CONDUCTING CONTAMINATION ASSESSMENT WORK AT DRYCLEANING SITES

By William Linn[1], Lisa Appel[2], George Davis[7], Richard DeZeeuw[3], Craig Dukes[2], Pat Eriksen[9], Jennifer Farrell[1], Douglas Fitton[1], James Gilbert[4], Jennifer Haas[6], Leo Henning[8], Robert Jurgens[8], Barbara Pyles[4] Robin Schmidt[5], Juho So[9], Amanda Spencer[3], Dale Trippler[6], Pamela Wilson[7]

1. Florida Department of Environmental Protection
2. South Carolina Department of Environmental Control
3. Oregon Department of Environmental Quality
4. Tennessee Department of Environmental Conservation
5. Wisconsin Department of Natural Resources
6. Minnesota Pollution Control Agency
7. Alabama Department of Environmental Management
8. Kansas Department of Health and Environment
9. Drycleaner Environmental Response Trust Fund of Illinois

Background

There are approximately 36,000 active drycleaning facilities in the United States. This number includes commercial, industrial and coin-operated facilities (EPA, 1998). Soil and groundwater contaminated by drycleaning solvent are associated with most of these facilities. One recent study estimates that 75% of these facilities are contaminated (Schmidt, 2001). In addition to the active drycleaning facilities, there are an unknown number of former drycleaning sites that are also contaminated. Since drycleaning facilities are located in urban areas, drycleaning solvent contamination has impacted a large number of public water supply wells and threatens many other wellfields. To address this problem, 11 states have developed drycleaning solvent cleanup programs.

This paper was written by members of the State Coalition for Remediation of Drycleaners, an organization of 11 states (Alabama, Florida, Illinois, Kansas, Minnesota, Missouri, North Carolina, Oregon, South Carolina, Tennessee, and Wisconsin) that have developed drycleaning solvent cleanup programs. The paper is intended to aid those engaged in conducting site characterization work at drycleaning facilities.

In order to effectively conduct site characterization work at drycleaning facilities, it is necessary to have a basic understanding of drycleaning operations, including chemicals and equipment utilized, types of wastes generated and historical waste management practices.

Chemicals Used In Drycleaning Operations

Drycleaning Solvents

Drycleaning is the washing of fabrics in non-aqueous solvents. Spirits of turpentine is the first referenced drycleaning solvent – in 1690, but the first regular use of a non-aqueous solvent in garment cleaning was in 1716, when spirits of turpentine were used to remove grease and oil stains (Schwartz, 1997). The drycleaning industry was established in

Europe in the first half of the nineteenth century. The most widely used solvents in early drycleaning operations were petroleum based and included petroleum naphtha, benzene, kerosene, and white gasoline. White gasoline was the predominant drycleaning solvent in the United States from the late nineteenth century until the early 1920s (North Carolina DENR, 2001). Due to the high volatility of these petroleum solvents, fires and explosions were major hazards associated with drycleaning operations. In 1924, an Atlanta drycleaner named W. J. Stoddard worked with Lloyd E. Jackson of the Mellon Research Institute to develop specifications for a less volatile petroleum drycleaning solvent (flash point > 100° F.) that became known as Stoddard solvent (Martin, 1958). Drycleaners began using Stoddard solvent in 1928 and it was the predominant drycleaning solvent in the United States from the late 1920s until the late 1950s.

Petroleum Drycleaning Solvents

Stoddard solvent is a mixture of petroleum distillate fractions (petroleum naphtha), which is composed of over 200 different compounds. These solvents are composed predominantly of alkanes and cycloalkanes, with some aromatic compounds. Many people incorrectly refer to any petroleum drycleaning solvent as Stoddard solvent. More properly, Stoddard solvent is a mixture of C_5 – C_{12} petroleum hydrocarbons containing 30 – 50% straight and branched-chained alkanes, 30 – 40% cycloalkanes and 10 – 20% alkyl aromatic compounds (Sciences International, 1995). The high aromatic-content petroleum solvents are no longer widely used in drycleaning (Schreiner, 2001).

Since the introduction of Stoddard solvent, the industry trend has been towards the development of higher flash point petroleum drycleaning solvents including 140 flash solvents (flash point approximately 140^{o} F.), which have very low aromatics content (generally less than 4%) and most recently, the introduction of the so-called synthetic petroleum drycleaning solvents such as DF-2000 (flash point 147^{o} F) which reportedly contain no aromatics.

One of the problems associated with petroleum drycleaning solvents is biodegradation. Bacteria introduced into the drycleaning system, through the clothing or in water introduced into the system, will feed on the petroleum solvent and degrade the petroleum compounds producing a "sour" odor. Once the solvent has degraded, it must be discarded. To combat this problem, bactericides or biocides are added to the system, normally in detergents. The biocides used today are reportedly similar to those used in shampoos, laundry products and cosmetics. In the past, perchloroethylene (PCE) was added to drycleaning soaps as a bacterial inhibitor (Albergo, 1997).

Chlorinated Solvents

The first chlorinated solvent utilized in drycleaning operations was carbon tetrachloride, which was used as a drycleaning solvent in the United States from the 1920s until the early 1950s (Clothes Care Gazette, 2000). Carbon tetrachloride was commonly blended with other solvents. Because of its high toxicity and tendency to corrode equipment, carbon tetrachloride is no longer used as a drycleaning solvent. In 1930, trichloroethylene (TCE) was introduced as a drycleaning solvent in the United States (Martin, 1958). TCE causes bleeding of some acetate dyes and therefore, it is no longer used as a primary drycleaning solvent.

In 1934, perchloroethylene was introduced as a drycleaning solvent in the United States (Martin, 1958). The superior cleaning ability of PCE, coupled with petroleum shortages during World War II and municipal fire codes prohibiting the use of petroleum solvents resulted in increased use of PCE. In 1948, PCE surpassed carbon tetrachloride use in drycleaning operations (Morrison, 2000). By the early 1960s, PCE had become the predominant drycleaning solvent in the United States. It is estimated that over 80% of the commercial drycleaners in the United States use PCE today (HSIA, 1999).

Drycleaning-grade PCE is produced in the United States by Dow Chemical (trade name DowPer), Vulcan Chemicals (trade name PerSec), and PPG Industries, Inc. Drycleaning-grade PCE is also produced by Ineos Chlor Americas, trade name Perklone, and exported to the United States. Perchloroethylene manufacturers claim that drycleaning-grade PCE is 99.9% pure. The impurities are other chlorinated compounds. Perchloroethylene is a very stable solvent and is not normally corrosive. However, in the presence of heat and moisture, hydrochloric acid can be formed from PCE and cause corrosion problems. The presence of other chlorinated compounds, such as 1,1,1-trichloroethane (TCA), which has been widely used in spotting agents, can also contribute to acid formation in PCE. To combat this problem, stabilizers (acid acceptors) are added to PCE in small quantities (0.05 to 0.2% by volume). Some of the common stabilizers added to drycleaning-grade PCE are n-methylmorpholine, diallylamine, tripropylene, cyclohexene oxide, benzotriazole, and betaethoxypropylnitrile.

Some drycleaners purchase and use reclaimed PCE. This reclaimed solvent has a reported purity of 95 – 99% (Hoover, 1995). Typical impurities in reclaimed PCE are methyl ethyl ketone, mineral spirits, toluene, 1,1,1-trichloroethane and other chlorinated solvents. A color inhibitor, butylated hydroxytoluene or BHT is added to some reclaimed PCE (Moyer, 1995). Since reclaimed PCE typically does not contain stabilizers, it is often blended by the drycleaner with commercial (stabilized) PCE.

In the late 1960s, DuPont began marketing a chlorofluorocarbon (Freon 113 or 1,1,2-trichloro 1,2,2-trifluoroethane) as a drycleaning solvent. It became known in the drycleaning industry as Valclene. Freon 113 is one of the chlorofluorocarbons subject to the Montreal Protocols and is no longer being manufactured. It was never widely used in drycleaning operations and has been phased out in the United States.

Dow Chemical began marketing 1,1,1-trichloroethane (TCA) as a drycleaning solvent in the early 1980s. It was used as a primary drycleaning solvent (particularly in leather cleaning) by a small number of drycleaning operations - approximately 50 plants in the United States (Hickman, 1995). TCA is a rather unstable solvent and there were problems with machine and equipment corrosion associated with its use. It is no longer being used as a drycleaning solvent.

Other Drycleaning Solvents

Several new drycleaning solvents were developed beginning in the mid-1990s. These solvents include RYNEX (dipropylene glycol tertiary-butyl ether), liquid carbon dioxide, GreenEarth^{TM} (a silicon-based solvent - decamethylcyclopentasiloxane), and PureDry (a mixture of petroleum hydrocarbons, hydrofluoroethanes and perfluorocarbons).

Spotting/Precleaning Chemicals

Prior to being drycleaned, heavily stained garments are usually pre-cleaned or "pre-spotted" using a wide variety of chemicals. Spot cleaning is also performed after the clothes are drycleaned and stains still remain on the clothing. The types of chemicals used in spotting operations depend on the type of stain and the type of fabric being cleaned. Three types of pre-cleaning/spotting agents are used: "wet-side" agents, "dry-side" agents and bleaches.

Wet-side Spotting Agents

Wet-side spotting agents are used to clean water-soluble stains from clothing. Wet-side agents can be divided into three classes:

- neutral agents – which include water and neutral synthetic detergents (surfactants)
- alkaline agents – which include lye, ammonia, potassium hydroxide, sodium hydroxide; and
- so-called protein formula home detergents containing digester enzymes, and acid agents – which include acetic acid, hydrofluoric acid, gylcolic acid and sulfuric acid.

Dry-side Spotting Agents

Dry-side spotting agents are used to remove oily-type stains, fats, waxes, grease, cosmetics, paints and plastics. The primary constituents of dry-side agents are nonaqueous solvents and alcohols and include, or have included: PCE, TCE, TCA, carbon tetrachloride, methylene chloride, amyl acetate and petroleum solvents. In general, from a contamination and regulatory standpoint, dry-side spotting agents include some of the most toxic chemicals used in drycleaning operations.

Bleaches

Bleaches are used in stain removal when other spotting techniques have failed to remove a stain. This process is known as “spot bleaching”. Bleaches are also used in conventional laundry operations, which are conducted at most drycleaning plants. Bleaches can be classified as either oxidizing or reducing.

Oxidizing Bleaches	Reducing Bleaches
sodium perborate	sodium bisulfite
hydrogen peroxide	sodium hydrosulfite
sodium percarbonate	titanium sulfate
sodium hypochlorite	oxalic acid

Detergents

The earliest drycleaning detergents were soaps – paste soaps, gel soaps and liquid soaps. Most of these soaps were composed of surfactants, Stoddard solvent, free fatty acids and some moisture to create an emulsion. When filtration was first utilized in the drycleaning process, it was discovered that paste and gel soaps, also known, as “true soaps” tended to plug or “slime” filters, so the use of the true soaps was discontinued. The liquid soaps, which became known as “filter soaps”, sometimes contained a co-solvent such as: butyl cellosolve, hexylene glycol, isopropanol, cyclohexanol, ethanolamine or n-butanol, which was used to disperse moisture. By the early 1950s, the industry trend was from liquid soaps to the use of synthetic detergents (Martin, 1958).

Synthetic detergents are surfactants or mixtures of surfactants with solvents. The following surfactants have been used in commercial drycleaning detergents: soap-fatty acid mixtures; “mahogany” or petroleum sulfonates; sodium sulfosuccinates; sodium alkylarenesulfonates; amine alkylarenesulfonates; fatty acid esters of sorbitan; ethoxylated alkanolamides; ethoxylated phenols; and ethoxylated phosphate esters (Kirk-Othmer, 1965).

Detergents are introduced into the drycleaning machine by two different systems. In a *charged system*, detergent is added to the solvent or “charged” as a certain percentage of the solvent - normally 1 to 2% to maintain a continuous concentration of detergent. Pre-charged solvents (drycleaning solvent containing detergents) have been marketed in the industry – particularly for use in coin-operated drycleaning machines. Most detergents are premixed with solvents. Petroleum naphtha is the most common detergent carrying agent. In *injection systems*, also known as batched detergent injection, solvent is added to the wheel saturating the garments and then detergent is injected into the flow line or into the drum.

Sizing

Sizing is a finish used to impart body to a fabric. It is applied to fabrics when they are manufactured and is depleted after several fabric cleanings. Sizing used in drycleaning operations today is composed of hydrocarbon resins (polymers or polymer blends). Two forms of sizing are used in drycleaning operations: a solid form of sizing, the bead form, is commonly used in PCE drycleaning systems and a liquid form. Most of the liquid sizing used today has a petroleum naphtha carrier. It is not uncommon for liquid sizing to contain over 50% petroleum solvent by volume. Anti-static agents and optical brighteners are commonly added to sizing.

Sizing can be applied to garments in three different ways: by a continuous bath in the drycleaning machine, by dipping garments in a tank of sizing, or by spraying sizing in an aerosol form (generally containing a propane/isobutane carrier). In the continuous bath application method, a 0.5 to 1.5% charge of sizing is added to the drycleaning machine. The concentration of sizing used in the dipping method ranges from 1 to 4% (Eisenhaur).

Other Chemicals

Waterproofing of garments by the clothing manufacturer is a relatively recent development. Historically, much of garment waterproofing was performed by drycleaners. The waterproofing agent was usually a wax-base product and the predominant carrying agent utilized was PCE and petroleum solvent. Several methods have been used to apply the waterproofing agent, including immersion in the waterproofing agent in a dip tank; spraying the waterproofing agent on the garments in a tank; applying the waterproofing agent in the form of an aerosol spray and, in some cases, applying the waterproofing agent in an auxiliary tank in a drycleaning machine (Rising, 1997).

