TECHNICAL MEMORANDUM

NATURAL ATTENUATION AT THE ROSEN BROTHERS SUPERFUND SITE CORTLAND, NEW YORK

PRESENTED TO:

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ON BEHALF OF

THE ROSEN SITE CPRP GROUP

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This Technical Memorandum has been prepared concurrent with the Feasibility Study (FS) Report for the Rosen Site, and is based upon data presented in the Remedial Investigation (RI) Report (Blasland, Bouck & Lee, Inc. [BB&L]; May 1994) the Baseline Risk Assessment (RA) (BB&L; January 1995) for the Rosen Site, and results from the aquifer performance test and the ground water sampling conducted in 1995. This memorandum demonstrates that natural attenuation is occurring in the ground water system associated with the Rosen Site at rates that will reduce concentrations of constituents of interest to levels that do not pose a risk to human health in a suitable time frame. In addition, this Memorandum describes the feasibility of and costs associated with any ground water pumping and treating that could be conducted at the site.

Natural attenuation processes occur in all ground water sources and plumes and include physical processes such as dispersion, volatilization, and sorption; biological processes such as aerobic or anaerobic degradation; and chemical processes such as hydrolysis and dehydrohalogenation. The rates of natural attenuation depend on site specific conditions for the source(s); the vadose zone geology and geometry; the ground water chemistry, geology, and hydrogeology; the nature of the contaminants; and the distance from the source(s) to the point of compliance.

There are two significant organic ground water contamination plumes at the Rosen Site, and both plumes occur within the upper outwash hydrogeologic unit. One is a trichloroethene plume which originates upgradient of the Rosen Site and the other is a 1,1,1-trichloroethane plume which originates in the southwestern portion of the Rosen Site.

An evaluation of the RI data for the Rosen Site demonstrate that:

- Contaminant source depletion is occurring;
- The hydrogeologic setting is conducive to natural attenuation;
- Decreasing concentrations of dissolved organic constituents in ground water occur over time;
- There is no discernable plume of dissolved metals in the ground water due to the Rosen Site; and
- Biological degradation of chlorinated solvents is occurring.

The concentration of organic compounds in the shallow aquifer at the site is decreasing over time as a result of natural attenuation of the source areas (which include volatilization, hydrolysis and biodegradation) and hydrodynamic dispersion and biological degradation of the plumes. The rates of attenuation for the 1,1,1-trichloroethane and trichloroethene families have been calculated based upon site data collected during the RI using wells along the plume centerlines. The half lives of 1,1,1-trichloroethane and trichloroethene (respectively) range from 1.3 to 1.9 years and 0.5 to 1.7 years, which are supported by published literature.

Using the data for the wells located within the plumes and concentrations of trichloroethene and 1,1,1-trichloroethane as measured in March 1995, the levels of trichloroethene and 1,1,1-trichloroethane are projected to degrade to (or below) the New York State "standard" of 5 μg/L within approximately 5 to 10 years.

The only dissolved metal consistently detected above New York State "standards" at the Rosen Site is naturally occurring manganese, which does not show any statistically significant changes between upgradient, downgradient and off-site wells. The dissolved metals ground water data for the other metals do not indicate the presence of any dissolved metal ground water plumes, as these metals are not consistently detected.

Site data clearly demonstrate that inorganics are not of concern and that natural attenuation processes are actively occurring and are reducing the concentrations of volatile organic compounds (VOCs) in the ground water. A review of Records of Decisions (RODs) indicates that natural attenuation is an acceptable remedial alternative and that several sites are utilizing this approach. Natural attenuation will effectively reduce potential hypothetical risk to human health and the environment.

The acceleration of the biodegradation of constituents in the site ground water (should this prove desireable) through *in situ* injection of nutrients and possibly an electron donor into the outwash aquifer is currently being evaluated. The only other viable remedial alternative for the site is the pumping and treating of ground water. While the duration of pump and treat has not been determined at this time, it would likely continue for at least 5 years based on experience at other sites (USEPA, 1992). A pump and treat remedial alternative for the Rosen Site would result in the extraction and treatment of a minimum of 4 billion gallons of water, and produce approximately 6,500 cubic yards of sludge per year, requiring dewatering, treatment and landfilling. Furthermore, the discharge options available to the Site place severe additional constraints on this remedy (i.e., construction of a dedicated sewer or flood management) such that the only feasible option for discharge to treated groundwater would be a dedicated pipeline to the Tioughnioga River. The present value cost of the pump and treat alternative (exclusive of sludge disposal costs) is approximately, $18 million, compared to the present value cost of $0.7 million for natural attenuation.

1.0 INTRODUCTION AND SITE HISTORY

The objective of this Technical Memorandum is to summarize the facts related to the soil and ground water contamination at the Rosen Brothers Scrap Yard Superfund Site (the "Rosen Site") located in Cortland, New York, in order to evaluate the suitability of natural attenuation as a remedial alternative.

This Technical Memorandum has been prepared concurrent with the Feasibility Study (FS) Report for the Rosen Site. The Technical Memorandum is based upon data presented in the Remedial Investigation (RI) Report (Blasland, Bouck & Lee, Inc. [BB&L]; May 1994) and the Baseline Risk Assessment (RA) (BB&L; January 1995) for the Rosen Site. Results from the aquifer performance test conducted in January 1995 and the ground water sampling event conducted in March 1995, were also utilized.

This memorandum demonstrates that natural attenuation is occurring in the ground water system associated with the Rosen Site at rates that will reduce concentrations of constituents of interest to levels that do not pose a risk to human health in a suitable time frame. This memorandum includes a theoretical discussion of plume development and transport in addition to natural attenuation processes, including physical, chemical, and biological processes (in Section 2), followed by a discussion of the elements at the Rosen Site conducive to natural attenuation achieving ground water Remedial Action Objectives (RAOs) in Section 3. This section includes discussion of demonstrated source depletion, appropriate hydrogeologic setting, decreasing concentrations of organic and inorganic constituents in ground water, background concentrations of dissolved manganese, and evidence of biological components of natural attenuation, the sum of which results in the reduction of site contamination and thus reduction of risk. Utilizing both natural attenuation theory and site-specific considerations, the time frames for natural attenuation processes to achieve ground water RAOs are then estimated in Section 4. Natural attenuation is compared to previously identified remedial alternatives in Section 5, and conclusions are presented in Section 6.

1.1 SITE HISTORY

Until 1902, vacant land known as "Randall's vacant fields" occupied the Rosen Site area. In 1902, a brick foundry occupied a portion of the site. From 1908 until 1971, Wickwire Brothers, Inc. Wire Mill (Wickwire) manufactured wire, insect screen, industrial-type screens, poultry netting, and nails at the site.

From 1971 to 1980, Philip and Harvey Rosen (the Rosen Brothers) ran a scrap processing operation at a portion of the Wickwire site shortly after Wickwire closed. Operations at the Rosen Site consisted mainly of crushing and recycling cars. Demolition debris and other waste materials from the site operations were reportedly disposed of in the former Wickwire cooling pond. In addition to salvaging scrap metal, the Rosen Brothers also reportedly disposed of municipal and industrial waste on the Rosen Site.

In 1986, New York State Department of Environmental Conservation (NYSDEC) conducted a Phase II Investigation at the Rosen Site. From July to November 1987, the U.S. Environmental Protection Agency (USEPA) completed a response action at the site that included sampling, securing, and temporary staging of drums, tanks, cylinders, capacitors, and visibly contaminated soil. In addition, the USEPA installed fencing around the site where existing fencing was absent. In early 1990, a Potentially Responsible Party (PRP) Group completed the removal and proper disposal of the materials previously staged by the USEPA. This group also upgraded a section of fence along the northern and western perimeter of the site to secure the site.

Overhead Door Corporation, Monarch Machine Tool Company, and Niagara Mohawk Power Corporation (in accordance with an Administrative Order of Consent), along with Cooper Industries, Inc., Keystone Consolidated Industries, Inc., and Potter Paint Company, Inc. (in compliance with the terms of a Unilateral Administrative Order), conducted a Remedial Investigation/Feasibility Study (RI/FS) beginning in 1991.

1.2 *SURROUNDING LAND USES*

The Rosen Site occupies approximately 20 acres on the southern side of the City of Cortland, Cortland County, New York. The site is bordered on the north, east, and south by Perplexity Creek and its tributary, and by a shallow swale on the west.

A former City of Cortland dump site is located immediately to the south (upgradient) of the site. To the north of the site (downgradient) are railroad tracks associated with the former Lehigh Valley Railroad, and several industries. The eastern boundary of the site borders a parking lot of the former Kirby Company and Pendleton Street. To the west of the site is a vacant lot and several industries.

Perplexity Creek and its tributary flow into a storm water catch basin near the northeast corner of the site. From this catch basin, the creek flows through an underground culvert that ends south of the City of Cortland Department of Public Works facilities. Upon emerging from the culvert, the creek flows into an open channel and then discharges into the Tioughnioga River, approximately 1.25 miles from the Site. The 100-year flood plain of the Tioughnioga River lies approximately one mile north and east of the Rosen Site.

The City of Cortland is located on glaciofluvial deposits at the intersection of five valleys. The ground water within these unconsolidated glacial sand and gravel deposits comprise the 25-square mile Cortland-Homer-Preble Aquifer System. In this aquifer system, ground water flows from the edges of the valley toward the center part of the valley, where it then flows northeast to east. Subsequently, most of the ground water then discharges into the Tioughnioga River. This aquifer system was designated by the USEPA as a sole-source aquifer in June 1988 and by the NYSDEC as a primary aquifer. However, municipal ground water supply wells for the City of Cortland and the town of Cortlandville are hydraulically upgradient of the Rosen Site and therefore are not impacted by the Rosen Site. Furthermore, there are no known potable ground water users utilizing the upper outwash hydraulically downgradient of the Site. Future ground water use hydraulically downgradient of the Site is highly unlikely given the availability of the municipal water supply and the Cortland County regulations controlling well installation.

2.0 THEORETICAL BASIS FOR NATURAL ATTENUATION

This section sets forth a review of the natural attenuation processes and its application to historically impacted sites. The following discussion includes source/release mechanisms; contaminant movement within ground water; and the physical, chemical, and biological processes of natural attenuation.

2.1 PLUME DEVELOPMENT

Salvage, recycling and waste disposal operations, such as those conducted at the Rosen facility result in uncontrolled (and unregulated) releases of hazardous substances/constituents. Depending upon the site specific geology and hydrogeology, those releases may result in ground water contamination, due to direct infiltration of the hazardous substances/constituents from the soil, or due to leaching of the hazardous substances/constituents from the soil in dissolved form by percolation of rainfall, snow melt, surface water run-on, storm water, etc. If the mass of hazardous substances/constituents leaching to ground water is sufficient, a ground water plume (i.e., a continuous zone of detectable constituents dissolved in ground water) may be created. The soil or surficial material that contains the hazardous substances/constituents being transported to the ground water is generally referred to as a "source" or “source area”.

2.2 PLUME MIGRATION

For a given source, the movement of constituents within ground water is described by the advection-dispersion equation, which for two dimensional flow can be expressed as:

$$\frac{\partial C}{\partial t} = D_L \frac{\partial^2 C}{\partial x^2} + D_T \frac{\partial^2 C}{\partial y^2} - v_x \frac{\partial C}{\partial x}$$

(Fetter, 1993, eqn. 2.19)

where:

- $\partial C/\partial t$ = the change in ground water constituent concentration over time,
- D_L, D_T = the longitudinal and transverse dispersivity of the aquifer,

- $\partial C/\partial x$, $\partial C/\partial y$ = the spatial changes in ground water constituent concentration, and

- v_x = the ground water velocity in the x direction.

When a continuous and uniform source is present, the concentration at any point in time can be predicted by:

$$C(x, y, t) = \frac{C_o Q}{4\pi(D_L D_T)^{1/2}} \exp\left(\frac{v_x x}{2D_L}\right) [W(0, B) - W(t, B)]$$

(Fetter, 1993, eqn. 2.31)

where:

- $C(x,y,t)$ = Concentration at point x,y at time t

- C_o = Concentration at time 0.

- Q = rate at which a constituent of concentration C_o is being introduced

- $B = [\frac{(v_x x)^2}{4D_L^2} + \frac{(v_x y)^2}{4D_L D_T}]^{1/2}$

and

- W[t,B] = a function derived by Hantush known as the leaky well function.

and will reach steady state as shown by:

$$C(x, y) = \left(\frac{C_o Q}{2\pi(D_L D_T)^{1/2}}\right) \exp\left(\frac{v_x x}{2D_L D_T}\right) K_o \left[\left(\frac{v_x^2}{4D_L}\left(\frac{x^2}{D_L} + \frac{y^2}{D_T}\right)\right)^{1/2}\right]$$

(Bear, 1972, eqn. 10.6.39)

where:

- K_O = the modified Bessel function of the second kind and zero order

This change in concentration at any point in time in the plume (relative to its steady state level) is shown in Figure 1 and the isopleths (lines of equal constituent concentration in ground water) at steady state are shown in Figure 2. These equations may be readily modified to include decay or degradation and retardation by the addition of two variables. The form of the solutions will not change, but the concentration at a given point and time of a constituent, subject to retardation or decay, will be less than or equal to the concentration predicted by these equations for a constant mass without retardation.

2.3 *NATURAL ATTENUATION PROCESSES*

Natural attenuation processes include physical processes such as dispersion, volatilization, and sorption; biological processes such as aerobic or anaerobic degradation; and chemical processes such as hydrolysis and dehydrohalogenation.

2.4 *ATTENUATION OF PLUME*

In the plume development phase, the rate of constituent contribution is greater than the rate of natural attenuation processes resulting in the net growth of the plume over time. In the steady state plume phase, the rate of constituent contribution is balanced with the rate of natural attenuation processes, resulting in a plume with generally similar concentrations in space and time. Although the constituent concentration in the aquifer will be lower at greater distances from the source, the concentrations will increase to some steady state value and remain at that level until the source is sufficiently depleted by physicochemical and biological mechanisms.

In the plume depletion phase, the rate of constituent contribution is less than the rate of natural attenuation, resulting in a shrinking plume over time. The rate of constituent contribution is due to source depletion by various attenuation processes.

Regardless of the type and magnitude of source depletion mechanisms, the overall impact on the plume will be to eventually reduce the ground water concentrations with time. The effect of source depletion is illustrated on Figure 3.

