Drycleaner Site Assessment & Remediation – A Technology Snapshot (2003)

March 5, 2004

Bob Jurgens, Kansas Department of Health & Environment, Topeka, Kansas, USA
William Linn, Florida Department of Environmental Protection, Tallahassee, Florida, USA

Abstract: The State Coalition for Remediation of Drycleaners (SCRD) consists of states with drycleaner remediation programs. The core member states include Alabama, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Wisconsin. An estimated 20,000 drycleaners are contaminated across the country and based on an average cleanup cost of $250,000 per site, $5 billion is needed to address these sites. With such a focused category of contaminant sources, SCRD conducted a survey of all the states requesting information on technologies used or evaluated for assessment and remediation of drycleaning solvent-contaminated sites. The survey yielded program and project-specific information concerning contaminant types, general costs, technologies, clean-up standards, guidance documents, and lessons learned.

The survey responses were compiled and by comparing the results to a 1999 survey, SCRD evaluated the changing trends of technologies used across the country over the past 3 years. A detailed summary has been prepared to describe and discuss the advantages and disadvantages of the technologies as viewed by the regulatory community. The summary will be posted on the SCRD web page (www.drycleancoalition.org). Assessment technologies were addressed to determine frequency of use. These technologies include: soil gas surveys, groundwater and soil sampling, geophysical techniques, analytical techniques, DNAPL detection, and other assessment-specific technologies.

Remediation technologies identified included: Soil – SVE, bioventing, excavation, chemical treatment, and thermal. Groundwater - air sparging, pump & treat, multi-phase extraction, recirculating wells, bioremediation, chemical oxidation, *in-situ* flushing, thermal treatment, permeable reactive barrier walls, and monitored natural attenuation.

1.0 INTRODUCTION

The State Coalition for Remediation of Drycleaners (SCRD) was formed in 1998 with the assistance of the United States Environmental Protection Agency's (EPA) Technology Innovation Office to facilitate states sharing program and technical information from their individual drycleaning cleanup-related programs. Twelve states have developed programs that address drycleaning industry-related issues, such as contamination associated with current or former drycleaning facilities. These states include Alabama, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, Texas, and Wisconsin. Other states are considering similar legislation. Several associate member states participate in SCRD meetings. The associate member states have other programs active in the remediation of drycleaner-related contamination.

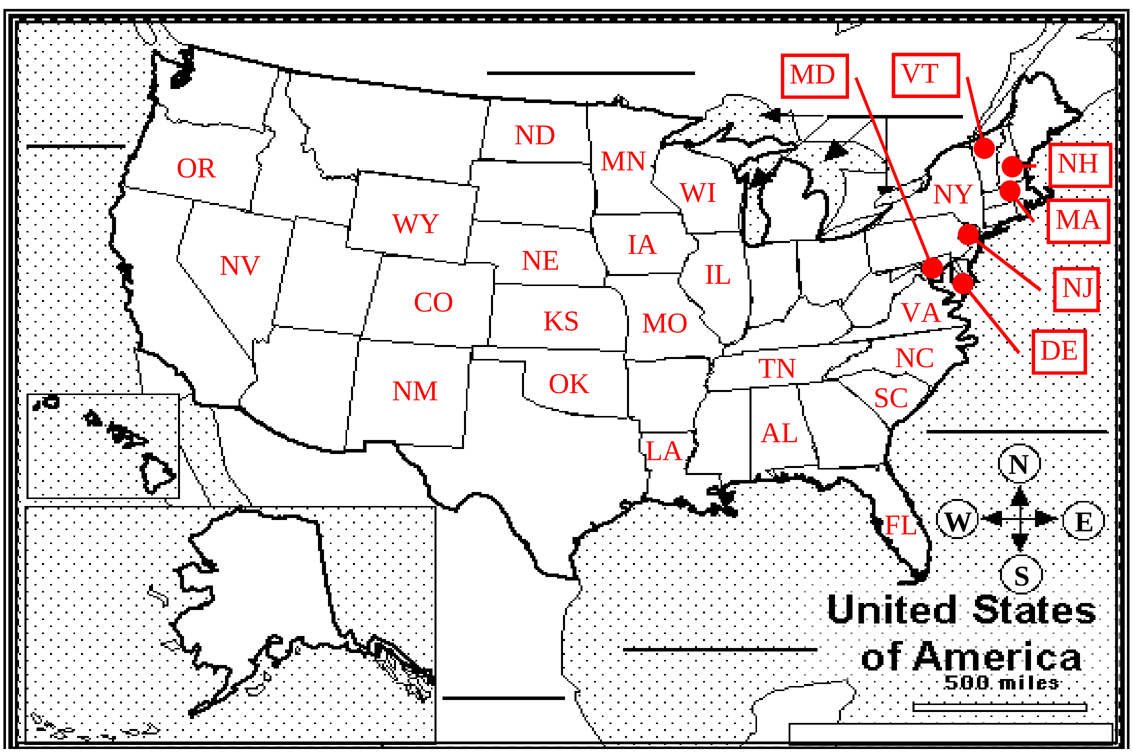
A Project Management/Technical Issues Subgroup conducted a survey of state governments in 1999 to research the state programs and identify innovative technologies used to assess and remediate drycleaning solvent-contaminated sites. Results from this research project were documented in a paper titled *Study of Assessment and Remediation Technologies for Drycleaning Sites*. The paper can be found on the SCRD web page at (www.drycleancoalition.org). In 2002 the Subgroup conducted a new survey to determine if technologies used by States were changing as innovative technologies became more prevalent in the environmental consulting industry. This paper addresses the findings from the 2002 survey and trends observed when comparing the responses from 1999 to 2002.

