the Academy by BWT is located on a later development phase of the site, allowing it to operate in this location for up to 10 years. Its sustainable design allows it to be easily relocated either to another location on Southall Waterside or to an alternative development site.

BWT has worked with trade partners to develop a curriculum to ensure this meets its needs ("By Industry, For Industry") to deliver work ready employees. The Academy has also secured Kite Mark status under the Mayor's Construction Academy scheme. The first intake of students is in September 2018. Other training facilities to support the local community include: a "Digger School" for plant and traffic marshal training; and a "Constructionarium" to provide hands-on experience of construction works to university/college students.

Represents efficient use of funds

Economic benefits have been led by the outline remediation approach and the technical excellence demonstrated in the remediation design. A detailed conceptual site model led to controlled waters zoning and a realistic and pragmatic remediation

Left: Construction Academy currently under construction on site to help young people obtain construction skills

Below: Street Elite youth development programme, designed to prevent young people from slipping into gangs and crime

design, which reduced the anticipated remediation volumes by approximately 200,000m^3 when compared with an earlier remediation strategy developed by an alternative consultant. Two preferred contractors were taken through from the initial tender process to a three-month, funded pre-contract site assessment period. This allowed both contractors to research and trial the most appropriate remediation technologies to address the extensive soil and groundwater contamination on the site, work towards the optimum earthworks objective of minimising off-site disposal of soils, and forward planning to develop fully the soil hospital in advance of the works commencing.

The BWT team is also leading one of the working groups within the Get It Right Initiative (GIRI), a cross industry initiative targeted at improving quality, productivity and value for money by tackling avoidable errors in construction, as well as helping to develop innovative training schemes for employees as part of a CITB funded project.

Effective use of space and environmental sustainability

BWT redefined the masterplan for the development in 2016 with a view to creating the highest quality public space, promoting health and wellbeing and cultivating a safe and thriving community for the long term. This involved: increasing the diversity and footprint of the public realm areas; ensuring a clear and simple street network that limits the impact of commercial vehicles on the heart of the neighbourhood to ensure a safe pedestrian environment; relocation of the main square towards the existing hubs of South Road and Southall rail station to provide a complementary extension of the current town centre; repositioning the primary school to allow early delivery and integration with the existing community; and opening up the canal-side to create an attractive and safe landscaped thoroughfare.

In addition to the environmental benefits of remediating the site, approximately 50% of the final development will comprise green spaces. These will include recreational facilities but also the creation of habitats including: native species rich hedgerows, neutral and marshy grasslands, wild flower meadows, ponds, reed beds, native woodland, scrub and green/brown roofs.

Habitats will reflect and supplement the ecological character of the surrounding area and the *Ealing Biodiversity Action Plan*. Landscaped areas are designed to provide connectivity across the site via green (vegetation) and blue (water) fingers, providing transit corridors for a variety of fauna supporting the Minet Country Park and the Grand Union Canal,

The proposed development, including "Central Park" which links the residential areas with the commercial hub

each of which is designated as a non-statutory Site of Importance. These routes will comprise areas designed to ensure low disturbance with minimal lighting, benefiting local priority species such as bats, butterflies, finches, thrushes and raptors. Water features and wetlands will provide diverse habitats for invertebrates and mammals such as water voles through carefully designed scrapes, hollows and embankments with differing depths of inundation and combinations of open and shaded planting.

Southall Waterside is on course to become an exemplar project nationally, demonstrating the successful transition from a heavily contaminated brownfield site to one of wide ranging and continually evolving biodiversity. Over the duration of the remediation activities, on-site treatment will remove over 86,000 HGV road movements, as well as the associated haulage miles, minimise congestion on local vehicle routes and address the excessive costs of both exporting contaminated soils and importing replacement materials to the site. Innovative use of methods to dispose of difficult soils is also in operation, such as the burial of 2,000m^3 material contaminated with Japanese Knotweed in dedicated cells within a former gasholder base, constructed in line with Environment Agency guidance and in accordance with the CL:AIRE Definition of Waste: Development Industry Code of Practice via an Environment Agency approved Materials Management Plan.

These methods are currently helping the project to achieve a goal of zero off-site disposal of site won soils. A concrete batching plant has also been established on the site, saving 7,500 lorry movements on the first phase of the project alone. Raw materials are being delivered by barge via the adjacent canal, diverting approximately 25 vehicle movements each day, and more than 93,000 up to 2020, saving over 5,000 tonnes of CO_2 emissions, reducing impacts on local air quality and congestion on local routes.

Effective multidisciplinary team working

BWT acquired the Southall Gasworks site in 2014 and assembled a team comprising masterplan architects **JTP**, landscape architects **HED** and consulting engineers **Atkins** and **Vectos** to deliver a coherent scheme with emphasis on placemaking and community engagement.

BWT's "hands-on" project management approach, including weekly workshops/design review sessions enabled the revised masterplan to be developed and submitted for determination by LB Ealing within a nine-month period. A matrix management organisation was developed to facilitate the design and implementation of the works on site. This comprises individual project teams, each under a dedicated BWT Project Manager, and includes multidisciplinary teams responsible for:

- On-site remediation and infrastructure (roads, utilities and landscaping) including the diversion of existing utilities
- Eastern access, including a new entrance plaza opposite Southall Crossrail station and the diversion of a 750mm diameter medium pressure gas main under the Great Western main line railway
- Western access from the A312, including road and footbridges across the Grand Union Canal and Yeading Brook and future upgrades to off-site junctions including M4 Junction 3 and
- Multiple individual mixed-use development plots (Phases A-J).

Regular coordination between these teams, overseen by a core management team of five directors (Operations, Development, Technical, Commercial and Construction), will see the delivery of the first phase of properties on site, including 30% for shared ownership and affordable rent, in November 2018. This is two years ahead of schedule and has come about despite highly restricted site access and daily road deliveries being limited to 20 vehicles.

Health and Safety is managed under the **Berkeley Group** policy of "Good Order, Good Work, Good Health". These themes are promoted on site via posters and notice boards, promotional handouts and aide memoirs to the workforce, and further reinforced by regular, focused Tool Box Talks allowing good practice to be shared between the supply chain. The BWT Leadership team believes that a safe environment is not just one in which there is an absence of serious injuries and incidents but is the result of active participation by both management and staff in identifying hazards and taking positive action to eliminate or control them. Directors' H&S tours are completed in each of the five areas of the project on a weekly basis and recorded BWT's Integrated Management System.


Issue 6
Spring 2018

SouthAll
Community News

Inside this issue:

Construction news | Staff spotlight | Great British Spring Clean

Berkeley | SOUTHALL WATERSIDE

SouthAll Community News publication

JUDGES' QUOTE:

Best Urban Regeneration category
"This winning project finally addresses a complex and long derelict contaminated site with significant constraints. There was use of innovative risk assessment modelling which enabled management of potential vapour pathways, management of the project facilitated by use of online real-time reporting software, well planned and effective public outreach, investment in future skills with an academy and the mixed use development creates real social benefits. Of the high standard entries in this category, the judges were clear that this demonstrated the broadest range of innovative and interesting aspects of urban regeneration, with the potential to be the most influential case study for future projects."

