

CASCADE'S COMBINED REMEDIES APPROACH PROVIDES ONE-STOP SHOP FOR COMPLEX SITES

Cascade executives offer perspective on the latest remediation technologies, innovation in drilling, and how the company is responding to critical challenges.

Cascade is a field services provider that partners with clients to provide seamless environmental and geotechnical solutions from concept to completion. They provide the industry's most comprehensive in-house suite of field services to support geotechnical and environmental drilling, site characterization, and environmental remediation projects no matter how routine or complex.

John Cowdery, CEO. *Mr. Cowdery joined the company as CEO and President in April 2018. He has over 30 years of experience in the environmental industry. Prior to joining Cascade, he served as President of the Environmental Sector for TRC Companies where he was responsible for leading the growth strategy for the \$300 million division within TRC. Previously, Cowdery has held leadership positions at ICF International, Jones & Stokes Associates and ATC Group Services.*

Eliot Cooper, VP of Technology & Business Development. *Mr. Cooper was appointed Vice President of Technology and Business Development in 2019. His environmental remediation career spans over 30 years, and he specializes in injected remedy delivery, remediation design support, characterization of VOCs and tackling complex sites by combining multiple remediation technologies.*

John LaChance, VP of Technology. *Mr. LaChance has more than 30 years of experience in the assessment, design and implementation of remediation systems at hazardous waste sites, including 18 years working in in situ thermal remediation (ISTR).*

Bill Poupis, SVP of Operations. *Mr. Poupis is responsible for strategy development, P&L management to support business operations, capital expenditure planning, and financial performance of his division.*

EBJ: Please give us an overview of the new remediation technologies that have emerged over the last few years and how they have impacted the industry.

Cooper: The major shift in the last five years has been from treatment by chemical oxidation or bioremediation to the injection of sequestration amendments like activated carbon. These amendments are applied primarily at petroleum sites, but there has been some early research and pilot testing on their applicability to the longer chain PFAS contaminants. In most cases the manufacturers are claiming these amendments also provide for biological or chemical treatment (e.g., BTEX, MTBE,

chlorinated solvents) that can also occur for contaminants sorbed into the carbon pore space. While there are some technical and regulatory issues related to these sequestration and potential integrated treatment approaches, their application is scaling within the in-situ remediation industry.

Additionally, since contact of amendment and contaminants is critical for treatment, the industry is optimizing injection and fracturing technologies to improve amendment distribution. These include advancements in automated liquid injection pumping systems and optimization of hydraulic and pneumatic fracturing