Flame retardants are normally applied to garments by the garment manufacturers. However, in the past, some drycleaners have treated or re-treated garments with flame retardant. Some of the chemicals used in flame retardants include: decabromodiphenyl oxide (DBDPO), organo-phosphates, phosphate salts and phosphated esters. Dry-side application of flame retardants used drycleaning solvent as the carrying agent. The flame retardant chemicals were applied by immersion or dipping in a tank or by spraying the garment with the flame retardant (IFI, 1995).

Stain retardants are also generally applied by the garment manufacturer, but some drycleaners apply stain repellents to clothing. Historically, these products have been silicon based and the carrying agent has been 1,1,1-trichloroethane or petroleum naphtha (IFI 1994).

Drycleaning Equipment and Drycleaning Operations

Drycleaning Machines

In early drycleaning operations, solvent was applied to the garment with a brush on a table. The garments were then rinsed in tubs filled with solvents and were hung to dry in a warm room. In the late nineteenth century washing machines were utilized in drycleaning but dryers or “tumblers” were not utilized until the 1920s. This marked the introduction of transfer machines or “first-generation machines” which were actually two or three machines including a washer (where the garments were washed), an extractor (where the solvent was extracted from the garments by centrifugal force), and a tumbler (where the garments were dried). Later transfer machines incorporated the extractor into the washing machine. In a transfer machine operation, the clothing is physically “transferred” from the washer to the tumbler. This clothing transfer results in solvent vapors escaping to the atmosphere. Some transfer operations capture some of the solvent vapors using inductive fans and a carbon adsorption unit known as a "sniffer".

In the late 1960s "dry-to-dry" machines were developed in Germany. Washing, extraction and drying of garments occur in the same machine. The garments go into the machine dry and come out dry, hence the name "dry-to-dry". The earliest dry-to-dry machines are also known as "second-generation machines". A number of improvements have been incorporated into dry-to-dry machines over the years to improve solvent mileage - the pounds of clothing cleaned per gallon of solvent. These improvements include the incorporation of inductive fans, refrigerated condensers and carbon adsorption units designed to recover solvent vapors and minimize solvent emission losses. It is estimated that PCE transfer machines used approximately 82 pounds of solvent to clean 1,000 pounds of clothing compared to 34 pounds of PCE used by second-generation machines. The latest PCE drycleaning machines, known as "fifth-generation machines" use approximately 10 pounds of PCE to clean 1,000 pounds of clothing (National Clothesline, 2002).

The Clean Air Act Amendments of 1990 identified PCE as a hazardous air pollutant. On December 9, 1991, the U.S. Environmental Protection Agency (EPA) proposed the National Emission Standards for Hazardous Air Pollutants (NESHAP). One consequence of these standards was the regulation of PCE emissions from drycleaning plants. On September 15, 1993, the EPA Air Office published the final air standard for perchloroethylene drycleaners (University of Tennessee, 1995). These air regulations require record keeping, inspections and reporting as well as mandates for retrofitting or replacing certain types of drycleaning equipment based on PCE use. In short, these air regulations have had a greater impact than any previous regulations with regards to changes in drycleaning equipment, practices and solvent usage. Transfer machines are no longer being manufactured. New PCE drycleaning machines have refrigerated condensers, carbon adsorption units, inductive fans and lockout devices, which prevent operators from performing certain operations until PCE concentrations in the air in the machine drum are below certain levels. Drycleaning operations in the United States have changed dramatically in the last ten years.

Coin-operated drycleaning machines were introduced in 1960 by Whirlpool (Kirk-Othmer, 1965). These are small (clothing capacity 8 – 12 pounds) dry-to-dry machines that use PCE or Freon 113. Spent solvent is purified by filtration. Although the early models had powder filtration systems, the later models used cartridge filters. These machines do not have distillation units and therefore do not produce separator water. Most of these machines were manufactured in Europe (Renzacci/Suprema) and they are no longer being manufactured. However, they are still being used in the United States, primarily in laundromats.

Filtration

Filtration is one of the processes used to purify spent solvent in drycleaning operations. A wide variety of filter types have been used in drycleaning operations, including powder filtration, cartridge filters and spin disc filters.

Early filter systems used powder filtrate materials, typically a combination of diatomite (a siliceous powder composed of the remains of microscopic, single-cell aquatic plants) and granular activated carbon. The spent solvent was filtered through these powders, which were held by a screen or tube.

Cartridge filters generally consist of an outer perforated metallic shell enclosing a pleated paper filter element that encloses a perforated canister filled with activated carbon or clay. Polishing filters utilize resin-bonded fibers or a spiral cotton element as the filter medium.

A spin disk filter is a device containing a series of disks covered with polyester mesh (to filter impurities) mounted on a hollow central shaft with a motor drive to spin the shaft. Solvent enters the central housing through the hollow central shaft. Some spin disk filters utilize filtrate powder.

Distillation

Another process used to purify spent solvent is distillation. This process vaporizes the spent solvent in the distillation unit or “still” by heating with steam. The solvent vapors are routed to a condenser leaving nonvolatile residues and impurities behind in the distillation unit. The solvent vapors are cooled in the condenser. The liquid resulting from condensation is a mixture of solvent and water. The solvent is recovered by gravity separation in a water separator. Distillation units used in conjunction with drycleaning machines that use powder filtration systems are called “muck cookers”.

The distillation unit is incorporated into modern drycleaning machines. In some older operations it is a separate piece of equipment.

Spotting Boards

Pre-cleaning or pre-spotting of stained clothing is generally performed on what is known as a spotting board. The spotting board is supplied with live steam, compressed air and a vacuum line and controlled by pedals mounted at the base of the spotting board. Wet or dry steam, or warm air can be applied to clothing using a steam/air gun. Steam, steam condensate, water and spotting wastes are disposed through a vacuum line. A metal drain receptacle, that receives spotting wastes is generally mounted at the base of the spotting board. Spotting agents are either contained in bowls, known as “soap cups” mounted on the spotting board or in containers that are often placed on the spotting board. Spotting agents, steam and compressed air are used to clean stained garments on the spotting board.

Steam Presses/Vacuum Units

After garments are drycleaned they are usually pressed utilizing steam presses. The steam presses are served by steam lines which transport live steam from the boiler, and by vacuum lines, which serve to create a partial vacuum at the base of the steam press to hold garments in place for pressing. Steam and steam condensate from the pressing operation is evacuated from the steam press through the vacuum lines that are routed to the vacuum unit - a tank with a vacuum pump mounted on top. The steam condensate also known as vacuum water or press return water is collected in the vacuum unit tank and any live steam is vented to the atmosphere, through a pipe that exits the wall of the facility.

Wastes Generated in Drycleaning Operations

A variety of wastes are generated during the drycleaning process. In chlorinated solvent drycleaning operations, most of these wastes are hazardous. Discharges of these wastes have caused soil and groundwater contamination at drycleaning sites. Prior to November 21, 1980, when the Resource Conservation Recovery Act (RCRA) was promulgated, wastes generated at drycleaning operations were virtually unregulated. Firms that collect hazardous wastes from drycleaners generally did not offer these services prior to the mid-1980s.

Contact Water

Contact water is any water that has come into contact with drycleaning solvents or drycleaning solvent vapors. Contact water contains some level of dissolved solvent. Several types of contact water are associated with drycleaning operations: separator water, vacuum water, mop water and process water.

<u>Separator water</u> is generated during the distillation and solvent recovery processes. As discussed earlier, vapors from the distillation process are condensed into a liquid, a mixture of solvent and water. The solvent is separated from the water by gravity separation in a water separator. The recovered separator water is generally routed to a five-gallon plastic bucket located behind the drycleaning machine. The separator water is saturated with solvent. At room temperature, approximately 150 milligrams per liter PCE will be dissolved in the separator water. In PCE drycleaning operations, some free-phase PCE is generally found in the bottom of the separator water bucket. Separator water is also recovered from steam stripping carbon adsorption units, known as “sniffers” which are used to capture solvent vapors.

<u>Vacuum Water</u> This is also known as press return water. Drycleaned clothing retains some residual drycleaning solvent. When the drycleaned clothes are steam pressed, some of the drycleaning solvent retained in the clothing will be dissolved into the steam and steam condensate. The contaminated steam and condensate from this operation is collected in a vacuum unit. Vacuum water samples collected from PCE drycleaning operations generally contain PCE in concentrations in the tens of parts per billion range, but some samples have had PCE concentrations exceeding 100 parts per billion.

<u>Process Water</u> Some drycleaners have steam-cleaned drycleaning machines. The steam condensate generated by these operations is contact water.

<u>Mop Water</u> This is a commonly overlooked source of contact water at drycleaning facilities. Mop water can collect solvent from vapors, lint and still bottoms at a drycleaning facility. It is not uncommon, during the operation of some drycleaning machines, to splash still bottoms or cooked powder residues when cleaning out the

distillation unit or muck cooker. When these distillation residues are mopped up they will saturate the mop water with solvent.

Boiler Blowdown Water In order to prevent scale buildup, water/steam is normally purged daily from boilers through a process known as blowdown. Normally, boiler blowdown water is not contact water. However, some drycleaners have disposed of separator water to the boiler. Drycleaning solvent can also be introduced into the boiler from the distillation unit by backflow of still bottoms into the boiler during steam sweeping operations.

Conventional Laundry Water If clothing is pre-cleaned or spot-cleaned with solvents prior to conventional laundering, the washwater will be contact water.

Still Bottoms/Muck/Cooked Powder Residues

The waste product generated from the distillation process is known as either still bottoms or cooked powder residues (from powder filtration systems). Still bottoms contain grease, oil, detergent, dyes, sizing, waxes, filter materials and other non-volatile residues. Distillation residues can contain up to 75% solvent by weight (Beak Consultants, 1990). Not all drycleaners perform distillation. This is particularly true of many petroleum solvent drycleaning operations, which purify solvent by filtration alone. If these operations use a powder filtration system the filter waste generated, known as "muck", can contain considerable solvent.

Spent Filters

Spent jumbo cartridge filters can contain up to one gallon of solvent. Some of this solvent can be recovered if the filters are allowed to drain before they are changed. Additional solvent can be recovered from the spent cartridge filters in a steam cabinet.

Spent Solvent

At drycleaning facilities that waterproofed garments, PCE was used as the carrier for the waterproofing agent. The waterproofing agent was applied in a dip tank. Oils, fats and other non-volatile residues from the garments would accumulate in the dip tank and periodically the spent waterproofing agent, containing solvent (generally up to 30 gallons or more), would have to be discarded (Albergo, 1997). Also, petroleum drycleaning solvent that has biodegraded and acquired a sour odor has to be discarded.

Solvent Vapors

A considerable amount of solvent is lost to the atmosphere as vapors in PCE transfer machine operations and even from first generation (vented) dry-to-dry machines. Based on emission factors (pounds of PCE per 100 pounds of clothing cleaned) the Center for Emissions Control estimates that approximately 53% of PCE losses for transfer machine operations were through the machine vents and in clothing transfer. This figure is estimated to be approximately 25% for vented dry-to-dry machines (University of Tennessee, 1995).

Spotting Residues

These wastes are generated during the pre-cleaning or spotting process and can contain a variety of solvents, bleaches, detergents, etc. as discussed earlier. Spotting wastes are generally collected by a vacuum line at the spotting board and routed to the vacuum unit and a drain receptacle mounted at the base of the spotting board.

Lint

Lint accumulates in the button trap, pump strainer, bag filters and on the fins surrounding the condensing and heating coils of the drycleaning machine. Lint generated from drycleaning operations contains drycleaning solvent. The lint collected from the button trap and pump strainer is saturated with solvent.

Historic Operational and Waste Management Practices

Solvent Delivery/Storage/Transfer

Although much of the drycleaning solvent being used today is delivered via closed-loop systems, historically drycleaning solvent has been delivered in drums and by tank trucks. Some drycleaning wholesale supply facilities receive solvent deliveries via railroad tank cars. Numerous instances of solvent discharges, associated with these deliveries, have been documented including:

- Discharge of solvent during transfer from railroad tank car (wholesale supply facility)
- Discharge of solvent when delivery hose uncoupled from tank truck
- Overfilling of solvent storage tanks
- Discharge of solvent to facility floor or ground when delivery hose is reeled in
- Discharge of solvent from drums dropped during delivery
- Discharge of solvent when withdrawing solvent from an AST or transferring solvent to a drycleaning machine
- Discharge of solvent while filling drycleaning machine and from overfilling machine

Due primarily to the industry conversion to more efficient drycleaning machines, PCE use by drycleaners in the United States has dramatically declined. A recent survey conducted by the Textile Care Allied Trade Association found that PCE use by drycleaners in the United States in 2001 was 52 million pounds compared to 260 million pounds used in 1985. PCE use has been reduced by 72% by drycleaners in the last ten years (National Clothesline, 2002). Since today's fourth and fifth generation drycleaning machines are more efficient, they use much less solvent and therefore, much less solvent is stored at drycleaning facilities. Most facilities store drycleaning solvent in the tanks located at the base of the drycleaning machine. In the past, additional solvent was often stored in tanks, primarily aboveground storage tanks (ASTs) for PCE and both aboveground and underground storage tanks (USTs) for petroleum solvents. There have been solvent discharges associated with these storage tanks from leaks (valves, flowlines and tanks) and from spills (during both tank filling and solvent withdrawal).

A study of reported solvent leaks, spills and discharges at 334 drycleaning facilities and 14 drycleaning wholesale supply facilities located in Florida found that the largest average solvent spill volumes were associated with solvent transfer and storage (Linn, 2002).