Brownfield Project of the Year category
"The judges were pleased to see several very good entries in this new category for the award, but there can be only one Brownfield Project of the Year. As we have already heard, this was an impressive project to unlock a long derelict site of significant complexity and with wide community engagement and social impacts. It demonstrates excellence in long term planning and management. Particular features of note included the use of the canal for materials transport, the goal of zero soils to landfill, and the establishment of a Construction Academy for the training of construction professionals beyond the duration of the project."

WINNER

Littlecombe Development

ORGANISATIONS

Rodgers Leask Environmental and St. Modwen

The Littlecombe development is an on-going regionally important brownfield regeneration project led by **St. Modwen,** located on the periphery of Dursley in Gloucestershire, at the edge of the Cotswolds. It occupies the site of the former Lister-Petter works and comprises 37ha of brownfield land to the north of the market town.

RA Lister and Company was founded in 1867 in the valley of the River Ewelme, merging many years later with **Petters Ltd** to form the **Lister-Petter Company** in 1986. Initially producing farming equipment, the engineering works manufactured diesel and petrol engines throughout the 20th century. The works housed its own foundry from the 1930s and by the mid-1970s the casting division was producing 19,200t of engine parts annually. At its peak, Lister-Petter employed 5,000 people, the population of Dursley today being approximately 6,700.

The vision for Littlecombe is to transform the former engineering works into a sustainable development, delivering high-quality residential properties with employment opportunities. The final development will provide 600 homes and a community hospital, as well as a 15ha business park providing permanent jobs for the local community and ensuring a positive impact to the local economy.

Following purchase of the site in 2002, St. Modwen entered a development agreement with the **South West Development Agency** and subsequently **Stroud District Council** to undertake a complex reclamation and remediation programme to transform the derelict factory into a new environmentally focussed community.

Rodgers Leask Environmental Ltd was lead consulting engineer for the project and was involved in the enabling works, reclamation, remediation, ecological enhancement and infrastructure engineering.

Removing Traffic from Old Market Town

The key challenge to delivering the redevelopment of the polluting engine manufacturing site, in such close proximity to the narrow streets of the old market town, was the road network. The main design brief of the new road infrastructure was to remove traffic from the congested streets in the historic market town, restoring the appeal of the town centre by providing an alternative route for through traffic while serving and improving journeys of the residents of the new development.

The improved infrastructure of the new development, within walking distance of the town centre, comprises a main spine road through the site and three crossings of a newly deculverted river system (the rivers Delkin and Cam/Ewelme). The platform to house the new development required extensive works to the existing factory site to make the scheme efficient for the construction of the infrastructure to minimise local nuisance, stress on the roads, viability and programme duration. The restoration of the River Ewelme as a surface water course, which had been culverted for more than 100 years, was completed as part of the project in 2017. St. Modwen identified the environmental benefits of reinstating the river channel at an early masterplanning stage to better manage flows while benefitting the amenity value and biodiversity.

JUDGES' QUOTE:

"The project focusses on melding new development with the existing town centre and incorporates sensitive design of infrastructure. Elements included management of traffic congestion in the old town, new bridges, complex level changes and reuse of material. The opening-up of the culverted river to a flood resistant river corridor is a great asset to the development. The consideration of practicalities (access, reuse of existing) at an early stage is to be encouraged. "

Efficient Use of Brownfield Land

The regeneration of the Lister-Petter works is complex and the restrictions of access to the site have shaped much of the design. Complex changes in levels across the site required careful design and earthworks to form a viable development platform for housing, while providing a footprint for the new river system and road layout; the gradients across the site also presented a challenge with respect to designing a road network to adoptable standards.

Natural soils from the valley sides were used as clean cover and extended the footprint of developable area to maximise the reuse of this brownfield site. Soils impacted by contamination were treated on site and re-used at depth below clean cover; site won demolition material was also crushed and screened to allow it to be used as sub-base for roads. The use of the local material enabled the reclamation of this impacted site without the disruption, risks, pollution, cost and time of hauling thousands of tonnes of material through the narrow streets. The ability to use this natural resource greatly improved the project's viability and programme.

The Three Bridges

Once the river had been deculverted, three bridges were required to form the main accesses: two on the main spine road and one serving the eastern part of the development. The southern crossing was initially designed to be a large pre-cast box culvert requiring cranes, however, due to the narrow streets of Dursley, alternative options had to be explored. The internal road system was remodelled to enable the parts of an existing structure to be retained and enhanced to carry the new traffic loads required for the new road. This change removed the need for the significant constrained engineering operation with complex health and safety mitigation; it also saved additional disruption to the sensitive watercourse and existing roads while also maintaining access to nearby business, reducing costs and improving programme. The sympathetic design choice in retaining the fabric of the old town at the gateway to the new development enhances the visual amenity, provides a sense of place and respects the integrity of former infrastructure.

The northern crossings were new structures but had to be sympathetic with the surrounding environment. The initial design was a bridge with piled foundations, given the deck heights above the watercourse and risk of settlement due to the presence of compressible geology (alluvium). Close liaison with the ecologists, **Environment Agency,** civil engineers and geo-environmental engineers revealed that the window for working within the watercourse and accessing the construction site with the necessary plant would deliver the solution but at significant cost to the project in time and money but also in disruption to the sensitive watercourse, residents and wider road network. This led the project team to recommend a cast in situ solution with supporting piles removed from the design.

The Dursley development

Cast in situ bridge post-construction, earthworks

The innovation of casting such a feature in situ was borne through value engineering and collaborative thinking but the removal of the piles came from the inherent strength of the box and the delayed requirement to construct the road above. The delay in road construction allowed for predicted settlement, within the tolerance of the structure, to complete well before final construction materials and surfacing were to be placed.

Sympathetic Regeneration

The transformation of the disused factory, which was polluting the watercourse, into an elegant residential development with subtle modern infrastructure has benefitted Dursley and the wider area. The retained southern crossing and the innovatively designed northern crossing complements the newly formed topography, softening the engineered appearance of the structures.

Ecological Benefits

As demonstrated by winning the *Brownfield Briefing* award in 2017, the excavation and relocation of the River Ewelme was integral to the masterplan in order to enhance biodiversity and local ecosystems as well as creating excellent visual amenity to the future residents of Littlecombe.

By integrating infrastructure into the wider landscape and using local stone to clad structures, the new sustainable infrastructure blends into its environment and forms an attractive landscape for residents.

The local authority and Environment Agency have been a key part of the design process, allowing the structures to be built to adoptable standards but remaining protective of the sensitive watercourse.