2.0 2002 SURVEY

The objective of the 2002 survey was to collect information from state environmental agencies regarding the state programs and accumulated site information. The information requested included:

- Technologies used to assess and remediate contaminated drycleaning sites,
- General program information regarding the state's responsibilities, policies, and strategies used to regulate drycleaner cleanups,
- General cost information for assessments, and
- Common obstacles encountered during site corrective action.

SCRD sent surveys to all the states in the United States of America. SCRD received responses from twenty-eight (28) of the fifty (50) states. A total of 1,229 drycleaner sites were assessed for corrective action in the 28 states. The states labeled on the below map submitted surveys to SCRD in 2002.



Eleven of the responding states (39%) have programs dealing solely with the drycleaning industry. These states include: Alabama, Florida, Illinois, Kansas, Minnesota, Missouri, North

Carolina, Oregon, South Carolina, Tennessee, and Wisconsin. Drycleaning sites in states without drycleaner cleanup programs are typically handled through their state superfund, federal superfund, voluntary cleanup, or hazardous waste programs.

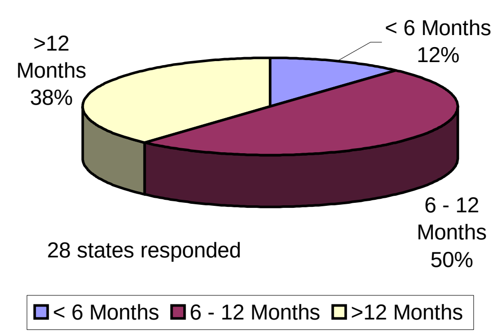
State programs dedicated solely to drycleaning sites will often approach site remediation differently based on how the program contracts consultants, as well as the experience that comes with working a large number of sites directly related to the drycleaning industry. States with state-led trust funds often are limited significantly by the annual funds available from their trust fund receipts. Therefore, the importance placed on cost may be different than a site requiring the responsible party (RP) to complete the work utilizing their own funds. The consistency and level of review for work plans and reports may also vary if large numbers of consultants are conducting work compared to a small number of contractors that may have been awarded state-run contracts.

Quite often the level of assessment and remediation is directly related to the cleanup standards adopted by the individual states. Many states have adopted risk-based levels for soil and groundwater. Alternative evaluation methods that are often considered include: presence of receptors, risk pathways, beneficial use of water, current and future land use onsite and on offsite property impacted by the contaminant plume. Groundwater cleanup guidelines varied from the maximum contaminant levels (MCLs) established by the EPA to state calculated or approved risk-based standards.

2.1 ASSESSMENT - GENERAL

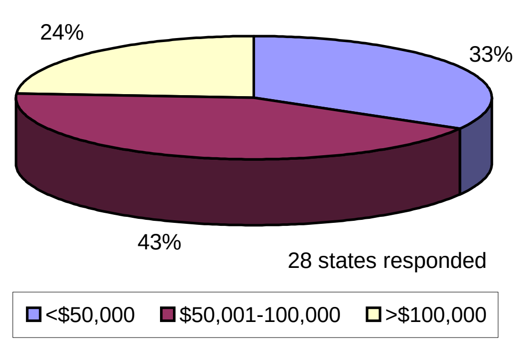
2.1.1 Duration For Completion: All but one of the responding states have conducted or provided state regulatory oversight for assessments at drycleaner sites. Assessment duration for completion ranged greatly due to severity of contamination, depth to groundwater, geologic and hydrogeologic conditions, method of sample collection, etc. See Table 1 for a general comparison of assessment duration.

Table 1 - Assessment Duration



2.1.2 Cost Per Assessment: The average cost per assessment also varied greatly due to the solvent type, severity of contamination, geologic and hydrogeologic conditions, contracting methods, and waste disposal regulations. Chlorinated solvent plumes are generally more expensive to assess due to the ability of chlorinated solvent contamination to remain in the soil and groundwater for long periods of time, which creates larger, often more complicated contaminant plumes. See Table 2 for a comparison of assessment costs.