Drycleaning Equipment Operation/Equipment Failure

Approximately 20.9% of the solvent and solvent-contaminated waste discharges reported in the Florida solvent leaks, spills and discharges study were due to equipment operation problems including still boilovers, clothing caught in the machine door, loose cartridge filter housings, overflow of water separator, and open valves. The largest number of reported spills/discharges (39.2% of reported discharges) were associated with equipment failure, including leaking gaskets, seals, valves, ruptured hoses, failed couplings, and equipment corrosion (Linn, 2002).

Machine/Equipment Maintenance

The Florida solvent leaks, spills and discharges study found that 13.8% of the reported solvent/solvent waste discharges were associated with drycleaning machine/equipment maintenance. This includes spills associated with filter changes, still cleanouts, servicing of the solvent pump and button trap cleanouts.

Waste Management Practices

Contact Water

In 1988, the International Fabricare Institute conducted a study of drycleaning equipment and plant operations, including waste disposal practices. Over 70.7% of the 909 drycleaning operations that responded to the survey indicated that separator water was being discharged to either a sanitary sewer or a septic tank (IFI, 1989). It is reasonable to conclude that historically, sanitary sewers and septic tanks have been the most common disposal points for contact water (separator water, vacuum water and mop water). A study of drycleaning solvent contamination in California concluded, “The main discharge point for dry cleaners is the sewer line” (Izzo, 1992). Studies conducted in California have found evidence of the presence of free-phase PCE in sewer lines serving drycleaning plants.

Other disposal practices for contact water have included discharge to the ground, discharge to storm sewers and soakage pits, and discharge to blind drains. Contact water has reportedly been discharged to cooling towers and boilers at drycleaning facilities. Separator water is used by some drycleaners as a spotting or pre-cleaning agent. Separator water has also been used to mop floors.

Evaporation has been a common means of disposing of separator water. More recently, equipment has been developed to filter and either evaporate or mist the treated separator water to the atmosphere. The most common filter material is granular activated carbon. Polymer filters are also utilized. Some drycleaners utilize a hazardous waste hauling firm to dispose of separator water.

Still Bottoms/Cooked Powder Residues

Still bottoms and cooked powder residues from chlorinated solvent drycleaning operations are hazardous wastes managed under RCRA. Still bottoms and cooked powder residues from petroleum drycleaning operations are hazardous wastes if their flash point is greater than 140° F. Prior to the mid-1980s, most still bottoms/cooked powder residues were either disposed of in landfills or were discharged to the ground.

Many petroleum drycleaning solvent facilities do not perform distillation. If powder filtration systems are utilized in these operations, the muck is a waste product. Much of the muck generated in these operations was historically disposed of in landfills or discharged to the ground.

Spent Filters/Muck

Spent cartridge filters should be allowed to drain in the drycleaning machine overnight prior to being changed. This practice is not always followed and spent solvent is often spilled during filter changes. Historically, spent cartridge filters were discarded to the trash. A common storage point for spent cartridge filters was a cardboard box stored inside the drycleaning facility or on the ground outside the facility near the service door. Residual spent solvent will drain from spent cartridge filters.

Spotting and Pre-cleaning Agents and Spotting Wastes

A greater variety of chemicals are used at the spotting board than at any other location in a drycleaning plant. Sometimes a large number of containers containing spotting agents are temporarily stored on the spotting board. In addition to splashing and other discharges during the spotting process, containers of spotting agents have leaked or been spilled around the area of the spotting board. The drain receptacle (semi-circular cylinder) located at the base of the spotting board, which receives steam condensate and spotting wastes will tend to corrode over time and will eventually leak. Some operators have replaced these receptacles with cans or plastic containers, but others have allowed these wastes to discharge to the floor or a floor drain. Most containers of spotting agents at drycleaning facilities are not stored in secondary containment, but instead on shelves or on the floor. Spotting board wastes have been discharged to floor drains (sanitary sewer), septic tanks and to the ground.

Lint

Historically, lint from drycleaning operations has been disposed with trash and in some cases discharged to the ground outside the facility. As stated earlier, lint from a drycleaning machine contains solvent and lint extracted from the button trap or the pump strainer will be saturated with solvent.

Other

A few odd waste management practices and drycleaning solvent uses that have been reported include still bottoms being used to undercoat vehicles, and PCE being used to kill weeds and fire ants outside a drycleaning facility (Dukes, 2002).

Preliminary Site Characterization – Planning for the Assessment

The key to a successful site assessment is preparation. Preliminary site assessment work involves a review of existing data including a desk-top review, and site reconnaissance. The objectives of the preliminary assessment phase are as follows:

- Identification of potential contaminant point sources and environmental concerns at the site;
- Identification, in a preliminary manner, of the subsurface conditions at and near the site vicinity to develop a site conceptual model; and
- Establishment of a framework for subsequent site investigation work (Waterloo, 1994).

Desk-top Review

In the desk-top review, existing data for the site and site area are reviewed. These data may include the following:

- Regulatory and compliance data including records of regulatory inspections, warning letters, enforcement actions, consent orders, etc. for state, county and local regulatory agencies;
- Environmental property audits;
- City directory searches to determine historical land use and potential contaminant source areas in the site vicinity;
- Occupational liscenses and business permits
- Review of historical aerial photographs;
- Review of topographical maps;
- Historical maps and fire insurance records (such as Sanborn maps);
- Review of assessment/remedial work at nearby sites (particularly service stations);
- Review of facility as-built drawings;
- Utility records, including videos of sewer lines and pressure testing and;
- Determine locations of nearest potable/public supply wells.

Site Reconnaissance

A site reconnaissance is absolutely necessary prior to mobilization for the site assessment. At a minimum, the following individuals should be interviewed: real property owner, business owner/operator and employees. These interviews are an important means of gathering information on facility operations and waste management practices. Long term employees are generally an excellent information source. Consultants are generally much more successful at collecting useful information from interviews with property and business owners than are regulatory personnel. Valuable information is often obtained from employees during the actual assessment activities. Drycleaning facility employees are generally very curious about the actual site assessment activities and useful information on waste management practices and contaminant source areas can be gleaned in conversations with these employees. During these interviews and a site inspection, the following information needs to be collected:

- Determine facility operation dates and location(s). It is not uncommon for drycleaning businesses to relocate within a strip shopping mall. If the shopping mall has been in existence for a long period of time, it is possible that more than one drycleaning business has operated on the property. Check the tenant lists.

- Collect historical information on businesses that occupied the facility and nearby businesses that may use or have used solvents and other chemicals. Note that a variety of businesses have used both chlorinated and petroleum solvents. For example, chlorinated solvents and petroleum solvents have been used in the printing and publishing industry, including PCE, TCE, TCA, Freon 113 and petroleum naphtha – all of which have also been utilized as drycleaning solvents (EPA, 1995). Other businesses that use or have used chlorinated and/or petroleum solvents include: auto repair facilities (PCE is the solvent of choice for brake cleaning and the most common parts washer is petroleum naphtha or mineral spirits which is compositionally similar to Stoddard solvent.), uniform rental/linen supply businesses, paint dealers, circuit board manufacturers, telephone companies, machine shops, metal platers, furniture strippers, power stations, boat dealerships and elevator service companies. TCE has been used to clean out septic tanks (Pankow & Cherry, 1996).

  Small coin-operated drycleaning machines have been utilized at some laundromats. It is prudent to determine if any nearby laundromats use or have used these machines. Some large hotels and resorts have onsite drycleaning operations.

- Identify the solvents and chemicals used at the facility. Note that if the facility operated prior to the early 1960s, it is very possible that petroleum drycleaning solvent was utilized. At older facilities where there have been changes in the business owner/operator, the current operator generally has little knowledge about past operations.

  PCE and its degradation products are commonly found as contaminants at facilities that use or have used petroleum drycleaning solvent. Several possible sources for the PCE include: bacterial inhibitor in soaps, spotting agents, and as a carrier in sizing and in waterproofing operations. Drycleaning using petroleum solvent is the preferred method for cleaning coats. These facilities have traditionally offered waterproofing services (Albergo, 1997).

- Document the equipment that is/was used at the facility including current and historical locations of the equipment.

- Document the historical waste management practices, including the types of wastes that are/were generated (contact water, filters, distillation residues, spotting wastes, lint, etc.) and how the wastes were stored and managed.

Determine where wastes are/were stored and where the facilities dumpsters are located.

- How is/was solvent delivered to the facility (drums, tank truck), and where was it delivered? Where did the tank truck park? Is there any record of solvents being spilled during delivery/transfer?
- Where is/was solvent stored at the facility (machine base tanks, AST, UST)?
- How and where was the drycleaning machine filled with solvent (through the machine door, button trap)?
- Document any leaks, spills and discharges of chemicals at the facility. Under Title V, PCE drycleaners are required to conduct equipment inspections at least twice a month. PCE drycleaners are required to maintain a log documenting any PCE leaks, any repairs made to correct leaks and the amount of PCE purchased every month. Drycleaners are required to keep a copy of the log on the premises. Additionally, some states require that drycleaners report solvent leaks, spills or discharges to a state agency. These reports can be valuable in determining contaminant source areas.
- Is or was the facility ever served by a septic tank/drainfield? Note that chlorinated solvents have been used to clean out septic lines and grease traps. If the facility is served by a sanitary sewer, determine the flow direction for the main sewer line. Note that some municipalities sample sewer lateral lines at businesses (including drycleaners). Results of such sampling may be available. Also note that some city utility departments conduct video surveys of sewer lines and keep these videos on file. Utility departments generally maintain records of sewer line leaks, repairs and replacements.
- Are floor drains present? At some facilities the floor drains have been sealed with concrete and concrete patches in the floor will mark the former floor drain locations.
- Are there expansion joints and/or cracks in the facility floor slab located near solvent storage, solvent transfer, solvent use, or waste storage area?
- Determine the types of utilities that serve the facility and document their locations.
- Collect information on any regulatory or compliance issues, including dates and actions. Regulatory files often contain pictures of equipment and waste management areas taken during compliance inspections.
- Check for the presence and integrity of secondary containment structures in solvent use, solvent storage and waste storage areas.

- Determine how stormwater is drained from the site (storm sewers, soakage pits, drainage ditches) and document the locations of these features.

- Determine locations of nearest private and public water supply wells and irrigation wells, and obtain well construction information. Collect information on the producing aquifer, producing interval and water quality data.

During the site reconaissance, a facility layout diagram should be prepared. The diagram should be a drawing of the facility that houses or housed the drycleaning operation. The following should be shown on this diagram: facility service door(s), current and historical locations of drycleaning equipment (drycleaning machines, stills, spotting board, presses, vacuum unit, chiller, boiler, separator water treatment unit, etc.), solvent storage areas (ASTs and USTs), location of septic tank drainfield or the sanitary sewer lateral line, floor drains, expansion joints and cracks in the facility floor, location of utilities and location of dumpsters.

Contaminant Source Areas – *Where to Sample*

In general, sampling to delineate contaminant source areas should occur in areas where solvents were transferred, stored, and used and where solvent wastes were stored and disposed.

Drycleaning machine
Based on data collected from contamination assessments performed at 150 drycleaning sites in Florida, the drycleaning machine is the most common contaminant source area at drycleaning sites (Linn, 2002). Discharges of solvent and solvent-contaminated wastes are associated with solvent transfer, solvent storage, and machine operation and maintenance. Historically, solvent has been added to drycleaning machines through the door of the machine (front of the machine) or through the button trap door, located at the back of the machine. Solvent discharges are related to overfilling the machine, leaking door gaskets, cleaning out the button trap, replacing seals on the solvent pump, changing filters, distillation cleanout, and equipment failures. A bucket used to collect separator water is normally located behind the drycleaning machine. If the bucket is not emptied on a regular basis the separator water will overflow to the facility floor. This has been a common occurrence at drycleaning facilities. There have been cases where the separator water bucket has fallen or been knocked over, releasing separator water to the facility floor.

If drycleaning is no longer performed at the facility and the former locations of the drycleaning equipment in the building are unknown, look for cut off lag bolts protruding from the concrete floor slab. The machines were anchored to the floor with these bolts. Sometimes the bolts have been removed and their former locations are marked by concrete or mortar patches. Sometimes the floor in a former drycleaning facility is covered with carpet or floor tile and the former location of the drycleaning machine is unknown. As a general rule, in strip shopping centers, the drycleaning machine is most often, though not always, located in the rear portion of the drycleaning facility.

If feasible, sampling should be conducted beneath the facility floor slab at both the front and back of the drycleaning machine. Look for discolored and/or peeling floor tiles near the solvent use, solvent storage and waste storage areas. If expansion joints or cracks (pathways for solvent and solvent waste migration) in the floor slab are located near the drycleaning machine, sampling should be focused in these areas.

If transfer machines and/or vented dry-to-dry machines are or were used at the facility, considerable solvent was lost in the form of vapors from clothing transfer and as vapors vented during clothing drying. Over 32% of the solvent used in a transfer machine operation is vented to the atmosphere (University of Tennessee, 1993). If no vapor collection system is utilized, all of these solvent vapors are released into the environment. In transfer and vented dry-to-dry operations, collect samples at locations of the vents for the tumblers (dryers).

Distillation Unit

Although distillation units are built into the newer drycleaning machines, they are sometimes a separate piece of equipment in drycleaning facilities. A common operational problem with distillation units is overfilling (when too much spent solvent or muck is placed in the still/muck cooker) and subsequent boilover of distillation residues resulting in the discharge of still bottoms or cooked powder residues to the facility floor. Boilover can also be caused by excessive still operating temperatures. In early drycleaning operations, the distillation unit was often located in a separate room or even outside the facility in a covered area due to the strong odors generated during the distillation process. Former still locations can often be identified by brown colored staining on facility floors or walls. This staining is associated with either boilover of still bottoms or from splashing or spilling of still bottoms or cooked powder residues during still cleanout. The area around the still is a prime sampling location at drycleaning facilities.