Multidisciplinary Skills – Reduced Risks

At the cornerstone to the design of the infrastructure has been a multidisciplinary project team with a variety of skills to consult and design, allied to a common sense approach to engineering, has seen the normal engineering solution challenged for the betterment of the scheme. Hydrologists have modelled the watercourse, civil engineers have designed the roads and drainage network, structural engineers have designed the river crossings and geo-environmental consultants have managed the contamination and settlement risks. Asking the questions, such as "how will we get it to site" or "can we use the existing" led to minimising the upheaval of large-scale engineering solutions and the reduced health safety risks that go with intensive heavy goods traffic movements and complex construction in confined, topographically challenged areas.

Summary

The design of the infrastructure at Dursley is exceptional in how it has connected the fabric of old and new infrastructure, between the historic market town of Dursley and the brownfield regeneration site at Littlecombe.

It has done so with minimal disruption and tangible amenity enhancement while breathing life into the river and reducing congestion on the narrow streets of the town centre. The level of experimentation, innovation and refinement seen on this development is rare on smaller complex sites. The rapid expansion of the development programme currently underway is evidence of the success achieved in delivering the vital infrastructure on this site.

The long term benefits from the reduced traffic flows within the town and increased residential population within walking distance of the high street will help grow and sustain the community centre for the long-term.

The river channel offered a significant enhancement to both ecology and the local environment, with significant lengths of segregated footpaths in a riverside setting. While meeting the requirements of the Littlecombe development, in terms of the channel's location and accommodation of a 1:100 year storm, St. Modwen was keen to ensure that the river channel was designed carefully to maximise ecological benefits.

Adopting innovative designs and a flexible approach has deliver the client's requirements while reducing risks to health, safety and the environment. Hard engineering has been avoided where possible to allow the use of subtle bioengineering techniques to reduce erosion, while encouraging biodiversity and improving the visual impact. Where hard engineering could not be avoided, such as the bridges, sympathetic designs hss allowed the features to blend into the surrounding landscaped environment.

The long-term positive impacts from the development to the town centre will be considerable, while also creating a sustainable brownfield development that provides a tranquil living environment for new residents and workers.

WINNER

Walthamstow Wetlands

ORGANISATION

Ramboll UK Limited

Walthamstow Wetlands opened in 2017, and at 211ha is now Europe's largest urban wetland nature reserve. The site forms part of the Lea Valley Reservoir chain, encompassing 10 operational **Thames Water Utilities Limited (Thames Water)** reservoirs in north-east London.The reservoirs are primarily used as settlement lagoons for potable water treatment works but in addition, now provide an exceptional habitat and environment for wildlife and enhanced local community access for recreational uses, including running, cycling and leisure fishing.

Ramboll was selected by the **London Borough of Waltham Forest** to assist them in enhancing the existing wetlands at the site and to provide a solution to the disposal of dredged sediments from the settlement reservoirs. To achieve this, Ramboll provided environmental, geotechnical, hydrological, and ecosystem services to support the development of the reserve's new reed beds.

The reed bed creation scheme resulted from **London Wildlife Trust** and Waltham Forest aspiring to enhance the existing wetlands habitat at the site. The reservoirs form part of a designated Ramsar Site – recognised as a Wetlands of International Importance. They are also part of a site of Special Scientific Interest (SSSI) for Biology, an EU Birds Directive Special Protection Area, and has been home to several rare wading birds.

The second significant driver for the scheme was Thames Water's requirement to dredge the reservoirs. Two of the three reservoirs that were the focus of the reed bed creation are used by Thames Water as settlement lagoons for the Coppermill water treatment works. To remain operational, the reservoirs have to be dredged – an activity which hadn't been carried out for more than 10 years, causing reduced water depths and detrimental impacts on settlement capacity and water flow. There was also an opportunity to further enhance the accessibility of the site to the general public and local communities.

During previous dredging works, the sediment had been spread on adjacent agricultural land; however, as this land was to form part of the wider wetlands scheme the dredged sediment was destined for off-site disposal until an alternative solution, using the proposed reedbeds, could be implemented.

Photograph of reedbed construction

To achieve Waltham Forest's aspiration, Ramboll developed the solution through the following stages:

- Development of the concept design through to implementation
- Characterisation of the existing ecosystem, associated constraints and opportunities for enhancement
- Characterisation and assessment of the hydrological regime and sediment quality and suitability for re-use and
- Detailed design of ecological enhancements, dredging and retaining structures and provision of Clerk of Works through to completion of the project and opening to the public.

Initially Ramboll undertook hydrological assessments of the Thames Water reservoirs to specify areas to carry out dredging of settled material that could then be re-used by careful placement and physical retention on site to create reedbeds. During this process areas of available sediment were identified and reed beds designed to maximise waterflow through the reservoirs, ensuring settlement efficiency following dredging. Areas with high water flow and erosion potential were identified, and the retention design was modified to account for this.

Ramboll also reviewed specialist ecological survey data, prepared an outline design of reed bed planting plots (including reed stock, species mix and plant specifications) and prepared biosecurity notes to consider the presence of invasive species present on or around the site during the reed bed creation works (such as zebra mussel, quagga mussel, giant hogweed, Himalayan balsam and floating pennywort). Ramboll subsequently prepared the specification for the planting, ensuring ecologically diverse planting mixes and suitable plants were specified for more shaded or exposed areas.

The proposed placement of the material behind retaining structures was undertaken in such a way as to create channels, ponds and backwaters to create enhanced habitat for wading birds and fish fry. The location of reedbeds around islands within the reservoirs was also designed to discourage fishery users from casting towards the islands. Historically this had caused fishing lines and hooks to get caught in the trees which could entangle birds.

During design development Ramboll scoped and supervised an overwater site investigation to understand the chemical and geotechnical quality of the materials. The investigation techniques were defined to allow practical implementation around key site constraints such as nesting birds, potential unexploded ordnance and tight programme timescales and to achieve best recovery from the anticipated sediment types.

The investigation and subsequent risk assessment identified low levels of solid and leachate contamination that could be mobilised during dredging and placement and identified phytotoxic contaminants (copper and zinc) within the sediment. However, species of reeds (phragmites) that are suitable for this environment and are commonly used in bioremediation schemes due to their ability to bioaccumulate metals were selected. The material was considered suitable for re-use subject to appropriate environmental controls and monitoring during the reed bed construction.

On this basis Ramboll prepared a design statement and specification for the works culminating in the preparation of a

Enhanced habitats were created to benefit local wading birds and fish fry populations

materials management plan (MMP) under the provisions of the *CL:AIRE Definition of Waste: Development Industry Code of Practice* to allow the material to be re-used. The Principal Contractor's implementation of the MMP was audited during the construction phase and subsequently verified as part of Ramboll's Clerk of Works role.

