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Special Study Report

S-AREA/WATER TREATMENT PLANT CONTAMINANT PRESENCE AND MIGRATION ASSESSMENT

City of Niagara Falls, New York

APRIL 1989
Project:0337-13-1

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S-AREA/WATER TREATMENT PLANT
CONTAMINANT PRESENCE AND MIGRATION ASSESSMENT

APRIL 1989

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S-AREA/WATER TREATMENT PLANT
CONTAMINANT PRESENCE AND MIGRATION ASSESSMENT

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EXECUTIVE SUMMARY

1. Malcolm Pirnie was retained by the City of Niagara Falls to perform a detailed assessment of Conestoga-Rovers & Associates Ltd. and Occidental Chemical Corporation (CRA/OCC) surveys and studies related to migration of organic contaminants from the S-Area landfill to the City's Water Treatment Plant (WTP) property. Malcolm Pirnie completed an extensive review of over 60 studies, surveys and other documents; as well as construction records and plans for the water treatment plant.

2. CRA/OCC contend that contamination detected in the overburden below the treatment plant property is not attributable to S-Area chemical migration, but instead is the result of previous fill activities undertaken by the City and others. Key CRA/OCC arguments include:

   - Contaminant concentrations do not decrease steadily with distance from the S-Area, therefore the patterns are inconsistent with overburden chemical migration;

   - Overburden ground water elevations indicate that the treatment plant site is not down-gradient from the S-Area, and;

   - The presence of "non-mobile" chemicals on the water treatment plant site is evidence that contaminated fill materials were used to reclaim parts of the Niagara River and extend the former shoreline.

3. Re-evaluation of borehole and well data by Malcolm Pirnie strongly suggests the existence of distinct linear depressions in the subsurface clay layer which were not identified in previous studies including CRA/OCC's most recent assessment. One channel-like feature shows an east-to-west trend, and is generally located between Plant A and the central Filtered Water Reservoir. This linear depression corresponds roughly with the historical location of the outfall of a 20-inch diameter wash water drain from Plant B, which has not been previously identified. The second feature is located immediately west of Plant A and has a north-to-south orientation. Regular daily discharges of filter backwash wastewater

to the river via this drain may well have created the clay depressions by scouring action of the discharge.

4. The fill/alluvium which is the principal water-bearing zone in the overburden is highly variable in texture and thickness, which would facilitate ground water and contaminant movement in non-uniform patterns. For example, it is quite possible that dense NAPL could move in a downslope direction along the top of the clay/till aquitard which underlies the fill, and that the clay depression and intersection excavations would provide pathways not identified in previous studies.

5. It is widely recognized that foundation and utility trench excavations will act as preferential pathways for ground water and contaminant movement, particularly where backfill materials are more permeable than the original excavated materials. The construction records clearly show that excavations for several site structures and pipelines extend below the original clay surface creating channel-like depressions/troughs in the clay. Specifically, the central Filtered Water Reservoir and the 1955 Pumping Station are linked by three excavations for filtered water pipelines which extend below the clay surface. The Filtered Water Reservoir itself and pipelines connecting to the 1915 Pumping Station were also excavated into the clay, providing another potential west-to-east pathway for contaminant movement.

6. CRA/OCC's conclusion that the WTP is not hydraulically downgradient from the S-Area is based only on recent water level survey data. Historical information on overburden ground water levels is very sparse; however, it is almost certain that subsurface flow patterns were substantially altered during construction activities during the 1940s and 1950s. It is possible that dewatering of excavations associated with construction of the Filtered Water Reservoir, 1955 Pumping Station and associated pipeline could have induced

significant west-to-east ground water movement along the potential pathways discussed above.

Recommendations

1. Significant spatial gaps exist in CRA/OCC sampling locations. The requirement for additional data is recognized by CRA/OCC who have proposed to install a monitoring well in the area west of CW6A to further define overburden ground water quality in that area. It is recommended that additional investigations to be undertaken by CRA/OCC, focus on defining the extent of the suggested linear depressions in the clay surface. These depressions should be investigated through the use of geophysical techniques, test borings/wells, and additional sampling.

2. CRA/OCC should direct the utility bedding investigations required under the 1984 Stipulation and Judgement toward the 48-inch reinforced concrete pipeline and control chamber (1943) between the 1915 Pumping Station and central Filtered Water Reservoir, the 42-inch pipelines which connect the new Pumping Station to the Plant A control chamber (1955), and the 49-inch pipeline from Plant A to the central Reservoir (1955).

3. The characteristics and source of site fill materials are largely unknown. CRA/OCC propose to collect samples of fill materials above the saturated zone from select areas of the site and analyze for S-Area survey parameters. It is recommended that these samples be distributed in a pattern which is cognizant of past landfilling, construction and dewatering activities.

1.0 INTRODUCTION

Malcolm Pirnie, Inc. was retained by the City of Niagara Falls to conduct a detailed review/assessment of available reports and other existing documentation related to migration of organic contaminants from the S-Area Landfill to the City's water treatment plant (WTP) property. The site location is shown in Figure 1-1 and the assessment area is shown on Plate 1 (in pocket in back of report). This assessment was prepared in response to the contention by Conestoga-Rovers & Associates Ltd./ Occidental Chemical Corporation (CRA/OCC) that contaminants detected in the WTP overburden are not attributable to previous S-Area Landfill operations but instead were present in the soil/fill materials used in reclaiming land from the Niagara River. Key arguments presented in CRA/OCC's 1988 assessment report titled City of Niagara Falls Drinking Water Treatment Plant, Assessment of Overburden Chemical Migration to the Water Treatment Plant, (pp.41-43), which CRA/OCC claim support this position, are presented below.