Table 2 - Cost per Assessment



2.1.3 Non-Aqueous Phase Liquid (NAPL): NAPL can be difficult to detect during normal assessment activities. Often NAPL is assumed to exist based on presumptive evidence of the presence of DNAPL. The states were asked what percentage of their sites had either direct or presumptive evidence of NAPL given any of the following criteria:

- Recovery of free-phase solvent;
- Groundwater – at least one sample with a contaminant concentration of 1% of the aqueous solubility of the parent compound (drycleaning solvent); or
- Soil – at least one sample with a parent compound (drycleaning solvent) concentration of >10,000 mg/kg.

Almost 41% of the sites in the responding states reported direct and/or presumptive evidence of NAPL. The percentage of sites within each state ranged from 3 to 100%. NAPL detection technologies include hydrophobic dyes, ultraviolet fluorescence, NAPL ribbon samplers, oil-water interface probes, and visual observation. Hydrophobic dye was the most common technology used to detect DNAPL.

2.1.4 Analytical Suites and Cleanup Standards: The specific analytical suites and cleanup standard used in each state varied greatly which is to be expected since the individual states place differing importance on risk to human health and the environment. In general EPA Methods 8260, 8270, and 8271; total petroleum hydrocarbons (TPH) diesel range organics (DRO, OA-2) and gasoline range organics (GRO, OA-1); and total extractable hydrocarbons (THE) were the most common analytical methods. The use of groundwater as a potable drinking water supply is an important deciding factor when considering risk to the public. Ten of the twenty-eight responding states have risk-based standards as an option when considering cleanup standards.

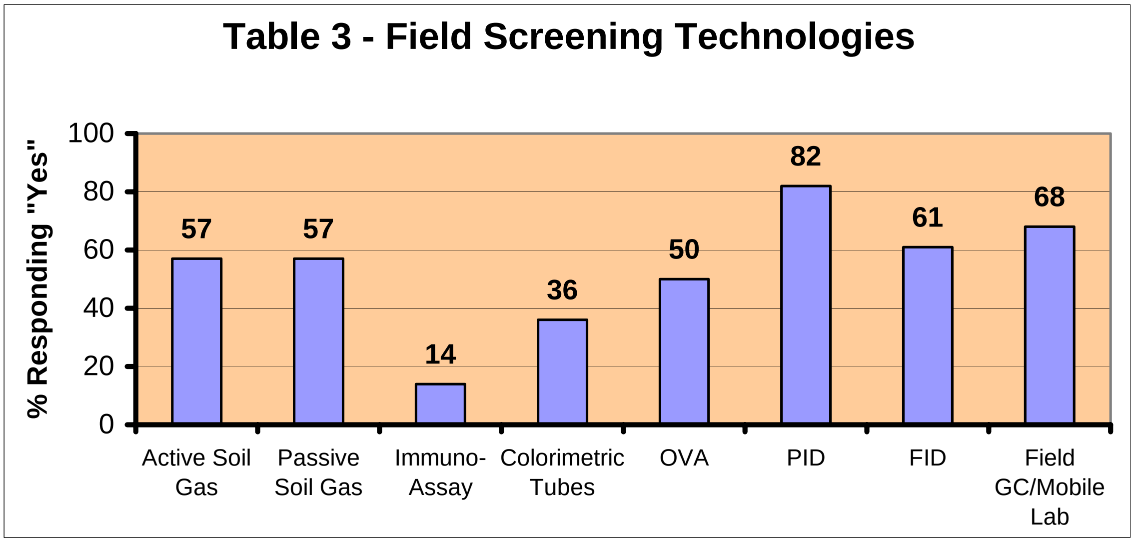
2.2 ASSESSMENT - SITE CHARACTERIZATION

States were asked what characterization technologies were commonly used when assessing drycleaning sites. Most regulatory agencies will agree that site characterization is extremely important for understanding how the contaminants were introduced into the subsurface and how they move through the vadose zone to the saturated zone. Many of the site characterization tools are expensive and difficult to use. Consultants must determine what information is most useful when attempting to manage costs during an assessment. Funding limitations are a common concern for the state-led trust funds and responsible party-led corrective action. The following information provides a snapshot of site characterization technologies in use up to and in 2002.