Figure 3 also shows the changes in ground water concentration when the source depletion processes have removed all leachable material (source extinction). The source extinction phase can be marked by rapidly accelerating decreases of constituent concentrations in ground water. To the extent that a plume has both major and minor sources, the extinction of the major source may still leave some concentrations in ground water due to the minor source(s) or due to slow leaching of residuals associated with the major source. In some cases, usually further downgradient from the source, the plume depletion phase occurs before steady state is achieved as illustrated in Figure 4. Steady state concentrations of constituents will not be observed at these locations.

2.5 APPLICATION OF NATURAL ATTENUATION THEORY

Natural attenuation processes occur in all ground water sources and plumes. The rates of natural attenuation depend on site specific conditions for the source(s), the vadose zone geology and geometry, the ground water chemistry geology and hydrogeology, the nature of the contaminants, and the distance from the source(s) to the point of compliance.

When plumes similar to that shown in Figure 2 are observed, some portion of the aquifer may be above chemical specific limits and/or health risk-based criteria. That portion of the plume above chemical specific limits and/or risk based criteria and beyond the point of compliance (such as the property line) that poses a potentially unacceptable risk represents a zone of unacceptable concentration.

If the ground water concentrations at the point of compliance are greater than the chemical specific and/or health risk-based criteria, then the rate of natural attenuation will determine the compliance time (i.e., the time required for the ground water constituent concentration to be reduced below chemical specific limits and/or health risk-based criteria). If the ground water source, or at least the major source area, is in the plume depletion phase, then that portion of the plume that represents a potential risk to human health or the environment will diminish in size over time. If available data demonstrate that the plume is declining in concentrations due to natural attenuation processes, then an estimate of the compliance time can be made and compared to the time required for implementation of other FS alternatives.

Active remediation should only be necessary if natural attenuation is unable to reduce concentrations to acceptable levels or the time required to do so is not acceptable. An upper bound estimate of the duration of natural attenuation can be made by plotting the concentration of ground water constituents at the center line of the plume (which is the highest concentration in the plume) and extropolating the length of time required before the concentration at that location is below the limits. The compliance time can also be more accurately estimated by plotting the data in a logarithmic form such as shown in Figure 6. The time to achieve remediation utilizing natural attenuation can then be evaluated compared with other FS alternatives.

3.0 OVERVIEW OF ROSEN SITE DATA

This section describes the Rosen data that are relevant to evaluating the natural attenuation remedial alternative. These data demonstrate that:

- Source depletion is occurring;
- The hydrogeologic setting is conducive to natural attenuation;
- Decreasing concentrations of dissolved organic constituents in ground water occur over time;
- There is no discernable plume of dissolved metals in the ground water due to the Rosen Site; and
- Biological degradation of chlorinated solvents is occurring.

3.1 SOURCE DEPLETION

Hazardous substances/constituents associated with miscellaneous drums, cylinders, contaminated soils, etc. were removed from the Rosen Site in 1990. In addition to these sources (since removed), the salvage, recycling, and waste disposal operations at the Site resulted in releases of hazardous substances/constituents at the site. Based on the RI, the existing sources (the alleged drum disposal pits which were not observed during the RI and generally only low levels of constituents in the soil/fill) do not contribute significantly to ground water. Further, although a more significant source area of 1,1,1-trichloroethane was historically present in the area of the former cooling pond, this source has since diminished significantly. A plot using the well W-06 data (Figures 5 and 6) indicates that the plume near well W-06 has significantly reduced in magnitude, signaling (at a minimum) source depletion and likely source extinction.

3.2 HYDROGEOLOGICAL SETTING DATA

The surficial ground water system at the Rosen Site is comprised of an upper outwash, a collapsed kame terrace, and a lower sand and gravel hydrogeologic unit in the southern portion of the site. Near the northern perimeter of the site, the upper outwash and lower sand and gravel units become separated by a lacustrine unit and form two distinct hydrogeologic units. The upper outwash hydrogeologic unit, ranging from 39 to 45 feet in thickness, is the primary unit for constituent migration from the Rosen site.

Horizontal ground water flow in the upper outwash moves towards the north and northeast. Horizontal ground water flow is approximately two orders-of-magnitude greater than the downward vertical flow within the upper outwash unit. The flow of ground water from the Rosen Site is away from the water supply wells serving the cities of Cortland and Cortlandville (located over a mile upgradient).

Aquifer performance tests (APTs) were conducted during the RI and post-RI investigations to determine the aquifer characteristics at the Rosen Site. The mean hydraulic conductivity of the upper outwash hydrogeologic unit calculated from the results of the post-RI APT was approximately 10 times higher than the mean hydraulic conductivity calculated from the slug tests conducted during the RI. The hydraulic conductivity values calculated from the post-RI APT (the pump test) were 150 to 350 feet/day with a geometric mean of 220 feet/day. These values are representative of the hydraulic characteristics of the upper outwash. In general, on-site horizontal hydraulic gradients ranged from 0.01 to 0.018 ft/ft. Based upon these ground water gradients, the geometric mean hydraulic conductivities and a porosity of 0.25, the horizontal ground water velocity within the upper outwash ranges from approximately 9 to 16 feet per day using the equation:

$$v = \frac{Ki}{n_e}$$

(Freeze and Cherry, 1979, eqn. 2.82)

where:

- v = average linear ground water velocity (ft/day)
- K = horizontal hydraulic conductivity (ft/day)
- i = horizontal gradient (ft/ft)
- n_e = effective porosity

3.3 *ORGANIC DATA*

There are two significant organic ground water contamination plumes at the Rosen Site and both occur within the upper outwash hydrogeoligic unit. One is a trichloroethene (TCE) plume which originates upgradient of the Rosen Site and the other is a 1,1,1-trichloroethane (TCA) plume which originates in the southwestern portion of the Rosen Site. Volatile organics have not been detected in the lacustrine unit nor the lower sand and gravel unit, indicating that the lacustrine unit acts to confine the migration of chemical constituents to the upper outwash hydrogeologic unit. The 1,1,1-trichloroethane and trichloroethene plumes are shown on Figure 7.

Table 1 summarizes the most recent ground water sampling results (March 1995) for volatile organic compounds (VOCs) compared to Maximum Contaminant Levels (MCLs) and New York State Ground Water standards. During the 1995 sampling event, only three VOCs (tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane) and two trichloroethene degradation products (1,1-dichloroethene and vinyl chloride) were detected above the MCLs. (Tetrachloroethene was detected above the MCL at only one well, W-03, and does not represent a significant ground water issue). The highest concentration of trichloroethene and its degradation product vinyl chloride were detected at the hydraulically upgradient well W-24, which is between the former City of Cortland dump and the Rosen Site. Trichloroethene was also detected above the MCL at three wells hydraulically downgradient of the site (W-12, W-17, and W-18). 1,1-Dichloroethene was detected at three downgradient wells, W-11, W-19, and W-26, at concentrations at or just above the MCL. 1,1,1-Trichloroethane was detected at or slightly above the MCL at two downgradient wells, W-19 and W-25.

The areas where ground water exceeds MCLs or New York State standards for the most prominent VOCs at the Rosen Site (trichloroethene, 1,1,1-trichloroethane and tetrachloroethene) are shown on Figure 8.

New York State ground water standards are essentially equal to MCLs for trichloroethene, tetrachloroethene, 1,1-dichloroethene, and vinyl chloride. However, the New York State standards (which are not based on health risks) are lower than the MCLs (which are based on health risk) for 1,1,1-trichloroethane, 1,1-dichloroethane, and 1,2-dichloroethene. As a result, 1,1,1-trichloroethane and 1,1-dichloroethane exceed the New York State standards in most of the monitoring wells located at or hydraulically downgradient of the site. Concentrations of cis-1,2-dichloroethene in ground water exceed the New York State standard at well W-24 (hydraulically upgradient) and at well W-18 (hydraulically downgradient).

The remaining organic compounds have been detected sporadically and clearly originate from small localized source areas (e.g., drums previously removed or small areas of waste materials in the site fill) at the Rosen Site, or from the City of Cortland former dump. For example, the polychlorinated biphenyl (PCB) Aroclor 1254 detections at well W-07 in 1991, 1992, and 1995 can be correlated with PCBs detected in the soil immediately adjacent to this well. However, PCBs were not detected in any other on-site or off-site wells indicating a localized source area and no migration of these constituents. These sporadically detected constituents are also subject to natural attenuation.

3.4 INORGANIC DATA

Table 2 shows the 1995 inorganic data compared to the MCLs and New York State standards. Most inorganics were detected below the method detection limits. Analytical results indicate that (as expected) most metals were detected in the non-filtered ground water samples and not in the filtered ground water samples (using 0.45 micron filters) as shown on Table 2. Metals in unfiltered ground water samples consist of suspended particulates, colloids, and dissolved metals while the metals present in the filtered samples consist entirely of dissolved metals and small (less than 0.45 micron) colloids. Recent studies have shown that the concentration of particulates in a ground water sample is often related to the sampling technique and not the amount of mobile colloids present (Backhus *et al.*, 1993). Recent research has also shown that only dissolved metals and some inorganic colloids (less than 0.1 micron) are transported to any significant degree in ground water (Hahn, 1995; Puls and Powell, 1992; and Buddemeier and Hunt, 1988). These inorganic colloids with significant transport potential easily pass through standard 0.45 micron ground water filters (Buddemeier and Hunt, 1988). USEPA (1991) also indicates that all contaminant-mobility estimates based on unfiltered ground water samples are biased towards overestimation. Others studies indicate that only the filtered results provide consistent and reliable data about inorganic ground water plumes (Watts, 1987). Thus, only the filtered results are considered to be useful in evaluating the inorganic data from the Rosen Site.

The majority of the concentrations of dissolved metals exceeding federal MCLs were detected in samples from wells hydraulically upgradient of the site (between the Rosen Site and the City of Cortland former municipal dump) and/or off-site downgradient of the Rosen Site. The most commonly detected dissolved metal was manganese, which was consistently detected in all upgradient wells (W-23, W-24, W-21, W-22 and temporary wells) during the sampling events completed in 1992 and 1995. Dissolved manganese was also detected at hydraulically downgradient wells, at levels comparable to those of the upgradient wells.

When evaluating the dissolved manganese detected in ground water with respect to location, the data can best be analyzed when placed in three sub-sets: wells south (upgradient) of the site (TW-1, TW-2, TW-3, W-04, W-21, W-22, W-23, W-24); wells along the (downgradient) northern boundary of the site (W-01, W-02, W-07, W-08, W-10, W-11, W-12, W-25, and W-26); and wells off-site (downgradient) to the north (W-16, W-17, W-18, and W-19). At two wells (W-25 and W-26), the concentration of manganese in ground water sample results indicated that dissolved concentration of manganese were greater than total concentrations. This is physically unrealistic, as the dissolved concentration is inherently less than (or at least, equal to) the total concentration. In these cases, the totals result was also used as the dissolved metals concentration. Because organic constituents, which can be more easily transported in ground water than inorganic constituents, are not present in the lower unit, the inorganic constituents detected in the lower sand and gravel unit are considered to be naturally occurring and are therefore, not considered in this analysis. The locations of dissolved manganese exceeding the New York State standard is shown in Figure 9.

Oxidation/reduction (redox) potential measurements were taken at most monitoring wells during the March 1995 ground water sampling event. Redox potentials were measured over time during monitoring well purging prior to sampling. The average redox values observed range from -10 to 250 millivolts (mv), indicating reduced conditions site wide. The lowest averaged redox values were observed at wells W-25 and W-26 (at 80 and -10 mv, respectively) which indicates that the reduced conditions cause manganese to be present in the more soluble 2^{+} valence state. Thus, naturally occurring manganese, is reduced and mobilized as a dissolved species in the ground water (Hem, 1986).

The Student's *t*-test (Davis, 1986) is used to judge the significance of deviations in sample data based on the *t* probability distribution. In this particular case, Student's *t*-test was performed using Quattro Pro (Novell, Inc., 1994) for each of the three well groupings defined above to determine if the mean concentrations of dissolved manganese are statistically different. (The difference in the standard deviation for each sample population is accounted for in the analysis.) The *t*-test analyses are shown on Table 3 . The results of the *t*-test indicate that the means of dissolved manganese in ground water do not vary significantly from upgradient to downgradient or to downgradient off-site. Therefore, there is not a distinct plume of dissolved manganese at the Rosen Site or attributable to the Rosen Site and there is not statistically discernible site related impact.

3.5 *POTENTIAL RISK ASSOCIATED WITH GROUND WATER*

The Baseline RA (BB&L, 1995a) indicated that there are no unacceptable potential risks with the current use scenario for the site. The hypothetical future scenarios involving potential risk associated with ground water included ingestion of, dermal contact with, and inhalation of constituents from the upper outwash ground water by future residents and/or commercial/industrial workers rather than residential. Given the history of the site, surrounding land use and zoning, the expected future use for the site is commercial/industrial. For this scenario, potentially unacceptable risk associated with hypothetical exposure to ground water is primarily attributable to arsenic, manganese, Aroclor 1254, and tetracholorethene (BB&L, 1995a). These compounds have been shown (for the hypothetical future use scenario) to contribute to a hazard index greater than one and/or lifetime carcinogenic risks greater than $1x10^{-4}$.

The areas contributing to risk are limited and sporadic, and have significantly decreased in concentration since the data used in the RA (BB&L, 1995a) calculations were collected. For example, the risk for PCBs ($6x10^{-4}$) was calculated from the RI data where PCBs were detected in only one well which had only one detection (W-07), rate a highest concentration of 11 µg/l in 1991. The PCB concentration at the same sample location decreased to 4.7 µg/l in 1992 and to 0.9 µg/l in 1995 (which would reduce the risk associated with PCBs to less than $1x10^{-4}$ if only the latest dataset were considered). PCBs were not detected in the filtered samples in 1995. Furthermore, dissolved arsenic was not detected in the 1995 sampling event and thus poses no additional risk. Therefore, the site risks should be recalculated for the hypothetical future use scenario in light of the most recent data.

