



See inside cover for caption

The environmental remediation market has evolved from traditional “dig and dump” remedies to highly technical solutions; and Golder Associates holds a leadership role in this transformation. To showcase the range of this experience, this issue of Technically Speaking features several projects in which we have worked with our clients to solve a number of site remediation challenges worldwide. From the cold climates of northern Canada to the tropical jungles of Brazil and Asia to the semi-arid climate of South Australia, Golder people have pioneered the development of a range of remedial alternatives. And through our Site Remediation Technology Network – whose members are pictured above – we are sharing these ideas that benefit our clients, our peers and the environment worldwide.



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GOLDER PIONEERS REMEDIATION TECHNOLOGIES GLOBALLY

BY THE SITE REMEDIATION TECHNICAL NETWORK ORGANIZING COMMITTEE

To give clients access to the leading edge solutions they need to meet rising expectations, Golder has pioneered several remediation technologies around the world. In some cases we have handled entire projects, and in others, our role was to handle design, supervision of work and verification for work done by specialist contractors. Golder's remediation "Firsts" include:

Europe

- ▶ First zero valent iron reactive barrier in Europe (second in the world), Northern Ireland
- ▶ First thermal desorption of PCBs and other soil contaminants in the UK and Sweden
- ▶ First nano-scale iron use in Europe in pilot tests performed in the Czech and Slovak Republics, and in Italy
- ▶ Designed and performed the first air-sparging remediation in Hungary
- ▶ First pressurized aeration tower in Italy, 2005
- ▶ Designed the first groundwater remediation using humic acids-driven and sulphate-driven enhanced natural attenuation in Finland

North America

- ▶ The first use of nano-scale zero valent iron to treat chlorinated solvents in bedrock at a site in North Carolina
- ▶ First nano-scale iron pilot test for groundwater impacted by chlorinated solvents on a Canadian active military site
- ▶ Construction of the first in-situ bio-reactor in the state of Maine to treat chlorinated solvents at a former mill site
- ▶ Completed the first major hydrocarbon remediation project in Quebec guided by sustainability principles
- ▶ First in Canada to use in-situ cutter soil mixing to stabilize contaminated soils for seismicity concerns and containment

- ▶ First use of the Limnofix in-situ sediment treatment technology in the US at sites in New York and Massachusetts
- ▶ Use of apatite reactive barrier in the US for metals treatment

Asia Pacific

- ▶ Pilot remediation trials for a tribromomethane contaminated groundwater plume
- ▶ Bioremediation of dichlorobenzene contaminated soils and fuel oil impacted soils using biopiles
- ▶ Use of dual venturi techniques to increase vacuum and groundwater extraction rates from a low permeability aquifer for hydraulic control
- ▶ The first use of enhanced thermal conduction plant to remediate gasworks contaminated soils in Victoria, Australia
- ▶ Cleanup of the largest decommissioned explosives factory in Victoria, Australia

Jim Gusek, Golder Denver, standing next to the pilot scale sulfate reducing bioreactor



PROTECTING WATER QUALITY AT A REMOTE CALIFORNIA SITE

BY JIM GUSEK, DENVER, USA
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Lake Shasta is an important source of drinking water for Northern California. Thanks to an innovative treatment system that suits the site's remote location, this reservoir is now better protected from mineral contamination. One of the sources of chemical impacts to water has been the Golinsky copper mine, which was closed in 1937 but is still causing acid rock drainage, with flow including iron, aluminum, copper, zinc, cadmium and manganese.

Because the mine site is accessible only by air, boat and a steep, narrow trail, it was important to have a solution that did not require electrical power or frequent maintenance. Accordingly, Golder looked to sulphate-reducing bioreactors as a possible solution.

A bench test used four 200-litre (55 gallon) drums, each filled with a different recipe of biomass, such as wood chips, hay, rice hulls, cow manure as a bacteria source, and limestone chips. The second stage, a pilot test, involved ferrying 39,000 kg (43 short tons) of organic material across the lake in a rented World War Two landing craft, building an aerial tramway to winch the 364 kg (800-pound) bags along part of the route, and trucking them the rest of the way. Water from the mine was piped through a gravity-fed line into a plastic-lined wooden frame containing the biomass.

