ATTACHMENT 1

Technical Impracticability Evaluation for Groundwater Restoration
Investigation Area WIA-KPW - Study Area No. 1
Kodak Park - Rochester, New York

Introduction

This document presents the Department's evaluation of the practicability of groundwater restoration for the site designated as WIA-KPW. Based on hydrogeologic and contaminant related factors discussed below, the Department concludes that restoration of groundwater to pre-release conditions is technically impracticable at this time. Alternate remedial goals for the site that are attainable are presented. These alternate goals may in the very long term approach the restoration objective for the groundwater.

Restoration of contaminated groundwater is one of the primary objectives of the RCRA Corrective Action Program. The RCRA Corrective Action Program requires a facility owner/operator to institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit. As discussed in the preamble to the Proposed Subpart S to 40 CFR 264, this protectiveness provision would require potentially drinkable groundwater to be cleaned up to levels safe for drinking throughout the contaminated plume, regardless of whether the water was in fact being consumed. Experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to limitations of available remedial technologies in complex hydrogeologic settings.

The Department must evaluate whether groundwater restoration at RCRA groundwater clean-up sites is attainable from an engineering perspective. Many factors inhibit groundwater restoration. Factors that affect the practicability of full restoration may be grouped under two general categories:

- hydrogeologic factors
- contaminant related factor

Hydrogeologic Conditions

Hydrogeologic limitations to aquifer restoration include conditions such as complex sedimentary deposits; aquifers of very low permeability; fractured bedrock flow systems; and heterogeneous subsurface conditions.

Conditions at WIA-KPW include overburden and fractured sedimentary bedrock. The overburden consists of fill materials and glacially derived deposits. The glacial materials range from tills and lacustrine clays to sands. The fill materials include construction and demolition debris and boiler ash. Rapid thickness changes occur. Some of the deposits are discontinuous as well. As a result, hydrogeologic properties in the overburden are heterogeneous. Although hydraulic conductivity values at specific wells vary widely, the geometric mean for the overburden is relatively low, indicating limited permeability.

Sedimentary rocks that include interbedded sandstones, siltstones and shales, underlie the overburden. Groundwater flow in the bedrock is controlled by the distribution and density of fractures. Site investigations have identified various flow zones in the bedrock. The uppermost is called the top-of-rock zone and is a relatively highly fractured zone near the upper surface of the rock. The thickness of this zone varies but is generally on the order of 15 feet thick. Hydraulic conductivity of individual wells varies widely depending on the number of fractures encountered in the borehole. The geometric mean conductivity for this zone is moderate.

The Intermediate Grimsby, a less fractured zone of relatively low conductivity, that functions as an aquitard, underlies the top-of-rock zone. The thickness of this interval varies but is on the order of 25 feet thick. This interval serves to limit the degree of hydraulic connection between the overlying and underlying higher conductivity units. Hydraulic conductivity of the Intermediate Grimsby is generally very low, but at some boreholes, high conductivities occurred throughout the interval. These results suggest that there are localized areas of greater fracture density and increased hydraulic connection.

The Grimsby/Queenston (GQ) flow zone underlies the Intermediate Grimsby. This zone is an interval of elevated conductivity that occurs near the contact between the Grimsby Sandstone and the Queenston Shale. The increased conductivity generally occurs within plus or minus 10 feet of the contact. The increase may be due to more open bedding plane partings and fracturing/weathering of the Queenston Shale. The upper surface of the shale is an erosional surface that was subject to weathering before the Grimsby sandstone was deposited.

The Queenston Shale underlies the GQ zone. The Queenston Shale does not appear to have laterally continuous zones of elevated hydraulic conductivity. The Queenston generally has a very low hydraulic conductivity. However, as with the other bedrock units, boreholes that intersected fractured intervals had higher conductivity values.