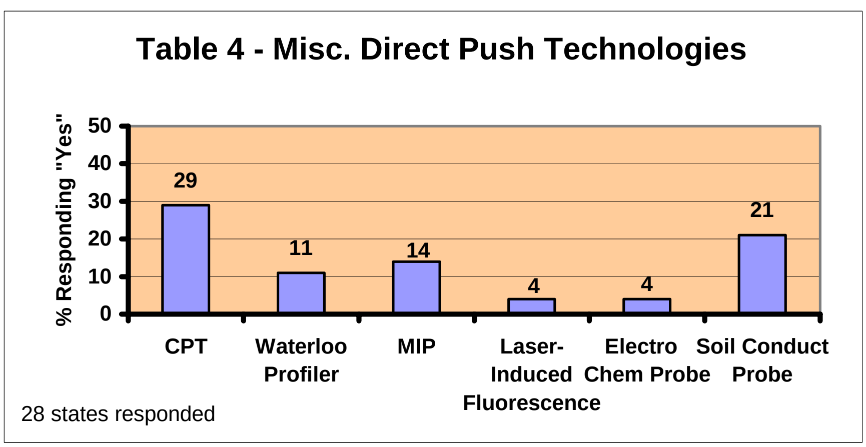
2.2.1 Geophysical Techniques: None of the geophysical techniques had widespread use across the country as less than 18% of the states indicated use of the geophysical technologies. Ground penetrating radar, magnetometer, gamma borehole geophysics, electrical resistivity surveys and electromagnetics are among the technologies sporadically used at sites in a few states.

2.2.2 Screening Technologies and Analytical Techniques: Most of the responding states used screening technologies to help identify the general contaminant location. Screening technologies such as soil gas surveys, immuno-assay kits, colorimetric tubes, and detectors (e.g. organic vapor analyzers (OVA), flame ionization detector (FID), and photoionization detector (PID)) help provide rapid delineation of a contaminant plume.

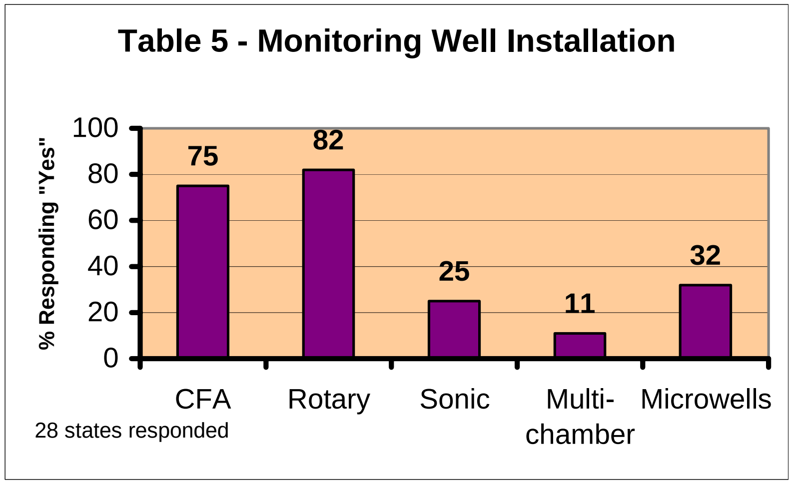
Most states also used field gas chromatographs (GC) to provide reliable analytical results in a short time frame. Chlorinated plumes in particular can extend several miles, therefore the ability to quickly screen groundwater samples can save time and money preventing multiple mobilizations. The use of direct push technology, where applicable has increased the efficiency of characterizations by allowing quick collection of samples from multiple groundwater depths and access to tight locations. Laboratory confirmation is still very important to ensure the field screening technology is accurate. Table 3 depicts the common field screening/analytical techniques used during site characterization.



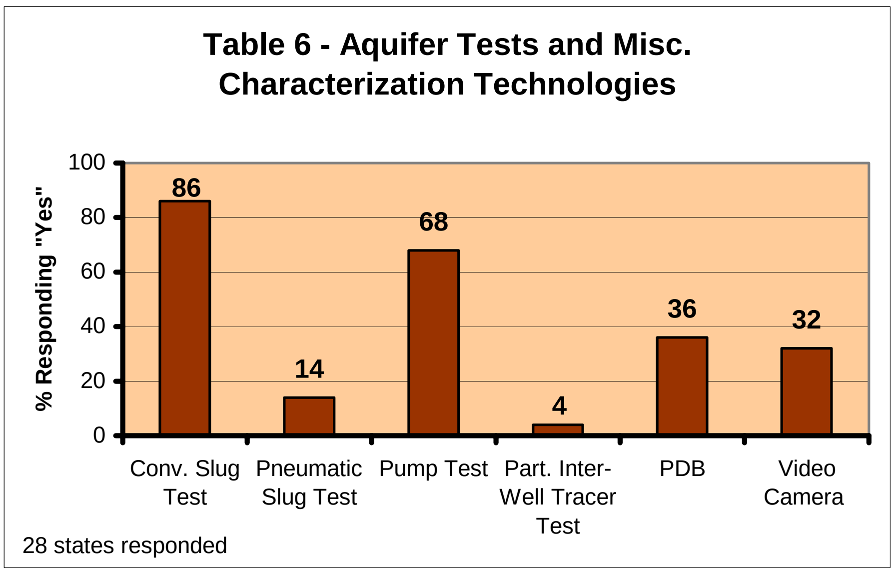
2.2.3 Direct Push/Cone Penetrometer: Direct push technology, such as Geoprobe®, has revolutionized the way environmental consultants assess contaminated sites with favorable geologic conditions. Approximately 93% of the responding states used direct push technology when characterizing drycleaning sites. Direct push rigs are often mounted on pickups, vans, or small track-driven vehicles. The smaller vehicles allow crews to sample underneath overhead utility lines, trees, and canopies, as well as within buildings. Direct push sample rods are smaller than drill rig tools therefore they can also get into tighter locations. Cone penetrometers are available for direct push rigs, but drill rigs are still more common when using standard cone penetrometer technology (CPT). Various technologies are available for use with direct push and drill rigs. These technologies include: CPT, Waterloo Profiler, Membrane Interface Probe (MIP), laser-induced fluorescence, electro chemical probe, and soil conductivity probes. Table 4 depicts the use of these technologies.