Test results have been encouraging – for the past two years, the pilot system has raised the pH of the mine water from 3.0 to 7.2, and mineral contamination has typically been reduced by 99 percent. As design and construction funds become available, 40 litre per minute (10 gpm) sized "modules" may be constructed based on the pilot system's exemplary performance.



Cover picture (from left to right)

Front Row

[1] Tony Choy, Hong Kong [2] John Hinchliff, UK [3] Andrew Howes, Adelaide
[4] Geoff Ellis, Melbourne [5] Andrew Brown, Johannesburg [6] Wendy Morrison, Sydney
[7] Guy Patrick, Vancouver

Middle Row

[8] Edson Batello, Sao Paulo [9] Florin Gheorghiu, New Jersey [10] Michael Pupeza, Italy
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[16] Jonathan Medd, Melbourne [17] Todd Rees, Massachusetts [18] Francesco Ducco, Turin
[19] Roger Parker, Melbourne [20] Paul Scells, Cairns [21] Frank Njiman, Jakarta

HYDRAULIC DREDGING CREATES OPTIONS FOR PORTS IN NORTH AMERICA

BY ROBERT MCLENEHAN, VANCOUVER, CANADA
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Port managers in North America are in a position to offer better service to the ships that use their facilities, through dredging methods that can cause less environmental impact and that have recently seen regulatory approval.

Ports are in a highly competitive business, seeking to gain more traffic in part by accommodating larger vessels. To keep their waterways dredged to the appropriate depth, ports need flexibility regarding where and when they can dredge. This need runs squarely into the importance of protecting the undersea environment from dredging-caused sediment disturbance.

Dredging using clamshell methods can cause unacceptable amounts of suspension and transport of sediments, calling for new dredging methods. One solution, long used in Europe, is low turbidity hydraulic dredging. It uses what is in effect a giant vacuum cleaner to remove sediment in a way that minimizes sediment dispersal. Accurate positioning of the dredge-head using Global Positioning Satellite technology, three-dimensional mapping of the seabed and real-time turbidity measurement round out the package of technologies that makes hydraulic dredging more feasible.

An application of low turbidity hydraulic dredging in Prince Rupert, on Canada's West Coast, has opened the door to regulatory approval of a wider range of hydraulic dredging applications in Canada, possibly extending to the rest of North America. This application was particularly significant because it involved some 50,000 cubic metres (65,000 cubic yards) of contaminated sediment. The method was subsequently applied at Kitimat, BC to also remove contaminated sediment and to achieve navigational dredging requirements.

The success of these projects has created the opportunity to use these technologies at other ports facing similar challenges.



Dredging from a wharf in Prince Rupert, British Columbia





The 350 hectare (865 acre) ERG ISAB refinery located in Eastern Sicily

DIVERSIFIED TOOLBOX HELPS REMEDIATION IN SICILY

BY MICHAEL PUPEZA, TURIN, ITALY
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A variety of investigation tools has helped produce speedier results on a refinery site investigation/remediation project near Syracuse in eastern Sicily, saving the client both financial and managerial resources.

The ERG ISAB refinery, which is on a 350 hectare (865 acre) site, presented significant challenges: complex subsoil, varied sources of contamination, and several potential pathways for contamination to follow. Using the classical approach endorsed by the Italian environmental authorities, 350 borings or monitoring wells (one per hectare) would have been needed to characterize the site.

To reduce project time and cost, Golder used a combination of methods to determine the extent of subsurface conditions. Some were indirect, such as geological mapping and down-hole geophysical logs. Direct methods included continuous core recovery drilling to study lithology and bedrock fracturing, and collecting soil and groundwater

samples, the borings being finished as monitoring wells. The results of the indirect and direct investigations were constantly verified against each other and reinterpreted where necessary on the basis of reciprocal results.

Statistical and risk-based tools, as well as both traditional and advanced investigation methods, were combined to provide a well-attested picture of the refinery's subsurface.

The result was the completion of the study in six months compared to the expected 18 months, reducing the number of boreholes from 350 to 40 and the overall site characterization costs from €2,800,000 to €800,000.