When evaluating the 1995 organic ground water data, the MCLs have been exceeded only for 1,1-dichloroethene (W-11, W-19 and W-26); tetrachloroethene (W-03), trichloroethene (W-12, W-17, W-18 and W-24), vinyl chloride (W-24) and 1,1,1-trichloroethane (W-06, W-19 and W-25). Ground water data for inorganics analyzed in 1995 indicate that New York State standards were exceeded only for manganese (in the dissolved form) at wells W-11, W-12, W-18, W-19, W-20, W-24, W-25, and W-26.

4.0 DATA TRENDS AND INTERPRETATION

This section presents an evaluation of natural attenuation as a viable remedial alternative to reduce the organic constituents of interest to levels that do not pose a potentially unacceptable risk to human health. Specifically, the spatial and temporal variations of ground water constituent concentrations were examined in order to evaluate the progress of the ongoing natural attenuation.

4.1 ORGANICS

The concentration of organic compounds in the shallow aquifer at the site are decreasing over time as a result of natural attenuation of the source areas (which include volatilization, hydrolysis and biodegradation) and hydrodynamic dispersion and biological degradation of the plumes.

4.1.1 *Evidence of Natural Attenuation*

The decrease of the 1,1,1-trichloroethane, and trichloroethene "families" can be seen in Figures 10 and 11 showing concentrations detected in 1992 and 1995. These trends demonstrate that natural attenuation of the VOCs sources is occurring at the site. In addition to the families as a whole, the concentrations of trichloroethene and its primary degradation products (1,2-dichloroethene) in ground water have decreased between February 1992 and March 1995. The concentrations of 1,1,1-trichloroethane and its primary degradation product (1,1-dichloroethane) in ground water at the site and at most of the hydraulically downgradient locations have also decreased since May 1991. The most significant decreases in concentration were observed at well W-06. The concentrations of 1,1,1-trichloroethane and 1,1-dichloroethane in ground water samples from well W-06 decreased from 3,400 to 110 µg/L and 430 to 23 µg/L, respectively, from May 1991 to March 1995.

4.1.2 *Evidence of Biodegradation*

Trichloroethene and 1,1,1-trichloroethane in ground water at the Rosen Site are biodegrading. Biodegradation is confirmed and quantified by the presence and relative distribution of the degradation products (daughter products) to the parent compound. The biodegradation of 1,1,1-trichloroethane under anaerobic conditions results in the formation of a 1,1-dichloroethane and chloroethane (McCarty *et al.*, 1992) which has occurred at the Rosen Site. Similarly, the anerobic biodegradation of trichloroethene results in the formation of 1,2-dichloroethene, 1,1-dichloroethene, and vinyl chloride (McCarty et al., 1992). These degradation products have been identified in the ground water in several of the wells at the Rosen Site. The speciation data (the relative distribution of parent to daughter products) from these wells are fairly consistent as shown in Table 4. The reduction in the percent 1,1,1-trichloroethane from W-06 to W-19 provides an estimate of the biodegradation/attenuation rate for 1,1,1-trichloroethane in the plume. Biodegradation acts with other biological and physical processes to increase the rate of natural attenuation.

4.1.3 *Rate of Natural Attenuation*

The rates of attenuation for the 1,1,1-trichloroethane and trichloroethene families have been calculated based upon historical site data. 1,1,1-Trichloroethane attenuation was calculated using data from wells W-06, W-11, and W-19 (the wells along the centerline of the plume). Trichloroethene attenuation was calculated using data from wells W-06, W-18, and W-24. The data trends can be evaluated using a first order linear decay rate (Herremeous, 1976) as follows:

$$(C_1/C_2) = exp\ (K\Delta t)$$

where:

- C_1 = concentration (µg/L) at time 1;
- C_2 = concentration (µg/L) at time 2;
- K = first order rate constant (1/day); and
- Δt = the time between sampling events 1 and 2.

Using this equation, the half lives of 1,1,1-trichloroethane and trichloroethene (respectively) range from 1.3 to 1.9 years and 0.5 to 1.7 years (Table 5). These ranges are supported by published literature (Howard *et al.*, 1991) which quantify half lives in the range of 0.5 to 1.5 years for 1,1,1-trichloroethane and 0.9 to 4.5 years for trichloroethene.

Using an average decay constant from the data evaluated and the initial concentrations of trichloroethene and 1,1,1-trichloroethane as measured in March 1995, the following locations are projected to degrade to or below the New York standard of 5 µg/L within approximately 5 to 10 years: MW-6, MW-11 and MW-19 (1,1,1-trichloroethane) and MW-24 and MW-18 (trichloroethene). MW-06 currently is below the standard for trichloroethene. These predictions provide a realistic estimate of the time frame needed to achieve compliance with the New York State standard. The calculated data are shown in Figure 12.

4.2 *INORGANICS*

While metals do not biodegrade to any significant degree, they do disperse and mineralize (Allen *et al.*, 1993).

The metals data for the Rosen Site show the number and concentration of metals detected above state and federal standards is decreasing with time. Based on the March, 1995 post-RI sampling data, only iron, magnesium, manganese and sodium are above state or federal ground water standards. The concentrations of dissolved iron detected in previous samples (February 1992) have decreased in wells W-19, W-07, W-17 and W-21 to below the state standard. Furthermore, dissolved antimony (wells W-11 and W-19), dissolved chromium (W-21) and aluminum (wells W-21, W-17, and W-19) were no longer detected above State or Federal standards in 1995.

The only dissolved metal consistently detected above New York State standards at the Rosen Site is naturally occurring manganese, which does not show any statistically significant changes between upgradient, downgradient and off-site wells. The dissolved ground water data for the other metals do not indicate the presence of any dissolved metal ground water plumes, as these metals are not consistently detected.

5.0 DISCUSSION OF REMEDIAL ALTERNATIVES

The goals of the selection of a remedial alternative for the Rosen Site are to identify remedies that protect human health and the environment, reduce risk in a timely manner, are cost-effective, and promote redevelopment of the site. The following sections will evaluate natural attenuation as compared to previously identified remedial alternatives with respect to these criteria.

Site data demonstrate that these processes are actively occurring and are reducing the concentrations of VOCs in the ground water. The calculations presented in Section 4.1.3 indicate that natural attenuation in ground water will meet the New York State standards for 1,1,1-trichloroethane and trichloroethene within 5 to 10 years assuming the estimated rates of attenuation continue or accelerate. A review of Records of Decisions (RODs) indicates that natural attenuation is an acceptable remedial alternative and that several sites are utilizing this approach (Kenmark Textile Printing, NY, 3/30/94; Sarney Farm, NY, 3/27/90; Wilson Farm, NJ, 8/93; Conklin Dump, NY, 3/29/91; Caldwell Lace Leather, KY, 6/30/94). Natural attenuation will effectively reduce risk to human health and the environment, and will not create the risks associated with the extraction and treatment of large quantities of ground water. The cost of the natural attenuation remedy predicted by the USEPA CORA model is presented in Table 6.

The acceleration of the biodegradation of constituents in the site ground water (should this prove desireable) through *in situ* injection of nutrients and possibly an electron donor into the outwash aquifer is currently being evaluated. The only other viable remedial alternative for the site is the pumping and treating of contaminated ground water. Calculations using the model Quickflow® (Geraghty and Miller, 1991) indicate that pumping approximately 1500 gallons per minute (gpm) from six extraction wells would be necessary to collect ground water above New York State standards. While the duration of pump and treat has not been determined at this time, it would likely continue for at least 5 years based on experience at other sites (USEPA, 1992). Therefore, a pump and treat remedial alternative for the Rosen Site will result in the extraction and treatment of approximately 4 billion gallons of water, at a minimum. Furthermore, the discharge options available to the site place severe additional constraints on this remedy.

The formerly proposed options included: discharge to the City of Cortland sewers for treatment at the POTW, discharge to the POTW via a separate sewer, discharge to Perplexity Creek and discharge to the Tioughnioga River approximately 1.25 miles away (BB&L, 1995b). Discharge to the city sewer is not feasible, due to lack of hydraulic capacity in, and question about the integrity of, the main trunk sewer under Port Watson Street. Discharge to the POTW is not feasible, as the pump and treat flow exceeds available capacity. Discharge to Perplexity Creek will exacerbate existing flooding conditions, due to the hydraulic limitations of the underground channelized segment downstream of the site. Therefore, the only feasible option for discharge to treated groundwater would be a dedicated pipeline to the Tioughnioga River. In addition, the high inorganic levels in the ground water (iron and calcium) would result in significant sludge generation. These sludges (estimated at 6,500 cubic yards per year) would require dewatering, treatment, and land filling. The cost of the pump and treat alternative (exclusive of sludge disposal costs) is presented in Table 7. The costs for the two alternatives is compared in Table 8.

6.0 *SUMMARY AND CONCLUSIONS*

The residual ground water chemical constituents at the Rosen Site consist of two plumes: a 1,1,1-trichloroethane plume which originates in the southwestern portion of the site and a trichloroethene plume which originates upgradient of the Site (from the City of Cortland former dump property). The impact to ground water is limited to the upper outwash hydrogeologic unit.

There are no water supply wells downgradient of the Rosen Site and all of the monitoring wells on-site and downgradient are below or only slightly above MCLs for organic contamination. The upgradient trichloroethene plume exceeds MCLs for trichloroethene, 1,1-dichloroethene and vinyl chloride. The ground water concentrations downgradient of the Site exceed New York State "standards" for trichloroethene, 1,1,1-trichloroethane, 1,1-dichloroethane and cis-1,2-dichloroethene. The current site data indicate that there is no significant impact to ground water for other VOCs, SVOCs, pesticides, PCBs, metals or other inorganics attributable to the Rosen Site.

The residual areas contributing chemical constituents to ground water on the Rosen Site are rapidly attenuating, as demonstrated by significant reductions in constituent concentrations at monitoring wells over time. The constituent concentrations in ground water are also decreasing over time due to hydrodynamic dispersion, physicochemical transformation, and biological decay. As a result, plume concentrations downgradient of the site (which already are at or near the MCLs) are calculated to achieve the New York State "standards" within 5 to 10 years. The alternative to natural attenuation is a pump and treat remedy, which is severely limited with respect to discharge options.

Because of the permeable nature of the upper outwash hydrogeologic unit, ground water velocities are high (9 to 16 ft/day) with correspondingly high flow rates (approximately 1,500 gpm across the downgradient site boundary). As a result, the present value cost of implementing a pump and treat remedy (based on EPA's CORA Model), would be approximately $18 million, versus less than $1 million for natural attenuation.

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TABLES

TABLE 1
SUMMARY OF GROUND WATER ANALYTICAL RESULTS
VOLATILE ORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
MARCH 1995

ROSEN SITE
CORTLAND, NEW YORK

Compound	W-01	W-01DL	W-02	W-03	W-03DL	W-04	W-05	W-05DL	New York State Standards/Guidance Values	MCLs/MCLGs
Chloromethane	0.06 J	<4	<8	<1	<2	<1	<1	<2	5	
Vinyl Chloride	<1	<4	<8	<1	<2	<1	<1	<2	2	2/0(G)
Chloroethane	<1	<4	<8	<1	<2	<1	<1	<2	5	
Acetone	<5	<20	<40	<5	<10	<5	<6	<10	50(G)	
1,1-Dichloroethene	0.09 J	<4	0.7 J	<1	<2	<1	<1	<2	5	7/7(G)
1,1-Dichloroethane	12	8 D	28	2	1 DJ	<1	1	1 DJ	5	
cis-1,2-Dichloroethene	<1	<4	<8	<1	<2	<1	<1	<2	5	70/70(G)
trans-1,2-Dichloroethene	<1	<4	<8	<1	<2	<1	<1	<2	5	100/100(G)
1,2-Dichloroethane	1	<4	<8	<1	<2	<1	1	0.7 DJ	5	5/0(G)
Chloroform	<1	<4	<8	<1	<2	<1	<1	<2	7	100*/100(G)
1,1,1-Trichloroethane	59 E	41 DJ	120 J	<1	5 D	<1	34 E	24 DJ	5	200/200(G)
Trichloroethene	0.2 J	<4	1 J	<1	<2	<1	1	1 DJ	5	5/0(G)
Tetrachloroethene	<1	<4	<8	27 E	20 D	<1	<1	<2	5	5/0(G)
Toluene	<1	<4	<8	<1	<2	<1	0.2 J	<2	5	1,000/1,000(G)
Chlorobenzene	<1	<4	<8	<1	<2	<1	<1	<2	5	100/100(G)
Total TICs	--	--	--	--	--	--	--	--		

See notes on Page 5.

TABLE 1 (Cont.)
SUMMARY OF GROUND WATER ANALYTICAL RESULTS
VOLATILE ORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
MARCH 1995

ROSEN SITE
CORTLAND, NEW YORK

Compound	W-06	W-06 Dup	W-06DL	W-06DL Dup	W-07	W-08	W-08DL	W-09	W-10	W-10DL	W-11	New York State Standards/Guidance Values	MCLs/MCLGs
Chloromethane	<1	<1	<10	<8	<1	0.08 J	<2	<1	<1	<5	<8	5	
Vinyl Chloride	<1	<1	<10	<8	<1	<1	<2	<1	<1	<5	<8	2	2/0(G)
Chloroethane	6	5	4 DJ	4 DJ	<1	<1	<2	<1	0.4 J	<5	<8	5	
Acetone	4 J	<5	<50	<40	<5	<5	<12	<5	<5	<25	<40	50(G)	
1,1-Dichloroethene	0.1 J	0.1 J	<10	<8	<1	0.4 J	0.2 DJ	<1	1	0.7 DJ	7 J	5	7/7(G)
1,1-Dichloroethane	30 E	23	19 D	20 D	2	11	7 D	<1	42 E	36 D	67	5	
cis-1,2-Dichloroethene	1	1	<10	0.6 DJ	<1	<1	<2	<1	<1	<5	<8	5	70/70(G)
trans-1,2-Dichloroethene	<1	<1	<10	<8	<1	<1	<2	<1	<1	<5	<8	5	100/100(G)
1,2-Dichloroethane	<1	<1	<10	<8	1	1	<2	0.6 J	1	<5	<8	5	5/0(G)
Chloroform	0.03 J	<1	<10	<8	<1	<1	<2	<1	<1	<5	<8	7	100/100(G)
1,1,1-Trichloroethane	210 E	130 E	110 DJ	120 DJ	18 J	59 E	32 DJ	<1	120 E	110 DJ	160 J	5	200/200(G)
Trichloroethene	4	3	2 DJ	2 DJ	<1	<1	<2	<1	0.7 J	<5	<8	5	5/0(G)
Tetrachloroethene	0.1 BJ	<1	<10	<8	<1	<1	<2	<1	<1	<25	<8	5	5/0(G)
Toluene	<1	<1	<10	<8	<1	<1	<2	<1	<1	<5	<8	5	1,000/1,000(G)
Chlorobenzene	<1	<1	<10	<8	<1	<1	<2	<1	<1	<5	<8	5	100/100(G)
Total TICs	--	--	--	--	--	--	--	3 J	--	--	--		

See notes on Page 5.