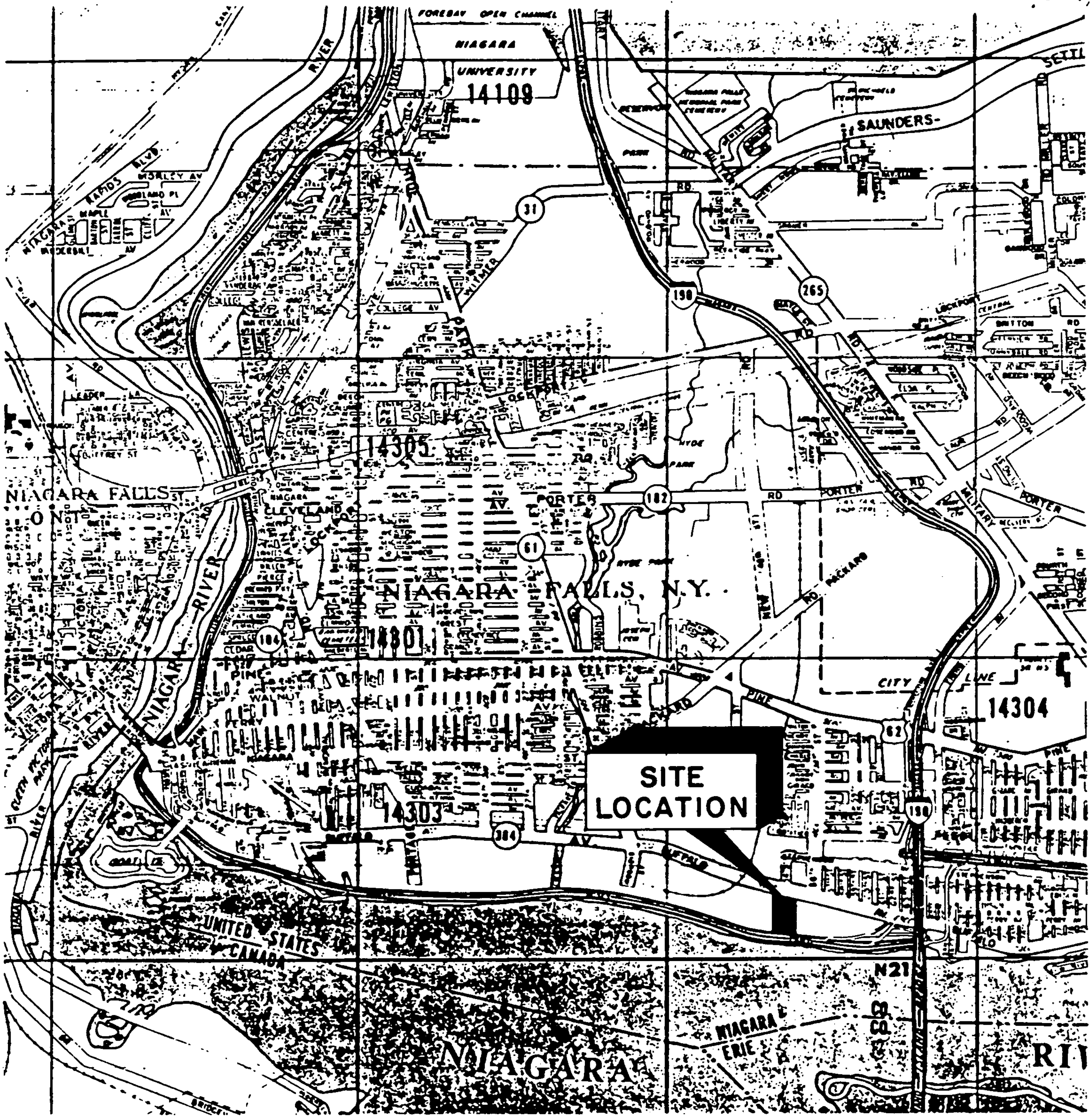
- The concentrations of S-Area Survey Parameters in the soil at the WTP generally indicate a trend of decreasing concentrations in a westerly direction (i.e. toward the S-Area). This is inconsistent with chemical migration from S-Area in the overburden.

- The concentrations of S-Area Survey Parameters in the ground water at the WTP indicate that the wells exhibiting the highest survey parameter concentrations on the WTP are typically separated from the elevated S-Area APL (aqueous phase liquid) plume observed along the eastern property line of the S-Area by an area showing no survey parameters.

- From a hydrogeologic perspective of the overburden ground water the WTP is not downgradient of the S-Area and therefore, would not be expected to receive chemicals which have migrated from the S-Area in the ground water.

- The patterns of identified chemical presence in the soil and water are inconsistent with the solubility, transport properties and attenuation characteristics of chemicals which would have migrated from the S-Area.

FIGURE 1-1



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LOCATION MAP

- Fill materials were observed at the WTP property, including one case of non-mobile, non-aqueous phase chemical presence. The areas of identified placement of fill on the WTP are consistent with historical records of the southerly progression of the Niagara River shoreline. The sources of the fill material used to extend the WTP property are unknown.

- It is evident from the survey that fill materials containing chemicals have, in fact, been deposited on the WTP in the vicinity of the Filtered Water Reservoir and Plant A. The chemical concentrations measured in the soil and ground water collected in this area are consistent with the pattern that would be expected from filling using contaminated soil.

This assessment focuses on overburden geology/hydrogeology, overburden and ground water analytical data and historical information, to assess the likely source(s) and potential migration pathways for specific contaminants detected in the WTP overburden. Specific components of this assessment include:

- Collection and compilation of available geologic and hydrogeologic data from studies and geotechnical investigations completed on the WTP property, as well as from historical information (maps, plans and resident engineering reports) on buried utilities, foundations and structures at the WTP. The 66 documents reviewed as part of this assessment have been assigned a Source Number and are listed in Appendix A. References to specific reports and investigations in the following text is by Source Number.

- Adjustment of all surveyed elevation data for boreholes, structures, etc. to a common datum, namely that established by OCC in 1986, and review/verification of geologic horizons from on-site test borings as presented in CRA/OCC 1988 study report.

- Preparation of a series of historical site utility plans (1915 through 1985) which correspond with major plant construction events and preparation of plan maps of specific geologic horizons and cross-sections of the site. Record drawings, plans and specifications used in preparing the historical site plans and construction history have been assigned a Reference Letter, and are listed in Appendix B.

- Complete documentation of findings, and preparation of this summary report.

2.0 BACKGROUND

2.1 WATER TREATMENT PLANT CONSTRUCTION HISTORY

This historical review of the City of Niagara Falls Water Treatment Plant (WTP) construction is based on an extensive review of engineering plans, specifications, record drawings and reports obtained from the City of Niagara Falls and other sources. The primary references are listed and summarized in Appendix B. The WTP site development is illustrated on Plates 2 through 6 which present a visual chronology of key events in the construction history.

<u>Circa 1915</u> - The City of Niagara Falls first constructed a water treatment plant at the present location (Buffalo Avenue and 53rd Street) between 1908 and 1912 (Ref.B). Plate 2 shows the plant site as it existed around 1915. The original plant (known today as Plant B) consisted of sixteen sand filters, four underground sedimentation basins, and a one million gallon filtered water clearwell. The raw water and filtered water pumping equipment was located in a separate building immediately adjacent to Plant B. Raw water was pumped to Plant B from the Pumping Station after gravity feed from the East Branch of the Niagara River via a 48-inch riveted-steel intake pipeline. Settled solids and filter backwash wastewater were discharged to the Niagara River through a 20-inch cast iron sewer located at the southwest corner of the plant (Refs. B, N). This pipeline was not identified in previous histories.