Service Door

Historically, solvents have been delivered to the facility and wastes have been stored and discharged outside the service door of the drycleaning facility. If the drycleaning solvent was delivered to the facility by tank truck, find out where the solvent delivery truck parks or parked during deliveries. If solvents were delivered by tank truck there were likely incidental spills or discharges associated with the solvent transfer. If the delivery area is paved with asphalt, sample in areas where the asphalt is deteriorated or dissolved. The area outside the service door has also been a favorite discharge area for contact water and a storage area for spent cartridge filters. The area outside the service door on the side to which the door opens is a prime sampling area. If there are several doors at the facility, the door located nearest the dry cleaning machine/distillation unit was the most likely waste disposal point. Stressed vegetation or unpaved areas with no vegetation may be indicators of waste disposal areas.

Sanitary Sewer - Septic Tank/Drainfield

As stated earlier, the sanitary sewer and septic tank/drainfield have historically been popular disposal points for contact water. Some older drycleaning machine service manuals even prescribed discharging contact water to drains (Izzo, 1992). Sewer lines in urban areas can be constructed from a wide variety of materials. Within a city, many different kinds of sewer piping may be utilized depending on the time period the sewer lines were installed. Older sewer lines are made of cast iron and vitrified clay and newer lines have been constructed from concrete or more recently thermoplastic. Manholes were typically constructed of brick/mortar and concrete. Early sewer line joints were sealed with mortar and bituminous compounds. Neither of these materials is watertight and subsequent settling and cracking have provided pathways for contaminant migration. Many local sewer authorities specify permissible leakage rates for newly-constructed sewer lines "of approximately 500 gallons per inch diameter per day per mile" (Siler, 1994).

Contact water, free-phase solvent and solvent vapors can leak from sewer lines through cracks, joints or breaks. Contact water and free-phase solvent can also leach through sewer piping. Studies conducted at drycleaning sites in California detected higher PCE concentrations in wastewater samples collected from sewer lines after the sewer lines were flushed with water. The higher PCE concentrations are attributed to PCE liquid or sludges that settle to the low spots in the sewer line. The higher PCE concentrations after line flushing are attributed to free-phase PCE and PCE in sludges dissolving into the flushing waters (Izzo, 1992).

Wastewater samples should be collected from sewer lateral lines and wastewater and sludge samples should be collected from septic tanks. Soil gas sampling along sewer lines can be used to delineate contamination associated with leaking sewer lines. Sanitary sewers and particularly septic tanks offer favorable conditions for reductive dechlorination of PCE. Samples of wastewater and sludge collected from sewer lines and septic tanks often contain PCE degradation products as well as PCE. Sometimes groundwater samples collected at drycleaning sites contain PCE degradation products even though natural attenuation monitoring parameters do not indicate favorable conditions for reductive dechlorination. This may indicate that a leaking sewer line or septic drainfield is a contaminant source area at the site.

Floor Drains

Sampling should also be conducted near floor drains. If solvent wastes are discharged down floor drains plumbed with PVC piping, PCE can soften and even dissolve the PVC. The elbow joints of drain lines are particularly susceptible to dissolution. Floor drains are commonly located in the boiler room at drycleaning facilities. Since PCE vapors are denser than air, the vapors tend to settle to the floor, particularly after the drycleaning plant has been shut down for the day. These vapors will migrate to low spots along the facility floor and floor drains, floor expansion joints and cracks in the floor slab are prime entry point for these vapors.

ASTs/USTs

Today, most drycleaning solvent is stored in tanks located in the base of drycleaning machines. Historically it was commonly stored in separately located ASTs or USTs. Discharges associated with solvent storage included spills associated with filling the tank, and valve leaks and discharges associated with collecting solvent in containers from the tank to fill the drycleaning machines.

Most of the storage tanks associated with PCE drycleaning operations were ASTs. USTs are commonly used to store petroleum drycleaning solvent. A study of drycleaning equipment and plant operations conducted by International Fabricare Institute in 1988 found that only 96 of 809 solvent tanks (11.9 %) reported in the survey were USTs. Only 2 of these 96 USTs were used to store PCE (IFI, 1989). USTs and ASTs are also used to store fuel oil (boiler fuel) and gasoline for facilities that operate vehicles to transport clothing to and from the dry drop-off stores/main plant. Some former solvent or fuel USTs have been utilized to store solvent wastes. Sampling should be conducted near the storage tanks and any flow lines associated with the storage tanks.

Storm Sewers

Storm sewers, particularly those located near the service door of a drycleaning facility, have been historical waste discharge points at drycleaning facilities. Sediment and water samples should be collected from these sewers.

Dumpsters/Trash Cans

Prior to the advent of hazardous waste haulers, many of the wastes generated by drycleaning operations were disposed to waste containers, including filters, muck, and lint, spotting wastes and chemical containers. Sampling should be conducted in these areas. It is important in interviews to determine where the waste containers were located in the past.

Other Source Areas

Other contaminant source areas include the spotting board, blind drains, and storage buildings. In transfer machine and vented dry-to-dry operations, solvent vapors and solvent-contaminated lint are discharged from vents on non-recovery tumblers (dryers). At some drycleaning plants these vents are mounted on the roof of the facility. Rainwater contacting these vapors forms contact water and discharges from downspouts that drain the roof may contain solvents.

Site Characterization Work – Other Considerations

Drycleaning sites can pose some unique problems in site characterization work. Drycleaning solvents have diverse properties that control their fate and transport in the subsurface. At some sites, both chlorinated and petroleum solvents have been used. PCE, TCE, carbon tetrachloride, TCA and Freon 113 are dense non-aqueous phase liquids (DNAPLs), and petroleum drycleaning solvents are light non-aqueous phase liquids (LNAPLs). Although these are well known facts, the experience of environmental consulting firms has been dominated by work on LNAPL sites, particularly work associated with petroleum storage tanks. There is a strong tendency among many environmental consulting firms to approach site assessment work at drycleaning sites in the same manner as petroleum sites. An example of this approach would be utilizing monitor wells screened only across the water table in contamination assessment work at former PCE drycleaning facilities that have been inactive for more than 10 years. A combination of shallow water tables, permeable aquifers and high rainfall and/or surface water drainage features located near the former drycleaning facility can act to flush most of the contaminants from the shallow portion of the aquifer, often resulting in contaminant levels in water samples collected from water table wells to be below cleanup target levels. Additionally, the chlorinated drycleaning solvents are DNAPLs and will sink in the aquifer, concentrating above the lower permeability zones in the aquifer. Collection of deeper groundwater samples very often results in finding groundwater contaminant levels several orders of magnitude higher than cleanup target levels. All of this may seem very fundamental, but a number of site assessments conducted at drycleaning sites have utilized only monitor wells screened across the water table and perhaps one deeper monitor well, that very often has been installed up-gradient of the contaminant source area.

Other problems associated with drycleaning site characterization work include site access and equipment access. Most onsite work will be conducted in and around active businesses, which generally are commercial retail in nature. Establishing good working relationships with the property owner, business owners and business operators is imperative. Often, work must be scheduled after business hours and on weekends. Collecting samples beneath building floor slabs in active drycleaning operations is difficult because of space limitations and the presence of utilities. If the drycleaning business is no longer active, and the building is occupied by another business, attaining access is generally even more difficult.

A study of site assessments conducted at 150 contaminated drycleaning sites in Florida found that contaminated groundwater had migrated off-property at approximately 57% of the sites. Off property site access is even more problematic than access to on-site businesses. A possible alternative is to obtain access to road right-of-ways from municipal, county and state government agencies.

As stated earlier, until the early 1960s petroleum solvents were the most widely used solvents in drycleaning. If a drycleaning facility operated prior to 1960, it is very possible that petroleum drycleaning solvents were utilized. At some drycleaning plants both petroleum solvents and PCE have been used. The current drycleaning owner/operator may not know what solvents were used in the past. The presence of petroleum drycleaning solvent contamination along with PCE contamination can impact the remedial design for the site.

Petroleum drycleaning solvent is a mixture of many compounds. Its composition varies and is dependent on its parent crude oil composition and the refining processes used to produce it. It is not feasible to identify every compound contained in the solvent. Anlaytical suites used at sites with petroleum drycleaning solvent contamination typically include a total petroleum hydrocarbon method. One approach is to obtain a sample of the petroleum solvent that is being used at the facility to “fingerprint” the contaminant. At inactive drycleaning sites, it is difficult, if not impossible, to determine what petroleum solvent was used. Another complication is that petroleum solvent biodegrades, is leached and some constituents volatilize. The weathered petroleum products have a significantly different composition than the parent solvent (Fitzgerald, 1998). Stoddard solvent typically has an aromatic content of greater than 20%. Some of the aromatic compounds typically present in Stoddard solvent are toluene, ethylbenzene, xylenes, naphthalene and 1,2,4-trimethylbenzene. Note however, that the aromatic compounds in petroleum drycleaning solvents are generally more volatile and more soluble than the alkanes, which are the predominant constituents of petroleum drycleaning solvents. The later petroleum drycleaning solvents contain little to no aromatic compounds. Some mobile laboratories have the ability to analyze extractables and perform total recoverable petroleum hydrocarbon analyses.

Assessment Technologies

Following are a few examples of assessment technologies that have been utilized in drycleaning site characterization work. A more detailed description of these technologies, can be found at http://www.epa.gov/tio/char.htm.

Color-Tec Screening

Color-Tec is a screening method used to determine if a groundwater, soil, sediment or surface water samples contain PCE or its breakdown products. This screening method uses colorimetric tubes and their reaction to chlorinated ethenes to give an immediate visible sign of its presence. This indication is partially quantitative but for delineation purposes, the indication of the presence of the contaminant is sufficient to delineate the extent of contamination at a site.

The colorimetric tubes can be used to prescreen samples and determine which samples should be analyzed by the mobile laboratory. This method reduces delays associated with the direct push unit waiting on the mobile laboratory analysis to determine where the next samples will be collected. The Color-Tec method can also be used independently of the mobile laboratory to delineate contamination at a site. In utilizing this method, duplicates of approximately 20 to 25% of the samples are sent to a fixed laboratory for analysis. If the Color-Tec method is utilized to analyze samples from newly installed monitor wells and chlorinated solvents are detected in a sample from a lateral or compliance monitor well, then an additional well can be installed while the drilling rig is still in the field, saving the costs associated with an additional mobilization.

The Color-Tec method has been utilized by the South Carolina and Florida drycleaning solvent cleanup programs. For additional information on the Color-Tec screening method refer to a paper entitled *Ecology & Environment's Color-Tec Screening Method for Detection of Chlorinated Solvents in Groundwater and Soil Samples* at the State Coalition for the Remediation of Drycleaners website:
http://www.drycleancoalition.org/download/Color_tec_2005.pdf

Direct Push-Installed Monitor Wells (Microwells)

A significant portion of the costs of site assessment work are associated with monitor well installation and managing investigation-derived wastes (drill cuttings, well development water, purge water and decontamination water). Investigation-derived wastes generated during drycleaning site investigations often contain hazardous constituents and waste disposal can be expensive. Waste minimization should be an integral part of any site investigation. Utilization of microwells as permanent monitor wells in drycleaning site investigations can result in significant cost savings in both the investigations and subsequent groundwater monitoring.

Microwells are small diameter (inner casing diameters of one-half, three quarters, or one inch) PVC monitor wells. These wells are generally installed utilizing direct push technology. If direct push sampling is conducted at a site and sample analysis is performed on site (utilizing a mobile laboratory, portable GC or Color-Tec screening); microwells can be installed upon completion of contaminant plume delineation saving time and the expense of an additional mobilization. Additionally, no drill cuttings are generated during installation and wastewater generated through well development and purging is minimized. Minimal purge water is generated during future groundwater monitoring events. A considerable cost savings can be realized in the installation of compliance monitor well clusters by installing multiple microwells in a single borehole rather than installing a cluster of monitor wells by conventional means.

A recent study comparing groundwater samples collected from microwells to those collected from conventional monitor wells installed utilizing hollow stem augers found that "no significant performance differences were observed between the direct-push wells and hollow-stem auger drilled wells. … More significantly, the chemical variability among the different well types was less than that displayed by spatial heterogeneities associated with well screen depth differences and temporal variability." (Kram, 2001). Microwells have been used extensively as permanent monitor wells by the Florida Drycleaning Solvent Cleanup Program.

Membrane Interface Probe

The membrane interface probe (MIP) is a device used to detect volatile organic compounds (VOCs) in the subsurface. The probe is advanced using direct push technology and is used in conjunction with a soil conductivity device, which is used to characterize the subsurface lithologies. The MIP contains a fluorocarbon membrane mounted on the direct push drive point. The membrane is heated (100° - 120°C) and VOCs partition from the soil, soil gas or groundwater across the membrane where they are transported to the surface by a carrier gas (Griffin, 2002). At the surface the vapors are analyzed in a truck-mounted laboratory using one or more detectors. A good choice of detectors for drycleaning work would be an electron capture device (ECD) for the chlorinated solvents and a PID and FID for the petroleum solvent constituents.

The MIP provides continuous profiling offering real-time data. It is effective in both the saturated and unsaturated zones and in clays. Most state regulatory agencies require groundwater contamination to be delineated to contaminant levels that are much lower than the 100 µg/Liter concentration claimed as the effective detection limit by some MIP vendors. Nonetheless, the MIP can be a highly effective tool in site characterization work at contaminated drycleaning sites. The primary application of the tool at drycleaning site assessment work would be to provide a picture of the distribution of contaminants in source areas. At highly contaminated sites where remediation is anticipated, a day or two of MIP work performed in the contaminant source area will provide valuable information concerning where the predominant portion of the contaminant mass is located and how it occurs in the soil and groundwater. These data will prove to be invaluable in remedial design, particularly where in-situ remediation is being considered. The MIP work will also aid in choosing strategic locations and screen intervals for monitor wells to evaluate the performance of the remedial system and for injection wells, if applicable. The MIP has been utilized at several sites in the Florida Drycleaning Solvent Cleanup Program.