JUDGES' QUOTE:

"The project combined the sustainable re-use of materials from maintenance of existing settlement lagoons into designed red beds, with effective and beneficial enhancement of biodiversity. The further opening up of the site for public access to this important wetland habitat was also commendable."

The reedbeds scheme delivered 1.8ha of new reed bed habitat through the re-use of 30,000m^3 of settled silt that was placed behind 619m of retaining structures.

If the reedbeds had not been created, Thames Water would have had to remove a significant volume of the sediment from the reservoirs to maintain their functionality as a settlement system. Ramboll estimated that this would equate to approximately 9000m^3 of sediment. Because of the presence of contaminants, albeit at low concentrations, and in the absence of suitable agricultural land for re-use, the dredged sediment would have been disposed of off-site as non-hazardous waste. A conservative estimate for disposing this volume of material would cost around £1m including landfill tax. As well as the financial impact, over 600 vehicle movements would have been required to transport the sediment from site, causing impacts on the local road network, air quality and carbon emissions.

The project has shown how, through detailed environmental and geotechnical characterisation of the sediment, coupled with hydrological and ecological conceptual site models, sediment within the reservoir structures can be successfully re-used on-site to create a significant biodiversity enhancement.

The re-use has provided various ecosystem services, through habitat generation and enhanced leisure opportunities for visitors to the wetlands. Going forward, as the reservoirs require re-dredging in another five to seven years' time, the dredged sediment could again be used to create additional reedbeds in a similar manner or to supplement existing reed bed structures.

In summary, the project has delivered clear benefits to the client, the stakeholders, the public and the environment and specifically fulfils the following "best biodiversity enhancement" award criteria:

Represents good rather than best practice

Multidisciplinary approaches and the involvement of key stakeholders throughout the design development were key to the project's success. Ramboll's hydrologists, water quality specialists, ecologists and environmental and geotechnical engineers collaborated seamlessly to provide an innovative sustainable solution to enhance the wetland habitat at the site. The incorporation of industry best practice initiatives such as the re-use of dredged materials under a MMP saved significant off-site disposal costs and provided ecosystem service benefits for wildlife and visitors to the site. The re-use solution was also low cost and low maintenance compared to other retention methods and provides an enhanced wetland ecosystem and habitat for a variety of birds, fish and invertebrates.

Demonstrates clear biodiversity and/or flooding benefits

Walthamstow Wetlands opened to the public in October 2017 and is now the largest urban wetland nature reserve in Europe. The reedbed creation scheme serves to enhance wildlife and biodiversity at the site and provides significant community benefits. The retention scheme maximised the possible area of reed bed creation, with 1.8ha of new reedbed habitat formed which also created enhanced habitats for wading birds and fish fry.

Demonstrates protection and enhancement of a visual amenity

The site is a Ramsar Site, part of a SSSI and a Special Protection Area under the EU Birds Directive. The overall scheme has opened up the 211ha Thames Water reservoir site for free public use, and also restored a Victorian Engine House and listed Coppermill Tower as a visitor centre and viewing tower. Over a quarter of a million visitors are expected to use the site in the first year of opening. Outdoor learning spaces are also being developed at the site to allow school visits in an area of London where access to natural environments can be limited.

Demonstrates innovative design and long-term thinking

The reservoirs require maintenance dredging on a five to seven-year cycle. The design solution provided allows future dredged material to be placed elsewhere within the reservoirs as new reedbeds or to be placed in front of the recently constructed reed beds to increase their design life and to expand the available wetland habitat.

Other parties involved in the project include:
London Borough of Waltham Forest (Client)
London Wildlife Trust (Stakeholder)
Heritage Lottery Fund (Stakeholder)
Thames Water Utilities Limited (Stakeholder)
Kinnear Landscape Architects (Landscape Architects)
Salix (Principal Contractor)

WINNER

Roseanna Bloxham

ORGANISATION

RSK

Roseanna is a senior geoenvironmental engineer at **RSK** with over six years' industry experience with particular knowledge of designing and managing intrusive site investigations, contaminated land risk assessments and development of preliminary shallow and deep foundation recommendations.

Roseanna trains new graduates in the fundamentals of site work and data collection by mentoring them in the field and leading training presentations. She also delivers RSK's report writing course.

Roseanna is currently responsible for managing medium-value projects, supervising and reporting on all aspects of geoenvironmental investigations and has specialist skills in the following areas:

- site conceptualisation through preliminary risk assessment
- human health and controlled waters generic quantitative risk assessment (GQRA)
- detailed quantitative risk assessments (DQRA) for controlled waters using the Environment Agency's RTM spreadsheet
- geotechnical appraisal
- production of remediation verification reports
- regulatory liaison
- groundwater monitoring by low-flow techniques
- gas monitoring and vapour sampling
- asbestos in soil awareness
- experience of working on active and closed petrol station forecourts
- experience of working on oil terminals
- health and safety management on site.

Roseanna joined RSK in 2011 as a graduate geo-environmental engineer. She immediately contributed to project delivery with hard work, commitment and dedication. Supported by RSK's culture of continuing professional development, Roseanna leads by example and makes a significant contribution to RSK. She safely delivers high-quality work to some of RSK's most prestigious clients and is motivated to move the construction industry forward with technology.

Roseanna is part of RSK's European intrusive investigation and remediation delivery team for a leading petroleum retailer. In this role, she is a permit issuer and enables work to be undertaken safely. She is the health and safety lead for the contract in the UK. She manages the collation and analysis of key health and safety metrics on the contract, prepares and leads safety campaigns for continuously improving RSK staff's safety and attends and leads at key internal and external safety events. For this client and others, Roseanna designs investigations, estimates costs and workscopes, and manages project teams on-site and in the office.

JUDGES' QUOTE:

"We were pleased to see so many entries into this important award category. They were all amazing and terrifyingly competent young professionals who will all have exciting careers ahead of them. However, we felt though that there was a clear winner for this year's award, highlighting the work done with young starters on-site and the course devised for report writing training, use of StopCard for unsafe working practices which sounded very novel and should be used widely, and work as a STEM Ambassador and winning a Women in Construction and Engineering Award."

Roseanna delivers RSK's report writing course and trains the company's graduates in the fundamentals of site work and data collection by mentoring them in the field and leading training presentations. Roseanna communicates well with staff throughout the company. An RSK colleague says, "Roseanna is enthusiastic, dynamic and proactive and an absolute pleasure to work with." She is an advocate of mobile data capture, so has spent time developing prototype forms and trialling tablets in the field.

She has also provided constructive feedback on RSK's automated soil and groundwater data screening tool that helps engineers identify if there is a potential problem with the ground.

In 2016, Roseanna led RSK's stop-work card initiative to support employees in stopping unsafe work.

Although staff have the authority to stop work, the cards reinforce management support and have now been adopted across the company.