<u>Circa 1935</u> - Extension of the shoreline south of Plant B commenced in the 1920s as the area was landfilled with construction rubble and municipal waste including soil, refuse, cinders, and ash. The 20-inch wash water drain was abandoned as fill activities progressed and wastewater was diverted into a new sewer along Buffalo Avenue (Refs. N, S). By 1935 the shoreline was extended southward as much as 750 feet (Refs. F, S). A small bay existed near the terminus of the 24-inch wash water drain, as shown on Plate 3.

Expansion of Plant B in 1935 included improvements to the raw water supply capability, general upgrading of plant production capacity, and the addition of a new forebay and heating plant. The raw water supply facilities were upgraded by construction of a bedrock intake tunnel and vertical shoreshaft. The shoreshaft is essentially a vertical shaft which provides access and enables raw water to be brought from the bedrock tunnel to the surface. A 54-inch steel pipeline was installed to connect the shoreshaft to the pump station, and the original 48-inch intake pipeline was relegated to auxiliary use (Ref.P). Plant B was expanded through the addition of eight rapid sand filters and underground sedimentation basins. A 24-inch wash water drain was also installed at the east end of Plant B which allowed discharge of filter backwash, settled solids, and plant overflow to the Niagara River (Refs. O, S).

Circa 1945 - Plate 4 is a plan of the WTP in 1945. Plant additions in 1943 included a four million gallon finished-water reservoir, a 48-inch filtered water line and control chamber immediately south of Plant B. The project was funded under the War Powers Act and administered by the Federal Works Agency (Ref. H). The parcel of land on which the Reservoir was built was owned by the Federal Government and not transferred to the City of Niagara Falls until 1953. A meter and control pit was also constructed adjacent to the existing Pump Station (now Water Department Office). In addition, a 20-inch cast iron pipeline was constructed from the shoreshaft to the Pump Station to augment the raw water supply, and new pumping equipment was installed at both of these locations.

Circa 1955 - The water treatment facilities were expanded again after World War II in response to significant population and industrial growth in Niagara Falls. Expansions included a new filtration plant (known today as Plant A), a new pumping station, and the extension of the 1935 intake tunnel (Refs. C, G, Q). Four underground mixing basins were also added to the east end of Plant B to enhance flocculation (Ref. A). Plant A consisted of eight rapid sand filters, four flocculation basins, four underground sedimentation basins, a 2.5 million gallon underground finished-water reservoir, and a chemical pretreatment and control building. A new 66-inch steel pipe was constructed from the existing shoreshaft to the new pumping station, and the 54-inch and 20-inch raw water pipelines were subsequently abandoned. The 48-inch auxiliary intake was also connected to the new pumping station for use when the bedrock tunnel intake was not in service. Wastewater from Plant A was discharged through a 48-inch sewer extending from the south end of the filter building to the Niagara River. The old pumping station was converted into office and garage space for the City Water Department.

The raw water intake was extended in 1954 to the Emerald Channel (west branch) of the Niagara River between Navy and Buckhorn Islands. The new intake included: a) a bedrock tunnel 30 feet below the river bottom approximately 3,400 feet long, and b) a hexagonal shaft which extends down from the intake to the bedrock tunnel. Raw water is conveyed from the shoreshaft to the new pumping station via the 66-inch raw water line. The pumping station utilizes four low-service pumps with a combined capacity of 90 MGD to pump raw water to Plants A and B via two 42-inch low-service discharge lines. Finished water is pumped from the three reservoirs (Plant A, Plant B and Filtered Water Reservoir) to the distribution system by six high-service pumps having a total capacity of 115 MGD. Plate 5 shows the WTP in 1955 after this construction was completed.

Circa 1985 - Plate 6 shows the plant and shoreline as it existed in 1985. As shown, the shoreline was extended by the State of New York an additional 300 feet after 1955 in order to accommodate the Robert Moses Parkway. The most recent additions to the water treatment plant occurred in the late 1970s with the construction of wastewater handling facilities (i.e., filter backwash and sedimentation basin sludge), and installation of an emergency diesel generator. The new sludge thickener and sludge pumping station were constructed to provide equalization and thickening of filter backwash wastewater, and recycle of supernatant to the headworks of Plant A. The emergency generator provides complete backup electrical capability in the event that the off-site power supply is interrupted.

2.2 PREVIOUS INVESTIGATIONS

Malcolm Pirnie completed an extensive review of the source documents listed in Appendix A. A synopsis of each group of reports is presented in Appendix C, and key findings and conclusions are discussed in the following sections.

Numerous test borings/well installations have been completed at the WTP and the adjacent S-Area Landfill, as shown on Plate 1. Test borings completed at the WTP property prior to 1978 (i.e., after contamination was discovered) were typically for the purpose of obtaining geotechnical information in support of WTP construction activities. After 1978 the emphasis shifted to identifying potential environmental impacts attributed to past S-Area Landfill disposal activities. Initial hydrogeologic investigations of the WTP property were completed by Leggette, Brashears and Graham, Inc. in 1979-1980 on behalf of the Department of Justice/Environmental Protection Agency and State of New York. Similar investigations were being conducted by Conestoga-Rovers & Associates Ltd. (CRA) for Occidental Chemical Corporation (OCC) at the S-Area site beginning in 1980. These and subsequent investigations throughout the 1980s have focused on the S-Area itself and on that portion of the WTP property adjacent to the S-Area. Table D-1 in Appendix D provides a summary of available test boring and monitoring well information for the WTP property. More details on the chronology of geologic investigations conducted at the WTP is presented in Source 52.

2.3 DATA BASE INTERPRETATION

A number of assumptions and/or generalized observations concerning the available data base are presented below.

<u>Borehole Locations</u> - It has been assumed that borehole/monitoring well locations presented in the original study reports are correct. Borehole/well locations were scaled off the source figures/plans and transferred to Plate 1. Locations were not verified in the field (i.e. resurveyed). Under circumstances where the boring/well location