2.2.4 Drilling/Monitoring Well Installation: Collection of soil and groundwater samples using continuous flight augers, rotary, and sonic percussion drilling methods, among others is still necessary when geologic conditions prevent direct push probing or depth to groundwater exceeds the probe rigs capacity. Installation of monitoring wells is generally completed with drill rigs, although micro-wells are sometimes installed with probe rigs. Table 5 depicts the installation methods for standard monitoring wells and different monitoring well construction, such as multi-chambered tubing and microwells, which are wells smaller than 1-inch inside diameter.



2.2.5 Miscellaneous Testing & Characterization Technologies: Aquifer testing is a good tool used to understand the hydrogeology of a site. Collecting data during the assessment phase can save valuable time and resources when preparing for a remediation design. Conventional and pneumatic slug tests, pump tests, and partitioning inter-well tracer tests are some of the technologies used to collect the information needed to determine hydrologic parameters. Passive diffusion bag (PDB) samplers can be used to vertically delineate contamination in an aquifer. The PDBs are also valuable as a monitoring tool since purge water is not generated when the bags are deployed for long term monitoring. Video cameras have become a valuable tool for inspecting sewer lines, boreholes and problem monitoring or remediation wells. The cameras allow the user to view the inside of the lines or wells and find obstructions. The inspection may also find a break in a sewer line which can help pinpoint "hot spots" or spot preferential pathways in complex geology in a borehole or screened interval in a well. Table 6 details the use of the above-mentioned technologies.



2.3 ASSESSMENT – OBSTACLES & PROBLEMS vs. STRATEGY& APPROACH

The 2002 survey identified many obstacles to site assessment and the problems encountered at sites were virtually universal everywhere in the country. The common assessment obstacles included:

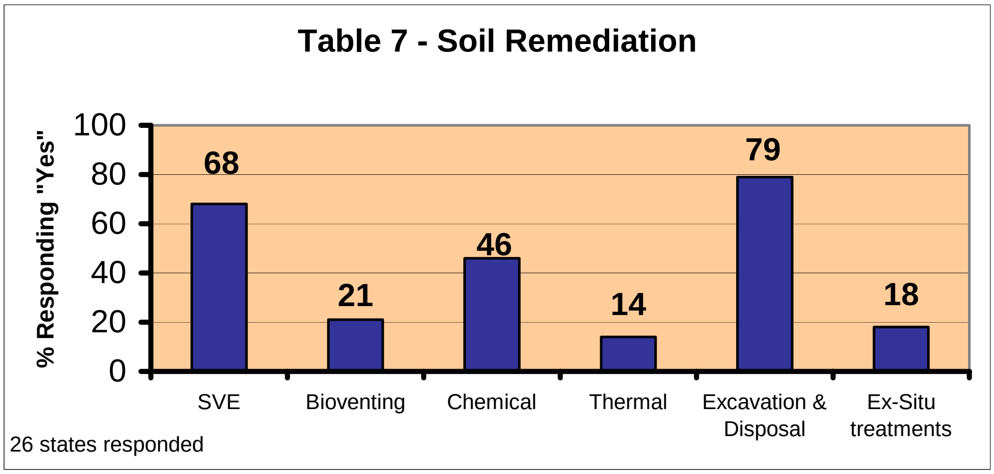
- Finding and interviewing personnel familiar with the business operations (especially at closed facilities);
- Communication problems with various ethnic backgrounds (e.g. language barrier);
- On- and off-site access from uncooperative tenants, landowners, or independent third parties (commercial areas);
- Physically accessing the source areas due to buildings, utilities, streets, etc.;
- Space limitations and access problems due to operating businesses;
- Off-site migration of contamination;
- Vertical delineation of chlorinated solvents;
- Bedrock contamination;
- Investigative derived waste (IDW) disposal – Is it hazardous waste?;
- Identifying DNAPL; and
- Cost, COst, COSt, COST!!!!! How to fund the corrective action.