2017 was a hugely successful year for Roseanna, as evidenced by her project work, career development and prestigious external recognition. In May 2017, she was named Best Woman Consultant at the Women in Construction and Engineering Awards. The award represents her dedication to her role, her commitment to the construction industry and her willingness to go beyond what is expected to try new initiatives that will improve efficiency and safety.

Roseanna is committed to sharing her skills and training with the next generation. This has inspired her to become a STEM (science, technology, engineering and mathematics) Ambassador. She is passionate about encouraging the younger generation to join the engineering sector and promotes the importance of diversity in the industry by visiting schools. After receiving her Best Woman Consultant award, Roseanna visited her former secondary school to present as a guest speaker. She has used the award to highlight the importance of encouraging diversity in engineering and construction. She hopes that the industry will attract more young professionals.

Key project experience

Shell Oil Products, petrol station sites throughout the UK, 2011–ongoing

As a site engineer and project manager, Roseanna has worked on numerous Shell petroleum retail sites as part of a large, UK-wide site investigation contract. Her responsibilities have included developing work plans and costing scopes; coordinating and delivering investigations in accordance with Shell's requirements; supervising site works, including utility clearance surveys; overseeing various drilling operations using shell-and-auger, window-sampling and rotary drilling methods; supervising soil verification following the removal of petroleum dispensary infrastructure; and sampling groundwater and vapour.

Since 2016, Roseanna has been the HSE lead for the Shell GESS 2015 contract in the UK. This requires her to manage the collation and analysis of key HSE metrics on this contract, prepare and lead safety campaigns, aimed at continuously improving our staff's safety, and attend and lead at key internal and external safety events.

Training

The Site Supervisor Safety Training Scheme (SSSTS): holder of Site Safety Plus certification
Safety Pass Alliance (SPA): holder of the safety passport for petrol forecourts
Client Contractor National Safety Group (CCNSG): holder of the safety passport
RSK Safeground: trained on the effective use of CAT and Genny locators
Construction Skills Certificate Scheme (CSCS) card holder
Shell permit to work system – issuing authority and RSK UK Custodian
Asbestos awareness
First aid at work

Napier Park – Luton, 2017–ongoing

As a site engineer and assisting with project management, Roseanna successfully aided the client in the construction of a textomur retaining wall. RSK was responsible for the global stability of the project as well as ensuring the chalk fill was laid correctly and tested in accordance with the in-situ test plan. Roseanna was responsible for liaising with the client and contractor, overseeing the construction onsite, and reporting the findings.

BP Walton Oil Terminal – Walton-upon-Thames, 2014 – ongoing

Roseanna current assists the project manager by coordinating and undertaking the annual groundwater sampling at BP Walton Oil Terminal. This includes the low flow sampling and scheduling of over 50 monitoring wells over three days with various assisting engineers and technicians.

Peterborough School – Peterborough, 2016

Roseanna was the project manager for a geotechnical investigation at a school sports hall. The sports hall structure was failing and various parties were involved in the project. RSK was responsible for investigating the failure and providing unbiased conclusions and recommendations to assist the client with legal proceedings. Roseanna was responsible for liaising with clients, coordinating the investigation and reporting the findings.

Fresh Wharf – Barking, 2014

Roseanna was the assistant project manager and the site engineer responsible for borehole supervision and installation; in-situ geotechnical testing; and soil, groundwater and gas sampling and data interpretation at Fresh Wharf Estate. She was also was responsible for producing the site assessment report, which included undertaking a generic quantitative risk assessment process (GQRA) for human health and controlled waters and geotechnical design of foundation solutions.

Peter Witherington – statement

In addition to my role as deputy chairman of RSK, I have previously been responsible for our geosciences business within which Roseanna works.

I have known Roseanna since she joined RSK in 2011 on our graduate scheme. With her engineering geology and geotechnics degree complemented by a year of previous consultancy work she immediately contributed to project delivery within our Hemel Hempstead office by supervising site investigations and preparing factual and interpretative reports for our clients.

It rapidly became apparent that Roseanna was a quick learner, dedicated and diligent in her day to day project work and keen to support and drive wider business initiatives. Consequently and as part of my retirement planning, I asked Roseanna to take over presentation of the report writing course I previously gave across the RSK business that comprises more than 2,000 people. Although Roseanna is relatively junior to give such training, her communication abilities and her own report writing capabilities led me to believe she would do an exceptional job in training our staff.

Roseanna's communication skills, willingness to drive innovation and her ability to organise the safety metrics for one of our key clients is and will continue to be fundamental to her success. Roseanna leads her colleagues with respect to implementation of efficiency initiatives such as data management, onsite data capture and use of technology which will lead to our business being more profitable. Roseanna's work has been instrumental in RSK achieving more than 2,339 days worked without incident or injury.

I congratulate Roseanna's commitment to safety, competence and client deliverables. However, it is Roseanna's positive attitude and commitment to driving forward with innovation that is the hallmark of her achievements thus far. I have no doubt that her already impressive career will continue to provide an exceptional influence on many professionals dealing with land management issues globally.

WINNER

The Avenue Remediation and Landscaping Project

ORGANISATIONS

Homes England, Jacobs, VSD and Turner &Townsend

The Avenue Remediation and Landscaping Contract is a large scale remediation which has recently been completed in Chesterfield, Derbyshire. Taking nearly two decades to design, plan and execute, the total project budget of £180m indicates the scale of the challenge which the project team faced.

Jacobs was first appointed in 1999 and since then has held many roles on the project with one of the most significant being remediation designer. Working with **Homes England**, over the course of the project many hundreds of the staff have contributed. The focus throughout has been to develop a strategy which is both efficient in returning the site to productive use but also demonstrably robust.

The recently completed verification process for the site shows that it is one of the most detailed and significant tasks that the land quality team has ever undertaken.

Project History and Scope

The 98ha site of the former Avenue Coking Works, used to be one of the most contaminated industrial sites in western Europe. The coking plant closed in 1992, leaving a legacy of derelict plant, heavy pollution and contamination of the underlying soils, groundwater and adjacent River Rother.

The Avenue Remediation and Landscaping Project is an extensive voluntary remediation project with the objective of returning the site to beneficial use. The restored landscape, which will bring long-lasting environmental, social and economic benefits to Chesterfield and North Derbyshire, can be considered to be an exemplar in terms of land regeneration.

With the remediation works complete, the site has now been handed back to Homes England. Wildlife is re-establishing itself in the new landscaped areas and the open space is ready to be opened up to public access for recreational use. Work to develop the first homes has commenced in the development area.