CLEANING UP A FUEL OIL SPILL IN SOUTH AUSTRALIA

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Bioremediation was used to clean some 3,000 cubic metres (3,900 cubic yards) of contaminated soil at the Penrice Soda Products factory in Osborne, South Australia, which was the site of a fuel oil spill in the late 1960s.

As part of a divestment program by the site owner, the impacted soil had to be remediated in a short time frame. Limitations on off site disposal meant that the goal was to provide fit-for-purpose soil that could be used for landscaping on site. The impacted soils had to be cleaned up and re-used on site. In-house laboratory studies were also conducted to develop target cleanup criteria that would support vegetative growth as part of the reuse.

After a bench trial, bioremediation was chosen over alternative treatment methods. This process used fresh green organics from local producers, combined with oxygen, fertilizer and chicken manure. Engineered biopiles were constructed with vacuum enhanced aeration and leachate, nutrient recirculation. The soils were successfully treated from concentrations of up to 40,000 mg/kg down to 3,000 to 5,000 mg/kg in 12 to 16 weeks.

The remediated soils were re-used as sound mounds and were re-vegetated with native Australian plant species which are still going strong after two years. The success of the project was exemplified by the site owner and local environmental regulator who held a media conference on site to promote the adopted approach.





RESTORING A RIVER IN HONG KONG

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In Hong Kong, where residential real estate prices are among the highest in the world, the improvement of the environment and aesthetic appeal of residential areas can have a significant positive impact on real estate value.

The Shing Mun River, a drainage canal running through the densely populated district of Shatin, has been an increasing source of concern to local residents as strong odors and poor water quality impact quality of life.

The problem is caused by sediments contaminated through historical discharges of untreated municipal and agricultural wastewater. Golder was commissioned to develop and supervise a remediation program combining dredging and bioremediation of the sediments.

The main bioremediation works involved in situ treatment of over 120,000 cubic metres (157,000 cubic yards) of sediment, using a calcium nitrate solution as an oxidant and bio-stimulant. This solution was injected into the riverbed from an anchored vessel. Calcium nitrate dosages were calculated to provide not only oxidation of sulphides (which rapidly reduces sulphide-related odours), but also to maintain a suitable concentration of residual oxidant in the sediment to stimulate the more gradual biodegradation of general organic matter. Performance of the remediation works was assessed with respect to sediment redox levels, acid-volatile sulphides, toxicity and residual nitrate concentrations for three months following injection.

The successful implementation of this bioremediation technique has led to extended treatment work in the Shing Mun and its application to other rivers and canals in Hong Kong.



USING A FULL TOOLBOX TO PROTECT GROUNDWATER IN FLORIDA

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The State of Florida, USA has initiated a program to remediate soil and groundwater contamination resulting from dry cleaning solvents from commercial dry cleaning operations. Assigned to 23 sites across the State, Golder has found that the variety of site conditions requires a wide range of remediation tools.

After completing a detailed site assessment at each location, Golder evaluated remedial alternatives based on the nature of the contamination, soil type, facility use and other factors. A thorough evaluation of the effectiveness and efficiency of potential remediation alternatives provided the basis for selecting the best alternative.

Golder implemented a variety of remedies to address the contamination, including soil vapour extraction, source removal, accelerated bioremediation, focused groundwater source-zone extraction, and dual-phase extraction. Additionally, Golder implemented innovative remediation strategies including injection of nano-scale zero-valent iron at four sites and incorporation of contaminant flux measurements using methods developed by the University of Florida for evaluating the effectiveness of site cleanup.

Site conditions occasionally pose special challenges, such as the need to remediate contamination underneath an active shopping centre in Jacksonville. This involved drilling horizontal vapour extraction wells 49 metres (160 feet) long to reach the contaminated area. At another site, Golder used helical piers to support an active facility during excavation of contaminated soil from beneath the structure.

At each location, remedial construction was followed by operation and maintenance, and site monitoring to determine the effectiveness of the measures. When monitoring showed that contamination levels met Florida Department of Environmental Protection requirements, a Site Rehabilitation Completion Order was issued, indicating that the location was no longer a threat to Florida's people or the environment.