TABLE 1 (Cont.)
SUMMARY OF GROUND WATER ANALYTICAL RESULTS
VOLATILE ORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
MARCH 1995

ROSEN SITE
CORTLAND, NEW YORK

Compound	W-12	W-13	W-14	W-15	W-16	W-17	W-18	W-18 Dup	W-18DL	W-18DL Dup	W-19	New York State Standards/Guidance Values	MCLs/MCLGs
Chloromethane	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	<1	5	
Vinyl Chloride	<4	<1	<1	<1	<1	<1	0.4 J	0.5 J	0.4 DJ	0.4 DJ	<1	2	2/0(G)
Chloroethane	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	0.3 J	5	
Acetone	<20	<5	<5	<5	<5	<5	<10	<10	<20	<20	<5	50(G)	
1,1-Dichloroethene	2 J	<1	<1	<1	0.3 J	<1	2	2	2 DJ	2 DJ	8	5	7/7(G)
1,1-Dichloroethane	12	<1	<1	<1	5	1	29	30	29 D	28 D	67 E	5	
cis-1,2-Dichloroethene	<4	<1	<1	<1	0.09 J	0.4 J	6	7	6 D	6 D	0.1 J	5	70/70(G)
trans-1,2-Dichloroethene	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	<1	5	100/100(G)
1,2-Dichloroethane	<4	<1	<1	<1	<1	<1	0.6 J	0.7 J	1 DJ	<4	1	5	5/0(G)
Chloroform	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	<1	7	100*/100(G)
1,1,1-Trichloroethane	38	<1	4	<1	23	4	69 E	70 E	68 DJ	61 DJ	140 E	5	200/200(G)
Trichloroethene	10	<1	<1	<1	3	10	10	11	9 D	9 D	0.7 J	5	5/0(G)
Tetrachloroethene	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	<1	5	5/0(G)
Toluene	<4	<1	<1	<1	<1	<1	<2	<2	<4	<4	<1	5	1,000/1,000(G)
Chlorobenzene	<4	<1	0.06 BJ	<1	<1	<1	<2	<2	<4	<4	<1	5	100/100(G)
Total TICs	--	--	--	--	--	--	--	--	--	--	2 J		

See notes on Page 5.

TABLE 1 (Cont.)
SUMMARY OF GROUND WATER ANALYTICAL RESULTS
VOLATILE ORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
MARCH 1995

ROSEN SITE
CORTLAND, NEW YORK

Compound	W-19DL	W-20	W-21	W-22	W-23	W-24	W-24DL	W-25	W-25DL	W-26	New York State Standards/Guidance Values	MCLs/MCLGs
Chloromethane	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	5	
Vinyl Chloride	<10	<1	<1	<1	<1	8	9 D	<5	<10	<8	2	2/0(G)
Chloroethane	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	5	
Acetone	<50	<5	<5	<5	<5	<5	<25	<25	<50	<40	50(G)	
1,1-Dichloroethene	6 DJ	<1	<1	<1	<1	1	1 DJ	2 J	3 DJ	7 J	5	7/7(G)
1,1-Dichloroethane	61 DJ	<1	<1	<1	<1	<1	<5	37	41 D	66	5	
cis-1,2-Dichloroethene	<10	<1	<1	<1	<1	39 E	37 D	<5	<10	<8	5	70/70(G)
trans-1,2-Dichloroethene	<10	<1	<1	<1	<1	4	3 DJ	<5	<10	<8	5	100/100(G)
1,2-Dichloroethane	<10	<1	0.5 J	<1	0.6 J	0.7 J	<5	<5	<10	0.9 J	5	5/0(G)
Chloroform	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	7	100*/100(G)
1,1,1-Trichloroethane	210 DJ	<1	<1	<1	<1	<1	0.8 DJ	160 E	210 D	140 J	5	200/200(G)
Trichloroethene	<10	<1	<1	4	<1	150 E	93 D	<5	<10	<8	5	5/0(G)
Tetrachloroethene	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	5	5/0(G)
Toluene	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	5	1,000/1,000(G)
Chlorobenzene	<10	<1	<1	<1	<1	<1	<5	<5	<10	<8	5	100/100(G)
Total TICs	--	--	9 J	--	--	--	--	--	--	--		

See notes on Page 5.

TABLE 1 (Cont.)
SUMMARY OF GROUND WATER ANALYTICAL RESULTS
VOLATILE ORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
MARCH 1995

ROSEN SITE
CORTLAND, NEW YORK

Notes:

All concentrations, detection levels, standard values, guidance values and MCLs/MCLGs are reported as micrograms per liter (ug/L) equivalent to parts per billion (ppb). The following parameters were also analyzed for, but were not detected:

1,1,2-Trichloroethane
1,1,2,2-Tetrachloroethane
1,2-Dibromomethane
1,2-Dichloropropane
1,3-Dibromo-3-chloropropane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
2-Butanone
2-Hexanone
4-Methyl-2-pentanone
Benzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
Carbon Disulfide
Carbon Tetrachloride
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Dibromochloromethane
Ethylbenzene
Methylene Chloride
Styrene
Total Xylenes

B = Analyte found in blank as well as sample.
D = Identifies compounds identified in an analysis at a secondary dilution factor.
E = Identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis.
J = Indicates an estimated value.
TICs = Tentatively Identified Compounds.
Dup = Duplicate.
[a]Applies to the total of trihalomethanes.
[b] = The standard value of 5 ug/L applies to each isomer individually.
The < sign indicates the compound was analyzed for but not detected.
Bold indicates NYSDEC standards exceeded; shading indicates federal MCLs exceeded.

References:

Standard and Guidance values are according to the New York State Department of Environmental Conservation, Division of Water Technical and Operation Guidance Series (1.1.1). Ambient Water Quality Standards and Guidance Values [designated by (G)], October 1993.

MCLs (Maximum Contaminant Levels), MCLGs [Maximum Contaminant Level Goals, designated by (G)], and SMCLs [Secondary Maximum Contaminant Levels, designated by (S)], according to the Code fo Federal Regulations, Protection of Environment 40, Part 141, July 1, 1991, and the Drinking Water Regulations and Health Advisories, Office of Water, U.S. Environmental Protection Agency, December 1993.

TABLE 2
GROUND WATER ANALYTICAL RESULTS
INORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
March 1995

ROSEN SITE
CORTLAND, NEW YORK

TAL Metals	Total W-01	Soluble W-01	Total W-02	Soluble W-02	Total W-03	Soluble W-03	Total W-03 Dup.	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	7,310	<90.0	4,940	<90.0	3,200	<90.0	2,490		50 to 200(S)
Antimony	47.0 B	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	<4.0	<4.0	5.0 B	<4.0	<4.0 NJ	<4.0	<4.0 NJ	25	50
Barium	67.0 B	<40.0	90.0 B	<40.0	<40.0	<40.0	<40.0	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0	<5.0	<5.0	<5.0	<5.0*	<5.0	<5.0*	10	5/5 (G)
Calcium	50,300 EJ	51,000	155,000 EJ	124,000	70,800	60,900	67,000		
Chromium	13.0	<10	11.0	<10	<10	<10	<10	50	100
Cobalt	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	24.0 B	<10	13.0 B	<10	<10	<10	<10	200	1,000(S)
Iron	13,000	<40.0	26,000	<40.0	5,280	42.0 B	360	300	300(S)
Lead	9.0	<2.0 J	8.0	<2.0 J	2.8 B*	<2.0 J	2.4 B*	25	15
Magnesium	11,300	8,900	27,400	22,600	13,400	9,050	12,500	35,000(G)	
Manganese	794	<5.0	2,280	289	214	100	209	500* 300	50(S)
Mercury	<0.20	<0.20	0.21	<0.20	<0.20	<0.20	<0.20	2	2/2 (G)
Nickel	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0		100/100(G)
Potassium	3,320 B	1,940 B	4,200 B	3,540 B	2,600 B	1,790 B	2,450 B		
Selenium	<5.0 WJ	<3.0 WJ	<5.0 WJ	<5.0 WJ	<1.0*	<3.0	<1.0*	10	50/50 (G)
Silver	<10 N	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	50	100 (S)
Sodium	16,500	17,100	25,500	24,700	15,200	15,300	14,600	20,000	
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0 WJ	4(G)	2/0.5(G)
Vanadium	14.0 B	<10	11.0 B	<10	<10	<10	<10		
Zinc	124	23.0	57.0	<15.0	317	56.0	253	300	5,000(S)

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TABLE 2 (Cont.)
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ROSEN SITE
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Compound	Total W-04	Soluble W-04	Total W-05	Soluble W-05	Total W-06	Soluble W-06	Total W-06 Dup.	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	16,800	<90.0	21,900	<90.0	5,050	<90.0	6,760		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	4.0 B	<4.0	5.0 B	<4.0	<4.0 W	<4.0	<4.0 NJ	25	50
Barium	143 B	<40.0	325	<42.0 B	88.0 B	<40.0	94.0 B	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0	<5.0	6.0 J	<5.0	<5.0	<5.0	<5.0*	10	5/5 (G)
Calcium	73,700 EJ	51,700	65,400 EJ	53,400	70,000 EJ	66,300	65,700		
Chromium	19.0	<10	81.0	<10	327	<10	376	50	100
Cobalt	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	62.0	<10	114	<10	49.0	<10	49.0	200	1,000(S)
Iron	28,700	<40.0	54,400	<40.0	15,700	<40.0	16,600	300	300(S)
Lead	24.0	<2.0 J	60.0	<2.0 J	14.5 J+	<2.0 J	12.0 *	25	15
Magnesium	21,600	8,200	20,000	9,450	14,100	11,800	13,300	35,000(G)	
Manganese	944	<5.0	4,120	<5.0	856	8.0 B	874	500* 300	50(S)
Mercury	0.23	<0.20	0.61	<0.20	0.21	<0.20	<0.20	2	2/2 (G)
Nickel	<20.0	<20.0	53.0	<20.0	77.0	26.0 B	77.0		100/100(G)
Potassium	3,950 B	560 B	5,440	2,450 B	2,410 B	1,300 B	2,800 B		
Selenium	<5.0 WJ	<5.0	<5.0 WJ	<5.0 WJ	<5.0	<5.0	3.5 B*J	10	50/2 (G)
Silver	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	50	100 (S)
Sodium	38,900	39,500	28,500	26,100	27,600	26,100	26,200	20,000	
Thallium	<4.0 W	<4.0 WJ	<4.0 WJ	<4.0	<4.0 WJ	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	29.0 B	<10	198	25.0 B	14.0 B	<10	15.0 B		
Zinc	124	<15.0	377	15.0 B	621	23.0	136	300	5,000(S)

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GROUND WATER ANALYTICAL RESULTS
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ROSEN SITE
CORTLAND, NEW YORK

Compound	Total W-07	Soluble W-07	Total W-08	Soluble W-08	Total W-09	Soluble W-09	Total W-10	Soluble W-10	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	1,860	<90.0	15,700	<90.0	<90.0	<90.0	18,800	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	<4.0	<4.0	6.0 B	<4.0	<4.0	<4.0	<4.0 NJ	<4.0	25	50
Barium	<40.0	<40.0	323	128 B	321	328	198 B	43.0 B	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0	<5.0	5.0 J	<5.0	<5.0	<5.0	<5.0*	<5.0	10	5/5 (G)
Calcium	47,500 EJ	46,600	180,000 EJ	127,000	140,000 EJ	140,000	150,000	85,300		
Chromium	55.0	<10	42.0	<10	<10	<10	140	<10	50	100
Cobalt	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	15.0 B	<10	36.0	<10	<10	<10	85.0	<10	200	1,000(S)
Iron	5,790	<40.0	32,100	<40.0	107	51.0 B	41,700	87.0 B	300	300(S)
Lead	6.0	<2.0 J	25.0	<2.0 WJ	<2.0	<2.0 WJ	28.7*	<2.0 WJ	25	15
Magnesium	11,600	10,600	47,400	32,000	40,900	41,300	39,700	12,800	35,000(G)	
Manganese	163	14.0 B	1,530	391	229	229	2,690	487	500* 300	50(S)
Mercury	<0.20	<0.20	0.29	<0.20	<0.20	<0.20	0.35	<0.20	2	2/2 (G)
Nickel	<20.0	<20.0	36.0 B	<20.0	<20.0	<20.0	103	<20.0		100/100(G)
Potassium	2,860 B	2,410 B	4,450 B	1,570 B	1,560 B	1,510 B	4,770 B	2,140 B		
Selenium	<5.0 WJ	<5.0 WJ	<5.0 WJ	<3.0 WJ	<5.0	<3.0 WJ	<1.0*	<3.0 WJ	10	50/2 (G)
Silver	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	50	100 (S)
Sodium	15,200	13,600	81,800	86,900	108,000	110,000	22,700	23,100	20,000	
Thallium	<4.0	<4.0	<4.0 WJ	<4.0 WJ	<4.0 WJ	<4.0 WJ	<4.0 WJ	<4.0	4(G)	2/0.5(G)
Vanadium	<10	<10	24.0 B	<10	<10	<10	33.0 B	<10		
Zinc	44.0	<15.0	131	<15.0	<15.0	20.0	176	23.0	300	5,000(S)