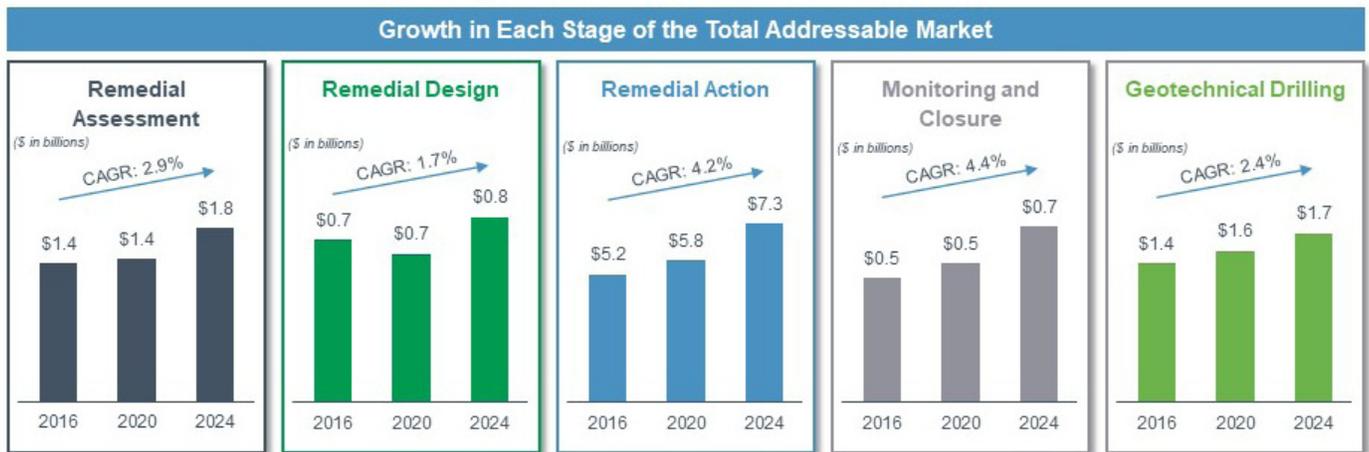
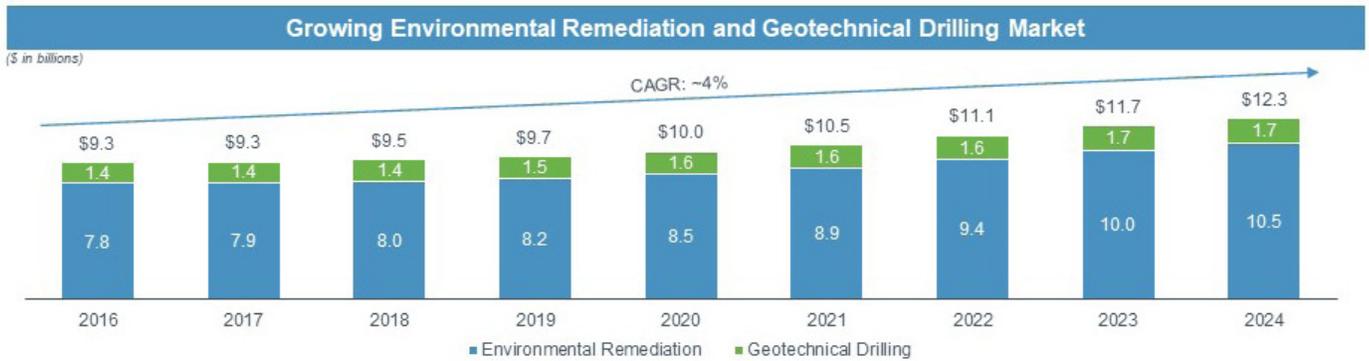
approaches for solid slurries such as zero valent iron (ZVI).

EBJ: Tell us about Cascade's new site characterization technologies. How do you see these technologies changing in the near future?

Cooper: The major challenges with in-situ remediation are treatment of contaminant mass that has sorbed to finer grained soils (this is common with chlorinated solvents), and optimizing risk reduction by targeting transmissive zones (this is common with PFAS). High resolution site characterization (HRSC) technologies address these challenges and have been increasingly adopted for remedial design. Utilizing HRSC tools such as the Membrane Interface Probe (MIP) integrated with the Hydraulic Profiling Tool (HPT), commonly referred to as the MiHPT improve site characterization. The MiHPT allows for rapid reconnaissance of sites to zero in on source areas and plume cores, while identifying both transport zones and contaminant mass storage zones. WaterlooAPS is an HRSC technology providing a more cost-effective means of obtaining discreet groundwater samples. WaterlooAPS is a complete direct push subsurface data collection platform, combining high-quality discrete sampling capability with continuous, real-time hydrostratigraphic logging. Based on this shift to higher resolution characterization, remediation performance expectations can be set more accurately and remediation results become more predictable.

Most recently, the Air Force is calling for advanced characterization proposals at their bases where existing remedies have not met their expectations. They recognize that the first round of conceptual site models needs to be updated to evaluate if better remediation performance can be achieved going forward. According to the Air Force Civil Engineer Center, "these optimized remediation contracts (ORCs) will effectively and efficiently manage the AF

Cascade's 'Available Market' or 'Competitive Gameboard' in Five Segments



Environmental Restoration Program in a performance-based, results-oriented, and cost conscious framework.”

EBJ: Cascade performs a great deal of remediation work at complex sites. What unique capabilities enable the company to perform this type of work?