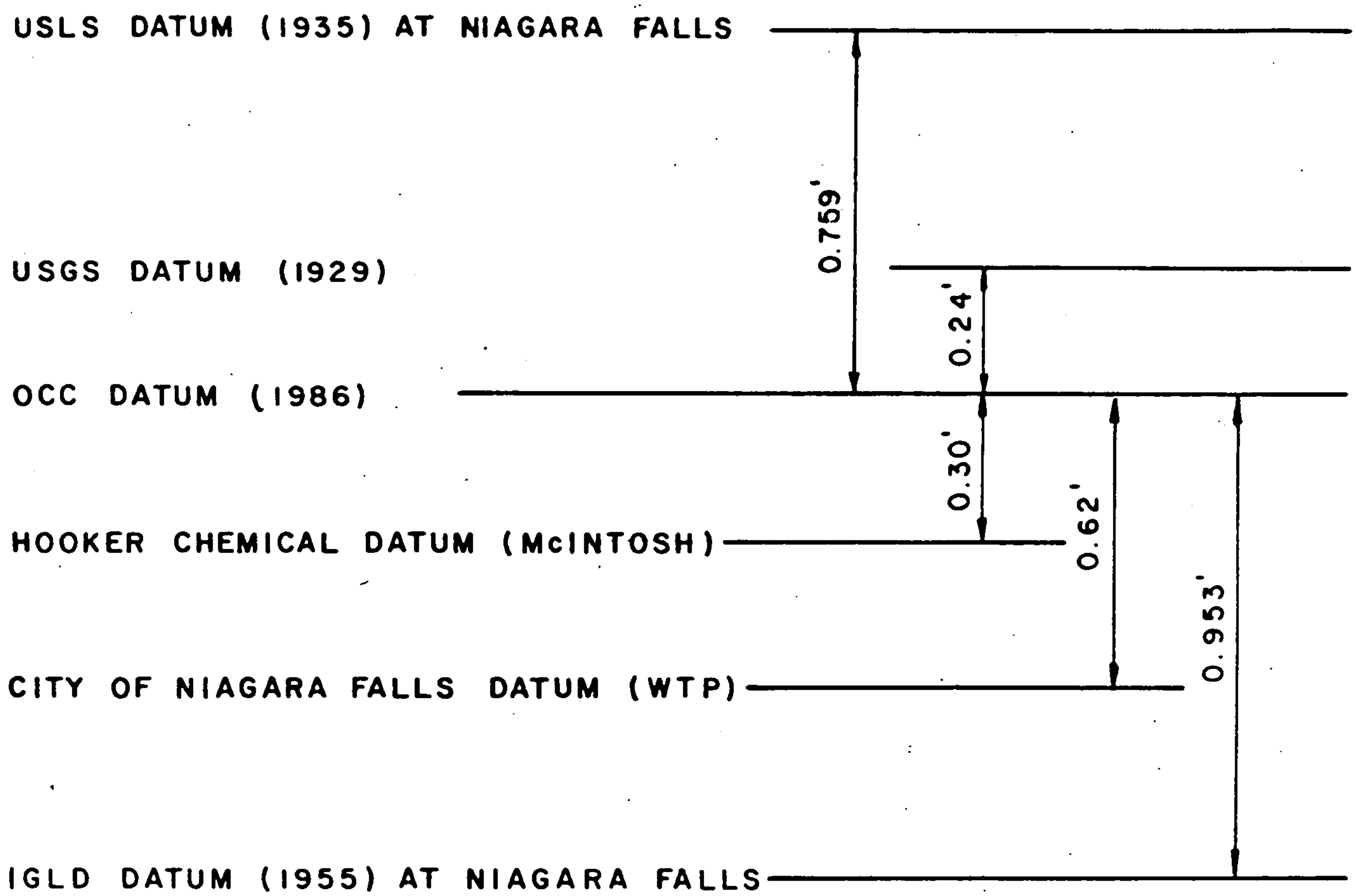
could not be established from the source document, a default location from CRA/OCC's 1988 report (Reference Source 61) was used.

OCC Datum - All ground and measuring point elevations were adjusted to a common reference datum (OCC 1986 Datum). The 1986 OCC Datum was chosen to enable easier comparison with elevations presented in existing CRA/OCC documents. This involved establishing the initial elevation of the point of interest from the source document, identifying the applicable datum and adjusting the elevation in accordance with Figure 2-1. Ground and measuring point elevations were not verified in the field. Where it was not possible to establish the datum, a default elevation corresponding to OCC's January 9, 1989 memorandum (J. Nichter to R. Grassi of USEPA) was used.

Field Procedures/Protocols - Protocols followed in boring and well completion, equipment decontamination, and sampling and analysis of soil and water are often not consistent between drilling programs and, in some instances, are not specified in any great detail, particularly in the case of sampling and analysis. It is, therefore, difficult to assess the integrity of the well installations or the validity of the collected sampling and analytical data presented in the older study reports which pre-date 1988. Observations concerning the availability of information and well completion considerations which may limit the usefulness of some of the data are listed by boring/ monitoring well in Table D-2, Appendix D. Specific comments with respect to well completion, as indicated in Table D-2, include:

- The screened interval for several of the monitoring wells straddles the contact between two hydrostratigraphic units (i.e. shallow water-bearing zone and aquitard or aquitard and bedrock). This results, where applicable to hydrologic interpretations, in composite hydraulic heads and non-representative hydraulic conductivities.

- Seals in several of the wells are either suspect or may potentially deteriorate with time. For example, many of the bedrock wells were constructed using a method which involves grouting



NOTE: MODIFIED FROM S-AREA HYDROGEOLOGIC EVALUATIONS
GEOLOGIC TESTING CONSULTANTS LTD. 1982 -
SOURCE REFERENCE 37.

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SUMMARY OF DATUMS USED IN THE VICINITY OF THE WATER TREATMENT PLANT

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casing into a one- to two-foot "rock socket", prior to completion of the well to a deeper depth. These wells may not completely seal off the upper weathered portion of the bedrock and it is, therefore, possible for overburden water to move around the grout seal through fractured rock into the open bedrock borehole. In other instances, the bentonite seals for bedrock wells either straddle or are completed above the overburden/bedrock contact, again resulting in a questionable seal. Many of the more recently completed bedrock wells did not utilize bentonite seals but instead involve pressure grouting of the annular space with a cement/bentonite slurry. Although this method results in an effective seal, it is conceivable that with time grout shrinkage or cracking could allow infiltration of overburden water into the bedrock through the well annulus.

- Sampling, analytical and decontamination protocols vary between references and on occasion have been judged by review agencies (e.g. Sources 40 and 49) to be inadequate. Often, chemical data reported in the references represents averaged values for two or more sampling events rather than original data (see Table D-2). QA/QC information in support of the chemical data sets is seldom reported in the references. An independent appraisal of the validity of the chemical analysis results was not undertaken as part of this assessment.

Historical Perspective - The majority of the information available for the site only dates back to 1979. Conditions (i.e. ground water levels and direction of flow) at the WTP property could have been significantly different during and subsequent to the period of active use of the S-Area for disposal (i.e. 1947 through 1975).