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ROSEN SITE
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Compound	Total W-11	Soluble W-11	Total W-12	Soluble W-12	Total W-13	Soluble W-13	Total W-14	Soluble W-14	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	14,000	<90.0	4,600	<90.0	2,960	<90.0	1,850	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	7.0 B	<4.0	<4.0 NJ	<4.0	<4.0 NJ	<4.0	<4.0	<4.0	25	50
Barium	175 B	<40.0	65.0 B	<40.0	<40.0	<40.0	56.0 B	41.0 B	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0	<5.0	<5.0*	<5.0	<5.0*	<5.0	<5.0	<5.0	10	5/5 (G)
Calcium	423,000 EJ	376,000	218,000	211,000	40,200	41,100	107,000 EJ	104,000		
Chromium	57.0	<10	<10	<10	305	<10	59.0	<10	50	100
Cobalt	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	44.0	<10	10 B	<10	23.0 B	<10	19.0 B	<10	200	1,000(S)
Iron	36,400	6,120	8,430	<40.0	8,050	<40.0	4,240	<40.0	300	300(S)
Lead	20.0	<2.0 J	5.7 *	<2.0 WJ	3.8 *	<2.0 WJ	4.0	<2.0 J	25	15
Magnesium	32,100	15,500	22,500	17,600	5,910	5,350	13,900	13,200	35,000(G)	
Manganese	1,330	904	1,010	813	109	<5.0	82.0	<5.0	500* 300	50(S)
Mercury	0.21	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.2	2	2/2 (G)
Nickel	46.0	22.0 B	<20.0	<20.0	<20.0	<20.0	<20.0	<20.0		100/100(G)
Potassium	4,830 B	2,150 B	2,220 B	1,100 B	1,880 B	1,280 B	1,480 B	2,320 B		
Selenium	<5.0 WJ	<5.0 WJ	<1.0*	<3.0 WJ	<1.0 *J	<5.0 WJ	<5.0	<5.0 J	10	50/2 (G)
Silver	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	50	100 (S)
Sodium	24,200	23,000	21,800	21,000	13,500	12,600	29,800	30,600	20,000	
Thallium	<4.0	<4.0	<4.0 WJ	<4.0	<4.0	<4.0	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	22.0 B	<10	<10	<10	<10	<10	<10	<10		
Zinc	103	<15.0	47.0	18.0 B	37.0	<15.0	45.0	<15.0	300	5,000(S)

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ROSEN SITE
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Compound	Total W-15	Soluble W-15	Total W-16	Soluble W-16	Total W-17	Soluble W-17	Total W-18	Soluble W-18	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	2,670	<90.0	1,280	<90.0	147,000	<90.0	48,600	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	45.0 B	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	<4.0 NJ	<4.0	<4.0	<4.0	4.0 B	<4.0	10	<4.0	25	50
Barium	41.0 B	<40.0	66.0 B	57.0 B	943	<40.0	459	43.0 B	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	5.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0*	<5.0	<5.0	<5.0	44.0	<5.0	13.0	<5.0	10	5/5 (G)
Calcium	123,000	131,000	139,000 EJ	136,000	546,000 EJ	95,000	505,000 EJ	158,000		
Chromium	<10	<10	64.0	<10	12,800	<10	338	<10	50	100
Cobalt	<40.0	<40.0	<40.0	<40.0	231	<40.0	57.0	<40.0		
Copper	20.0 B	<10	240	<10	410	<10	105	<10	200	1,000(S)
Iron	4,040	77.0 B	3,100	<40.0	338,000	40.0	88,200	<40.0	300	300(S)
Lead	1.7 B*	<2.0 WJ	8.0	<2.0 J	140	<2.0 J	105 S	<2.0 J	25	15
Magnesium	31,400	31,500	25,000	23,400	189,000	12,700	113,000	17,400	35,000(G)	
Manganese	318	316	165	13.0 B	8,620	<5.0	6,780	601	500* 300	50(S)
Mercury	<0.20	<0.20	<0.20	<0.20	0.83	<0.20	0.41	<0.20	2	2/2 (G)
Nickel	<20.0	<20.0	36.0 B	<20.0	1,600	<20.0	165	<20.0		100/100(G)
Potassium	1,860 B	1,210 B	1,440 B	1,090 B	16,900	1,540 B	8,040	2,000 B		
Selenium	<1.0*	<5.0 WJ	7.0	<5.0 WJ	<50.0 WJ	<5.0 WJ	<5.0 WJ	<5.0 WJ	10	50/2 (G)
Silver	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	50	100 (S)
Sodium	32,300	32,000	24,400	23,800	21,800	19,600	29,500	30,400	20,000	
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	<10	<10	<10	<10	264	<10	69.0	<10		
Zinc	29.0	15.0 B	90.0	<15.0	2,460	18.0 B	407	<15.0	300	5,000(S)

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ROSEN SITE
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Compound	Total W-18 Dup.	Total W-19	Soluble W-19	Total W-20	Soluble W-20	Total W-21	Soluble W-21	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	83,200	22,000	<90.0	9,580	<90.0	14,700	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	10	12.0	<4.0	6.0 BNJ	<4.0	10	<4.0	25	50
Barium	512	167 B	<40.0	115 B	<40.0	136 B	<40.0	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	17.0	10 J	<5.0	<5.0*	<5.0	16.0	<5.0	10	5/5 (G)
Calcium	501,000 E	452,000 EJ	373,000	226,000	163,000	69,300 EJ	21,900		
Chromium	512	45.0	<10	40.0	<10	269	14.0	50	100
Cobalt	84.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	167	73.0	<10	24.0 B	<10	119	<10	200	1,000(S)
Iron	151,000	42,400	<40.0	17,800	126	29,700	<40.0	300	300(S)
Lead	145 S	29.0	<2.0 J	9.1 *	<2.0 WJ	23.0	<2.0 J	25	15
Magnesium	154,000	49,600	21,500	48,400	37,500	19,700	9,160	35,000(G)	
Manganese	8,200	2,990	2,390	1,490	866	934	28.0	500* 300	50(S)
Mercury	0.51	0.33	<0.20	0.29	<0.20	0.27	<0.20	2	2/2 (G)
Nickel	242	50.0	25.0 B	33.0 B	<20.0	71.0	<20.0		100/100(G)
Potassium	12,700	5,360	1,630 B	3,050 B	1,260 B	27,200	26,600		
Selenium	<5.0 W	<5.0 WJ	<5.0 WJ	<1.0 *	<5.0 WJ	<5.0 WJ	<5.0 WJ	10	50/2 (G)
Silver	<10 N	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	50	100 (S)
Sodium	30,800	25,000	25,600	28,700	28,100	171,000	174,000	20,000	
Thallium	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	121	36.0 B	<10	16.0 B	<10	29.0 B	<10		
Zinc	619	171	<15.0	97.0	30.0	122	<15.0	300	5,000(S)

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ROSEN SITE
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Compound	Total W-22	Soluble W-22	Total W-23	Soluble W-23	Total W-24	Soluble W-24	Total W-25	Soluble W-25	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	42,500	<90.0	737	<90.0	18,200	<90.0	<90.0	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	<30.0	3(G)	6/6(G)
Arsenic	<4.0 NJ	<4.0	<4.0	<4.0	6.0 B	<4.0	<4.0 NJ	<4.0 N	25	50
Barium	960	115 B	478	483	292	<40.0	<40.0	<40.0	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	3(G)	4/4(G)
Cadmium	16.0*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0*	<5.0	10	5/5 (G)
Calcium	232,000	118,000	114,000 EJ	110,000	165,000 EJ	146,000	139,000	143,000		
Chromium	4,270	<10	<10	<10	42.0	<10	<10	<10	50	100
Cobalt	113	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0	<40.0		
Copper	168	<10	37.0	<10	33.0	<10	<10	<10	200	1,000(S)
Iron	111,000	<40.0	1,070	<40.0	36,800	50.0 B	2,340	2,270	300	300(S)
Lead	45.4*	<2.0 WJ	3.0 W	<2.0 J	23.0	<2.0 J	<1.0*	<2.0 WJ	25	15
Magnesium	61,100	20,100	28,100	26,800	41,100	32,100	17,000	17,200	35,000(G)	
Manganese	2,650	14.0 B	173	136	2,610	776	486	574	500* 300	50(S)
Mercury	0.65	<0.20	<0.20	0.21	<0.20	0.27	<0.20	<0.20	2	2/2 (G)
Nickel	1,500	90.0	<20.0	<20.0	38.0 B	<20.0	<20.0	<20.0		100/100(G)
Potassium	8,850	1,600 B	1,600 B	1,290 B	4,780 B	2,520 B	2,330 B	2,300 B		
Selenium	<1.0*	<5.0	<5.0 WJ	<5.0 WJ	<5.0 WJ	<5.0	1.2 B*J	<5.0 WJ	10	50/2 (G)
Silver	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	<10 NJ	<10 J	50	100 (S)
Sodium	132,000	132,000	72,800	72,000	64,200	64,600	30,400	29,300	20,000	
Thallium	<4.0 WJ	<4.0 WJ	<4.0 WJ	<4.0 WJ	<4.0	<4.0 WJ	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	81.0	<10	<10	<10	29.0 B	<10	<10	<10		
Zinc	269	<15.0	36.0	<15.0	142	<15.0	<15.0	20.0	300	5,000(S)

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ROSEN SITE
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Compound	Total W-26	Soluble W-26	New York State Standards/Guidance Values	MCLs/MCLGs SMCLs
Aluminum	1,540	<90.0		50 to 200(S)
Antimony	<30.0	<30.0	3(G)	6/6(G)
Arsenic	<4.0	<4.0	25	50
Barium	<40.0	<40.0	1,000	2,000/2,000 (G)
Beryllium	<3.0	<3.0	3(G)	4/4(G)
Cadmium	<5.0	<5.0	10	5/5 (G)
Calcium	416,000 EJ	426,000		
Chromium	<10	<10	50	100
Cobalt	<40.0	<40.0		
Copper	88.0	<10	200	1,000(S)
Iron	10,100	6,880	300	300(S)
Lead	3.0	<2.0 J	25	15
Magnesium	15,800	14.00	35,000(G)	
Manganese	679	701	500[a] 300	50(S)
Mercury	<0.20	<0.20	2	2/2 (G)
Nickel	<20.0	<20.0		100/100(G)
Potassium	2,530 B	2,310 B		
Selenium	<5.0 WJ	<5.0 WJ	10	50/2 (G)
Silver	<10 NJ	<10 J	50	100 (S)
Sodium	20,600	20,100	20,000	
Thallium	<4.0	<4.0	4(G)	2/0.5(G)
Vanadium	<10	<10		
Zinc	69.0	<15.0	300	5,000(S)

TABLE 2 (Cont.)
GROUND WATER ANALYTICAL RESULTS
INORGANICS COMPARED TO NEW YORK STANDARDS AND MCLs
March 1995

ROSEN SITE
CORTLAND, NEW YORK

Notes:

All concentrations, detection levels, standard values, guidance values and MCLs/MCLGs, are reported as micrograms per liter (ug/L) equivalent to parts per billion (ppb).
B = Indicates a value greater than or equal to the instrument detection limit but less than the contract required detection limit.
E = Indicates a value estimated or not reported due to the presence of interference.
N = Spiked sample recovery not within control limits.
S = Indicates a value determined by the Method of Standard Addition.
W = Post-digestion spike out of control limits.
\+ = Correlation coefficient for the MSA is less than 0.995.
* = Indicates result is outside QC limit.
ª Applies to the total of iron (maximum 300 ug/L) and manganese.
The < sign indicates the compound was analyzed for but not detected.
Bold indicates NYSDEC Standards exceeded; shading indicates federal MCLs exceeded.

References:

Standard and Guidance values are according to the New York State Department of Environmental Conservation, Division of Water Technical and Operation Guidance Series (1.1.1), Ambient Water Quality Standards and Guidance Values [designated by (G)], October 1993.

MCLs [Maximum Contaminant Levels], MCLGs [Maximum Contaminant Level Goals, designated by (G)], and SMCLs [Secondary Maximum Contaminant Levels, designated by (S)] according to the Code of Federal Regulations, Protection of Environment 40, Part 141, July 1991, and the Drinking Water Regulations and Health Advisories, Office of Water, U.S. Environmental Protection Agency, December 1993.

Table 3
Results of the Student t-test for Dissolved Manganese in Ground Water
Two Sample Populations Assuming Unequal Variances

Data from wells south (upgradient) of the site (Variable 1), and along the upgradient northern boundary of the site (Variable 2)

	Variable 1	*Variable 2*
Mean	393	452
Variance	277,414	101,581
Observations	8	9
Pearson Correlation	NA	
Pooled Variance	183,636	
df	11	
t	(0.27)	
P(T<=t) one-tail	0.39	
t Critical one-tail	1.80	
P(T<=t) two-tail	0.79	
t Critical two-tail	2.20	
Udelta, one tail		385
Udelta, two tail		472
Delta		59

Udelta > delta; means do not vary significantly

Data from wells along the upgradient northern boundary of the site (Variable 1) and off-site upgradient wells north of the site (Variable 2)

	Variable 1	*Variable 2*
Mean	452	752
Variance	101,581	1,271,239
Observations	9	4
Pearson Correlation	NA	
Pooled Variance	420,579	
df	3	
t	(0.52)	
P(T<=t) one-tail	0.32	
t Critical one-tail	2.35	
P(T<=t) two-tail	0.64	
t Critical two-tail	3.18	
Udelta, one tail		1,350
Udelta, two tail		1,826
Delta		300

Udelta > delta; means do not vary significantly

Data from wells south (upgradient) of the site (Variable 1), and off-site upgradient wells north of the site (Variable 2)

	Variable 1	*Variable 2*
Mean	392.81	751.63
Variance	277,413.57	1,271,238.56
Observations	8.00	4.00
Pearson Correlation	NA	
Pooled Variance	575,561.07	
df	4.00	
t	(0.60)	
P(T<=t) one-tail	0.29	
t Critical one-tail	2.13	
P(T<=t) two-tail	0.58	
t Critical two-tail	2.78	
Udelta, one tail		1,266
Udelta, two tail		1,648
Delta		359

Udelta > delta; means do not vary significantly

Note: Total manganese values were used for wells W-25 and W-26 as these values were less than the filtered samples.