Many of the strategies utilized by state agencies and/or the consultants to characterize sites were also similar. The use of direct push technology and on-site field screening tools provide a quick, cost-effective method for delineating drycleaning solvent plumes. Site reconnaissance visits and interviews with experienced personnel often help target the source area hot spots. Soil vapor surveys have also helped find additional hot spots not detected during soil sampling. Segregation of drill cuttings and excavated soil helps to reduce waste disposal costs. Some states have streamlined their waste handling procedures to make it easier to dispose of IDW, such as allowing re-injection of purge water or on-site treatment. Microwells and the use of passive diffusion bags helps cut down on purge water during long-term monitoring events. Overall states are basically looking to collect the necessary information to facilitate remediation in a cost effective manner.

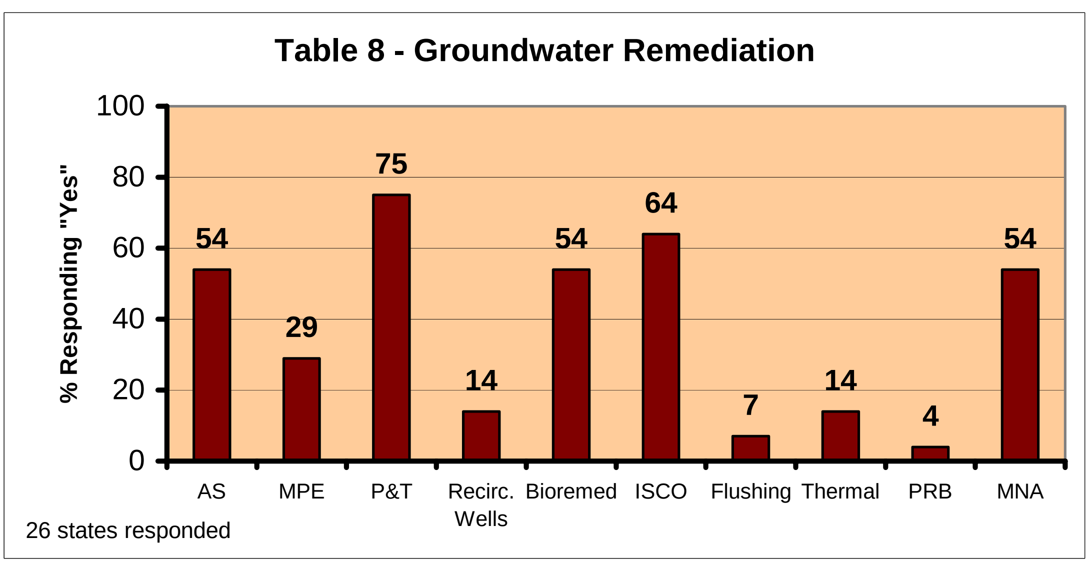
2.4 REMEDIATION – GENERAL

Twenty-six of the twenty-eight responding states have designed or provided regulatory oversight for remediation at sites contaminated with drycleaning solvents. The twenty-six states reported a total of 533 sites with remediation systems. Remediation systems at 187 of the sites (35%) still remained active as of late 2002. Several states noted that many drycleaning sites are provided regulatory oversight in other state programs so the statistics quoted above are probably not completely representative of the actual totals provided by the responding states.

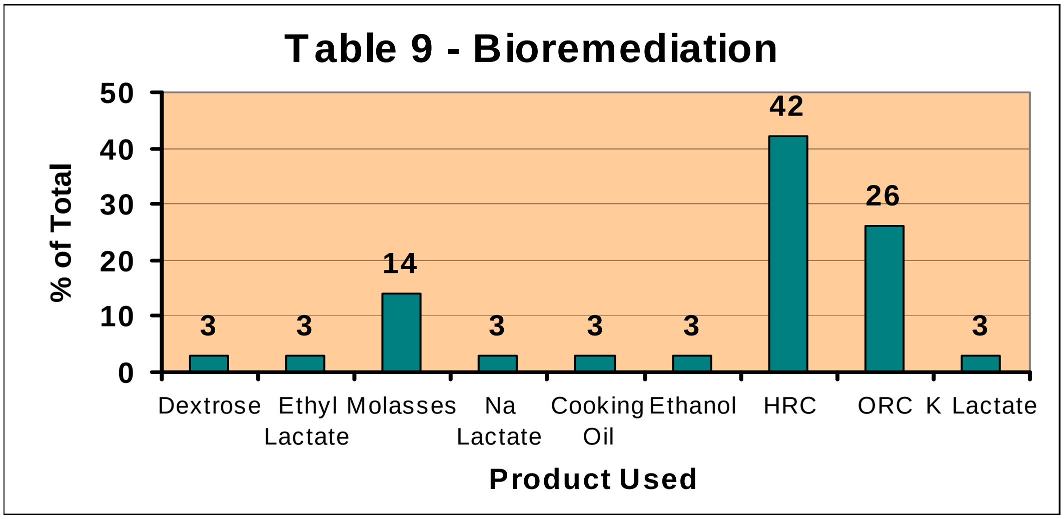
2.4.1 Soil Remediation: Soil remediation is vital to site cleanup because chlorinated drycleaning solvents have been detected at high concentrations in the vadose zone over 40 years following the closure of a drycleaning plant. Removal of the source area greatly enhances the efforts to cleanup groundwater contamination since the source is no longer contributing to the groundwater plume. Soil remediation is essentially split into two groups: *in-situ* vs. *ex-situ.* *In-situ* soil remediation includes soil vapor extraction (SVE), bioventing, and can include other biological, chemical and/or thermal treatment. *Ex-situ* soil remediation includes excavation of the material for direct off-site disposal or biological, chemical or thermal treatment with off-site disposal of the treated soil or returning the treated material to the original excavation. Table 7 depicts the use of the various technologies.