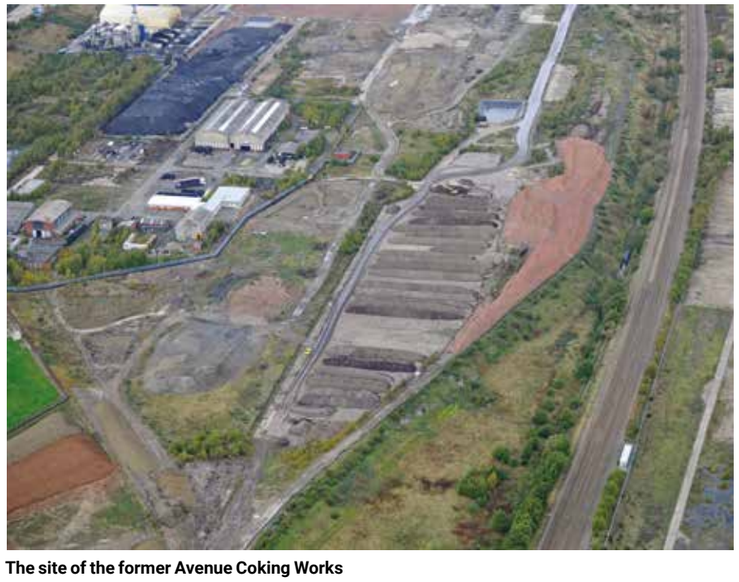
Site Characterisation

Between 1999 and 2009, the project focused on managing the development of a remediation strategy and masterplan which would ultimately form the basis for the contract to remediate the site.

Commencing early in the process, a programme of significant investigation and interpretation was implemented with the objective of understanding the key sources of contamination and their characteristics.

On first inspection, many of the key issues were abundantly clear. In particular, there were two tar lagoons which existed either side of the River Rother and which represented a significant hazard to the watercourse. These lagoons contained sediments which were essentially by-products of the processes which had taken place on site. The leaching of contaminants from the lagoon had had a significantly detrimental effect on the condition of the sediments in the river channel. There was also a licenced waste tip on site and the former plant area had been heavily impacted by the works which had taken place there.

Over time, each of these areas was characterised as the understanding of the risks they posed to the future development developed. The contaminants of concern comprised: PAHs (poly-aromatic hydrocarbons), phenols, DROs (diesel range organics), PROs (petrol range organics), BTEX (benzene, toluene, ethylene, xylene), cyanide, thiocyanate, ammonia, heavy metals (arsenic, nickel, cadmium, chromium) and asbestos.



The site of the former Avenue Coking Works

The Development of the Remediation Objectives

The remediation objectives were predominantly designed to decontaminate the site by the excavation and treatment (where required) of the identified sources of contamination in order to:

- Protect human health (future site users)
- Protect controlled waters, specifically the River Rother
- Create a development platform suitable for residential housing with garden areas
- Mitigate environmental liabilities that were associated with the site in its original condition
- Minimise material import/export and maximise material re-use on site.

In order to meet these objectives and create the proposed landform, significant quantities of material cut and fill were required to the existing landform.

As the project developed, it became clear that a number of forms of treatment and management would be required in order to meet these objectives. The specifications comprised:

- Thermal Desorption
- Ex-Situ Bioremediation
- Manual and mechanical sorting of waste
- Concrete crushing and grading.

The site as it existed circa 1999. Note the presence of the plant area prior to demolition. One of the principal tar lagoons is clearly visible towards the bottom of the photograph, below the large concrete slab area. The River Rother ran between this lagoon and a second one which is just visible to the very left

An aerial overview of the project during the peak earthworks production period. Note the significant number of individual excavations and work locations, all of which are addressed as part of the verification process

A Plan for Practical Application

Fundamental to a project of this complexity is a robust verification strategy. The ambitious masterplan was designed to allow the land to be used by the most sensitive of receptors. When combined with the local community's knowledge of the site and its history, it was clearly essential that the site was not just remediated but that it could be demonstrated to be so.

From the outset, the project team worked with regulators, including the **Environment Agency** and **North East Derbyshire District Council** in their role as planning authority and regulator for land contamination. The objective was to ensure that an understanding existed between the parties as to what was necessary in terms of verification and also what could be achieved. One of the outcomes of this was a planning condition that required a report to be provided at the end of the project which clearly demonstrated that the risk has been reduced to meet remediation criteria and objectives based on a quantitative assessment of remediation performance' (as defined under CLR 11).

Arising from this process was an agreed verification strategy which was fully aligned with the planning condition requirement to provide a completion report at the end of the project. The discharge of the associated planning condition was s a principal objective of the project and key to demonstrating its success.

The broad guidance available on the development of verification strategies is necessarily generic and covers a range of different applications. The strategy for the large scale Avenue Project is based on the procedure but builds on it to provide a final deliverable which is an absolute and definitive record of those works which have taken place.

Jacobs involved a team of experienced contract administrators and construction professionals at an early stage to ensure that the strategy which was being developed could translate into something that could be readily delivered on site.

Verification During the Works

The specification for the construction phase of the project was designed to reflect this strategy. Clear requirements in terms of sampling methodologies, sampling locations, testing schedules

and QA procedures for verification of excavation surfaces, remediation treatment performance, placed fill, and drainage and groundwater quality were established with the contractor prior to commencement. The required response to any failures was also clearly specified.

All testing was compared against a project specific set of assessment criteria which formed part of the construction contract. These criteria were derived following the human health and controlled waters Quantitative Risk Assessment for the identified contaminants of concern. That allowed materials to be identified which required excavation and treatment. They were also applied as criteria to determine the suitability of materials to be placed as fill with or without prior treatment.

Jacobs' team of supervisors ensured that there was attendance from the company at every key point in the remediation process. Staff inspected every square metre of exposed excavation surfaces as a means of ensuring that the testing undertaken was both adequate and representative.

Interim verification data was submitted monthly by the contractor which was systematically scrutinised and reviewed allowing any deviation from the remedial objectives to be identified and quickly addressed.

As any unexpected circumstances arose on site, the team was able to view these in the context of the overall design and make pragmatic decisions on how to proceed while maintaining the integrity of the remediation strategy and minimising delay to the contractor.

On occasion, this resulted in difficult decisions being made which added cost and/or delay to the project. In other situations though, the evolving understanding of the site conditions allowed identification of opportunities which could be developed to ensure that best value was derived for the client.

JUDGES' QUOTE:
"As has been said, there were several excellent entries in the new Brownfield Project of the Year category and we decided that two of these merited a mention:
The first was a regulator led, landmark/exemplar project from City of Wolverhampton Council.
A determined Part 2A site, it demonstrated how dealing with contamination on a site with homes in current use is complex in relation to technicalities, legalities and communications. The project has taken 14 years to complete with 84 residential properties successfully remediated.
We have also decided to give a special award to another marathon, landmark clean-up project. This was an example of a long term, large scale, technically and logistically complex project to unlock a fenced off highly contaminated site, which has been used as an exemplar since inception involving thermal desorption, ex-situ bioremediation and waste sorting. Many lessons have learned as it progressed and it has provided valuable practical experience for many in the industry."