Cooper: Cascade is unique in our abil-

ity to provide the full range of in-house services for every step of the continuous cycle of site investigation, characterization, remediation, and monitoring. We offer consultants a ‘one-stop-shop’ for complex sites that require combined remedy solutions. Cascade’s HRSC professionals provide guidance and support in selection and implementation of the

best technologies for each site’s conditions. Our team includes subject matter experts for each type of remediation technology thus providing consultants with an unbiased remedy recommendation. Complex sites are defined multiple ways. ITRC has developed a “Complex Site” document that should be used as a reference. Most of the complex sites we work on are either chlorinated site plumes that have matrix back diffusion issues or highly contaminated source areas that require thermal remedies to significantly reduce mass and flux to downgradient receptors.

To support our consulting customers on these sites, Cascade has developed an

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Cascade competes in the broad Environmental Drilling and Remediation and Geotechnical Drilling segments, which are set to grow significantly due to attractive tailwinds

- Cascade operates in a \$10 billion market⁽¹⁾ consisting of Remedial Assessment, Design, Action and Monitoring as well as Geotechnical Drilling
- Cascade is the only provider that straddles all of the environmental remediation segments
 - Remedial action is the largest market and recent M&A to penetrate remediation has significantly increased Cascade's total addressable market
- Overall addressable market expected to grow at a 5.2% CAGR through 2024

Large and Growing Addressable Market⁽¹⁾...

(\$ in billions)

Cascade currently serves a \$10B segment of the broader \$160B+ Environmental and Geotechnical Drilling industry



...Driven by Attractive Tailwinds

Increasing Regulations at the State Level

New Emerging Contaminants

Increased Focus on Environmental Stewardship

Rising Environmental Liabilities

(1) Environmental Business Journal Research

integrated methodology which applies a combination of appropriate remediation technologies to achieve project goals in the most cost-effective manner. This methodology incorporates the adaptive strategies promoted by ITRC and their membership.

This combined remedies approach requires in-house assets and expertise to apply advanced site characterization, thermal, chemical, and biological in situ remediation technologies.

EBJ: Emerging contaminants such as PFAS and 1,4-Dioxane are getting a lot of attention in the industry. What innovative technologies are being used to treat such contaminants?

Cooper: Currently, the majority of PFAS treatment approaches include pump-and-treat approaches with a wide range of ex-situ treatment technologies applied from activated carbon, proprietary resins, and reverse osmosis. It will take some years to determine which ex-situ treatment approaches prove most cost effective and reliable.

Research on in-situ remedies like activated carbon injection is underway looking for their sweet spot and how to weigh the benefits of sequestration versus treatment.

Source area treatment is common for contaminated soils. Primarily soils are transported off-site for commercial incineration. On-site thermal options are being developed to provide a more cost-effective solution. Further optimization of these technologies and a full understanding of combustion or heating byproducts are currently being evaluated.

Pump-and-treat is the most common option for large dilute plumes of 1,4-dioxane. Chemical oxidation and aerobic bioremediation/bioaugmentation have shown efficacy for these source areas. At this time, no anaerobic approaches have demonstrated to be effective.

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EBJ: Thermal remediation is one of Cascade's technology solutions. Today,

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thermal remediation appears to be more expensive than other technologies; what would be a perfect scenario for this technology?

LaChance: A blanket statement that thermal is more costly than other remediation technologies is misleading. All active remediation of source zones and groundwater plumes is costly to implement relative to doing nothing or even monitored natural attenuation (MNA). This includes in situ chemical oxidation (ISCO) and enhanced biodegradation (EB).

A cost comparison of remediation technologies must include the project's site conditions, chemicals of concern (COCs), remedial goals, and timeframe. For some projects, thermal is the only option to effectively achieve the remedial objectives.

Sites where thermal is the best or only option for effective and predictable remediation typically include dense non-aqueous phase liquid (DNAPL) source zones. Here, the COCs may consist of individual chemicals or complex mixtures of chlorinated solvents, chlorinated benzenes, fluorinated compounds, naphthalenes, PAHs, PCBs, dioxins, petroleum hydrocarbons, and even PFAS. The appropriate thermal technology to achieve the required temperature for mobilization and removal of the source zone COCs is selected based on the unique site conditions.

Former Manufactured Gas Plant (MGP) sites are also candidates for thermal remediation. Oftentimes excavation and disposal or in situ thermal stabilization are not practical due to the depth of treatment required, concerns with odors, or the significant impacts of associated truck traffic. MGP sites often have very large masses of light non-aqueous phase liquid (LNAPL) and DNAPL coal tars that consist of hundreds of different chemicals, including BTEX, naphthalenes, PAHs, and petroleum hydrocarbons. Thermal remediation effectively remediates all these chemicals, even to low residential soil and drinking water standards.