The overburden and top-of-rock zones are hydraulically connected. The top-of-rock zone is the dominant flow horizon in KPW in terms of recharge/discharge. Flow in the overburden is primarily downward vertically into the top-of-rock zone. In the top-of-rock zone, primarily lateral flow occurs. Even though there is a strong downward vertical gradient between this unit and the GQ, there is limited hydraulic connection due to the presence of the intermediate

Grimsby. In the top-of-rock, much of the flow discharges to the industrial sewer system. In many areas of the site, this sewer system is installed in trenches excavated into the bedrock surface, well below the water table. These sewer lines were not designed to be water-tight, so where they extend below the water table, groundwater leaks into the sewers. Although there is limited hydraulic connection across the intermediate Grimsby, some of the water from the top-of-rock discharges to the GQ. Much of the flow in the GQ appears to discharge to the Combined Sewer Overflow Abatement Program (CSOAP) tunnels that are installed below the site. The tunnels provide storm retention capacity for the combined municipal sanitary and storm water sewer systems in the vicinity of the site. A minor portion of water from the GQ zone discharges to the underlying Queenston Shale.

Contaminant-Related Factors

Contaminant-related factors, while not independent of hydrogeologic constraints, are more directly related to contaminant properties that may limit the success of an extraction or in situ treatment process. Key among these are the presence of non-aqueous phase liquids (NAPLs), particularly those denser than water (DNAPLs). These materials can be very difficult to locate and remove from the subsurface; their ability to sink through the water table and penetrate the deeper portions of aquifers is one of the properties that makes them very difficult to remediate.

The site has a long history of use for chemically intensive manufacturing operations. Large volumes of chlorinated and non-chlorinated organic compounds have been used at the site, and in recent years, numerous large spills (>1000 gallons) have been reported. Records for releases that occurred prior to 1980 are very limited. Nevertheless, it is reasonable to assume that significant releases have been occurring for at least the past 50 years. Many of the spills have involved chlorinated organic chemicals, materials that form DNAPLs. DNAPLs have been observed in the soils and in wells installed at the site. DNAPLs have also been reported in the top-of-rock zone and in the horizon that is now designated the GQ interval. EPA guidance uses a groundwater contaminant concentration criteria of 1% of the aqueous solubility limit as an indicator that the contaminant may be present at the site as a DNAPL. According to this criteria, the chlorinated volatile organic compounds listed in the table below are potentially present as DNAPL. A "yes" indicates that the most recent sampling results for the compound exceeded the screening criteria. The last two compounds in the table have historically exceeded the criteria, but did not when most recently tested.

Compound	Overburden	Top-of-Rock	GQ Zone	Queenston
Butylated hydroxy toluene	yes	yes	yes	yes
Chlorobenzene		yes		
1,1-Dichloroethene		yes		
1,2-Dichloroethane			yes	
1,2-Dichloroethene	yes	yes	yes	
1,2-Dichloropropane	yes	yes	yes	
Methylene Chloride	yes	yes	yes	
1,1,1-Trichloroethane				
Trichloroethene				

These releases have resulted in widespread dissolved (aqueous) phase contamination of the groundwater in all of the identified flow zones. Compounds in each flow zone detected at concentrations above the relevant clean-up criteria are listed in Tables 1 through 4 (attached). Laboratory testing of bedrock cores collected at the site has shown that contaminants have diffused into the rock matrix from adjacent fractures. Due to extended contaminant exposure, the rock itself now contains contaminant mass that will act as a long-term source. Even if all DNAPL and dissolved phase contaminants could be removed from the bedrock fractures, the rock would continue to release contaminants to the groundwater at levels that would likely exceed groundwater protection concentrations.

Because of the complex hydrogeologic conditions, investigations have not been able to locate significant pools of DNAPL. An additional factor may be diffusion of the DNAPL into the rock matrix. Recent research suggests that such diffusion could, under certain conditions, lead to the rapid (1 to 3 years) disappearance of the DNAPL through the transfer of dense phase contaminants into the rock matrix. DNAPL compounds with relatively high aqueous solubilities, such as methylene chloride (the major contaminant at the site), would be expected to diffuse more quickly than others. Although the DNAPL may no longer exist as a separate liquid phase, the contaminants are still present in the subsurface, but in a less environmentally accessible form.

<u>Evaluation of the Groundwater Flow System</u>

In conjunction with site investigations, Kodak has developed a computer model to simulate groundwater flow at the site and in the surrounding area. The multi-layer model uses the MODFLOW code developed by the USGS. The model integrates a large amount of physical information obtained from site investigations into an interactive system, where assumptions about properties in one part of the model have consequences in other areas of the model. The model was calibrated by minimizing the error between the predicted values (water level elevations) and those actually observed under various site conditions. The calibrated model was then used to quantify recharge and discharge relationships between the various flow zones. As part of a Corrective Measures Study, the model was also used to simulate the effects that different remedial alternatives would be expected to have on site conditions.