Table 4

Summary of TCA Speciation Data
VOCs Detected in Ground Water

Well	W-06				W-11			W-19	
Compound	5/91	2/92	12/93	3/95	5/91	2/92	3/95	2/92	3/95
Trichloroethane	3400	1100	100	110	270	380	160	260	210
Dichloroethane	430	340	23	23	100	100	67	86	61
Chloroethane		2	23	6					0.3
Total TCA Family	3830	1442	146	139	370	480	227	346	271.3
TCA/TCA Family (%)	88.8%	76.3%	68.5%	79.1%	73.0%	79.2%	70.5%	75.1%	77.4%
Average TCA/TCA Family (%)	78.2%				74.2%			76.3%	

Note: Data are shown for the wells associated with the TCA plume on-site

Table 5

Calculation of Half Lives and Degradation Rates for TCE and TCA Families
Rosen Site, Cortland, New York

Time	May-91	May-91	Feb-92	Feb-92	Mar-95	Mar-95	Time Period One to Two						Time Period Two to Three					
							TCA			TCA Family			TCA			TCA Family		
Well	TCA	Total TCA	TCA	Total TCA	TCA	Total TCA	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)
W-06	3400	3830	1100	1442.5	110	139	1.13	276	0.0041	0.98	276	0.0035	2.30	1124	0.0020	2.34	1124	0.0021
W-11	270	370	380	480	160	227	(0.34)	276	(0.0012)	(0.26)	276	(0.0009)	0.86	1124	0.0008	0.75	1124	0.0007
W-19			260	346	210	271							0.21	1124	0.0002	0.24	1124	0.0002
Projected Plume Decay Rate:									0.0014			0.0013			0.0010			0.0010
Time (years to C = 5 ug/l) based on Co = 210 ug/l at W-19 (Note 1)									7.2			7.9			10.2			10.4
Half life (years)									1.3			1.5			1.9			1.9

Time (2)	May-91	May-91	Feb-92	Feb-92	Mar-95	Mar-95	Time Period One to Two						Time Period Two to Three					
							TCE			TCE Family			TCE			TCE Family		
Well	TCE	Total P/TCE	TCE	Total P/TCE	TCE	Total P/TCE	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)	ln(C1/C2)	Time (days)	k (1/day)
W-06	45	114.5	16	50.3	4	6.2	1.03	276	0.0037	0.82	276	0.0030	1.39	1124	0.0012	2.09	1124	0.0019
W-24			200	318	93	143							0.77	486	0.0016	0.80	486	0.0016
W-18			19	52	11	20.3							0.55	1124	0.0005	0.94	1124	0.0008
Projected Plume Decay Rate:									0.0037			0.0030			0.0011			0.001448
Time (years to C = 5 ug/l) based on Co = 11 ug/l at W-18 (Note 1)									0.6			0.7			2.0			1.5
Half life (years)									0.5			0.6			1.7			1.3

Notes:

(1) The concentrations at W-18 and W-19 were used to calculate the time to C = 5 ug/l as these wells are downgradient and off-site
(2) W-24 is associated with the TCE plume, and the rate of degredation was calculated using data from June, 1993 and March, 1995 (the available data exhibiting degredation)

Table 6

Estimated Cost for Natural Attenuation and Degredation
Rosen Site, Cortland, NY

Item	Capital Cost ($1000)	Annual O & M ($1000)	Present Value ($1000)
Quarterly Monitoring	0	170	736
Total Cost for Remedy:	0	170	736

Present Value is based upon 5 years O&M at 5% annual interest
Costs based upon the CORA model and do not include the cost
of implementing institutional controls. More detailed cost estimates
will be presented in the Feasibility Study being prepared by
Blasland, Bouck & Lee

Table 7

Estimated Cost for Ground Water Pump and Treat
Rosen Site, Cortland, NY

Item	Capital Cost ($1000)	Annual O & M ($1000)	Present Value ($1000)
Quarterly Monitoring	0	170	736
Extraction (1500 gpm)	140	42	322
Metals Precipitation	3,900	1,756	11,503
Air Stripping	210	63	483
Carbon Treatment	1,800	520	4,051
Discharge to T. River	900	42	1,082
Total Cost for P&T:	6,950	2,593	18,176

Present Value is based upon 5 years O&M at 5% annual interest
Costs based upon the CORA model and do not include the cost of implementing institutional controls. More detailed cost estimates will be presented in the Feasibility Study being prepared by Blasland, Bouck & Lee

Table 8

Comparison of Ground Water Pump and Treat Cost to Natural Attenuation and Degradation Cost Rosen Site, Cortland, NY

Item	Capital Cost ($1000)	Annual O & M ($1000)	Present Value ($1000)
Natural Attenuation	0	170	736
Pump and Treat	6,950	2,593	18,176
Difference	$6,950	$2,423	$17,440

Present Value is based upon 5 years O&M at 5% annual interest
Costs based upon the CORA model and do not include the cost
of implementing institutional controls. More detailed cost estimates
will be presented in the Feasibility Study being prepared by
Blasland, Bouck & Lee

FIGURES

Figure 1
Change in Relative Constituent Concentration at a Single Location in a Plume Over Time

(modified after Roberts *et al.*, 1980 and Sauty, 1980)

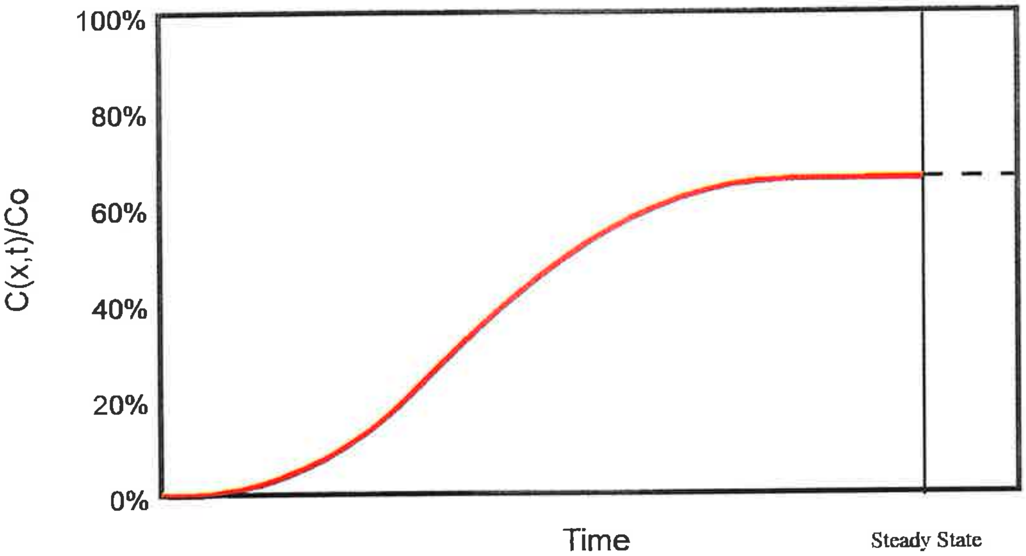


Figure 2
Concentration Isopleths in a Steady State Plume

(modified after Fetter, 1988)

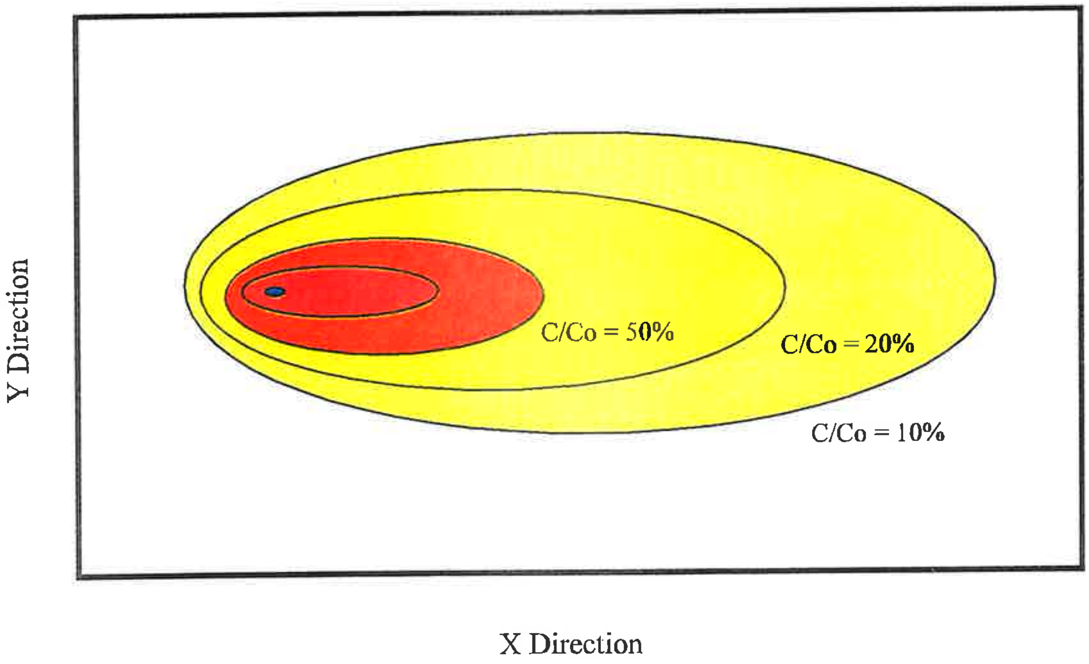


Figure 3
Effect of Natural Attenuation on Plume Concentration at any Point over Time (Steady State Achieved)
(modified after Roberts *et al.*, 1980 and Sauty, 1980)

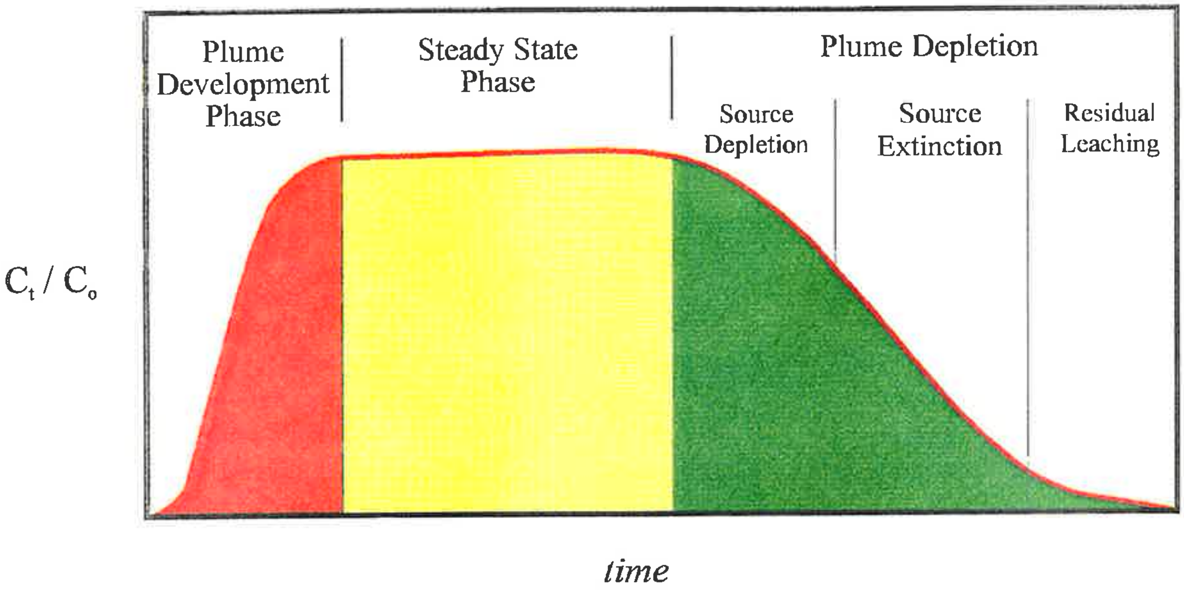


Figure 4
Effect of Natural Attenuation on Plume Concentration at any Point over Time (Steady State Not Achieved)
(modified after Roberts *et al.*, 1980 and Sauty,1980)