Mobile Laboratories

The iterative process practiced in conducting site assessments in the past involved multiple mobilizations that generated multiple reports and work plans requiring multiple reviews. Long delays occurred in the cycle. Data grew old and became obsolete and additional data had to be collected and reviewed. Mobile laboratories offer an alternative to the older process. The mobile laboratory is becoming a fixture in many site assessment programs. Coupled with direct push sampling, mobile laboratories offer an efficient means to provide accurate real-time data that allows field personnel to adjust the scope of work during the assessment and therefore minimize the number of mobilizations needed to complete a site assessment. Mobile laboratories can also be utilized effectively during remedial excavations. Onsite analysis allows excavations to be completed in one mobilization.

Mobile laboratories offer laboratory-grade gas chromatograph or gas chromatograph/mass spectrometer detectors. Many mobile laboratories have two and sometimes three gas chromatographs, allowing for faster sample run times. Typically, in drycleaning work, an abbreviated analytical suite is utilized to reduce sample run times. For a PCE drycleaning site this would include tetrachloroethene, trichloroethene, cis 1,2-dichloroethene, trans 1,2-dichloroethene, 1,1-dichlroethene and vinyl chloride. The BTEX suite is also typically included in the analysis. Some mobile laboratories offer extractables analyses. Mobile laboratories that offer these analyses would be able to perform a total petroleum hydrocarbon analysis that would be suitable for evaluating sites that use or used petroleum drycleaning solvents.

Passive Diffusion Bag Samplers (PDB)

PDB samplers are low-density polyethylene bags filled with de-ionized water and rely on passive diffusion of VOCs from the groundwater into the bags until constituent concentrations reach equilibrium. The PDBs are placed at target intervals within a monitoring well to allow representative samples to be collected from specific vertical intervals. The bag length can vary; however, the typical sampler is approximately two feet long. The monitoring wells are not purged prior to collection of the sample; therefore the investigative-derived wastewater is limited to the remaining water from the bag.

Multiple samplers are placed in a monitoring well to vertically delineate the screened interval. Periodic monitoring typically targets the vertical interval with the highest concentration as a worst case scenario. The samplers are commonly left in place for a minimum of two weeks, but can remain in place for extended periods of time allowing retrieval and installation of the bags during normal monitoring site visits. Due to data quality objectives, PDBs are typically used to monitor general contaminant concentration trends. Laboratory results from the water in the PDBs are typically not accepted for site closure. Use of PDBs for groundwater monitoring at sites with deep wells can result in considerable cost savings with regard to labor and minimization of investigation-derived wastes.

Soil Conductivity Probe

A soil conductivity profile provides a continuous reading of the conductivity of the soil/sediment (with it fluids). The device is advanced using direct push technology. By collecting conductivity data at several points laterally across a site, a transect can be developed. At least one probe point should be advanced adjacent to a borehole where a continuous core has been collected. The conductivity data can then be correlated with the lithological data to ground-truth the conductivity transects. At most drycleaning sites a day or two of conductivity profiling will be sufficient to develop the stratagraphic framework for the subsurface. Utilizing these data, groundwater sampling points can be selected, *particularly at breaks in lithology*, to accurately characterize groundwater contamination at the site. The cost savings realized by collecting fewer but more representative direct push groundwater samples and strategically locating monitor well screen intervals will more than pay for the conductivity probe work. These data will also pay dividends during site remediation by focusing remedial efforts in areas where the predominant portion of the contaminant mass is located. Soil conductivity profiling has been utilized in the Kansas Drycleaning Program and the Florida Drycleaning Solvent Cleanup Program.

Soil Gas Surveys

Soil gas surveys can be a useful means of identifying contaminant source areas. The primary applications for soil gas surveys are at drycleaning sites are where the building that housed the drycleaning facility has been razed and the location of the traditional contaminant source areas (drycleaning machine, distillation unit, solvent storage and waste storage areas) is unknown, and in identifying contaminant sources associated with leaking sewer lines. There are two types of soil gas surveys – passive and active.

Passive soil gas surveys utilize a sorbent material (granular activated carbon or zeolites) contained in a sampling chamber. The sampling chamber is placed in a shallow borehole, which is sealed at the surface, and the sampling chamber is left in the ground for a period of time varying from one day to two weeks. The sampling chamber is then retrieved, sealed and sent to a laboratory for analysis. Passive soil gas surveys can be successfully conducted in lower permeability soils. The drawbacks to passive soil gas sampling are that two site mobilizations are required and there is a waiting period for laboratory analysis. Passive soil gas surveys have been utilized by the Kansas and South Carolina drycleaning programs in locating contaminant source areas associated with leaking sewer lines and by the Illinois drycleaning program to identify contaminant source areas.

Active soil gas surveys collect soil gas from a hollow probe driven into the ground. These samples can be analyzed onsite utilizing a portable gas chromatograph or mobile laboratory or, the sample can be sent to a fixed laboratory. A qualitative evaluation can be obtained by utilizing colorimetric tubes. Active soil gas data analyzed in the field is real-time data and the scope of the survey can be adjusted to pinpoint "hot spots" and collect additional data during one mobilization. Active soil gas surveys are not suitable for low permeability soils or very shallow water tables.

Another form of active soil gas sampling involves installation of temporary piezometers and extraction of soil gas at a relatively high rate (up to 100 cubic feet per minute) by utilizing a portable regenerative blower. During sampling, wellhead vacuums are adjusted utilizing a valve at the wellhead. The discharge rate is measured for each wellhead vacuum. Vacuum measurements are taken from surrounding piezometers in order to estimate the area effected by each sampling point. Samples can be analyzed utilizing organic vapor analyzers, portable gas chromatograph or mobile laboratory. Confirmatory samples can be sent to a fixed laboratory. Source areas can be pinpointed by utilizing multiple sampling points.

The advantage of this method of active soil gas sampling is that it provides a much larger coverage area than conventional active soil gas sampling. The effective radius of influence of this technique in a sandy soil can be greater than 30 feet (Lewis, 2002). It provides an estimate of the average soil vapor contaminant concentration and therefore the available contaminant mass in the sampled area. The method also provides useful information for designing soil vapor extraction systems. This technique has been used at several sites in Florida Drycleaning Solvent Cleanup Program.

Sonic Drilling

A sonic drilling rig utilizes high frequency mechanical oscillations to transmit resonant vibrations and rotary power to the drill string. Sonic drilling offers some advantages over the more traditional mud-rotary and air rotary drilling. No drilling fluids are circulated in the borehole. A continuous core is obtained during drilling. A minimum amount of wastes are generated. Since an outer casing is advanced during drilling, groundwater samples can be collected as the borehole is being advanced. At sites where direct push technology cannot be used or where contamination has reached depths below direct push capabilities, sonic drilling can be utilized along with a portable gas chromatograph or mobile laboratory to collect real-time data and delineate the contaminant plume while minimizing site mobilizations.

The disadvantages to using sonic drilling are its higher cost (Though, this should be weighed against the minimal amount of investigation-derived wastes generated by this technology.), the large foot print of the rig (This can be a problem at drycleaning sites, but smaller track-mounted sonic drilling rigs are available.), and the availability of the technology.

State-by-state: Individual Site Assessment Approaches

Alabama

The Alabama Drycleaning Environmental Response Trust Fund (DERTF) is a self-insurance program for drycleaners to cover environmental contamination. The program is strictly voluntary and aims to help recover some of the costs involved in investigation, assessment and remediation. DERTF is managed jointly by the Alabama Department of Environmental Management and the DERTF Board.

Initial Investigation – The purpose of the Initial Investigation is to gather sufficient information about the site to allow the Department to prioritize the site. The owner must perform the investigation utilizing Board certified engineers and contractors. At a minimum the investigation should include the following information:

- Type of surrounding population, e.g. urban, rural residential;
- Results of well inventory within 1500 feet of the site which includes the location and where available information on the depth, elevation, aquifer, producing zones and ownership of each well.
- Location of any public water supply wells that are within 1 mile of the site and where available information on the depth, elevation, aquifer, producing zones and ownership of each well.
- Results of a receptor survey to include a description of any potential or real receptors of drycleaning-agent contamination. This description should include the hydro-geologic environment, the type and nature of geologic materials, location of surface waters, surrounding land and water users, and the location of all underground utilities, water lines or other conduits near the site or within the suspected area of impact that could influence or other wise affect thee migration of contaminants.
- A determination of the uppermost aquifer and an initial evaluation of the potential for hydraulic interconnection with lower aquifers. At least one boring should be advanced in a presumed un-impacted area to the first confining layer beneath the first significant water-bearing zone. The evaluation of this stage may be made based upon the results of site soil sampling and boring combined with available literature data;
- Groundwater samples will be collected from the first significant water-bearing zone that is likely to exhibit impact and analyzed to assess groundwater quality at a minimum of one up-gradient and three down-gradient locations unless directed to do otherwise by the Department. Upon discovery of free-phase drycleaning solvent, the Department will be informed immediately. The product should be described to provide the information regarding its likely fate-and-transport characteristics, and all proposed sampling within or through this area postponed until the site-specific hydrogeology is adequately characterized, the properties of the product are adequately characterized to allow for the area to be investigated using techniques that will not exacerbate the extent of contamination and/or feasibility of interim free-phase recovery or remediation activities can be evaluated.

- Soil and vapor samples will be collected, as appropriate, in areas most likely to have been impacted by a drycleaning agent release.

Following the Initial Investigation, the property owner will submit the results to the Department. Upon review of the results, the Department may require additional sampling and analyses to be performed if it is determined that the number or location of samples or methods used in the analysis of such samples are not sufficient to characterize the area and soil depth most likely to have been contaminated by a release. Once the investigation is complete, the Department will prioritize the site according to:

1. The degree to which human health and the environment are actually affected by exposure to the contamination;
2. The future risk to human health or the environment resulting from the contamination;
3. The present and future use of an affected aquifer or surface water;
4. The possibility of no further action;

The highest priority category is "Immediate Interim Action Necessary" which indicates that, based on information submitted to the Department, an immediate remedial action is necessary to protect human health and/or the environment. The second highest category is "Impact Assessment Needed" which indicates that contamination above the maximum contaminant level(s) (MCLs) has been discovered on site, but further investigation is needed to determine if the site poses a threat to human health and the environment. The third highest category is "Non-time Critical Investigation Needed" which indicates that contamination has been found on site but the samples taken did not exceed MCLs for the constituents involved. The lowest priority category is "No Further Action". Under this category, no additional activities will be required by the Department. The Department may reevaluate the site at a later date, and subsequently require addition activities.

Site Prioritization - On a quarterly basis, the Department will present to the Board, a site prioritization list. The list will include all existing drycleaning facilities, abandoned drycleaning facilities and wholesale distributing facilities. The following categories will be contained in the site prioritization list (in order from worst case to best case scenario):

1. Interim Action Necessary Site – This category denotes that a direct (potential or existing threat to human health and/or the environment exists as a result of drycleaning agent contamination and that immediate intervention action is warranted.
2. Immediate Comprehensive Assessment Necessary Site – This category denotes the existence of onsite drycleaning solvent contamination at levels that would necessitate a comprehensive assessment to define the soil and/or groundwater contamination which may pose a thereat too human health and/or the environment.
3. Deferred Investigation Status – This category denotes that the site does not exhibit drycleaning contamination at levels that would require an immediate comprehensive assessment.

Once all sites have been prioritized, those with the highest priority may submit a property assessment plan. The property assessment plan must describe in sufficient detail those actions planned for the development of information necessary to perform a risk assessment or for the identification of applicable remediation standards for the site by utilizing criteria found in Department-approved risk-based corrective action guidance. If necessary, the assessment plan will provide for the implementation of applicable responses, actions and/or land use controls. The plan should describe the methods to b e used to determine the types(s) and the amount(s) of any contamination including the delineation of any and all soil and groundwater contamination discovered or known to exist on-site. Information submitted in the assessment plan should be submitted in a formation consistent with the Alabama Environmental Investigation and Remediation Guidance Document.

Florida

The Florida Drycleaning Solvent Cleanup Program is managed by the Hazardous Waste Cleanup Section of the Florida Department of Environmental Protection utilizing private contractors to perform site assessment and remedial work. Program assessment goals are:

- Performance of site assessments in an efficient and timely manner with emphasis on minimizing the number of site mobilizations,
- Minimization of investigation-derived wastes and waste disposal costs, and
- Streamlined reporting emphasizing data summaries and concise reporting

Work Plan Development - The first phase of the assessment process is preparation of a work plan to be used to guide site assessment work. Preparation of the work plan includes file reviews and a site visit. A checklist is utilized by the contractor during the site visit to collect information on site history and operations; facility waste management practices; drainage and utilities; and identification of surrounding businesses. The site assessment work plan includes: a summary of site setting; outline of how the site will be assessed including proposed sampling points for all media and identification of potential problems. Work plan attachments include: site visit checklist; city/county maps including parcel identification numbers, zoning classifications and current property use within 1000 feet of the site; Identification of property owners adjacent to the site and all properties where sampling is proposed; health and safety plan; cost estimates and level of effort worksheets including subcontractor quotes; and a proposed resource-loaded schedule for site assessment.

Prior to assessment work, the Florida Department of Health identifies and samples all potable wells within ¼ mile of the site and identifies public water supply wells within ½-mile of the site.