To summarize, although more expensive than MNA, thermal remediation is often the best or only option for high mass sites where there are complex mix-

tures of recalcitrant COCs and a need to achieve stringent standards in a predictable timeframe. For most thermal projects, the implementation and remediation are accomplished in less than one year.

EBJ: How can thermal remediation be used with other technologies such as bioremediation and chemical oxidation?

LaChance: Low-temperature thermal is used to enhance other remedial processes on sites with low COC mass and chemicals that are readily biodegraded or treated with ISCO. This technology combination increases the remedy effectiveness and shortens the overall remedial timeframe.

The benefits of combining low-temperature thermal with these technologies are: 1) significantly reduced treatment times, 2) more robust and thorough treatment as a result of the increased reaction rates throughout the treatment zone, and 3) more predictable and reliable remediation outcomes.

For some chemicals, such as chlorinated ethanes (e.g., TCA, DCA, PCA), increasing the temperature of the soil and groundwater substantially increases the natural hydrolysis reaction rates. For example, the hydrolysis half-life of 1,1,1 TCA at 20°C is 858 days, while at 70°C it is 0.8 days. The hydrolysis half-life of a chemical is the time required for half of the mass to be degraded by hydrolysis.

Increasing the temperature of the subsurface results in an increase in natural and enhanced degradation reaction rates. Arrhenius' equation describes the empirical relationship between temperature and reaction rates and basically states that for every 10°C increase in temperature there is a doubling of the reaction rates. Basically, by adding energy to a system, in this case heating the subsurface, the kinetic energy or frequency of collisions of the reactants is increased (COCs and water for hydrolysis, COCs and enzymes for biologic processes, and COCs and oxidants for ISCO), which increases the reaction rates and speeds up the degradation processes.

For most microorganisms important to the degradation of common COCs, there is an upper limit to this rate increase, as

the bacterial enzymes begin to breakdown around 35°C to 40°C. Temperatures higher than this will reduce biological activity and associated degradation rates.

For thermally enhanced biotic (aerobic and anaerobic) and abiotic (hydrolysis and ISCO) degradation processes, increasing the subsurface temperature to between 30°C and 80°C, does not require the installation and operation of a vapor or groundwater extraction and treatment system, as with full thermal treatment. Low-temperature thermally enhanced degradation and treatment can be accomplished by installing only the heating technology. Depending on site conditions, depth of treatment, and desired temperature increase, either Thermal Conduction Heating (TCH) or Electrical Resistance Heating (ERH) may be applicable.

Increasing the subsurface temperature to 35 to 40°C for enhanced biodegradation increases the degradation rates by approximately a factor of 4. For many sites this reduces the time required for remediation by an equivalent amount. In other words, a site that takes 4 years for treatment without heating would take less than 1 year by heating from 15°C to 35°C.

Even better results are achieved for hydrolysis degradation reaction rates. For example, if a site with 1,000 mg/L of TCA is heated to 70°C, it takes only about 14 days to reach 5 µg/L, whereas at 20°C, it takes about 15,000 days.

For a site with a 10,000 cy treatment zone (100 ft x 100 ft x 27 ft deep), the costs for these low-temperature thermal approaches, can range from \$500K to \$700K, depending on the technology used, required target treatment temperature (e.g., 35°C or 70°C), and desired duration. These costs include materials,

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equipment, installation, and energy. Additional cost of any associated enhancements (e.g., amendment addition for bio, pH adjustment for hydrolysis, or reactant injection for ISCO) may apply.

DRILLING LEADS WITH INNOVATION & ADAPTATION

EBJ: What are some highlights of Cascade’s drilling practice; what percentage of total revenues does it represent?