Flow simulations from the model for existing conditions indicate that most of the groundwater in the upper flow zones (top-of-rock and overburden) discharges to the industrial sewer system. Minor flows exit the site in the upper zones. Similarly, the model indicates that the majority of flow in the GQ zone discharges to the CSOAP tunnel system. GQ discharge to the CSOAP tunnel system does not necessarily occur within the boundaries of WIA-KPW. Some water from the GQ discharges to the Queenston and eventually flows to the Genessee River or Lake Ontario.

Performance of Interim Remedial Measures

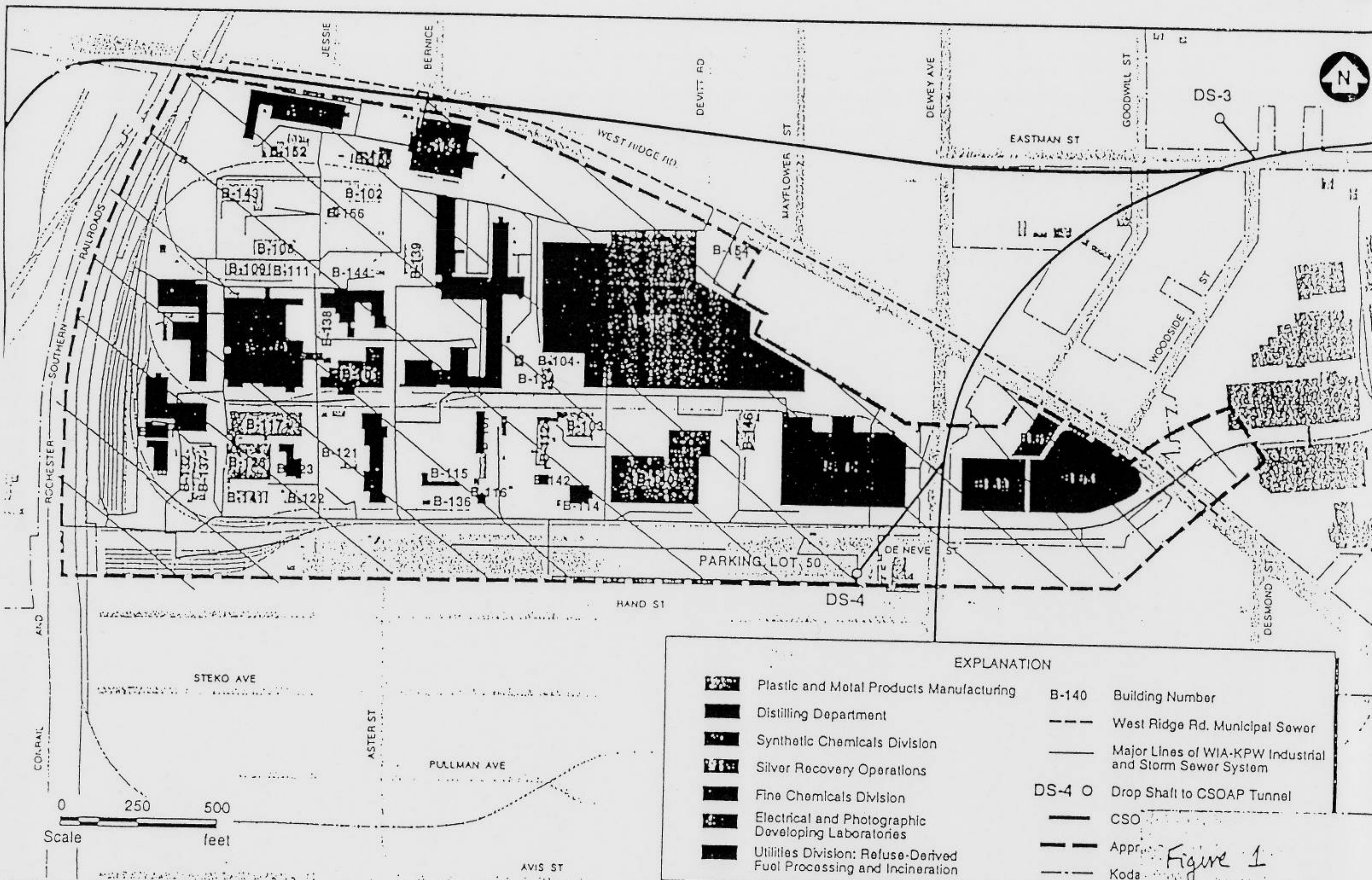
Several interim measures have been implemented at the site. These measures show that although restoration of groundwater to pre-release conditions may be impracticable, hydraulic containment of contaminated groundwater is achievable. Since approximately 1980, Kodak has been operating groundwater recovery wells in the upper flow zones in areas where significant releases were known to have occurred and where significant groundwater contamination was present. These measures could be considered hotspot control. The wells targeted heavily contaminated areas and served to limit the expansion of the plumes. Contaminant concentrations in these recovery wells have generally shown rapid initial declines, and then stabilized, at concentrations far above relevant groundwater quality criteria.