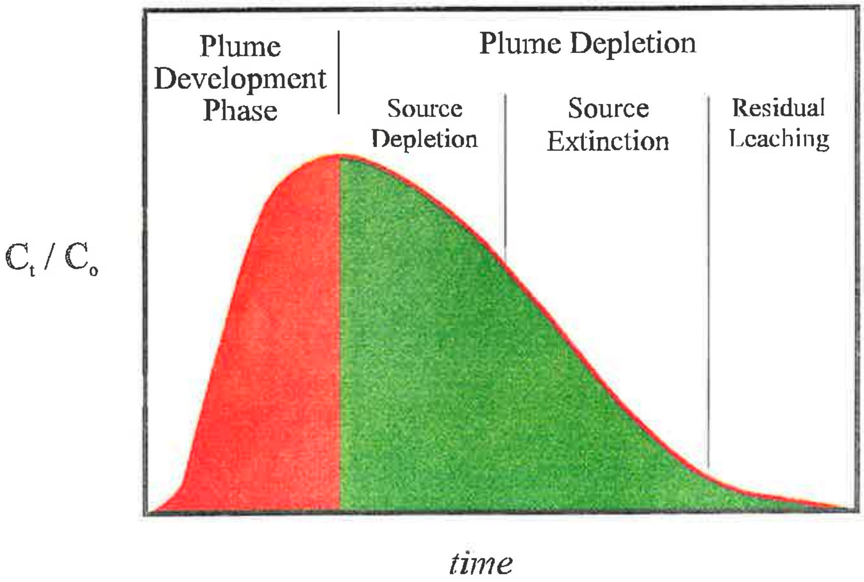
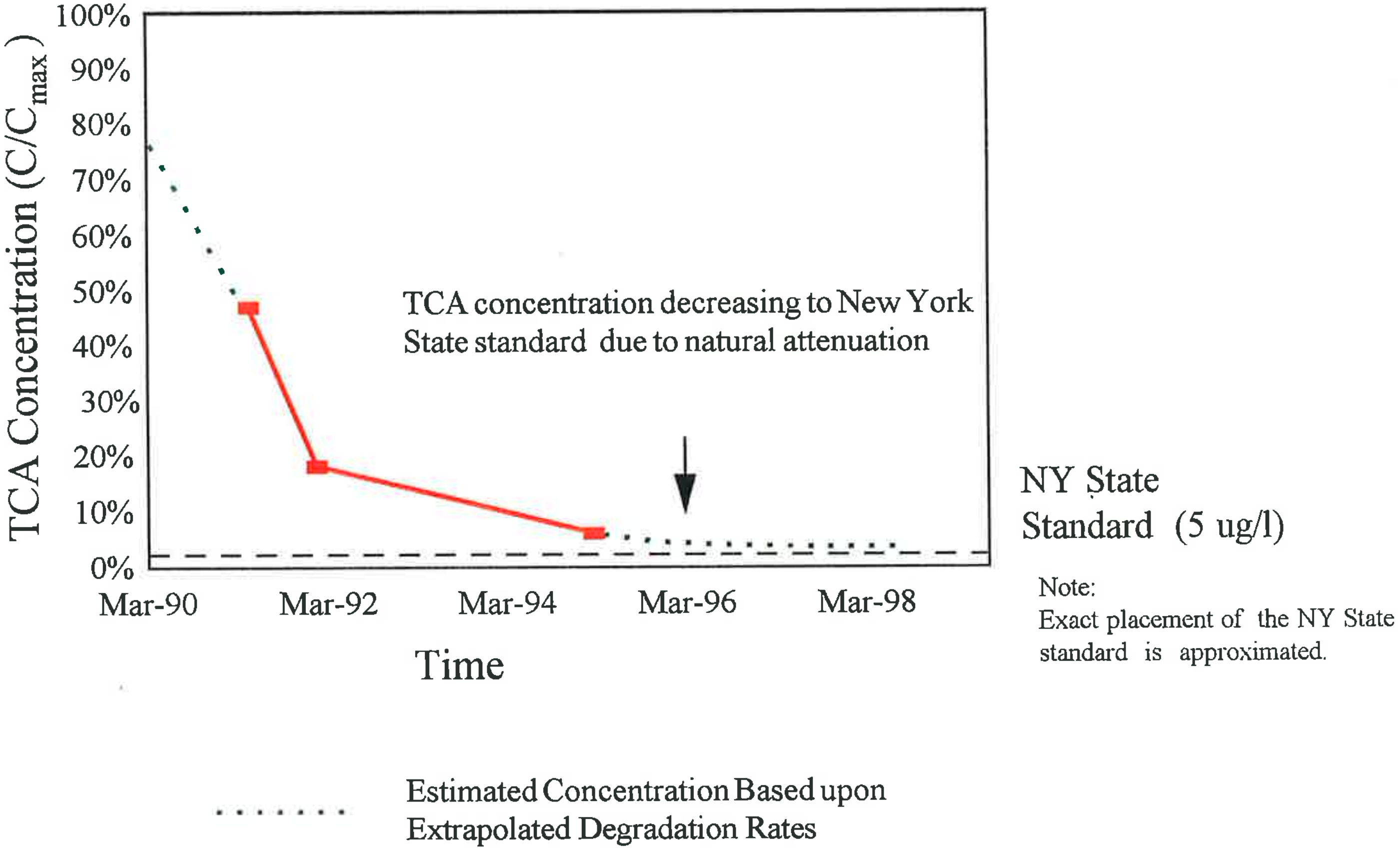
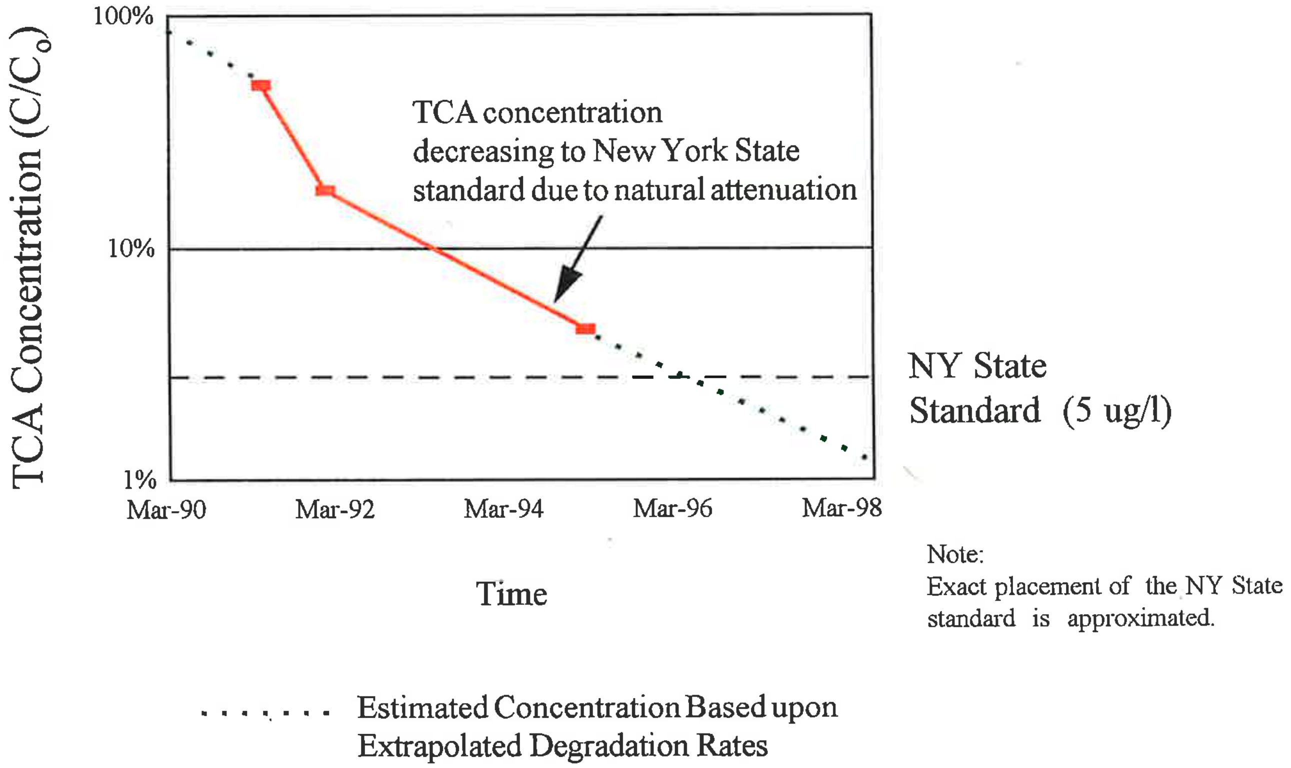


Figure 5
Estimated Concentration of TCA along Plume Centerline at W-06
(Arithmetic Scale)



Note:
Exact placement of the NY State standard is approximated.

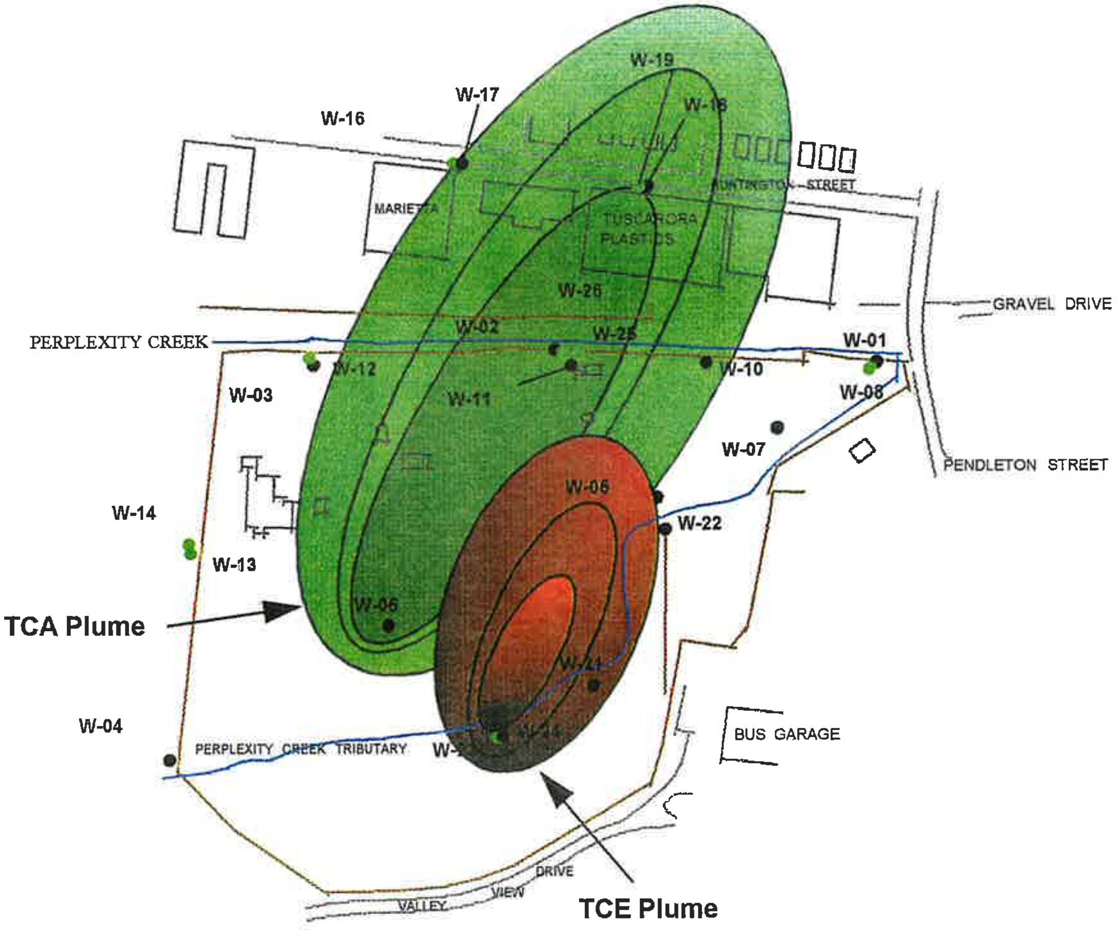
Figure 6
Estimated Concentration of TCA along Plume Centerline at W-06
(Log Scale)



TCA concentration decreasing to New York State standard due to natural attenuation

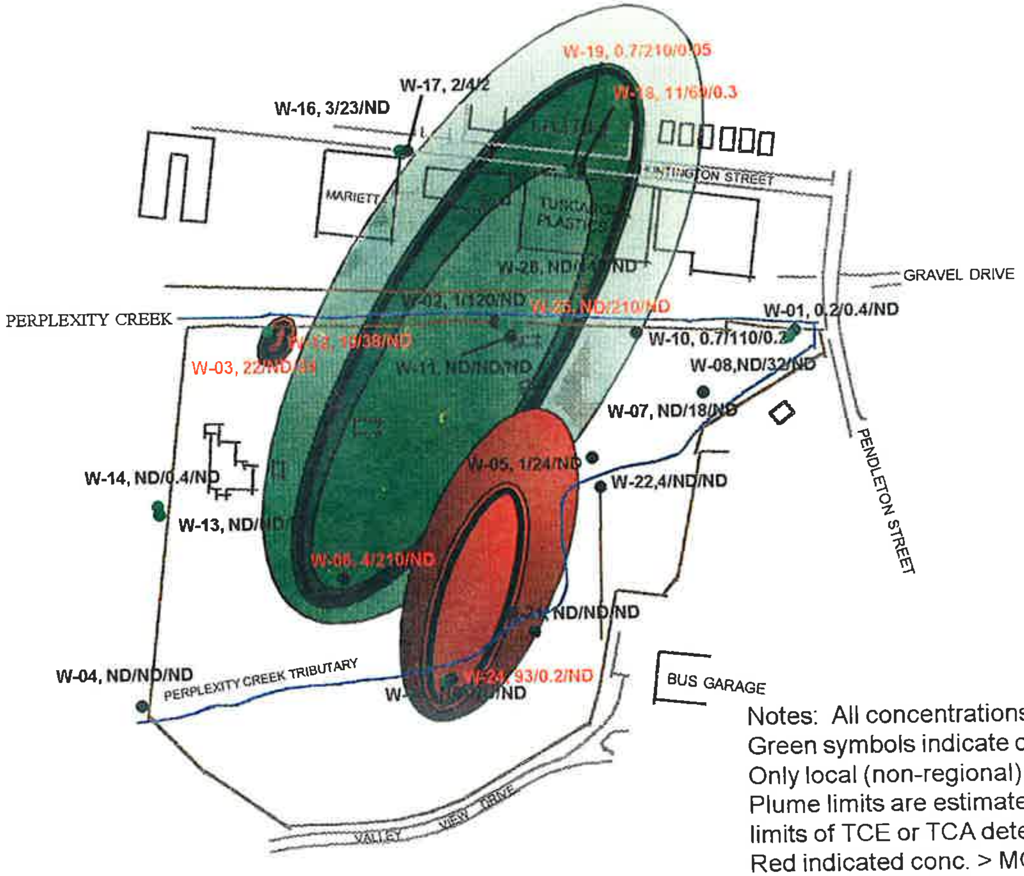
Note:
Exact placement of the NY State standard is approximated.