Final Verification

The verification strategy culminated in an interpretative report designed to systematically follow the development of the site from inception to closure.

In addition, the contamination migration model used to carry out the original risk assessment has been re-run using the new "remediated" geology to confirm that the work has been effective in protecting the River Rother in the long term. This showed that all the remediation objectives have been met and that the relevant pollutant linkages have been managed, removed or broken.

There are residual environmental and development risks that could not practically be accommodated by the remediation strategy. Generally, these relate to protection measures that need to be incorporated into the housing development such as gas protection.

The team has recognised that the integrity of the remediation strategy needs to be maintained into the future. The final documentation clearly defines the roles and responsibilities of project stakeholders and is integrated with the Health and Safety file to ensure that future landowners and developers understand the actions that they must take in order to ensure that the verification which has been undertaken remains valid.

It is testament to the integrity of the verification strategy that the planning condition has now been discharged and the first part of the development area has been purchased by a developer with preparatory works for the initial houses ongoing.

Legacy

The legacy which the Avenue Remediation and Landscaping Project leaves behind is remarkable. The history of dereliction and blight is a fading memory. Soon, families will live on the site and enjoy the recreational facilities it offers. Most will have some concept of the history of the site but few will appreciate the science which underpins its transformation, trusting it to companies like Jacobs to ensure that their health and wellbeing is not affected by the environment within which they live or spend time.

That is a responsibility that our industry takes seriously and it is one which has driven the project team at the Avenue to ensure that the verification of the works undertaken is as comprehensive and robust as is possible.

The verification which has been undertaken is both extraordinary in its scale and in its detail. Approximately 40,000 individual soil and water samples were recovered resulting in up to 1.2m individual data points to be assessed as part of the process. In many ways it is not the landscape or amenities which will provide the reassurance the community needs but the works undertaken over many years to prove that our concept became reality.

Meet the Judges

Clive Boyle
Managing Director
CRB Environmental

Ian Grant
Editorial Director
Environment Analyst

James Cartwright
Regional Director
McAuliffe

Lisa Hathway
Principal Land Quality Engineer, NHBC

Alex Ferguson
Managing Director
Delta Simons

Jonathan Atkinson
Technical Specialist
Groundwater & Contaminated Land, Environment Agency

Ann Barker
Lead Officer Contaminated Land, Bradford MDC

Dr Richard Boyle
Senior Technical Manager, Homes England

Prof Stephan Jefferis
Director
Environmental Geotechnics

Christine Mardle
Technical Director
WSP

David Rudland
Contaminated Land Officer and Remediation Project Manager
Swindon Borough Council

Jonathan Steeds
Technical Director,
Atkins

Frank Westcott
Director
Westenviro

Category 4 - Best scoping or operation of a site investigation

National Grid Property Holdings, WYG, RSK and RemedX

Integrated site investigation and in-situ pilot trials for coal tar NAPL characterisation and remediation at a major former gasworks

AECOM

Confidential Industrial Site, Northern Ireland – Assessment of an Historical Chemical Waste Area

Category 5 - Best project closure/verification process

Atkins

Groundwater Monitoring and Bio-Trap Microbial Analysis Sponsored by NHBC

Category 9 - Best digital innovation in brownfield

Ambisense and Institute of Environmental Analytics

Ambilytics

Category 10 - Best urban regeneration project

Atkins/SNC-L on behalf of The Inglis Consortium

Millbrook Park

Category 12 - Best biodiversity enhancement (including SuDS)

St Modwen Developments Ltd and Atkins

Coed Darcy and Crymlyn Bog - Natural Neighbours

Service Provider Directory

Below is a selection of service providers including land remediation consultants and contractors as well as flood risk & control services. For our full directory, please visit our website **www.developmentandinfrastructure.com/directory**

Land Remediation Consultants and Contractors

AECOM

A Fortune 500 firm, AECOM is the world's largest remediation company with more than 5,000 remediation staff world-wide and a gross annual revenue from remediation projects alone of over $1 billion. We design, build, finance and operate infrastructure assets for governments, businesses and organisations in more than 150 countries.
Rachel Odonnell
Business Unit Director,
Environmental Liability Solutions,
Environment & Ground Engineering
Tel: +44-7753912128
Email: rachel.odonnell@aecom.com
Web: www.aecom.com

Arcadis UK Ltd

Arcadis FieldTech Solutions has a dedicated team of environmental experts who specialise in meeting your environmental contracting needs including Geotechnical and Environmental Ground investigation; specialist in-situ probing (MIP and LIF);tailored design and build remediation contracting services; decommissioning and demolition services (including explosive demolition) and creating value from redundant assets.
Mark Webb
Senior Technical Director
34 York Way, London, N1 9AB
Tel: 01638 674767
Email: mark.webb@arcadis.com
Web: http://arcadis.com

Campbell Reith

Campbell Reith is an independent firm of consulting engineers providing structural, civil, environmental, geotechnical, highways and transportation services. With a reputation for producing imaginative and cost effective design solutions, we are recognised by our clients as a firm of innovative and pragmatic thinkers
James Clay
Partner
Tel: 01737 784500
Email: jamesclay@campbellreith.com
Web: www.campbellreith.com

Celtic EnGlobe

Celtic-EnGlobe is one of the leading remediation and brownfield enabling works contractors in the UK, with a proven track record of delivery after more than 25 years in the industry. Celtic-EnGlobe is part of EnGlobe Corp, a world leader in providing integrated environmental services which operates in the UK, France, Middle East, USA and Canada. By partnering with us, you are able to rely on our extensive experience and delivery capability.
Kathy Newall
Business Development Manager
Unit 8, Commerce Park Brunel Rad,
Theale, Reading, RG7 4AB
Tel: 07985 836227 | Tel: 01189 167340
Email: kathy.newall@celtic-ltd.com
Web: http://celtic-ltd.com

DEME

DEME Environmental Contractors UK Ltd
DEC is one of Europe's leading environmental remediation contractors with more than 25 years' worldwide experience in the treatment of contaminated soil, sediment and groundwater using both in-situ and ex-situ technologies (on and off site). Projects undertaken range from small petrol station clean-ups to large-scale, complex, multidisciplinary remediation schemes.
Jim McNeilly
General Manager UK
Tel: 07713 121839
Email: mcneilly.james@deme-group.com
Web: http://deme-group.com/dec

Ecologia

Ecologia is a multi-disciplinary, specialist contaminated land contractor that provides advice and undertakes remediation projects across the UK and Europe. We also have an established and excellent reputation for the construction and operation of in-situ remediation plant for soil and groundwater.
Giacomo Maini
Managing Director
Tel: +44 (0) 1795 471611
Email: g.maini@ecologia-environmental.com
Web: www.ecologia-environmental.com