Conducting the Site Assessment – Most drycleaning sites are assessed using direct push technology with onsite analysis of samples utilizing Department-approved mobile laboratories. Based on analysis of the real-time data, the scope of work is adjusted in the field to delineate the contaminant plume and complete the assessment. Where feasible, small diameter monitor wells - "microwells" - are installed using direct-push technology. Utilization of direct push technology, mobile laboratories and microwells has been very effective in meeting the site assessment goals of minimizing the number of mobilizations, completing assessments in a timely manner, and minimizing the production of investigation-derived wastes.

Lithology Borings/Soil Sampling – At least one continuous lithology boring is conducted at a location away from the facility. Vertical groundwater sampling points are selected based on the lithologies encountered in these borings. The soil sampling strategy is to collect samples at known or suspected contaminant source areas – under the facility floor slab near the location/former location of the drycleaning machine, distillation unit, solvent and waste storage areas, near the service door, AST/UST locations, floor drains, sanitary sewer lateral, septic drainfield, etc.

Most soil samples are analyzed in an on-site mobile laboratory, utilizing a gas chromatograph or a gas chromatograph/mass spectrometer. At drycleaning sites where chlorinated drycleaning solvents are/were utilized, either a modified EPA Method 8021 or a modified Method 8260 is utilized (analyzing for PCE, TCE, cis 1,2-DCE, trans 1,2-DCE, 1,1-DCE, vinyl chloride, Freon 113 and BTEX compounds). Some sample splits are sent to a fixed laboratory for analysis. For sites that use or used petroleum drycleaning solvent, most soil samples are sent to a fixed laboratory and analyzed using EPA Method 8021, a TRPH method (FL-PRO) and EPA Method 8310.

Groundwater Sampling – Groundwater sampling is conducted using an “inside - out” strategy, working out from the contaminant source area(s) to define the contaminant plume to cleanup target levels. Given the shallow water tables generally encountered in Florida, it is common practice to collect groundwater samples at the water table from some of the soil borings in the contaminant source area utilizing temporary monitor wells. Small, tracked direct-push units are generally utilized inside the drycleaning facility to collect groundwater samples beneath the facility floor slab. The direct push unit is positioned as near as possible to contaminant source areas.

As stated earlier, most groundwater samples are collected by vertical profiling using direct-push technology including Geoprobe-type equipment, the Waterloo Profiler and cone penetrometers. The soil conductivity probe has been used to a limited extent during assessment work (particularly with cone penetrometers) to aid in choosing vertical sampling locations. Typically though, groundwater samples are collected at five or ten foot intervals, depending on the type of direct push equipment utilized. Rather intensive sampling is conducted in the contaminant source areas. This is the area where most of the contaminant mass generally resides and where remediation will occur, if warranted. Outside the contaminant source area, sampling points are spaced further apart, both laterally and vertically. The objective here is to define the limits of the contaminant plume. Direct-push groundwater samples are analyzed using the same analytical methods utilized for soils (above).

In areas where direct-push technology is not applicable, groundwater assessment work is sometimes conducted by installing and sampling conventional monitor wells utilizing hollow stem augers or mud rotary drilling. However, sonic drilling is increasingly utilized at drycleaning sites where direct-push technology cannot be used. Groundwater samples are collected at intervals utilizing an inflatable packer.

After the contaminant plume has been delineated, monitor wells are installed and sampled. The following field parameters are measured at the site: water levels, temperature, pH, conductivity, Redox, and dissolved oxygen. Groundwater samples are sent to a fixed laboratory for analysis. For chlorinated drycleaning solvent sites, EPA Method 8021 analysis is run on groundwater samples. For sites that use/used petroleum drycleaning solvent, a TRPH method (FL-PRO), EPA Method 8021 and Method 8310 analyses are run on groundwater samples. Unless direct push samples indicate that contaminant concentrations in groundwater are below cleanup target levels, groundwater samples from a limited number of monitor wells (typically an up gradient well, a well located in the contaminant source, and a well located in the plume downgradient of the source area) are analyzed for the following natural attenuation parameters: nitrates, nitrites, sulfates, sulfides, chlorides, total organic carbon, ferrous iron, total iron, methane, ethene and ethane.

In addition to these data, if remediation is warranted at a site, any additional data needed to design the remedial system is collected during site assessment, if feasible. This can include samples for oxidant demand studies, soil samples for geotechnical analysis (bulk density, fraction of organic carbon, porosity, etc.), additional water chemistry – etc.

Preparation of Site Assessment Report - Site Assessment Reports are prepared using a standardized format. All data is entered into an Access database. In addition to hard copies, the report is also submitted on a compact disc.

Illinois

The Illinois Drycleaner Environmental Response Trust Fund is an environment reimbursement program based on the Illinois Environmental Protection Agency (IEPA) Voluntary Site Remediation Program clean-up concept. Eligible applicants (drycleaner owners/operators) are reimbursed for eligible cleanup costs at both active and inactive facilities after meeting specific eligibility criteria. A key criterion is maintaining pollution liability insurance coverage after a date certain to pay for any future releases at the drycleaning facility. In addition, there are cost controls built into the system via bidding requirements and pre-approval of all work plans, except in emergency conditions, prior to reimbursement of assessment expenses. Responsible parties are encouraged to use the most cost effective and comprehensive approach to assess their site. They must follow specifically the site assessment guidelines contained in Section 740.420(b) of the Illinois Administrative Code. All site investigation and assessment activities are to be conducted by, or under the supervision of a licensed professional engineer.

A Phase I (completed in accordance with ASTM E 1527-00) and a Focused Phase II Site Investigation Report (FSIR) for drycleaning solvents must be completed at the facility and the results reviewed prior to being accepted into the Fund's remedial benefits program. A Phase I is required to identify any chemicals that may have been stored or used prior to the facility becoming a drycleaning plant. The focused Phase II site investigation is performed to identify if drycleaning solvent has contaminated the soil and groundwater. The Fund requires at least one cost proposal for this phase of work and reserves the right to request additional cost proposal if the proposal is inadequate. The cost proposal must include a description of the work to be performed including the number and location of the soil borings and monitoring wells to be installed during the site investigation. Once the Fund has reviewed the cost proposal, a letter of authorization is sent to the drycleaner owner/operator to commence the investigation. The drycleaner owner/operator is not required to select the lowest cost work plan but they must have the work performed at or below the Fund's pre-approved cost.

The intrusive investigations at most of the drycleaner sites use direct push technology. This drilling technology is sometimes limited based on space limitations and geological conditions. The Fund strongly encourages the environmental consultant to use field-screening techniques during the sampling process to optimize resource use during the site investigation.

<u>Location</u> - Of primary importance during the investigation is to locate the soil borings and monitor wells to identify the presence and extent of contamination. Historically, these locations have been in the immediate proximity of the drycleaning machine, floor drain, sanitary sewer lateral, back door of the facility, hazardous waste storage areas, and solvent storage area. The initial assessment guidelines are based on the age and size of the facility, if a groundwater usage Memorandum of Understanding (MOU) exists between the local government and the IEPA, and apparent housekeeping practices.

0-3 years	Phase I environmental investigation is acceptable without intrusive testing provided the facility was constructed on a virgin site, secondary containment exists around the drycleaning machine, hazardous waste and solvent storage areas. Compliance with federal and state regulations.
3-7 years	Three to five borings, one to two monitoring wells
7-13 years	Six to eight borings, three to four monitoring wells
> 13 years	Eight borings, four monitor wells

All soil and groundwater laboratory analyses shall be conducted using SW 846 methods for volatile organic compounds (VOCs using the USEPA SW 846 Method 8270B) analyte screen respectively. Soil samples obtained for the purpose of defining the degree and extent of the contamination can be either discreet and/or composite samples. Sampling intervals depend upon the topography, visual and olfactory indications, and PID reading in the field during the site investigation. The depth of soil borings typically ranges between 10 and 25 feet below ground surface. Based on IEPA requirements for site investigations, it is recommended that consultants collect soil samples for laboratory analysis use USSEPA Method 5035 methodology.

At sites where monitor wells are installed, the static water level measurements are typically rescored at the nearest 0.01-foot from either the top of casing or the ground surface and these locations are surveyed relative to a specific on-site datum. After the measurement and prior to obtain a groundwater sample, the monitoring wells are purged (3 to 5 volumes) to insure the collections of a fresh groundwater sample. The IEPA regulations require quality control and quality assurance procedures for samples collected for a site investigation.

Reporting – At the conclusion of fieldwork, the consultant develops the Phase I and the Phase II FSIR. If additional site investigation is needed, a request for the additional budget approval must be made. Once the horizontal and vertical extent of the contaminant plume has been defined, the consultant is required to develop a Remedial Objectives Report, which identifies possible technologies that can be used to effectively remediate the contamination or identifies institutional controls that could be implemented to obtain a No Further Remediation Letter (NFR) without active remediation. The completed FSIR and Remedial Objectives Reports (ROR) are submitted to the IEPA for their review. The next step is the preparation of a Remedial Action Plan (RAP), which presents a description of how the drycleaner site will receive a NFR letter.

Kansas

The Kansas Drycleaning Program is managed by the Kansas Department of Health & Environment's (KDHE) Bureau of Environmental Remediation. KDHE has an environmental consultant on contract that provides technical support and performs site assessment field work. KDHE project managers provide detailed guidance for all phases of the assessment activities. Funding limitations often determine the level of effort for each phase of the assessment activities. Therefore, the assessment activities can vary depending on the funding that is budgeted to each site. A site is given a preliminary priority ranking until the assessment is complete. When the assessment is completed, the site is re-ranked and the prioritization is re-evaluated for remediation consideration.

Program assessment goals:

- Identify all potential drycleaning sources;
- Evaluate potential non-drycleaning sources if co-mingled plumes are encountered;
- Conduct site assessment and source investigations to achieve the following:
    - Vertically and horizontally delineate soil and groundwater contamination, as well as identify impacts to surface water,
    - Identify domestic and public water supply wells within ¼ mile of the contaminant plume,
    - Collect preliminary information for remedial design alternatives, and
    - Determine long-term monitoring locations where applicable.

- Minimize investigation-derived wastes and waste disposal costs;
- Address alternative risk pathways, such as: physical contact, indoor air intrusion pathways; and
- Provide a detailed Expanded Site Assessment (ESA) report for the above-mentioned findings.

The typical assessment, with limited budget, addresses a site in phases based on the following factors:

1. Preliminary source area identification;
2. Plume delineation with ¼ mile spacing on plume definition probe lines;
3. Fill in delineation gaps for monitor well placement, if needed; and
4. Detailed source area investigation.

When plume are anticipated to extend several miles downgradient from the source area(s), the plume definition probe line spacing may extend up to ½ mile due to rapid groundwater flow. Less side-gradient dispersion is expected to occur with higher groundwater flow rates (>1 foot/day groundwater velocity). Data Gaps are filled in after the general plume delineation is completed.

Scope of Work Development – KDHE project managers are environmental geologists who prepare the scope of work for all site assessments. The KDHE project manager discusses the funding needs and budget with the Program Manager and then determines the level of assessment for the fiscal year. The project managers review all available data from the trust fund application, real estate assessment reports, and/or other state or federal program information (Kansas Pre-Remedial Program, EPA, etc.). The project manager also conducts a review of available information from nearby contaminated sites in other state programs (Storage Tank, State Cooperative and Voluntary Cleanup Programs) prior to developing the scope of work. A scope of work packet is prepared for the consultant that includes, but is not limited to a scope of work memo, site history, work order, existing reports and property owner contact names.

ESA Work Plan Development – Based on the information provided by KDHE in the scope of work packet, the KDHE consultant prepares a work plan including the Field Sampling Plan, Health & Safety Plan and a QA/QC Plan. The consultant will conduct site reconnaissance to collect information regarding site history and operations; facility waste management practices; location of utilities and identification of surrounding businesses. The ESA work plan includes: a summary of the site history, proposed assessment methods and procedures, additional information to be gathered during the site visit, timeline for implementation of the work plan and reporting requirements. Attachments include: maps that identify the site and potentially impacted property, and KDHE utility clearance checklists. The work plans include standard operating procedures (SOP) for all potential assessment technologies including, but not limited to direct push probing (soil, groundwater and conductivity); auger boring and monitoring well installation; passive soil gas collection; passive diffusion bag sampling; and domestic well, monitor well, and surface water sampling. If additional assessment activities are required, a work plan addendum is prepared that only identifies supplemental sampling locations.

Conducting the Site Assessment – Most sites are assessed using direct push technology with onsite sample analysis utilizing approved mobile field gas chromatographs or field laboratories. Based on analysis of the real-time data, the scope of work is adjusted in the field to delineate the contaminant plume and complete the assessment. KDHE project managers are in constant communication with the consultant's field geologist or project manager.

Small diameter monitor wells "microwells" are occasionally installed using direct push technology. When geologic conditions prevent the use of direct push technology, borings and monitor wells are the main method of contaminant plume delineation.

Utilization of mobile laboratories is instrumental to rapid delineation by minimizing the number of mobilizations, completing assessments in a timely manner, and minimizing the production of investigation-derived wastes.

Historical research of nearby sites generally provides geologic information that should be reviewed prior to initiation of assessment activities. Soil sampling or conductivity probes are often used to confirm the historical information. Soil and groundwater sampling depths are selected based on the lithologies identified for the site. Soil samples are typically collected from the following areas: beneath the facility floor slab near the location/former location of the drycleaning equipment and solvent and waste storage areas; outside the utility/service door; AST/UST locations; floor drains; sanitary sewer lateral; connections on main sanitary sewer lines; septic drainfield and dumpster locations.