Contaminated soil remediation project site in the remote wilderness of Quebec, Canada



CLEANING UP A REMOTE SITE IN NORTHERN CANADA

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At a site in the wilderness of Quebec, Canada, a contaminated-soil remediation project has readied the land for return to the indigenous Cree people, in a project financed by Transport Canada, the Canadian government's transportation authority.

After a meteorological station had been operated on this site leaving a legacy of petroleum tanks and contaminated soil, cleanup was necessary so that the Cree people could develop it into a wellness centre and wilderness-travel facility. One of the project's biggest challenges was that the site was accessible only by floatplanes or helicopters, and was constrained by a short season of above-freezing temperatures.

Studies, pilot tests and a risk analysis conducted by Golder made it possible to identify a tailor-made remediation scenario, detailed in terms of logistics and costs, which would maximize the potential future use of the site for the Cree community.

The remediation technique selected consisted of soil chemical oxidation treatment with potassium

permanganate which combines in-situ and ex-situ treatment, and where the persistence of permanganate in the soils is exploited. Success in this process requires sound knowledge of the chemical reactions involved.

To manage the implementation of this leading-edge solution, Golder worked with GAIA Contractors, the construction arm of Golder Associates Ltd. GAIA worked with members of the nearby communities to dismantle and recycle the petroleum equipment, excavate the soils, put them into ten specially-made mixers for combining with the reagent and put them into piles for the reaction to continue. The collaboration between experts from the two teams with individual specialities was key to the success of this project.

News from Golder

WORLDWIDE RECOGNITION

For a ground engineering and environmental services firm to offer excellent service to clients over the long-term, being able to attract and keep highly qualified staff is important. This has recently been acknowledged in a number of places around the world.

AFRICA – We were voted the 20th Best Company to Work For in South Africa in the “Deloitte Best Company to Work For” business survey. In addition, Golder’s South African company was selected as the best in its Industry (Building, Construction and Engineering).

AUSTRALIA – We received two acknowledgements at the BRW-St. George Client Choice Awards – one award in the Overall category, for Best Medium Professional Services Firm of the year. The other recognized the company in the Engineering Profession category as the Best Large Engineering Firm.

CANADA – We were recognized as one of “Canada’s 50 Best Managed Companies” for the fifth consecutive year and as one of “Canada’s 50 Best Employers” for the fourth year in a row. In Saskatchewan, Golder was recognized with the inaugural Saskatchewan Work and Family Balance Award in the Medium Workplace Category.

UK – Entering such a competition for the first time, Golder’s U.K. company was ranked 38th Best Small Company to Work For in the country. The award recognized the company’s work-life-balance programs and flexible benefits package.

UNITED STATES – Golder was rated fourth of the top 50 CE firms by CE News Magazine, up from 25 in 2004. Our Seattle office was ranked the number one firm in the state by Washington CEO magazine. In Cherry Hill, New Jersey, our office achieved 17th out of the top 50 firms in the state from NJBiz, and was the highest ranked engineering firm. Our Buffalo office was a finalist in the Best Places to Work in Western New York.

CANADA COMMUNITY STURGEON RELEASE

Who doesn’t have a great fishing story? In Castlegar, BC, over 900 people, from school kids to grandparents, have one more. In May, as part of the 6TH ANNUAL WHITE STURGEON RELEASE sponsored by the Upper Columbia White Sturgeon Recovery Initiative, staff from Golder’s Castlegar office donned rubber boots to get in on the action. The kids are captivated, the fish are released, the cycle of life continues. The Upper Columbia White Sturgeon is an endangered species and this stocking program is one facet of a widely supported recovery plan. Fisheries Biologists from our Castlegar office have been involved in sturgeon research since 1990.

IRELAND WATERFORD CITY BYPASS PROJECT

Golder’s relatively new office in Naas, Ireland has won a major assignment to provide construction quality control services on behalf of the Celtic Roads Consortium during the 3-year construction phase of the N25 Waterford City Bypass project in the southeast of Ireland. The 23 km of new motorway will include a landmark 475 metre long cable stayed bridge across the River Suir. Golder Associates will establish an ISO 17025 accredited laboratory on site with a staff of up to 10 technicians during peak times.