Cowdery: Here are some highlights of our practice:

- Drilling services represented 72% of total revenue in 2019.
- Cascade has the most technologically diverse fleet, with more than 10x the number of sonic rigs as the second largest competitor.
- Fleet of nearly 300 drill rigs including sonic, rotary, auger, direct push, coring, and development rigs, as well as vacuum trucks.
- Recognized as a leading environmental firm by Engineering News-Record (ENR) with improving ranking for four consecutive years.
- Shown an overall drop in safety related events, TRIR, and CIR, along with a consistently low EMR, which can be traced back to the influence of our CORE Health and Safety Program. We’ve experienced a 12% reduction in overall incident activity and a 14% reduction in severity rate over the last 24 months. Three-year injury rates

| | 2019 | 2018 | 2017 |
|-------|------|------|-------|
| TRIR: | 0.69 | 0.68 | 0.79 |
| DART: | 0.26 | 0.34 | 0.44 |
| LTC: | 0.17 | 0.17 | 0.35 |
| EMR: | 0.75 | 0.70 | 0.753 |

- Recipient of 2019 Business Achievement Award - Project Merit: Dam Rehabilitation. Cascade successfully drilled and installed 8 inch PVC pilot casing at Boone Dam in northeastern Tennessee to direct the creation of a 55 inch flooded reverse secant pile seepage cut-off wall. Cascade was brought in to conduct pilot borings

for a vertical and plumb guide for the advancement and construction of a secant pile wall—which had never been previously done. The experienced sonic drilling crew achieved nearly perfect verticality in the first hole over 56 feet of vertical drilling. Once the first casing was completed successfully, Cascade proceeded to drill 57 other locations on the project site.

- Since Cascade’s growth into the site investigation and remediation sector starting in 2015, we are the only national service provider that has in-house capabilities to service consultants at every stage of the project lifecycle: remedial assessment, remedial design, remedial action, monitoring and closure.

- Received National Drilling Association’s Drilling Contractor Safety Award three consecutive years (2017-2019).

EBJ: What new drilling technologies are available?

Poupis: It’s not so much about what new drilling technologies are available, but rather how the current technologies are adapting to new challenges including access restrictions, lithology, and sustainability goals.

The powerful sonic technology provides many advantages over the conventional drilling methods typically used for geo-construction applications like installing tieback anchors or freeze pipes. Sonic is safer as it minimizes crew handling of the tooling, this is a critical factor when performing shoreline or over-the-water work. It reduces drilling time as the borehole is drilled, cored, and cased at the same time.

Environmental and geotechnical drilling frequently occurs in remote or restricted locations and getting the equipment on-site is challenging. This requires innovation in the drilling platforms so the drill rigs can reach the site. Options include track mounted, truck mounted, ATV, full size, mini size, electric, barge mounted, and even portable drill rigs. Portable rigs are built with an aluminum frame and can be disassembled, packed into the bed of a pickup truck, taken in pieces to the site, and reassembled where drilling will occur.

Incorporating multiple drilling technol-

Cascade by the Numbers

- Headquarters in Bothell, Wash.
- \$230 million in net sales
- 900 employees
- 37 locations across the United States
- 6,000 jobs performed annually

Mix of services as percent of 2019 revenue:

- Drilling 72%
- Thermal Remediation 11%
- Chemical Injection 9%
- Soil Removal and Stabilization 5%
- High Resolution Site Characterization 2%
- Hydraulic / Pneumatic Fracturing 1%

Cascade primarily works with consultants who hold the prime contract with the property owner or responsible party. End markets served as percent of 2019 revenue:

- Industrial - 33%
- State & Local Government - 26%
- Federal Government - 12%
- Power & Utilities - 8%
- Chemical - 8%
- Mining - 4%
- Water - 3%
- Oil & Gas - 4%
- Other - 2%

Source: Cascade

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ologies on a single rig platform enables swift changes in the field as drilling conditions or sampling requirements change. Combination rigs like the Geoprobe® 3230DT quickly transitions between direct push and rotary applications. The Geoprobe 7822DT offers direct push, hollow stem auger, air and mud rotary, and concrete & rock coring on a single platform.