Soil Gas Sampling – KDHE utilizes passive soil gas sampling and analysis techniques to assist in identification of "hot spots" in the source area. Passive soil gas collection nodules have been used at several sites and are placed above sewer lines and suspected spill locations such as dumpster storage areas and outside of back doors. This technology has been very successful at identifying sewer line leaks and spills/dumping locations. If "hot spots" are identified on a main sewer line, care must be taken to determine if the contaminant belongs to the drycleaning facility. Nodules must be placed above the sewer upgradient of the facility location to determine contaminant responsibility.

Soil Sampling – Most soil samples are analyzed in an on-site mobile laboratory, utilizing a gas chromatograph or a gas chromatograph/mass spectrometer. At drycleaning sites where chlorinated solvents were the drycleaning solvent, EPA Method 8260 is utilized to analyze for halogenated VOCs, such as PCE, TCE, cis 1,2-DC, trans 1,2-DCE, vinyl chloride and carbon tetrachloride. As of October 2002, KDHE has not addressed any petroleum drycleaning solvent-contaminated sites since these sites have ranked lower on the budgetary priority list. Samples collected at sites that used petroleum drycleaning solvent are field analyzed for BTEX constituents. Samples that are to be submitted to a fixed laboratory for petroleum analysis will be analyzed using EPA Method 8260 for halogenated and aromatic hydrocarbons, total petroleum hydrocarbons-gasoline range organics (TPH-GRO method OA-1), and total petroleum hydrocarbon-diesel range organics (TPH-DRO method OA-2). Twenty percent of all field samples are submitted for fixed laboratory analysis for QA/QC reasons per SOPs. Petroleum sites may have a higher submittal ratio due to the need for TPH analysis. Typically the confirmation samples are strategically selected based on importance of the sample location and/or field GC result.

Groundwater Sampling – Groundwater sampling is conducted starting with a preliminary assessment of the source area and working downgradient from the contaminant source area to define the contaminant plume. KDHE typically delineates the plume to approximately 20% of the EPA maximum contaminant level (MCL) or risk-based cleanup level. For example, a PCE plume, which has a MCL of 5 ug/L, is typically delineated to approximately 1 ug/L. Each of the degradation compounds are also delineated because natural attenuation or degradation due to the presence of other contamination (e.g. BTEX at a gas station) can result in larger plumes for the degradation compounds.

Groundwater samples are typically collected using direct-push technology. KDHE identifies the target aquifers and aquifer thickness. Groundwater samples are typically collected from two depths if the plume is less than 20 feet in thickness. Aquifers with 21 to 70 feet of saturated thickness have samples collected form three depths; aquifers > 70 feet of saturated thickness are evaluated on a case-by-case basis. Conductivity probes have been particularly useful in identifying the saturated thickness at sites with limited geologic information. Source area sampling will vary depending on the site characteristics. The objective is to define the limits of the contaminant plumes. Vertical sampling depths can also depend on the presence of geologic lenses that could restrict or enhance the movement of contaminants. Direct-push groundwater samples are analyzed by using the same analytical methods utilized for soils. Once again, 20% of all field samples are submitted for fixed laboratory analysis.

When geologic conditions prevent the use of direct push technology, groundwater assessment work is conducted by installing and sampling conventional monitor wells utilizing hollow stem augers or mud rotary drilling. These conditions include, but are not limited to: bedrock aquifers, presence of caliche layers, groundwater depths exceeding 100 feet, etc. Passive diffusion bags (PDBs) are often utilized to vertically delineate the aquifer in the screened portion of the monitoring well. This is helpful for aquifers with a thick water-bearing zone. The PDBs can also be used for long-term monitoring, which helps reduce the volume of purge water requiring treatment prior to disposal.

After the contaminant plume has been delineated, monitoring wells are installed and sampled. The monitoring well installation is often coordinated with remediation activities. The following field parameters are measured at the site: water levels, temperature, pH and conductivity. General groundwater parameters, including Redox, dissolved oxygen and other parameters needed for remediation design and consideration, are collected from target monitoring wells. On occasion the samples are collected from direct push probes during the assessment to provide information in a quicker manner.

If site remediation is warranted, any additional data needed to design the remedial system may be collected during site assessment, if feasible. This can include samples for oxidant demand studies, soil samples for geotechnical analysis (bulk density, fraction of organic carbon, porosity, etc.), additional water chemistry, etc.

Preparation of Expanded Site Assessment Report – Expanded Site Assessment reports are prepared using a standardized format. The report includes, but is not limited to the history of the site; scope of work; description of actual work completed; summary of information and data for all probes, monitor wells; geologic cross sections; groundwater flow maps; contaminant plume maps for each contaminant and aquifer depth; and boring logs. In addition to hard copies, the report is also requested in electronic format.

Minnesota

The Minnesota Drycleaner Environmental Response and Reimbursement Account (Drycleaner Fund) is a reimbursement program operated through oversight by the Minnesota Pollution Control Agency's (MPCA's) Voluntary Investigation and Cleanup (VIC) Program or the state's Superfund Program. Eligible applicants (former or current drycleaner owners or operators) are reimbursed for all of the costs of investigations and cleanups approved by VIC staff, with the exception of the first $10,000 deductible.

Minnesota's Drycleaner Fund allows drycleaners to use either the VIC Program or the state's Superfund Program. However, the MPCA strongly recommends that responsible parties go through the VIC Program.

Notably, to be reimbursed by the Drycleaner Fund, response actions must included cleanup activities. Sites where only investigation has been conducted are not eligible for reimbursement. If an investigation confirms the need for cleanup, then the investigation as well as the cleanup is eligible for reimbursement. In cases where a cleanup is not needed, investigation costs are not eligible for reimbursement.

The investigation and cleanup of drycleaner sites is approached in the same manner as any other site in the VIC program with similar contaminants. The VIC Program has developed guidance documents that outline the steps required to investigate and clean up a site or to document activities already underway. Pertinent guidance documents include: Phase I Investigation, Phase II Investigation Work Plan, Phase II Investigation Report, and Response Action Plan/Response Action Implementation. These guidance documents can be accessed on-line at http://www.pca.state.mn.us/cleanup/vic-guidedoc.html.

Additionally, the MPCA has developed guidance outlining a risk-based approach to decision making during site investigation and remedy selection under the VIC and Superfund Programs. This guidance can be found at http://www.pca.state.mn.us/cleanup/riskbasedoc.html. The MPCA's Risk-Based Site Evaluation Manual provides a tiered process for making decisions based on an evaluation of risks to human health and the environment.

For more detailed information regarding the Drycleaner Fund, including criteria which must be met for owners and/or operators of drycleaning facilities to receive reimbursement for investigation and cleanup expenses, please see the fact sheet located at http://www.pca.state.mn.us/cleanup/dryclean.html.

Oregon

The Oregon Dry Cleaners program is managed by the Environmental Cleanup and Tank Section within the Land Quality Division of the Oregon Department of Environmental Quality (ODEQ). Environmental assessments of drycleaners in the program are conducted utilizing both ODEQ equipment and staff, as well as private contractors retained by the ODEQ. Program assessment goals include:

- Performing site assessments in an efficient and timely manner with emphasis on minimizing the number of site mobilizations;
- Utilizing innovative approaches to minimize cost and maximize environmental protection;
- Minimizing investigation-derived wastes and waste disposal costs; and
- Streamlining reporting by emphasizing data summaries and concise writing.

Work Plan Development - The first phase of the assessment process is development and preparation of a work plan to be used to guide site assessment work. Development of the work plan includes reviewing existing information on the site, obtaining and reviewing available historical site use data, and a site visit. Historical information review includes accessing historical aerial photographs, Sanborn Fire Insurance maps, historical Polk reverse directories, and reviewing city planning files for the development history of the site. To the extent possible, the historical and current operators of the dry cleaning facility are interviewed to document past and present waste and chemical management practices and determine historical facility layouts. A beneficial land and water use survey is conducted to identify ground and surface water uses within approximately 1 mile of the site.

The site assessment work plan includes: a summary of the site setting; presentation of the historical site use information and waste management practices; summary of the beneficial land and water use survey; and a discussion of the approach, methods and procedures to be used to assess the site. Tabulations of previously collected site data and figures showing previous and proposed locations for soil and/or groundwater sampling are included to support the presentation of the approach and procedures for the assessment. Attachments include: selected historical aerial photographs: copies of pertinent supporting document (e.g., Polk directory files, maps from the city planning department, Sanborn Fire Insurance Maps); health and safety plan. If a contractor has been selected to do the field investigation, it will provide a separate Budget and Assumption Proposal for the work presented in the work plan.

Conducting the Site Assessment – Most drycleaning sites are assessed using direct push technology with onsite screening of soil and groundwater samples, and collection of soil and groundwater samples for analysis by an analytical laboratory. The results of the field screening can be used to adjust sampling locations to delineate the source area and contaminant plume. Small diameter (1 to 2-inch) monitoring wells are installed at selected locations using the direct-push technology equipment to provide a monitoring network for confirming the extent of the plume and tracking its migration. Utilization of direct push technology: field screening and small diameter wells has been very effective in meeting the site assessment goals of minimizing the number of mobilizations, completing assessments in a timely manner, and minimizing the production of investigation-derived wastes.

Lithology Borings/Soil Sampling – During development of the work plan, available files are reviewed to assess the lithology at and near the site, and identify the depth to groundwater and the water bearing zones in the site vicinity. The soil sampling strategy is to collect soil samples at known or suspected contaminant source areas – under the facility floor slab near the location/former location of the drycleaning machine, distillation unit, solvent and waste storage areas, near the service door, AST/UST locations, floor drains, sanitary sewer lateral, septic drainfield, etc. Results of the soil sample field screening are used to identify additional soil sampling locations to aid in delineating the source area. Selected soil samples are submitted to an analytical laboratory to confirm the field screening results and quantify the concentrations of the solvents in the samples. The selected sample analyses used are based on the solvents used at the drycleaner, and generally includes EPA Method 8260 for chlorinated hydrocarbons and/or NWTPH-HCID, NWTPH-G and/or NWTPH-DX for petroleum hydrocarbons (such as Stoddard Solvent).

Groundwater Sampling – The depth to first encountered groundwater in Oregon is often within 25 feet of ground surface. Therefore, a push probe rig is used to access the shallow groundwater. The push probe is used to both collect "grab" groundwater samples and install small diameter monitoring wells. The grab groundwater samples are collected from a 4-foot screened section of the probe. Prior to collection of the grab samples, groundwater is purged from the probe until it is visually clear and field parameters (temperature, conductance, and pH) are stabilized, to the extent feasible. The grab samples are field screened for the presence for VOCs an organic vapor analyzer (photoionization detector or equivalent). At selected locations, small diameter wells (1-inch diameter) are installed to allow future groundwater monitoring. The locations of the monitoring wells are selected based on the results of field screening of the grab samples, historical information on the direction of groundwater flow, and available information on the locations(s) of the source area(s) of the VOCs. Small direct-push units are generally utilized inside the drycleaning facility to collect grab samples beneath the facility, as near as possible to the possible source areas.

If the groundwater beneficial use survey indicates that deeper groundwater may be used for domestic or other purposes within the locality of the facility, deeper groundwater assessment will be conducted to evaluate the lateral and vertical extent of affected groundwater. The technology used to assess the deeper groundwater is dependent upon the specific site conditions, but may include hollow stem auger, mud rotary or air rotary drilling equipment. A vertical profile boring is located downgradient of the source area. The vertical profile boring consists of utilizing one of the three drilling methods listed above to advance the boring and collect groundwater samples every 5 or 10 feet (depending on the lithology) for field screening for the presence of VOCs. Additional downgradient assessment of the deeper groundwater is based on the results of the vertical profile and the depths that groundwater may be accessed for a beneficial use. The objective of the deeper assessment is to evaluate the potential that VOCs in the deeper groundwater are currently or could in the future reach the point where the deeper groundwater is accessed.

Groundwater samples collected from installed monitoring wells are sent to a fixed laboratory for analysis. Analyses for chlorinated solvents are completed using either EPA Method 8021 or EPA Method 8260. For sites that use/used petroleum drycleaning solvent, the groundwater samples are also analyzed by EPA Method 8310 for polynuclear aromatic hydrocarbons. During the initial groundwater sampling event, samples from a limited number of wells (typically an upgradient well, a well located in the contaminant source, a well located in the plume downgradient of the source area, and a well located downgradient of the contaminant plume) are analyzed for the following natural attenuation parameters: nitrates, nitrites, sulfates, sulfides, chlorides, total organic carbon, ferrous iron and total iron. Some of these parameters are measured in the field.

In addition to these data, if remediation is warranted at a site, any additional data needed to design the remedial system is collected during site assessment, if feasible. This can include samples for oxidant demand studies, soil samples for geotechnical analysis (bulk density, fraction of organic carbon, porosity, etc.

Preparation of Site Assessment Report – Site Assessment Reports are prepared using a standardized format. In addition to hard copies, the report (including text, tables and figures) is also submitted on a compact disc.

South Carolina

The Drycleaning Restoration Trust Fund is managed by the Federal and Drycleaning Remediation Section of the South Carolina Department of Health and Environmental Control. Private contractors perform site assessment work. The goals of the site investigation are to:

1. Determine sources of drycleaning contamination within the area of concern.
2. Define the vertical and horizontal extent of contamination.
3. Determine groundwater contamination.
4. Determine if human exposure to the contaminated media exists.
5. Establish groundwater flow direction.
6. Produce a Site Assessment Report
7. Keep IDW and Waste Disposal costs to a minimum.