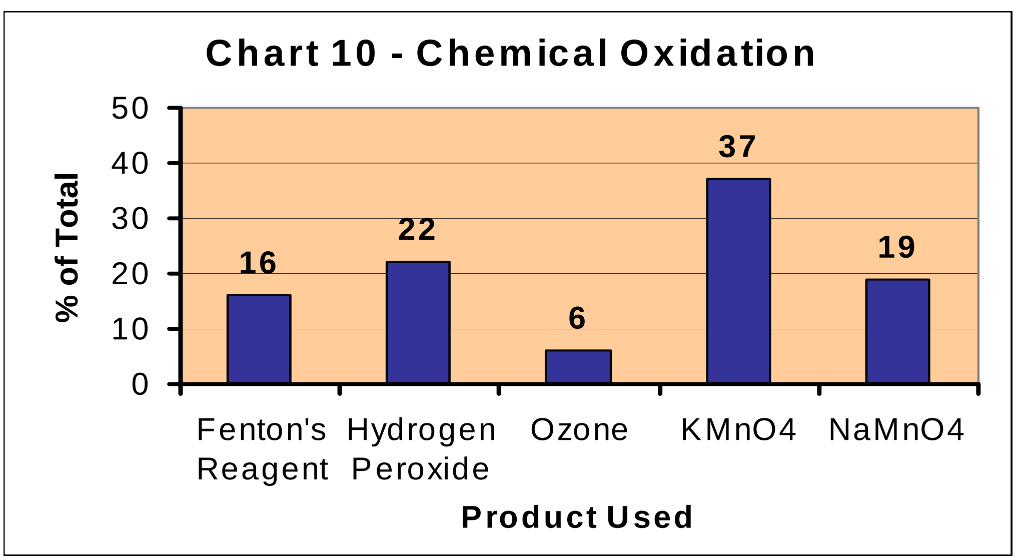
2.4.2 Groundwater Remediation: States indicated the majority of their groundwater remediation systems utilized *in-situ* technologies, such as air sparging (AS), recirculation wells, bioremediation, chemical oxidation (ISCO), flushing, thermal, permeable reactive barrier walls (PRB), and monitored natural attenuation (MNA). *Ex-situ* technologies included multi-phase extraction (MPE) and pump and treat (P&T) with treatment using an air stripper or granular activated carbon (GAC) system. For the purposes of the survey, mechanical methods typically use physical movement of the water by using pumps or injecting air into the subsurface. These systems rely on moving air through the contaminated media to strip the contaminants from the groundwater, either *in-situ* or *ex-situ*. Table 8 depicts the use of mechanical methods for groundwater cleanup.



2.4.3 Bioremediation: Bioremediation uses many different products to create an environment for optimizing growth of microorganisms. The survey respondents identified the following products that were used during bioremediation projects: dextrose, ethyl lactate, molasses, sodium lactate, cooking oil, ethanol, Hydrogen Release Compound® (HRC), Oxygen Release Compound® (ORC), and potassium lactate. Other products are available on the market for use in biostimulation and bioaugmentation projects so this list is not necessarily comprehensive. Table 9 compares products used in bioremediation projects.



2.4.4 Chemical Oxidation: Chemical oxidation typically involves the injection of chemicals into the contaminated groundwater to facilitate a reaction that converts the contaminant to harmless byproducts. The survey respondents identified the following products that were used during chemical oxidation projects: Fenton's Reagent, hydrogen peroxide, ozone, $KMnO_4$, and $NaMnO_4$. Other products are available on the market for use in chemical oxidation projects so this list is not necessarily comprehensive. Table 10 compares products used in chemical oxidation projects.