Many consultants are incorporating the best management practices (BMPs) from the ASTM Greener Remediation Standard on remediation projects. These BMPs improve workplace efficiency and limit the negative impacts field practices have on the environment, local communities and our employees. Drilling-related BMPs include:

- Crew carpooling and local mobilization.
- Emission controls on equipment.
- Dust control & mitigation on-site.
- Fuel reduction and efficiency.
- Habitat protection and restoration.
- No idle policy.
- On-site nuisance reduction.
- Preventative maintenance plan.
- Rubber tracked track rigs minimize surface disturbance.
- Site-specific health and safety plan.
- Spill prevention.
- Waste minimization.
- Waste recycling.
- Water conservation.

EBJ: Cascade does a lot of work for the infrastructure industry. How do technologies differ in that industry compared to the environmental industry?

Poupis: The drilling technology that Cascade utilizes in the infrastructure industry is the same drilling technology that is deployed to perform work on our environmental project applications. We do utilize conventional rotary and auger drills for infrastructure projects; however, sonic is the leading drilling technology. It accounts for more than 30% of our drill rig fleet and performs nearly half of all drilling revenue.

Sonic technology is breaking into the infrastructure market because of its production value over conventional methods. The production value (feet per day) of sonic can be double that of conventional methods such as air rotary and auger. Tie-back anchors, freeze walls, pre-drilling for sheet pile installation, confirmatory bed-rock coring, standard penetration testing (SPT), and grout confirmation are examples of infrastructure work we have performed using sonic technology.

Although the drilling equipment utilized in these two market sectors (environmental and geotechnical) are the same platform, the methods and drilling styles in which they are used may differ greatly. Site location, lithology, budget, and time-frame all are all factors in determining the most appropriate drilling technology and application for each drilling project. As it relates to R&D, our primary approach to this is on a project-by-project basis.

RESPONDING TO CHALLENGES FACING THE INDUSTRY

EBJ: What are the major challenges faced by the environmental services industry, and how have they influenced Cascade's priorities over time?

Cowdery: Many internal and external factors influence our priorities over time. These factors are dynamic and often outside of our organizational control. The way in which we respond to current and future, real and potential influences have a direct effect on the Company's growth. The most critical influences include:

Tight labor market. There is a shortage on the skilled labor required for environmental field services. The ability to recruit and retain this critical workforce directly impacts the quality of services our clients receive as well as the safety and efficiency of our everyday operations. We've found success driving both recruitment and retention efforts through our employee referral program. In 2019, 60 new hires came directly from employee referrals, nearly double that of the previous year. Our talent acquisition team maintains a comprehensive recruiting strategy with emphasis on veterans, diversity and inclusion, trade

school partnerships, training, performance recognition, and employer branding.

Emerging contaminants. The industry is identifying new chemicals of concern more rapidly than ever. Public perception of the negative health and environmental impacts of these contaminants, like PFAS, is driving regulation and legal action. These emerging contaminants represent potential future liabilities for clients, even on sites that were long considered remediated. These sites span the entire country and affect every one of our end markets. Our ability to offer integrated solutions for the project lifecycle means clients more easily assess the long-term impacts and performance of projects. This type of collaboration is essential to the future growth and stability of our organization.

Cybersecurity. No organization is immune to the digital attacks that cost businesses hundreds of thousands of dollars each year. Cyberattacks are a direct threat to our financial health and our reputation. Understanding how these threats attempt to breach sensitive data and critical technology systems is the first step in preventing the damage they cause. Adopting strategies to fight cyberthreats not only protects our employees and our business assets, it also protects our clients and their security efforts. We have invested more than \$1million in information technology to protect against threats in 500,000 emails and 100,000 logins each month.

COVID-19. This worldwide pandemic has jolted the entire world, including our industry. We moved quickly to develop employee safety training around the issues of the virus. Ninety percent of our employees completed the training and passed a test with an average score of over 90%. Further, we have equipped our field crews

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with the appropriate tools and PPE so that they are not only protected and trained regarding the hazardous materials and waste they may be dealing with, but are now equipped to also deal with COVID-19.

Being named an essential business, we were concerned that our employees may not wish to be out there and potentially exposed. Our field crews reported that they are confident, well-trained, and have the equipment they need to safely carry on operations. This is part of our adaptability and innovation that Cascade brings to every project with safety being the core value of everything that we do.

Many consultants are incorporating the best management practices (BMPs) from the ASTM Greener Remediation Standard on remediation projects. □

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