Project Information Package – Before the actual assessment of a drycleaning site begins, the contractor is assigned the task of providing the Department with a Project Information Package - PIP. The PIP will include detailed cost estimates for all aspects of the investigation. All assumptions and calculations used for determining these cost estimates are made available to the Department. The cost estimate will include unit rates and an estimated number of units covering all time and materials associated with the requested investigation including the rate for disposal of solid and liquid IDW. The cost estimate will provide subtotals for the Work Plan, Health and Safety Plan, a general field investigation (including preparation time), the Site Assessment Report (SAR), and a

Feasibility Study. Subcontractors should be identified in the PIP for the Department's approval. The final budget is approved along with the Work Plan.

Work Plan Package – The Site Assessment Work Plan Package includes: a Site Summary Report, a Site Location Map, a Site Plan Map (proposed sample locations), the Site Assessment Approach Summary, the Work Plan, the Drycleaning Site Visit Checklist and the Health and Safety Plan. The Site Summary Report includes all relevant information gathered about the site during a file review and site recon. During the site recon a checklist is used to gather information on the history, operation, and waste management practices of the facility. A copy of this checklist is included in the package. Other information gathered during the recon includes the drainage pathways; location of utilities; description of the surrounding area commercial and/or residential and the identification of potential problems. The Approach Summary outlines how the site will be assessed including proposed sampling points for all media, analytical methods to be used, in-depth description of the sampling method, IDW management and disposal issues, and a description of the site assessment report and feasibility study. A site-specific Health and Safety Plan is drawn up and submitted with this package.

Conducting the Site Assessment – Most of the drycleaning sites in South Carolina are assessed using direct-push technology to delineate the lateral and vertical extent of the contamination. Utilizing a screening tool called Color-Tec (refer to the Assessment Technologies section of this paper) and confirmatory analytical data from 25-50% of the samples collected during the screening process, the scope of work is adjusted in the field to delineate the contaminant plume and complete the assessment. After this delineation, a monitoring well network is installed to verify that delineation of the contaminant plume is complete. This monitoring well network is also used to monitor migration and degradation of the plume. Utilization of direct push technology and on-site screening has been effective in meeting the site assessment goals of minimizing the number of mobilizations; completing assessments in a timely manner; and minimizing the production of investigation-derived wastes.

Lithology Borings/Soil Sampling – At least three (unless the site plume area is small) continuous lithology borings are conducted at locations in the vicinity of the plume to obtain, as clear a picture as possible of the geology of the site. The soil sampling strategy is to collect soil samples from locations that are exposed to direct contact. Sediment samples are collected from ditches or low-lying areas that may be impacted by runoff or drainage pipes from the drycleaner. If present, sediment samples are collected from the drycleaning facility sewer lateral.

Soil/Sediment Analyses – Soil and sediment samples are analyzed in a South Carolina (and preferably National Environmental Laboratory Accreditation Conference [NELAC] certified) laboratory. At all chlorinated-solvent and petroleum-solvent drycleaning sites, soil samples are analyzed using EPA Method 8260/5035 by gas chromatograph/mass spectrometer GC/MS using the SW-846 (1986) VOC target compound list. For sites that used petroleum drycleaning solvents, soil samples are also analyzed for EPA Method 8270C. When investigating petroleum-solvent drycleaning sites where a gasoline contribution is suspected, ethylene dibromide and methyl-tert butyl ether should be requested in addition to the standard SW-846 VOC compounds.

Groundwater Sampling – Groundwater sampling is conducted using an "inside-out" strategy working out from the contaminant source area to define the contaminant plume to cleanup target levels. The first groundwater sample collected in the source area is taken at the water table and then at 5-foot increments until two sampling intervals are non-detect for contaminants of concern. Because the depth to groundwater changes so drastically across the state, from very shallow in the coastal plain to fairly deep in the upstate mountainous area, information is gathered from existing wells in the vicinity of the site as well as from the soil borings to determine the location of the water table prior to sampling.

In order to define the extent of the groundwater contamination horizontally, a "step out" from the original boring at the source in all directions is necessary. Outside the contaminant source area, sampling points are spaced further apart, both laterally and vertically. The objective here is to define the limits of the contaminant plume. Direct-push groundwater samples are analyzed using the same analytical methods utilized for soils (above).

In areas where direct-push technology is not applicable, groundwater assessment work is sometimes conducted by installing and sampling conventional monitoring wells utilizing hollow stem augers or mud rotary drilling. However, sonic drilling is increasingly utilized at drycleaning sites where direct push technology cannot be used.

After the contaminant plume has been delineated, monitoring wells are installed and sampled. The following field parameters are measured at the site: water levels, temperature, pH, conductivity, turbidity and dissolved oxygen.

Surface Water Sampling – Any surface water that is present at or near the site is sampled for contamination. This includes drainage ditches, sewer lines (from the nearest man way coming from the drycleaner), creeks, rivers, ponds, wetlands, stormwater impoundments, etc.

Groundwater/Surface Water Analyses - Groundwater and surface water samples are analyzed in a South Carolina (and preferably NELAC-certified) laboratory. At all chlorinated-solvent and petroleum-solvent sites, groundwater samples are analyzed using EPA Method 8260B by GC/MS using the SW-846 (1986) VOC target compound list. For sites that used petroleum drycleaning solvents, soil samples should also be analyzed for EPA Method 8270C. When investigating petroleum solvent drycleaning sites where gasoline contribution is suspected, EDB and MTBE should be requested for analysis in addition to the standard SW-846 VOC compounds.

Unless direct push samples indicate that contaminant concentrations in groundwater are below cleanup target levels, groundwater samples from a limited number of monitoring wells (typically an up-gradient well, a well located in contaminant source area, and a well locate down-gradient of the contaminant plume) are analyzed for the following natural attenuation parameters: manganese, nitrates, nitrites, sulfates, sulfides, chlorides, total organic carbon, carbon dioxide, alkalinity, ferrous iron, total iron, Redox, methane, ethane, and ethene. Some of these parameters are measured in the field.

In addition, if remediation is warranted at a site, any additional data needed to design the remedial system is collected during site assessment, if feasible. This can include samples for oxidant demand studies, soil samples for geotechnical analysis (bulk density, fraction of organic carbon, porosity, etc.), additional water chemistry, etc.

<u>Preparation of Site Assessment Report –</u> After complete delineation (all bordering monitor wells are clean or contaminant concentrations are below 5 ug/l), a Site Assessment Report (SAR) is prepared and submitted for review. After the review period, comments and change requests are submitted to the contractor to finalize the report. When the comments regarding the SAR are submitted to the contractor, a feasibility study is commenced.

Tennessee

The Tennessee Department of Environment and Conservation, Division of Superfund, manages the Tennessee Drycleaner Environmental Response Program (DCERP), which is a reimbursement program. Drycleaner Approved Contractors (DCAC), selected by the facility or property owners sign a contract with the DCERP to conduct DCERP approved assessment work. The facility or property owner then submits a reimbursement request to the DCERP for approval and payment. The DCERP only pays for work that has been reviewed and approved by the Program prior to work being done. DCERP assessment goals are:

- Completion of assessments in a cost efficient and timely manner utilizing innovative technologies where possible;
- Minimization of investigation-derived wastes and associated disposal costs through the use of diffusion sampling bags and other minimally invasive sampling techniques;
- Ensuring that potential human health risks are evaluated during the assessment process and that follow-up actions addressing risk are taken, if warranted; and
- Determination of a site remedy – initiation of a remedial alternatives plan, monitoring plan or other action – based on site conditions.

Tennessee breaks its site assessment work down into three distinct phases, the Facility Inspection (FI), the Prioritization Investigation (PI) and the Solvent Impact Assessment (SIA).

Facility Inspection The facility inspection is used to determine fund eligibility for the facility and is the beginning of the environmental investigation process. It provides relevant information concerning the facility in order that proper decisions regarding eligibility and future site action can be made. The objectives of the FI are:

- Determine of the facility is registered and has paid all fees;
- Determine if the facility is in compliance with BMPs;
- Establish foundation information for future investigations;
- Provide information for determining facility eligibility for fund.

A facility inspection and review of records is conducted by the DCAC. This includes:

- Inspection of equipment for evidence of leaks;
- Inspection of solvent transfer and storage areas;
- Inspection of waste storage and disposal areas;
- Search for visible evidence of solvent releases;
- Employee interviews;
- General housekeeping evaluation;
- Review of BMPs;
- Review of proper labeling of drums and containers.

The potentially eligible party (PEP) must submit a Facility Inspection Report documenting the results of the inspection and records review.

Prioritization Investigation The purpose of the PI is to present analytical data and site information to establish the site's relative priority ranking for fund disbursement. The PI will also determine the need for additional inquiry or investigation. The PEP prepares and submits a work plan, cost proposal and schedule of work for completing the PI to the Department. The work plan and cost proposal is broken down into Task Group A (site history), and Task Group B (media investigation).

Task Group A provides a 50-year history of the property ownership, an operational history including historic and current operations conducted at the property for each occupant, and a regulatory history. A property inspection is necessary to determine the presence of various structures and features. Much of this information can be gathered
during the FI. The inspection should include descriptions of the following and reference sections of the FI report: location of property and surrounding land use, surface and structural features, ASTs and USTs, storage containers, waste disposal areas, septic systems, utilities, wells. In terms of the physical setting the following should be addressed: geologic setting, topographic setting and indentification of potential receptors. The following maps and drawings should be included in the report: property location map, building drawing, property map and media sampling maps.

Task Group B (media investigation) includes sampling media from select locations at the facility. The objective is to determine if media at the site are contaminated with solvents or solvent degradation products. In order to make a cost-effective determination, minimally invasive characterization methods are employed. The media sampled can include soil gas, surficial soil, sediment and/or surface water. The sampling locations should be selected based on their probability of being contaminated. Potential sampling techniques that can be utilized in the PI include: soil gas, direct push, hand auger, other methods as appropriate for specific site conditions. The Prioritization Investigation Report must be submitted to the Department upon conclusion of the PI.

Solvent Impact Assessment The purpose of the SIA is to characterize the extent and occurrence of contaminants and the site hydrogeology. If remedial action is necessary, the data needed to support the selection of a remedy should also be collected. The scope of the investigation is site-specific and the scope can be modified based on the data collected at the site.

The subsurface characterization includes determination of soil types and thickness, soil permeability, depth to groundwater, groundwater flow direction, hydraulic gradient, identifications of contaminants, and contaminant concentrations and distribution in soil and groundwater.

The SIA process includes development of a work plan, cost proposal and work schedule for conducting an assessment of contamination identified in the FI and PI. The work plan includes: a site map depicting pertinent site information, a map with proposed sampling and monitor well locations, a sampling and analysis plan which includes the rationale for sampling locations, monitoring well locations and screen intervals and a discussion of parameters to be investigated, a Quality Assurance Project Plan, and a site-specific Health and Safety Plan. The work schedule includes a proposed time frame for completion of each phase of the SIA and an estimated completion time from the date of notice to proceed.

Solvent Impact Assessment Report Preparation The SIA report is submitted to the Department upon completion of the SIA. A generalized format for the report is provided in the DCERP Guidance Document. Quite frequently, multiple SIA phases will be conducted in order to complete the site assessment. In such cases there may be sequential work plans and reports submitted to the DCERP.

Wisconsin

The Wisconsin Dry Cleaner Environmental Response Fund (DERF) is a reimbursement program based on a voluntary cleanup concept. Eligible applicants (dry cleaner owners or operators) are able to get reimbursed for eligible cleanup costs after surpassing certain milestones and obtaining departmental approval for their actions. In addition, there are cost controls build into the system via bidding requirements and review and approval of work plans prior to contracts being awarded.

Responsible parties are encouraged to use the most cost-effective approach to assess and clean up their site. In addition, they must follow the requirements contained in Chapter NR 716, Wisconsin Administrative Code (W.A.C.). Once the initial site investigation scoping activities have determined a release to the environment, a responsible party must seek three consultants to prepare work plans for a complete site investigation. Often these site investigations are organized to allow a phased approach to the investigation. A range of actions can be included in the work plan, depending on site conditions determined after field activities are initiated. Bids must include a description of work to be done, including management of investigation-derived waste and monitoring for compounds necessary to evaluate natural attenuation or enhanced natural attenuation as a remedy. Once the responsible party obtains three work plans, they must submit each work plan to the Department with an explanation of which one they want to select. Responsible parties are not required to select the lowest bid work plan; however, they do need to justify why they want to select one consultant over another. Responsible parties cannot proceed without DNR project manager approval of the consultant selected.

Most of the drycleaner sites are initially assessed using direct push technology, however, that technology can be limited based on geologic conditions. Some consultants use on-site laboratory analysis, some do not. Each site investigation strategy is unique to that site. Wisconsin does not have authority to direct the strategy used in investigations. The regulations do, however, require that the investigation needs to define the degree and extent of the contamination before the remedy can be selected. It is common practice to install a series of groundwater monitoring wells to assess groundwater conditions. Data from permanent wells are required for the agency to make regulatory decisions – temporary wells can be installed to better locate permanent wells and data from temporary wells is used for evaluating site conditions, in conjunction with data from permanent monitoring points.

All chemical analyses used for decision making at the site must be conducted by a laboratory certified by Ch. NR 149 W.A.C. for that category. Non-laboratory methods of sample analysis may be appropriate to supplement information derived from laboratory analysis of samples. Soil samples obtained for the purpose of defining the degree and extent of the contamination must be discrete and not composite samples. Static water level measurements are required to be recorded to the nearest 0.01 foot in each monitoring well prior to obtaining a sample. Responsible parties are also required to make a good faith effort to sample public or private water supply wells as part of a regular monitoring program if they are known or suspected to have been affected by the groundwater contamination from the drycleaner site. DNR regulations also require quality control and quality assurance procedures for samples collected for a site investigation.

At the conclusion of the fieldwork, the regulations require the development of a site investigation report. This report is required to contain such items as background information, methods of investigation, soil and groundwater monitoring results, visual aids, well and borehole documentation, and conclusions and recommendations.

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