2.5 REMEDIATION – OBSTACLES & PROBLEMS vs. STRATEGY& APPROACH

Some of the obstacles faced by the states implementing remedial actions are similar to those encountered during assessment activities. Common remediation obstacles often encountered included:

- On- and off-site access from uncooperative tenants, landowners, or independent third parties (commercial areas);
- Physically accessing the source areas due to buildings, utilities, streets, etc.;
- Space limitations and access problems due to operating businesses;
- Off-site migration of contamination;
- Finding an effective technology for unfavorable geologic or hydrogeologic conditions;
- Permitting requirements (e.g. UIC, NPDES, etc.);
- Remediation waste disposal – Is it hazardous waste?;
- Noise from system operation; and
- Cost, COst, COSt, COST!!!!! How to fund the corrective action.

Fostering good relationships with city governments is important when trying to obtain access to city right-of-ways and gaining approval for remediation system installation. Aesthetics and noise pollution are concerns that can be overcome with innovative designs. Some states have reduced the risk to human health by extending water mains and connecting residents with private domestic wells to the city water systems. Most states and consultants familiar with remediation of drycleaning sites are well aware they must approach the corrective action in a phased approach. Many sites will utilize one technology for the source area, another for the plume containment, and sometimes additional technologies for finishing off the corrective action. Approximately 25% of the responding states have issued No Further Action (NFA) letters to drycleaning site, many due to risk-based standards.

2.6 2002 SURVEY CONCLUSIONS

Assessment and remediation technology is changing as consultants come up with innovative ideas to overcome the obstacles stated above. Geologic and hydrogeologic conditions generally dictate how a site is approached. Field screening techniques, waste minimization procedures and rapid assessment are important for conducting cost effective site characterization. States continue to search for new ways to complete effective, cost-efficient corrective action. Section 3 of this paper compares the 2002 survey results to a similar survey conducted by SCRD in 1999.

3.0 TECHNOLOGY TRENDS FROM 1999 TO 2002

Site Characterization: Site characterization technologies have remained fairly consistent over the past few years with the exception that field screening has incorporated tools such as colorimetric tubes for rapid screening. The use of field GC/mobile labs continue to be a desirable method for field screening. Fixed laboratories are still used to verify the field GC sample results.

Remediation: Remediation has shown a bigger change with regards to selected technologies. The standard technologies such as air sparging, pump & treat, multi-phase extraction, and monitored natural attenuation are still viable technologies, but bioremediation and *in-situ* chemical oxidation are becoming important tools for site cleanup. New products continue to be introduced that enhance bioremediation and chemical oxidation efforts. States and consultants are finding out that proper characterization is vital to understanding the subsurface geologic, hydrogeologic, and microbial conditions. Bench scale and pilot testing are used to help determine the concentration and volume of product that needs to be introduced to the contaminated areas. Delivery of the products into the subsurface is one area that needs additional research. Promoting thorough mixing in the subsurface is important for getting the bioaugmentation, biostimulation, and/or chemical oxidation products in contact with the contaminants or promoting microbial activity. Often injection is not adequate by itself, therefore recirculation wells/galleries and air sparging are being used to enhance the mixing zone.

4.0 CONCLUSIONS

Innovative technologies continue to evolve as more research is conducted in the lab and at contaminated sites. The search for a cost efficient and technically effective remediation technology will also continue since site-specific conditions vary greatly at these drycleaning sites. Technologies that work at one site may easily be a great failure at the next site. Bioremediation and chemical oxidation are being used more often at sites as consultants begin to understand what drives the processes to be a successful endeavor. However, the old boys on the block; pump & treat, air sparging, soil vapor extraction, and excavation; will probably always have a place at remediation sites due to the their time-tested reliability in certain situations. States and consultants will likely need to continue and mix the old with the new in their remediation designs. The comparison of the 1999 and 2002 survey was not a direct comparison of the responding states since five of the states responding in 1999 did not submit a completed survey in 2002. In addition, several states with a large number of drycleaners did not submit completed surveys; therefore the conclusions drawn from the survey comparisons are limited to the states noted below.

Please visit the SCRD web site at www.drycleancoalition.org for additional resources regarding drycleaning assessment and remediation. The Site Profiles section of the website includes assessment and remediation data for over seventy-five drycleaning sites, including costs and lessons learned.

5.0 ACKNOWLEDGEMENTS

Special thanks to the states that completed the 2002 survey for this SCRD project. These states include Alabama, Colorado, Delaware, Florida, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Minnesota, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, South Carolina, Tennessee, Vermont, Virginia, Wisconsin, and Wyoming. Additional thanks to the EPA Technology Innovation Office (TIO) for their continued support of SCRD and to staff at the North Carolina Drycleaning Solvent Cleanup Act Program for their assistance with data interpretation.