3.0 GEOLOGY AND HYDROGEOLOGY

Information on the regional geology and hydrogeology of the Niagara Falls area presented in this report is summarized from S-Area Hydrogeologic Evaluation, Geologic Testing Consultants, Ltd., August 24, 1982 (Source 37). The description of the geology and hydrogeology of the WTP property is summarized from the reports titled Current Hydrogeological Conditions, City of Niagara Falls Drinking Water Treatment Plant, Leggette, Brashears & Graham, Inc., October 14, 1980 (Source 17) and City of Niagara Falls Drinking Water Treatment Plant, Assessment of Groundwater Table Contours and Geologic Conditions, Conestoga-Rovers & Associates, June 1988 (Source 52). The interpretations contained in these reports have been updated to include observations made during this assessment.

3.1 REGIONAL GEOLOGY AND HYDROGEOLOGY

The regional geology of the Niagara Falls area is characterized by a thin deposit of glacial material overlying Paleozoic sedimentary bedrock. The glacial deposits consist of glaciolacustrine clay containing some silt and fine sand layers, underlain by till with varying amounts of sand, silt, clay and rock fragments. The till directly overlies the bedrock throughout the Niagara Region. Alluvial silt, sand, and gravel may be present locally as a thin veneer overlying the glacial deposits.

The thicknesses of the glacial deposits south of the Niagara Escarpment (general area of the WTP) range from about 15 to 50 feet.

The bedrock in the Niagara Falls area consists of dolomite, shale, limestone and sandstone forming the Lockport Dolomite, Clinton and Albion Groups, and the Queenston Formation.

In the Niagara Falls area, the water table is generally within the overburden at a depth ranging from near surface to several feet below the ground surface. The slope of the water table, which generally reflects the topography, is relatively flat. The low permeability silty clay and till limit regional ground water movement. Flow is expected to be primarily downward through these materials as is reflected in observed vertical gradients. This downward component of flow is expected to be the primary source of recharge to the bedrock. Direct recharge of surface water to the bedrock is evident in the vicinity of the Niagara River. This phenomena is attributable to regulation of river levels and the influence of the PASNY intake structures.

3.2 GEOLOGY OF THE WATER TREATMENT PLANT PROPERTY

The stratigraphic sequence which underlies the WTP varies from the regional geology in that much of the property is "made ground", that is land reclaimed from the Niagara River. Therefore, the stratigraphic sequence from top to bottom includes a distinct fill layer, in addition to the alluvium, glaciolacustrine clay, till, and bedrock which occurs regionally. The depths and elevations of the major stratigraphic units by borehole/well are presented in Table D-3, Appendix D. Geologic data presented in this table were compiled from the original boring logs, wherever possible.

Fill - The fill consists primarily of silt, sand and gravel of variable origin and is likely to include material excavated during various phases of WTP construction. Other fill materials identified in the borehole logs and collectively referred to as "refuse", include cloth, bottom ash, wire, filtercake, brick, cinders, ash, wood, precipitates, concrete, masonry, white material, coal, glass, shot rock, rebar, flyash, slag, rusted metal, cardboard, ceramic or metal fragments, fibrous material, rubber and industrial wastes. Fill thickness varies from 0 feet in the northern part of the site, to 42 feet at BH7-80 in the southern part of the site near the Niagara River, due to the extended shoreline and construction of the Robert Moses Parkway. Local pockets of thicker fill may be related to infilling of depressions in the river bottom or to eroded channels.

A contour map showing the top of native overburden material (pre-fill land surface condition) as determined from borehole logs is included as Plate 7. In reviewing the borehole logs, the natural ground surface was determined as the top of the alluvium, or where this unit is absent, the top of the clay/till. A layer of organic debris (muck) was noted in some of the older geotechnical borings (Circa 1943) completed in the vicinity of the Reservoir but was disregarded during contouring. This layer of debris likely originated as sediment from the outfalls of wash water drains (Plate 3) which conveyed sludge and backwash waste water from Filtration Plant B to the general area.

Based on the visual chronology presented in Plates 2 and 3 it is apparent that between 1915 and 1935, the shoreline along the western portion of the WTP property (south of the old Pumping Station) was expanded southward in advance of the eastern portion of the property (south of the Reservoir) to create a delta-like feature in the river. Between 1935 and 1945, landfilling occurred along the eastern side of the "delta" in a generally north-to-south direction. Review of construction reports for the Reservoir indicate that at least a portion of the fill originated as excavated soil/fill from construction of the Reservoir. The shoreline remained relatively static until about 1955 when it was extended an additional 300 feet southward by the State of New York to accommodate the Robert Moses Parkway.

The Niagara River level is maintained at a long-term average of 561.95 feet ±1.5 feet AMSL (OCC Datum) in the Grassy Island pool slightly downstream of S-Area (Source 37). Assuming that this level has historically been relatively constant, the prefill river shoreline likely coincided with the 562-foot elevation shown in Plate 7.

Alluvium - A discontinuous layer of river-deposited sediment (alluvium) consisting primarily of silty sand with varying amounts of clay, gravel, and cobbles underlies the fill at the WTP. CRA/OCC reported that the unit ranges in thickness from 0 to 14 feet, varying irregularly due to construction activities at the WTP.

Clay - The glaciolacustrine clay layer, a silty clay with varying amounts of fine sand and an occasional trace of gravel ranges in thickness from 0 feet at the southern part of the site (where it may have been eroded by the river) to as much as 27 feet in B-10, in the northeastern corner of the site. The clay, which is relatively uniform in thickness in the northern portion of the WTP, decreases in thickness toward the south where it thins to extinction below the Pump Station and Filtration Plant A of the WTP.

The top of the clay surface was re-contoured using the borehole/well data presented in Table D-3, Appendix D. The resulting clay surface as shown in Plate 8 is irregular, showing local mounds and depressions which may be related to erosion of the surface by the river. As indicated above, most of the site south of Filtration Plant B (elevation contour of 562 feet in Plate 7) was likely below the water surface prior to about 1915 (Plate 2).

The re-contoured clay surface shows two distinct linear depressions or channel-like features, a north-south trending depression just west of Filtration Plant A and an east-to-west trending depression between the Reservoir and Filtration Plant A. These two features, which appear to converge northwest of Filtration Plant A, may be pre-landfilling embayments or surface runoff channels eroded in the clay. The linear depression west of Plant A is evident in the top of clay contour plan presented in Source 55 (Figure 4). This depression slopes southward to the Niagara River.

The east-to-west trending depression has not been previously identified (Sources 17, 52 and 55). This difference in interpretation may be attributed to a number of factors: the data base used in this assessment is more comprehensive than that used previously; the locations of several boreholes/wells have been corrected based on information from original sources; the review of the borehole logs resulted in some modifications to the interpretation of stratigraphic horizons (in particular but not exclusively, the 1943 borings); and, the elevations of some of the older borings (specifically, from 1908, 1943 and 1949) have been adjusted to account for the present-day ground surface and to a common datum (OCC 1986 datum). Other data which support the presence of this trough or channel-like feature include the observed presence of a depression in the clay surface centered on wells CW11/11A; absence of clay at borehole B-2; area of low relief shown in the prefill ground surface (Plate 7) and the

Circa 1935 Site Plan (Plate 3) which shows a east-west trending embayment in the shoreline.