In 1991, Kodak also implemented an interim measure in the GQ flow zone. This measure, called the Parking Lot 50 Migration control system, was designed to intercept contaminated groundwater before it could migrate across the southern KPW boundary. The system utilizes four wells that were hydrofractured to ensure adequate connection to the flow zone. Monitoring data indicates that the system has been effective in controlling migration in this area. Groundwater recovery systems at the site have required intensive operation and maintenance activities to deal with fouling and control/pump failures due to poor water quality.

Remedial Strategy

The proposed remedy for this site acknowledges that full restoration of the groundwater appears to be impracticable in normally accepted timeframes. The alternative goal is to minimize risk by limiting potential exposures associated with contaminated groundwater. For the upper flow zones, the alternative provides containment of the contamination to the site. The interim measures implemented at the site show that containment can be effectively achieved at the site. Containment will prevent expansion of the plume, reduce potential for off-site exposures and impacts, and in the long term, reduce the contaminant mass within the plume through collection and treatment of groundwater. For the lower flow zones, the proposed alternative includes active and passive collection of groundwater that will provide containment in the vicinity of the site. Active collection will be directed at the area of where the highest concentrations of contaminants have been observed. As with the upper flow zones, actions in the GQ will eventually reduce the contaminant mass present in the subsurface. Under the proposed alternative, little would be done to address the contamination in the Queenston. Part of this water may passively discharge to the CSOAP tunnel system. However, the remainder that is not attenuated or degraded will eventually end up in Lake Ontario. Flow simulations for the proposed alternative indicate that only a very small fraction (estimated at ~2%) of the groundwater would discharge to any point other than recovery wells or sewer systems. For more details concerning the proposed remedy, please refer to the Statement of Basis for Remedy Selection for WIA-KPW (a document prepared by the Department).

The Department has determined that technical impracticability determinations are appropriate for this site at this time. These determinations will allow implementation of the proposed remedy. The Technical Impracticability decision applies to an area of limited horizontal and vertical extent. The boundaries are specific to the flow zones that have been identified during site investigations. For the shallow groundwater, which includes the overburden and top-of-rock zones, the impracticability decision applies within the boundaries of WIA-KPW, as indicated on Figure 1. For the GQ zone, the TI decision applies to the area indicated on Figure 2. For the Queenston, the TI decision applies to the area indicated on Figure 3.