ERS

Established in 1994 and wholly employee-owned, ERS is a team of >30 engineers and scientists dedicated to providing the most appropriate and cost-effective remediation of contaminated soils and groundwater. Trusted by property developers, house builders, contractors and consultants; projects range in value from under £5k to >£1m. ERS is Constructionline, CHAS, SMAS, PCA and Achilles registered. Services include: Remediation-oriented ground investigation; treatment of soil and groundwater for contaminants including hydrocarbons, chlorinated solvents, heavy metals and invasive plant species; In-situ and ex-situ remediation by physical, biological, chemical and thermal means; Waste classification and disposal via landfill or soil treatment centres
Andrew Mackenzie
Managing Director
Tel: 0141 772 2789
Email: andew@ersremediation.com
Web: www.ersremediation.com

GB Card & Partners

GB Card & Partners is a specialist environmental and civil engineering consultancy with an international reputation for the assessment and remediation of brownfield land. We have been at the forefront in setting industry standards and Government policy in both the UK and overseas, particularly in the compilation of guidance and policy documents for land quality, gas/vapour protection and development on former landfill and gassing sites. The expertise and skill that we bring to a project has enabled our clients to successfully develop award winning schemes.
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GeoStream UK Ltd

GeoStream UK is the only single source provider of tried and tested remediation technologies in the UK, offering the full range of physical, chemical and biological treatment techniques for soils and groundwater and exclusive providers of Trap & Treat® (BOS 100® & BOS 200®) and the full range of injectable substrates supplied by Carus Remediation Technologies for the UK and Ireland.

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John F Hunt

JFHR undertake innovative and sustainable soil and groundwater remediation projects across the UK. We work in a collaborative manner to deliver projects on time and on budget. As part of the wider JFH group, we are able to integrate other disciplines including demolition, civils and infrastructure, and asbestos consultancy.

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Kelbray remediation

Offering a wide range of treatment solutions, we specialise in the remediation of contaminated land and water. Our priority is to deliver compliant, sustainably remediated sites with the associated regulatory approval to enable onwards development and / or manage environmental issues. We pride ourselves on our specialist service integration, building strong relationships with our clients` consultancy team and statutory bodies. Our detailed understanding of the contaminated land regime and effectiveness of our remedial solutions enables the most complex and technically challenging projects to be delivered to our clients` and regulatory authorities specification.

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McAuliffe Civil Engineering Ltd

McAuliffe delivers solutions in brownfield site transformation at land acquisition and build-out stages. The business offers a full turnkey service, with core capabilities including soil and groundwater remediation, haulage and materials management, ground improvement and foundation solutions, and demolition services.

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Peter Brett Associates LLP

PBA is an independent practice of engineers, planners, scientists and economists delivering major development and infrastructure projects. We provide trusted advice to create value from the land and buildings owned or operated by our clients. We have a regional spread of offices with a depth of technical skills throughout the UK, including specialists in contaminated land and its remediation.

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Ramboll

Ramboll is a leading engineering, design and consultancy company employing 13,000 experts. Our presence is global with especially strong representation in the Nordics, UK, North America, Continental Europe, Middle East and Asia Pacific. We constantly strive to achieve inspiring and exacting solutions that make a genuine difference to our clients, end-users and society at large. Our globally recognised environment and health practice has earned a reputation for technical and scientific excellence, innovation and client service. Advances in science and technology and evolving regulatory, legal and social pressures create increasingly complex challenges for our clients. We evolve to keep pace with these changes – by adding new services, contributing to scientific advances or expanding geographically.

Greg Stoner, Marketing Communications Project Manager - Europe & Africa
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Sanctus Ltd

Sanctus is a specialist remediation contractor offering solutions for all issues associated with brownfield land development, including a wide range of in-situ and ex-situ soil and groundwater remediation techniques. Sanctus holds a bespoke environmental permit for the onsite treatment of hazardous waste and is also a licensed asbestos contractor.

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Shawcity Ltd

Shawcity is an independent business focused on bringing the latest technology from the world's leading manufacturers to the UK and Ireland. We enable customers working in Environmental, Occupational Hygiene and Health & Safety applications to achieve the highest levels of monitoring performance. We have the UK's largest hire fleet of GasClams, the world's first in-situ borehole gas monitor which gives high frequency unmanned data readings for up to three months at a time. Manufacturer-trained and approved, our technical team also offer in-house servicing, calibration, repairs and training as well as unlimited technical support.

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Soil and Water Solutions Ltd

S&WS Ltd is a licensed specialist environmental and enabling works contractor providing sustainable in-situ and ex-situ remediation, bulk excavation and disposal/recycling using our own plant, on time and budget. Our in-house expertise enables delivery of bespoke brownfield solutions for treatment of contaminants including hydrocarbons, asbestos and Japanese Knotweed, nationwide.

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Soilfix Limited

Soilfix is an award-winning remediation solutions provider to the development, industrial, commercial and public sectors. Our mission is "to understand and manage risk in the ground". Soilfix has developed an outstanding track record for delivering innovative remedial solutions for contaminated and brownfield sites.

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Strata Geotechnics

Van Elle has been providing Ground Investigation (GI) services since 1998 and rebranded the GI division as Strata Geotechnics in 2017. We currently employ approximately 50 staff including engineers and directly employed drilling operatives. Strata Geotechnics is part of the Van Elle Group (PLC) and delivers a comprehensive range of site investigation services to a broad variety of markets, including: transportation, construction, energy, utilities, housing and the environmental sector. We have earned an enviable reputation for providing high quality services throughout the United Kingdom and regularly work with Government agencies, local authorities, Network Rail, main contractors and developers.

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Waterman Infrastructure and Environment

Delivers multidisciplinary engineering solutions to the property, construction and redevelopment sectors. Services include site investigations, risk assessment, cost effective remediation and contract management, reporting to facilitate planning conditions discharge, and waste classification advice on excavated materials during development and contract negotiations. Our experience brings strategic advice to minimise risk and costs.

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4R Group

4R Group is a market leader in organics recycling, restoring brownfield sites across the country to the required end use with little or no cost to the land owner. We can deliver all operational and specialist technical work with our highly experienced teams.

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| Flood Risk & Control Services

Rivelin Bridge Ltd

Rivelin Bridge Ltd is a civil and environmental consultancy working throughout the UK and internationally. We provide engineering and advisory services related to flood resilience, water related development and adaption.

Our services include: project development and planning, business case development, stakeholder engagement and scheme promotion, programme and project management, tendering, training and advice. We help you create value by connecting water, people and places.

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UK Flood Barriers

Since being established in 2007, UK Flood Barriers has grown to become the UK's leading specialist flood contractor. It provides effective flood defence protection to members of the public, businesses, councils, main scheme contractors and the Environment Agency. UKFB has built an enviable project portfolio delivering world class flood defence solutions which are as effective at an individual property level as they are in large scale community infrastructure projects.

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