Till - The lowermost overburden unit at the WTP property is a till consisting of sandy silt, with varying amounts of clay and fine gravel. The till thickness varies from 0 to 15.5 feet at BH10. The till surface, as contoured by CRA/OCC, is relatively smooth, slopes slightly to the south, and contains small local mounds and depressions (Source 52).

Bedrock - The uppermost bedrock unit at the site is Lockport Dolomite. A review of the boring logs for this report identifies the depth to bedrock as ranging from 25.5 feet in BH-7-49, to 51.5 feet in BH4-80. The top of the bedrock surface dips to a low of about 536 feet AMSL in the east-central portion of the site (Source 52).

3.3 HYDROGEOLOGY OF THE WATER TREATMENT PLANT PROPERTY

There are three hydrostratigraphic units at the WTP: the fill/alluvium water-bearing zone, clay/till aquitard, and bedrock aquifer.

Shallow Water-Bearing Zone - The uppermost, water-bearing zone is under unconfined or water table conditions. The permeability of the fill/alluvium is reported to range from $1x10^{-2}$ cm/sec (in alluvium at OW260) to $3.9x10^{-5}$ cm/sec (in fill at CW-9a). Ground water flow in the shallow water-bearing zone is, for the most part, southward toward discharge in the Niagara River. A ground water mound centered on the northwestern corner of the Filtered Water Reservoir (possibly caused by leakage from the Reservoir and/or nearby piping) and a ground water sink to the west of Filtration Plant B (possibly caused by leakage to the sewer known to exist in the area) appear to have a pronounced local influence on ground water flow. The ground water mound is an artificial condition and could, if the leakage is eliminated or if the water level in the Reservoir is reduced, result in a significant change in hydraulic head distribution across the central portion of the site. Independent appraisal of water levels presented in the various source documents essentially confirms the depiction of ground water flow presented in the CRA/OCC 1988 reports (Sources 52 and 55).

Although it is not possible to assess historical patterns of ground water movement on the WTP property, it is recognized that excavation activities, as part of facility expansion, were supported by dewatering (e.g., for the construction of Filtration Plant A). These dewatering efforts, albeit of short duration, likely had a significant effect on overburden ground water flow in the past. Similarly, it is expected that excavations and utility trenches, particularly those footed or backfilled with granular material, will have a continuing localized effect on ground water and contaminant movement.

Aquitard - The clay and till, which underlie the shallow water-bearing zone over most of the WTP property, is relatively impermeable and acts as an aquitard, retarding downward movement of ground water and any contaminants. For example, a mobile non-aqueous phase liquid (NAPL) in the subsurface would likely pond on the surface of the clay in depressions and/or move across the surface in a downslope direction.

The permeability of the clay/till aquitard is reported to be less than 1×10^{-7} cm/sec. Water level measurements by CRA/OCC and others indicate the presence of a strong downward gradient across the aquitard. Using calculations by CRA/OCC for wells CW-9, CW-9a, CW-10, and CW-10a (wells screened across one hydrogeologic unit only), this gradient ranges from 0.099 ft/ft (in CW-10 and CW-10a) to 0.347 ft/ft (in CW-9 and CW-9a).

Bedrock - Ground water flow in the underlying bedrock aquifer (the upper 10 to 15 feet of the Lockport Dolomite) is primarily through fractures and bedding plane openings in the upper Lockport. Flow in the bedrock is in a northwesterly direction at the WTP, away from the Niagara River. The direction of flow appears to be strongly influenced by the PASNY intake structure.

4.0 CHEMICAL PRESENCE AND MIGRATION IN OVERBURDEN

4.1 AREAL EXTENT OF CONTAMINATION

Organic contaminants (NAPL and APL) have migrated beyond the S-Area Landfill boundary through the overburden onto the WTP property. CRA/OCC contends that, with the exception of the area immediately adjacent to S-Area, contaminants detected on the WTP property originated with the fill used to reclaim land from the Niagara River. This conclusion was based on CRA/OCC observation that "chemical concentrations at the WTP are inconsistent with expected migratory patterns from the S-Area" (Source 55). The areal extent of NAPL, and S-Area chemical parameters in the soil and overburden ground water (APL) is shown in Plate 9. This Plate was prepared using historical data presented in references Sources 20, 43, 55 and 61.

CRA/OCC identified NAPL and oily/iridescent sheens at a number of locations in or adjacent to the WTP property (Table 25A in Source 61), however, NAPL was noted at only two locations (CW1 and CW2A) on WTP property in Source 55. In order to assess the completeness of the CRA/OCC interpretation of NAPL distribution, the geologic logs for all boreholes/wells were reviewed to identify the potential presence of NAPL as determined by physical appearance (black oily substance, or oily or iridescent sheen). The criteria used in this review for identifying NAPL presence from the boring logs is the same as that used by CRA/OCC (Source 55); olfactory evidence was discounted, due to the possible use of respirators during previous investigations. However, it should be noted that chemical or petroleum odors were encountered in a number of additional borings during drilling, including: OW289, CW4a, CW5, CW6a, and CW13a.

The review of borehole logs resulted in the identification of one additional well (OW282) which may have a NAPL-like substances. An "oily sheen" was noted in the boring log for this well at elevation 563.1. In addition, Figure 33 in Source 55, which depicts the extent of overburden

NAPL migration at the WTP, does not include NAPL presence noted in Source 61 (Table 25A) at BH 106, BH 130, BH 223, OW236, OW264, OW282 and OW294.

The soil and ground water chemical concentration data for the WTP property is presented on Plate 9. The concentration data presented in Plate 9 is expressed as the summation of S-Area specific parameter concentrations. Historical ground water chemical data compiled in Source 20 are included along with data from Source 55 in Table 4-1. The historical data represent the average concentrations of the nine S-Area parameters, where available. In several instances, the historical data did not include results for the full suite of S-Area parameters. Consequently, the average may only represent one or two concentration values.

It is apparent from the distribution of the soil and ground water chemical concentration data that the majority of the elevated values are clustered in the following areas:

- in the central portion of the site, bounded by the S-Area to the west, Filtration Plant B to the north, and Filtration Plant A to the south (eastern boundary undefined); and
- a narrow strip immediately to the west and south of Filtration Plant A.