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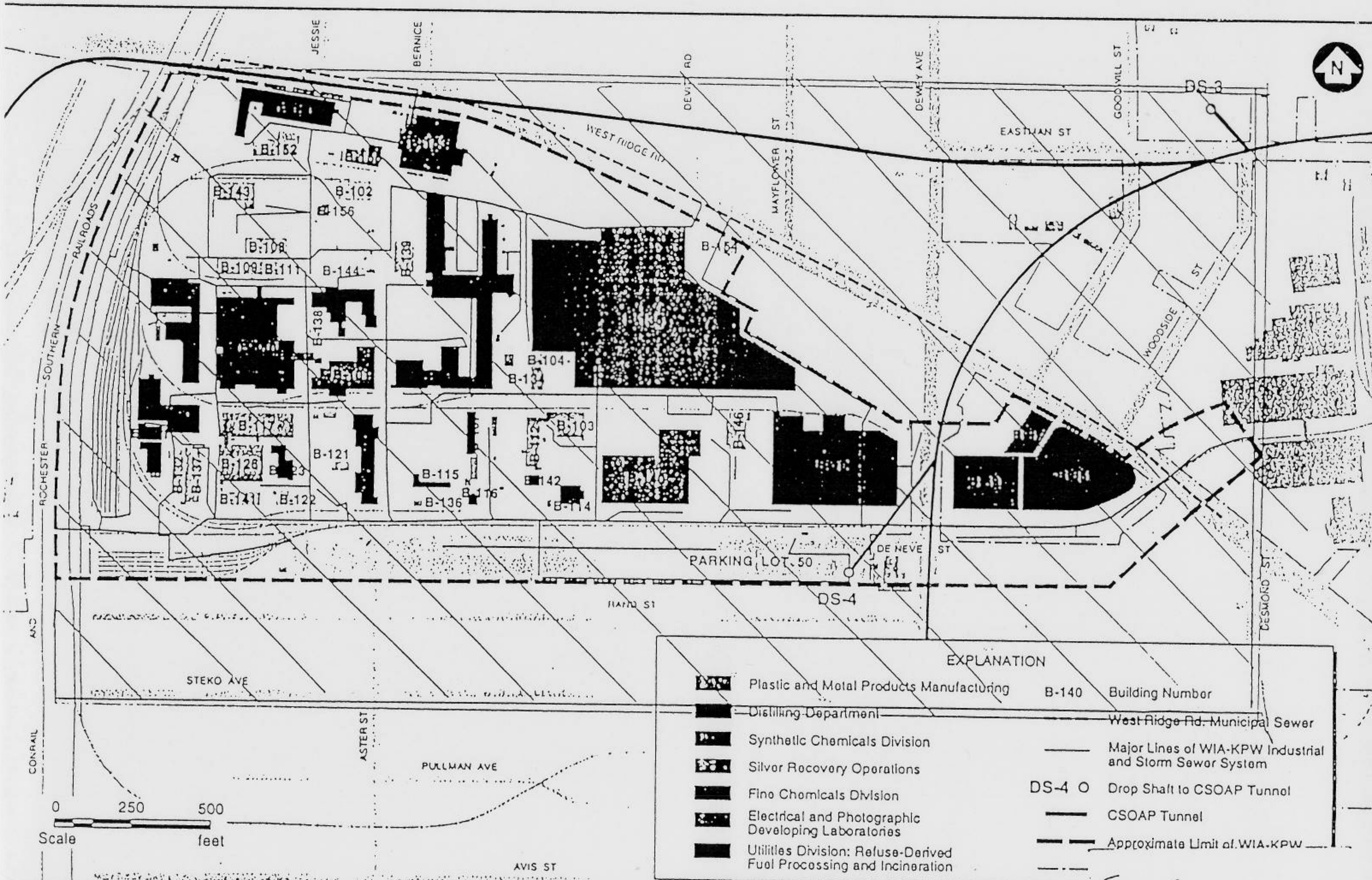
ENVIRONMENTAL INVESTIGATION AREA WIA-KPW

Figure 1
TI Area - Shallow Flow Zones
(Overburden + Top of Rock)