Figure 7
Generalized TCA and TCE Plumes in Ground Water



Notes:
Green symbols indicate deep wells in the upper outwash
Only local (non-regional) data from March, 1995 are shown
Boundaries are estimates and do not represent the outer limits of TCE or TCA detected

Figure 8
Zones of Ground Water with TCE, TCA, and PCE Concentrations Above MCLs

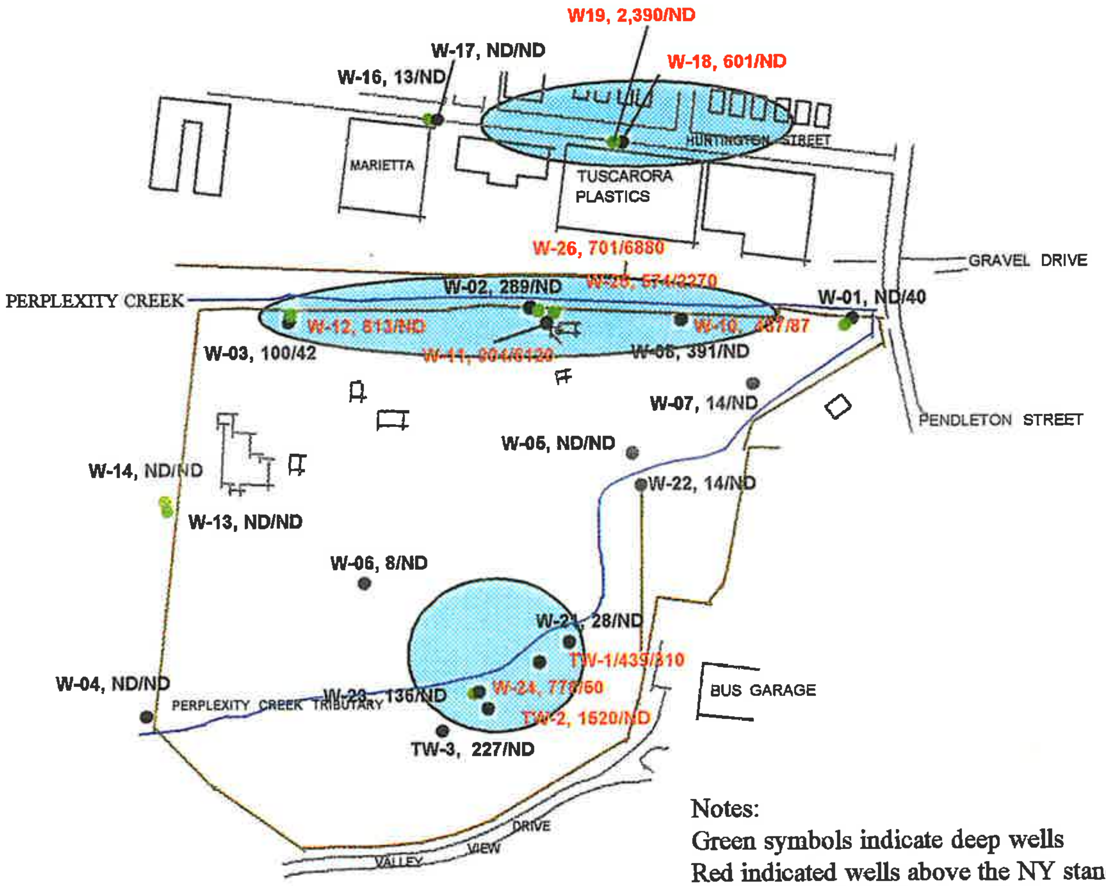


Notes: All concentrations in ppb
Green symbols indicate deep wells in the upper outwash
Only local (non-regional) data are shown
Plume limits are estimates and do not represent the outer limits of TCE or TCA detected
Red indicated conc. > MCL
Data presented as TCE/TCA/PCE detected in March, 1995
MCLs: TCE, 5 ug/l; TCA, 200 ug/l; PCE, 5 ug/l

🟩 TCA above MCL

🟥 TCE/PCE above MCL

Figure 9
Dissolved Manganese and Iron Concentrations Detected in Ground Water above the New York State Standard



Notes:
Green symbols indicate deep wells
Red indicated wells above the NY standard (500 ug/l
for the total of Mn and Fe)
Data presented as Mn/Fe in ppb as analyzed in March 1995
(TW data from July, 1992)
TW indicates a temporary well

▨ Areas above NY Standard (500 total for Mn, Fe)

Figure 10
TCA Family Concentrations
Plume Centerline Wells
Rosen Site, Cortland, New York

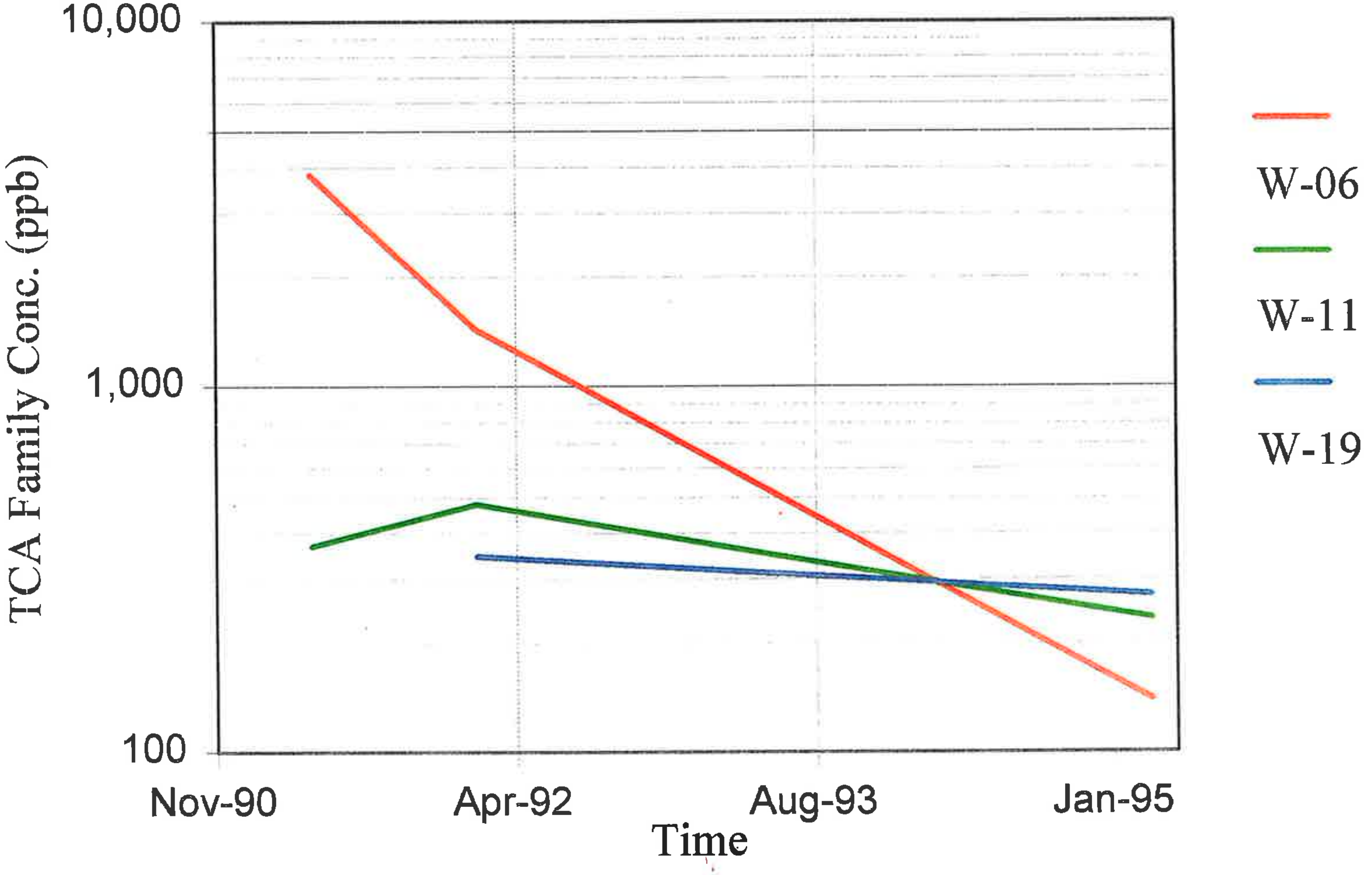


Figure 11
TCE Family Concentrations
Rosen Site, Cortland, New York

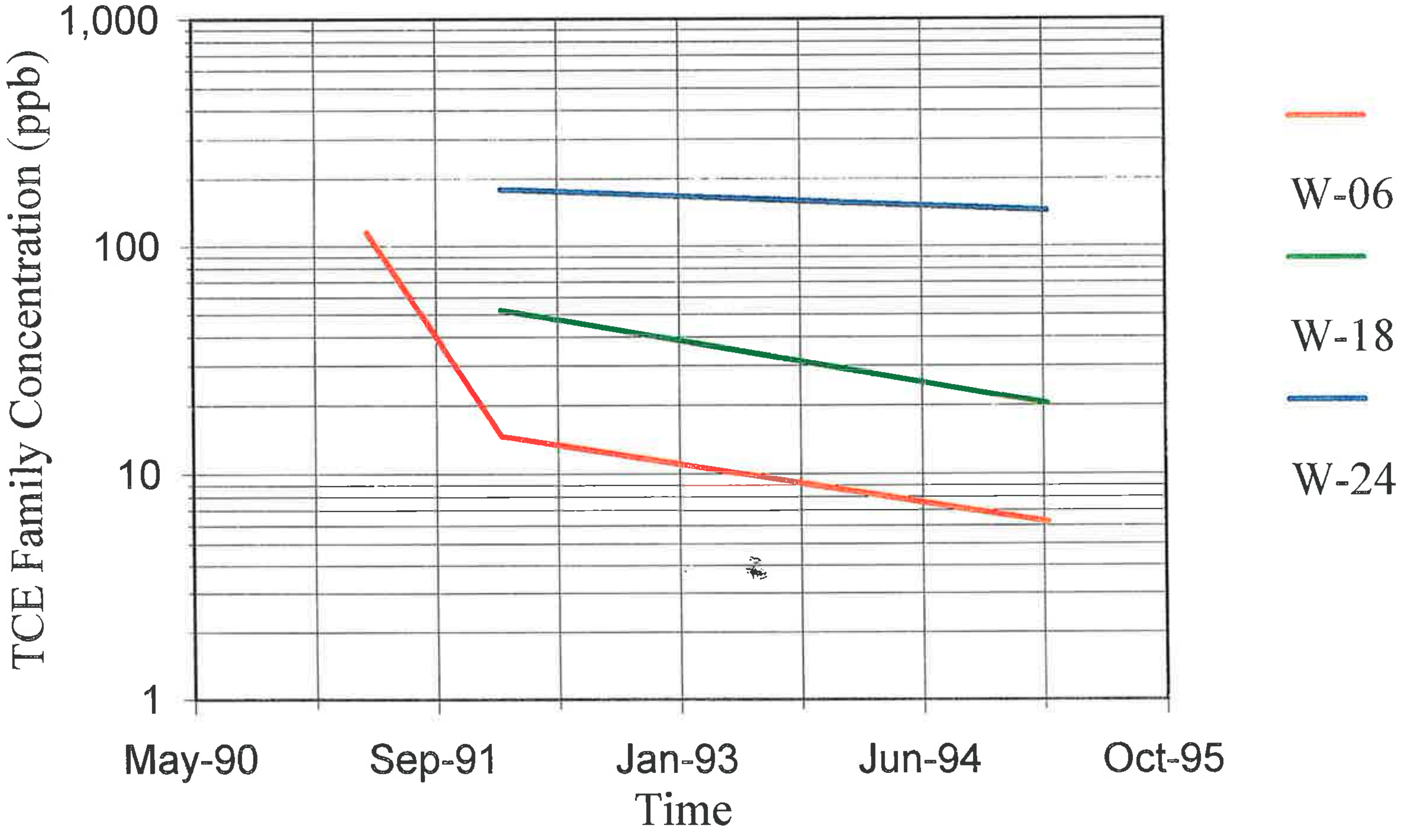
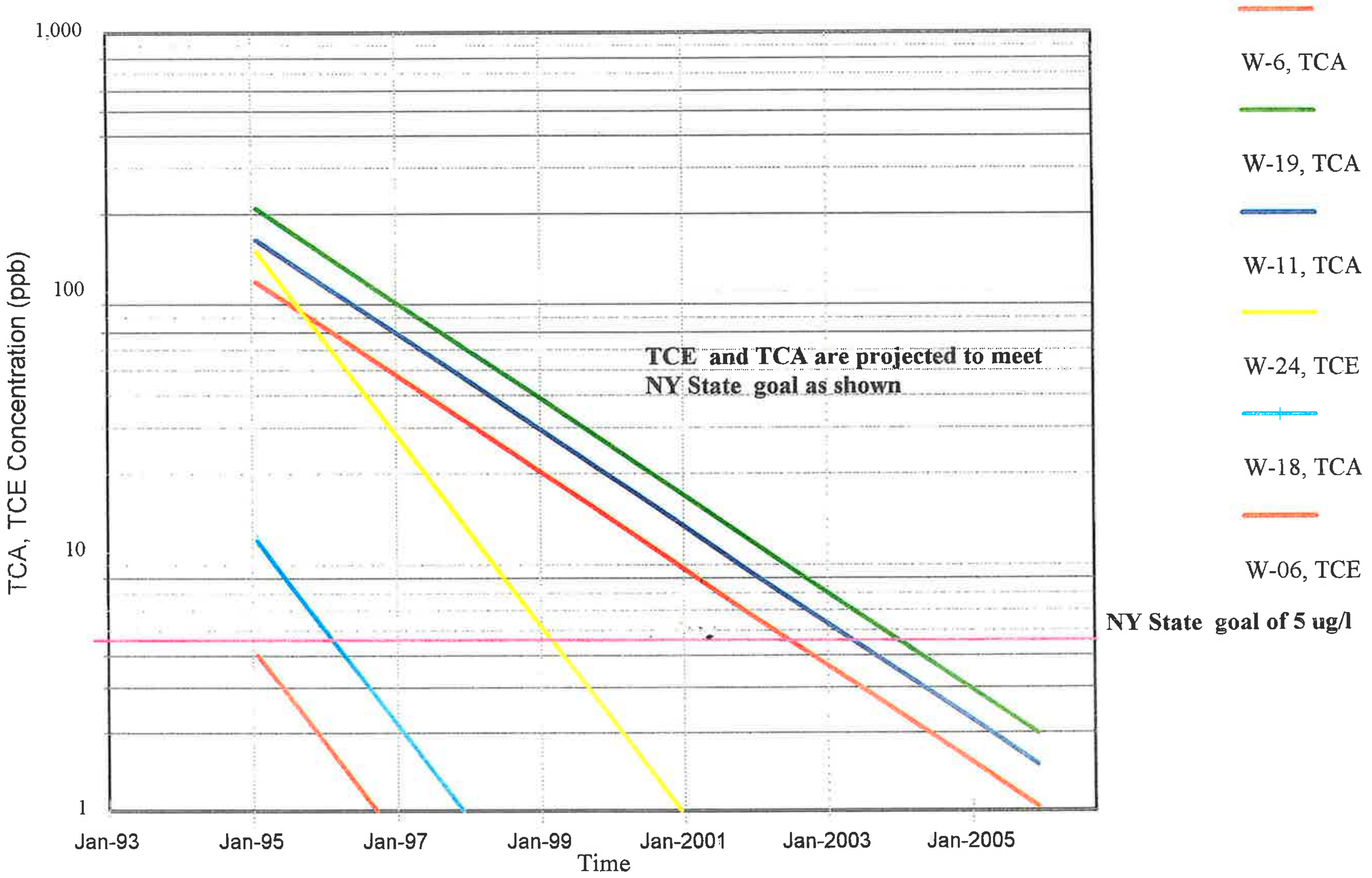


Figure 12
Predicted Degradation of TCE and TCA
Rosen Site, Cortland, New York



TCE and TCA are projected to meet NY State goal as shown