Additional chemical data are available in WTP files for water samples collected during plant facility construction in the Reservoir-Plant A area. For example, seepage samples (ground water) were collected during excavation for a waste line connection between Plant A and the sludge facility and for a raw water control valve for Filtration Plant B, just south of the Reservoir, in July 1979 and May 1980, respectively, in response to observed chemical odor. Analysis of the sample from the waste line excavation by GC/MS indicated the presence of chlorobenzene (3.1 ppb), 1,2-dichlorobenzene (64 ppb), 1,3-dichlorobenzene (2.4 ppb), 1,4-dichlorobenzene (140 ppb), trichlorobenzenes (320 ppb), C46 (2.3 ppb), C56 (<0.05 ppb), and tetrachlorobenzenes (47 ppb). Analysis of the control valve sample by electron capture gas chromatography indicated the presence of 1,2,3,4-Tetrachlorobenzene (390 ppb), 1,2,4,5-Tetrachlorobenzene (280 ppb), 1,2,3-Trichlorobenzene (1,350 ppb), and 1,2,4-Trichlorobenzene (6,950 ppb).

TABLE 4-1

GROUND WATER ANALYTICAL RESULTS FOR WATER TREATMENT PLANT WELLS

SPECIFIC PARAMETERS (ug/L)	CW-1A**	CW-2A**	CW-3A	CW-4A	CW-5**	CW-6A	CW-7A	CW-9A	CW-10A	CW-11A	CW-13A
Monochlorobenzoic Acids											
(long-term avg.*)	410	2020			0						
(CRA/OCC 1988 max. value)			0			0	0	0	0	0	0
Monochlorobenzene											
(long-term avg.*)	2115	998	0	0	10	348	1	634	6.5	21.3	0
(CRA/OCC 1988 max. value)			0			641	0	1220	35	0	0
Trichlorobenzenes											
(long-term avg.*)	126	1,830	7	2.1	19	797	2	63.8	2.5	1.5	4.43
(CRA/OCC 1988 max. value)			0			0	0	49	0	0	0
Tetrachlorobenzenes											
(long-term avg.*)	5	818	10	1	27	24.2	3	28.3	8.25	4.25	1.35
(CRA/OCC 1988 max. value)			0			0	0	18	0	0	0
Hexachlorobenzene											
(long-term avg.*)	0	8710	5	17	1.3	1.3	0	0	0	0	3.25
(CRA/OCC 1988 max. value)			0			0	0	0	0	0	0
Hexachlorobutadiene											
(long-term avg.*)	0	856	0	0	2.9	4	2	1.75	3.2	0	0.045
(CRA/OCC 1988 max. value)			0			0	0	0	0	0	0
Octachlorocyclopentene											
(long-term avg.*)	0	600	0	-	0	0					
(CRA/OCC 1988 max. value)			0			0	0	0	0	0	0
Hexachlorocyclohexanes											
(long-term avg.*)	102.2	42	2	25	16.8	4	1	177	44.7	20.2	7.35
(CRA/OCC 1988 max. value)			0			0	0	67	0	0	0
Perchloropentacyclodecane											
(long-term avg.*)	0	10	0	11		0	0		0	0	0.1
(CRA/OCC 1988 max. value)			0			0	0	0	0	0	0

* Long-term averages of parameter concentration values are compiled from Source 20.
** Wells CW-1A, CW-2A, and CW-5 indicate results for split samples.

Chemical concentration data for soil/fill and ground water samples collected from monitoring wells installed in late 1982 in the eastern portion of the WTP property are presented in Source 47. Only three of the nine S-Area specific parameters were analyzed (hexachlorobenzene, hexachlorobutadiene, 1,2,4-trichlorobenzene). The reported results for these three parameters were generally below detection limits. The wells were resampled by CRA and Arthur D. Little, Inc. (Source 48), and analyzed for S-Area Specific Parameters in July 1983. None of the specific parameters were detected in the ground water. The chemical analysis results for both sampling programs indicate that these compounds are not distributed widely in the soil/fill and ground water over the WTP property. A more comprehensive soil/fill and ground water sampling program would be required to substantiate this interpretation.

4.2 CHEMICAL MIGRATION THROUGH OVERBURDEN

Potential mechanisms by which contaminants from the S-Area Landfill could migrate eastward through the overburden onto WTP property include:

- flow of NAPL over the surface of the clay/till aquitard; and
- solute transport of contaminants with ground water.

As discussed in Section 3.2 and illustrated in Plate 8, two linear depressions have been identified in the clay surface immediately southeast of the Water Department Office Building, one trending east-to-west and the other north to south. Elevated concentrations of S-Area specific parameters from soil and ground water samples collected from boreholes/ wells completed in the vicinity of the linear depressions are consistent with concentration patterns that would be expected if NAPL flow were to have been channeled along these linear features in a downslope direction (Plate 9). The presence of the network of deep interconnected foundations and utility trenches in the same general area would tend to further promote the dispersion of S-Area contaminants along the flow path and would explain the presence of elevated concentrations of some of the S-Area specific parameters north and east of the Filtered Water Reservoir.

NAPL has been observed in boreholes completed along the western edge of the WTP property (Plate 9) in the general vicinity of the Water Department Office Building: BH130 at an elevation of 564.6 ft and 562.1 ft; BH-102 (564.8 and 559.8 ft); and BH-103 (567.1, 564.1 and 557.1 ft). The top of the clay layer in this area which is at an elevation of about 556 ft, slopes to the south and southeast (Plate 8). The excavation for the Water Department Office Building extends below the top of the clay to an elevation of about 553 ft (Plate 10). Considering the elevation difference between the observed NAPL and the clay surface, the potential exists for NAPL, unless it is immobile, to move eastward along the top of the clay layer to the WTP property. Flow would then be channeled along the foundation excavation and the existing linear depressions in the clay surface.

It is unlikely that the overburden APL plume present along the western boundary of the WTP property extends very far onto the property from S-Area. This conclusion is based on the existing distribution of hydraulic head and the apparent ground water mound centered on the northwestern corner of the Reservoir. Ground water contamination observed in the vicinity of the Reservoir is more likely related to contact with and dissolution of NAPL residue or organic contaminants sorbed on soil particles present along the linear depressions.

4.3 CONSTRUCTION INFLUENCES ON CONTAMINANT MIGRATION

It is widely recognized that foundation and utility trench excavations will act as preferential pathways for ground water and contaminant movement, particularly where the backfill has higher permeability than that of the excavated material. Foundation and trench excavations are shown in plan in Plate 6. Excavations which cut into the clay layer that underlie the site are highlighted in Plate 10, and shown in cross-section in Plates 11 and 12. Considering the magnitude of excavation which has taken place at the WTP, it is probable that these excavations have had a significant influence on both the movement and distribution of contaminants on the property.