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ENVIRONMENTAL INVESTIGATION AREA WIA-KPW

Figure 2
TI Area - GQ Zone

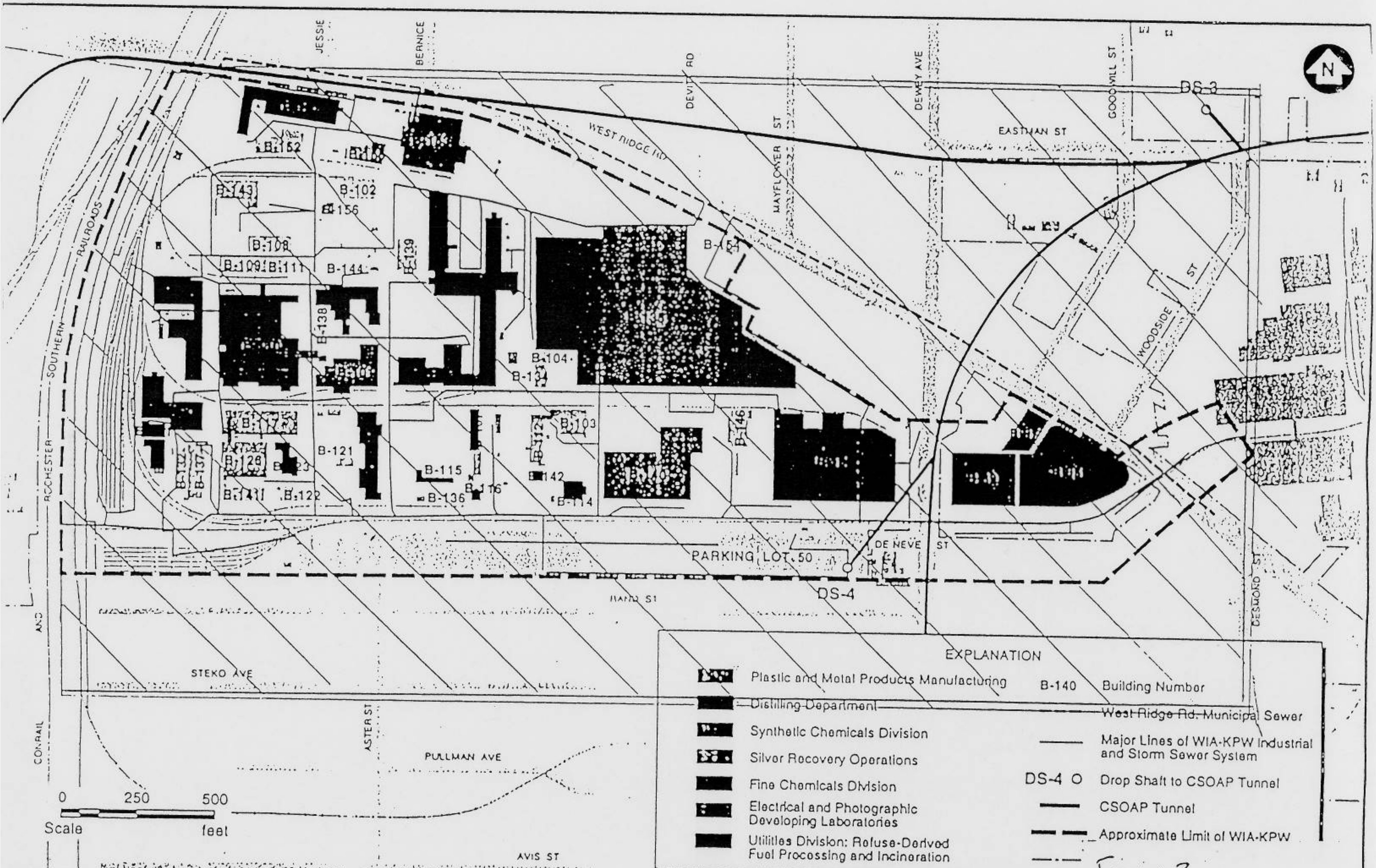

Figure 3

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ENVIRONMENTAL INVESTIGATION AREA WIA-KPW

TI Area - Queenston Zone

TABLE 1

COMPOUNDS IN WIA-KPW OVERBURDEN GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Metals:		
Antimony	3	1000
Arsenic	25	180
Barium	1,000	2400
Beryllium	3	5
Cadmium	5	30
Chromium	50	8260
Copper	200	2400
Iron	300	522000
Lead	15	3800
Magnesium	35000	887000
Manganese	300	13000
Mercury	2	22.5
Nickel	700	2650
Selenium	10	50
Silver	50	1300
Sodium	20000	6350000
Vanadium	250	550
Zinc	300	1400
Semivolatile Organics:		
Benzo(a)anthracene	0.002	2.2
Bis(2-Ethylhexyl)phthalate	50	95
2-Chloronaphthalene	10	180
2-Chlorophenol	f	200
Chrysene	0.002	3
2,4-Dichlorophenol	f	5300
Diethyl Phthalate	50	130
2,4-Dimethylphenol	f	170
Di-n-Butyl Phthalate	4	31