SWEDEN CITYBANAN RAIL PROJECT

There are currently more than 500 trains per day on the twin rail track between the Stockholm Central and Stockholm South Stations. To ease congestion, the Swedish National Rail Administration is building an underground rail line, called “Citybanan”, through central Stockholm. The six kilometre long rail section will carry up to 30 trains per hour in each direction and will have two commuter train stations. Golder Associates’ Stockholm office has been involved through the preliminary design stage for this project and now that it is going to construction, we are looking forward to significant on-going involvement for the next few years.

UNITED KINGDOM NEW DISASTER RESPONSE NGO

Golder Associates is taking the lead in establishing a new international Non-Governmental Organization (NGO) which will respond to disasters and emergencies by providing expertise and the necessary equipment and solutions to support affected communities. This may, for example, comprise sending waste management experts to areas impacted by earthquakes or floods to assist in the waste clean-up or by providing recycling equipment to process the huge quantities of wastes which arise following such disasters. By establishing this new Disaster Waste NGO with partners, we will be able to provide a broad spectrum of support and equipment in a timely and focused manner. At this time we are looking for a range of potential partners (i.e. waste management companies, waste management consultancies, manufacturers of waste handling and recycling equipment and academia) to join us in setting up and running the Disaster Waste NGO. We are also looking for potential donors and funders to support the operations. Questions can be directed to Martin Bjerregaard in our Chelmsford, U.K. office at: 44 (0) 1245 291949 or at: Martin_Bjerregaard@golder.com.

UNITED STATES OFFICE OPENED IN SILVER CITY, NEW MEXICO

Golder Associates Inc. opened an office in Silver City, New Mexico on February 1, 2006 primarily to support regional mining clients. The Silver City Office, a satellite of the Tucson Office, is located within approximately 15 minutes from three open pit copper mines where we have been working for the last several years. This new office provides a base of operations for Golder employees from other offices, a local staff, and closer ties with our clients and the local community. Our local projects – which have been managed by Golder offices in Seattle, Denver, Albuquerque, and Tucson – include environmental characterization and remediation, large-scale tailings and stockpile reclamation, regional groundwater characterization and modeling, systems modeling, and other projects in support of closure and operational permitting.



Silver City staff from left: John Purcell, Tom Wythes, and Jen Pepe. Additional staff will be added over the next few months.

MATCHING THE CURE TO THE PROBLEM – OIL SPILL REMEDIATION IN BRAZIL

BY DENIS MILLETTE, MONTREAL, CANADA
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In July 2000, a pipeline near a Petrobras refinery in Paraná, Brazil burst, releasing four million litres (one million US gallons) of crude oil into a nearby stream, the Arroio Saldanha, which crosses four wetlands before discharging into the Rio Barigüi. About 30% of the oil reached the waterways, 26% volatilized, and the rest stayed in the terrestrial area. The cleanup of this spill shows the value of using different remediation technologies to meet specific needs.

Working under the principle of sustainable development, the decision was made to avoid the ecological damage that would come from large-scale excavations of contaminated soil. Instead, the area was divided into several sectors according to soil type, vegetation cover and other factors. Six distinct treatment methodologies were used.

Some sections near the spill site could be treated with injection and recovery trenches to collect "free" or spilled product as it migrated underground. Bioremediation, which involves using micro-organisms to treat contamination, was used to decontaminate soil along the creek and in three of the four wetlands. For the larger wetland, 15 hectares (37 acres), the solution involved building a network of dikes, creating a system of cells connected by simple control structures that allowed water to flow across, with the exception of free-floating oil, which is skimmed off.

Visual observations and monitoring of surface water, groundwater and soil show that environmental conditions have improved and that the spill no longer contributes to the contamination of the waterways.



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TECHNICALLY SPEAKING

Technically Speaking is published for valued clients and employees of Golder Associates. This quarterly newsletter includes articles showcasing innovative and technically challenging projects that Golder professionals have worked on throughout the world.

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GOLDER ASSOCIATES

At Golder Associates, we strive to be the most respected global group specializing in ground engineering and environmental services. Employee-owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Our professionals take the time to build an understanding of our clients' needs and of the specific environments in which they operate. Golder has experienced steady growth in the number of people we employ and our technical capabilities. We now employ over 4,500 people who operate from more than 130 offices across Africa, Asia, Australia, Europe, North America and South America.