TABLE 1

COMPOUNDS IN WIA-KPW OVERBURDEN GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Ideno(1,2,3-cd)pyrene	0.002	1.3
Naphthalene	10	89
n-Nitrosodiphenylamine	50	90
0-Cresol	f	62
o-Dichlorobezene	4.7	21
p-Chloroaniline	5	13
p-Chloro-m-cresol	f	76
p-Cresol	f	62
p-Dichlorobezene	4.7	72
Phenol	f	4900
Pyridine	50	6300
p&m-Cresol	f	430
Triphenyl phosphate	50	91
Volatile Organics:		
Acetone	3500	14000
Acetonitrile	210	1000
Benzene	0.7	4500
Chlorobenzene	5	1500
Chloroform	7	83
1,1-Dichloroethane	5	410
1,2-Dichloroethane	5	38000
1,2-Dichloroethene	5	35000
1,2-Dichloropropane	5	280000
1,4-Dioxane	3.5	20000
Ethylbenzene	5	13000
Ethylene Glycol	50	39000
Methyl Chloride	5	12
Methyl Ethyl Ketone	1800	7400
Methylene Chloride	5	380000

TABLE 1

COMPOUNDS IN WIA-KPW OVERBURDEN GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
n-Butyl Alcohol	3500	2300000
Porpylene Oxide	0.1	23000
1,1,2,2-Tetrachlorothane	5	110
Tetrachloroethylene	5	13
Tetrahydrofuran	50	41000
Toluene	5	59000
1,1,1-Trichloroethane	5	220
Trichloroethylene	5	2200
Vinyl Chloride	2	7200
Xylenes	5	46000
Pesticides and PCBs:		
Aroclor-1248	0.1	0.5

* = Groundwater Quality Criteria refers to NYSDEC TAGM #3028 groundwater action level.
f = TAGM #3028 total phenols not to exceed 1 ug/l.

TABLE 2

COMPOUNDS IN WIA-KPW TOP-OF-ROCK GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Metals:		
Antimony	3	480
Arsenic	25	320
Barium	1,000	2700
Beryllium	3	3
Cadmium	5	16
Chromium	50	2300
Copper	200	1300
Iron	300	128000
Lead	15	364
Magnesium	35000	518000
Manganese	300	8800
Mercury	2	2
Nickel	700	290
Silver	50	93
Sodium	20000	2700000
Thallium	4	320
Zinc	300	1500
Semivolatile Organics:		
Bis(2-Ethylhexyl)phthalate	50	53
2-Chloronaphthalene	10	48
2,4-Dichlorophenol	f	26000
Diethyl Phthalate	50	1200
2,4-Dimethylphthalate	f	43
Di-n-Butyl Phthalate	4	52
Naphthalene	10	21
n-Nitrosodiphenylamine	50	300
0-Cresol	f	5
o-Dichlorobezene	4.7	62

TABLE 2

COMPOUNDS IN WIA-KPW TOP-OF-ROCK GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
p-Chloroaniline	5	38
p-Chloro-m-cresol	f	6
p-Cresol	f	220
p-Dichlorobezene	4.7	66
Phenacetin	5	6.8
Phenol	f	10000
Pyridine	50	67000
p&m-Cresol	f	560
Triphenyl phosphate	50	5200
Volatile Organics:		
Acetone	3500	50000
Acetonitrile	210	9200
Benzene	0.7	610
Chlorobenzene	5	10000
Chloroethane	5	4100
Chloroform	7	230
1,1-Dichloroethane	5	950
1,2-Dichloroethane	5	25000
1,2-Dichloroethene	5	220000
1,1-Dichloroethylene	5	180000
1,2-Dichloropropane	5	160000
1,4-Dioxane	3.5	71000
Ethylbenzene	5	4500
Ethylene Glycol	50	80000
Methyl Alcohol	18000	850000
Methyl Chloride	5	26
Methyl Ethyl Ketone	1800	19000
Methylene Chloride	5	810000
n-Butyl Alcohol	3500	90000

TABLE 2

COMPOUNDS IN WIA-KPW TOP-OF-ROCK GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Porpylene Oxide	0.1	220
1,1,2,2-Tetrachlorothane	5	680
Tetrachloroethylene	5	14
Tetrahydrofuran	50	510000
Toluene	5	43000
1,1,1-Trichloroethane	5	1000
1,1,2-Trichloroethane	5	150
Trichloroethylene	5	8500
Vinyl Acetate	35000	430
Vinyl Chloride	2	22000
Xylenes	5	35000
Pesticides and PCBs:		
Aroclor-1248	0.1	0.5

* = Groundwater Quality Criteria refers to NYSDEC TAGM #3028 groundwater action level.
f = TAGM #3028 total phenols not to exceed 1 ug/l.

TABLE 3

COMPOUNDS IN WIA-KPW G-Q ZONE GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Metals:		
Antimony	3	250
Arsenic	25	960
Barium	1,000	4120
Beryllium	3	7
Cadmium	5	7
Chromium	50	152
Copper	200	750
Iron	300	310000
Lead	15	710
Magnesium	35000	110000
Manganese	300	2650
Silver	50	110
Sodium	20000	4670000
Thallium	4	380
Zinc	300	498
Semivolatile Organics:		
Benzo(a)anthracene	0.002	5
Benzo(b)fluoranthene	0.002	17
Benzo(k)fluoranthene	0.002	1.5
Bis(2-Ethylhexyl)phthalate	50	180
2-Chlorophenol	f	2
Chrysene	0.002	8
2,4-Dichlorophenol	f	11
2,-4-Dimethylphenol	f	3.4
Di-n-Octyl Phthalate	50	400
Ideno(1,2,3-cd)pyrene	0.002	1.2
0-Cresol	f	16
o-Nitrophenol	f	23

TABLE 3

COMPOUNDS IN WIA-KPW G-Q ZONE GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
p-Cresol	f	9
Phenol	f	3900
p&m-Cresol	f	340
Triphenyl phosphate	50	260
Volatile Organics:		
Acetone	3500	23000
Acetonitrile	210	2000
Benzene	0.7	28
Chlorobenzene	5	1300
Chloroform	7	9
1,1-Dichloroethane	5	41
1,2-Dichloroethane	5	210000
1,2-Dichloroethene	5	85000
1,1-Dichloroethylene	5	700
1,2-Dichloropropane	5	340000
1,4-Dioxane	3.5	1000
Ethylbenzene	5	17
Ethylene Glycol	50	4500
Methyl Chloride	5	11
Methyl Ethyl Ketone	1800	7200
Methylene Chloride	5	2000000
n-Butyl Alcohol	3500	5400
Tetrachloroethylene	5	7
Tetrahydrofuran	50	1000
Toluene	5	9700
Trichloroethylene	5	22
Vinyl Chloride	2	54
Xylenes	5	1000

* = Groundwater Quality Criteria refers to NYSDEC TAGM #3028 groundwater action level.
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TABLE 4

COMPOUNDS IN WIA-KPW QUEENSTON GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Metals:		
Antimony	3	1700
Arsenic	25	980
Barium	1,000	8320
Beryllium	3	3
Cadmium	5	120
Chromium	50	1300
Copper	200	840
Iron	300	410000
Lead	15	1200
Magnesium	35000	200000
Manganese	300	7100
Nickel	700	830
Silver	50	57
Sodium	20000	1330000
Thallium	4	55
Vanadium	250	870
Zinc	300	2600
Semivolatile Organics:		
Bis(2-Ethylhexyl)phthalate	50	170
o-Nitrophenol	f	7
Phenol	f	52
Volatile Organics:		
Benzene	0.7	16
Chloroform	7	11
1,2-Dichloroethane	5	2700
1,2-Dichloroethene	5	8
1,2-Dichloropropane	5	1600
1,4-Dioxane	3.5	180

TABLE 4

COMPOUNDS IN WIA-KPW QUEENSTON GROUNDWATER IN EXCESS OF GROUNDWATER QUALITY CRITERIA*

Compound	TAGM 3028 Groundwater Action Level (ug/l)	Maximum Concentration Detected (ug/l)
Methylene Chloride	5	27000
Toluene	5	160
Vinyl Chloride	2	3
Xylenes	5	9

* = Groundwater Quality Criteria refers to NYSDEC TAGM #3028 groundwater action level.
f = TAGM #3028 total phenols not to exceed 1 ug/l.

Attachment 2

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