Several key site structures extend below the top of the clay layer as shown in Table 4-2. These structures include the 1955 Pumping Station, the 4 million gallon Filtered Water Reservoir, the northwest corner of the Plant A flocculation basins, and the Water Department Offices/Garage. These structures are linked together by numerous utility trenches which were also excavated below the top of the clay, as summarized in Table 4-3. The pumping station is linked to the Plant A control chamber via two east-west trending high-service suction line trenches. NAPL could migrate northward from Plant A along the utility bedding of the filtered water line which connects the Reservoir (southwest corner).

Another potential pathway of migration is between the Water Department Offices and the northwest corner of the Reservoir. These two structures are connected via two east-west trending filtered water line trenches that extend through the control chamber located immediately west of the reservoir.

Although the significance of these potential pathways has not been addressed to date, these structures were present during the active period of disposal at the S-Area landfill and it is conceivable that NAPL could have moved eastward through bedding materials to the reservoir and Plant A.

It should also be noted that most of the major structures on the WTP property are set on pilings which extend to the till/bedrock. NAPL and contaminated ground water could be channeled along the pilings and, considering the downward gradient at the WTP, move through the clay/till confining unit to the bedrock aquifer.

TABLE 4-2

FOUNDATION EXCAVATION EXTENDING BELOW TOP OF CLAY

STRUCTURE	DEPTH BELOW TOP OF CLAY (ft.)	EAST-WEST EXCAVATION LENGTH (ft.)	NORTH-SOUTH EXCAVATION LENGTH (ft.)
Plant B	1.9 - 10.0	300	210
Fire Hall	3.0 - 12.0	50	110
Control Chamber	6.9	18	20
Water Department	5.4 - 8.4	110	90
Reservoir	0.0 - 8.9	190	190
Plant A	0.0 - 3.0	60	70
Pumping Station	0.0 - 9.4	50	140

TABLE 4-3

UTILITY TRENCH EXCAVATIONS BELOW TOP OF CLAY

UTILITY	LOCATION	DEPTH BELOW TOP OF CLAY (ft.)	TRENCH LENGTH (ft.)	TRENCH WIDTH (ft.)
12-Inch Sewer	West Property Line	0.0 - 3.0	450	3.0
Electrical Conduit	Near Fire Hall	0.0 - 1.9	330	1.5
36-Inch Water Main	Near Firehall	0.0 - 0.2	270	5.0
6-Inch Sewer	Near Firehall	0.0 - 1.3	310	2.0
42-Inch Water Mains	North Property Line	3.2	420	5.5
24-Inch Sewer	Near Blant B	3.6	290	4.0
2-Inch Drain	Near Plant B	2.0	30	1.5
12-Inch Sewer	Near Plant B	0.0 - 1.1	40	3.0
2-Inch Drain	Near Plant B	0.2	10	1.5
20-Inch Sewer	Plant B	0.0 - 4.7	210	3.5
8-Inch Sewer	Near Water Dept.	0.3	70	2.0
6-Inch Sewer	Near Water Dept.	0.0 - 0.3	40	2.0
48-Inch Filtered Water Line	Water Dept.	5.0 - 6.1	180	6.0
48-Inch Filtered Water Line	Reservoir	6.1 - 8.0	40	6.0
48-Inch Filtered Water Line	Reservoir	4.1 - 6.0	40	6.0
36-Inch Filtered Water Line	Water Dept.	5.1 - 6.1	180	5.0
36-Inch Filtered Water Lines	Control Chamber	0.0 - 2.5	95	5.0
54-Inch Intake	Water Dept.	0.0 - 7.4	210	7.5
48-Inch Filtered Water Line	Plant A	1.0 - 3.0	210	6.0
24-Inch Sewer	Plant B	0.0 - 2.0	200	4.0
48-Inch High Service Suction	Pumping Station	1.5 - 3.5	140	6.0
48-Inch High Service Suction	Pumping Station	1.5 - 3.5	140	6.0

5.0 CONCLUSIONS AND RECOMMENDATIONS

This assessment addresses CRA/OCC's contention that contaminants detected on the WTP property are not attributed to previous S-Area Landfill disposal activities, but instead were present in the fill used in reclaiming land from the Niagara River. Conclusions and recommendations which arise from this assessment are presented below:

1) CRA/OCC concluded (Source 55) that concentration patterns of S-Area Survey Parameters in the soil and ground water at the WTP are inconsistent with chemical migration from the S-Area in the overburden. Under circumstances where the overburden geology is relatively uniform and the major water-bearing unit is homogeneous, this conclusion would be valid. This, however, is not the case; the fill/alluvium which is the principal water-bearing zone in the overburden is highly variable in both texture and thickness. In addition, the surface of the underlying clay/till shows considerable relief. Ground water flow and any movement of soluble contaminants would be preferentially through more permeable horizons/pockets within the fill/alluvium. Dense NAPL movement would be in a downslope direction along the top of the clay aquitard.

   This assessment of potential contaminant migration pathways has led to the identification of linear depressions and foundation and trench excavations in the clay aquitard surface which have likely had, and may still be having, significant influence on contaminant movement. These depressions would act to channel NAPL movement in a downslope direction away from the S-Area. Ground water in contact with NAPL residue and contaminants sorbed on soil would subsequently dissolve various contaminant constituents creating an APL halo. The concentration pattern of S-Area Survey Parameters at the WTP is consistent with this scenario of contaminant movement. The fact that CRA/OCC have not detected a pattern of decreasing concentrations of S-Area parameters with distance away from the S-Area source can be readily explained by spatial gaps in sampling locations.

It is recommended that the extent of the linear depressions in the clay surface be further investigated through the use of a combination of geophysical (seismic) techniques, test borings, and sampling and analysis of soil and ground water media. If seismic methods are employed, seismic lines should be run perpendicular to the orientation of the linear depressions. Considering the distribution of subsurface utilities, this is likely only feasible southeast of the Reservoir (east of Plant A) and south of Emergency Generator Building/Plant A. The presence of a depression would need to be verified by drilling. Alternatively, test borings could be completed perpendicular to the orientations of the depressions. This method, although more expensive, would likely result in data which is more conclusive. It would be necessary to space the borings relatively close together (i.e. 25 to 50 feet) across the expected width of the feature. Additional borings may be required to ensure that the linear feature is defined.

Fill samples should be selected for evaluation of mobile NAPL and analysis S-Area Specific Parameters based on observation of NAPL indicators.

2) Foundation and utility trench excavations will act as preferential pathways for ground water and contaminant movement, particularly where backfill materials are more permeable than the original excavated materials. The construction records clearly show that several site structures and pipelines extend below the original clay surface creating channel-like depressions/troughs in the clay. Specifically, the central Filtered Water Reservoir and the 1955 Pumping Station are

linked by three filtered water pipelines which extend below the clay surface. The Filtered Water Reservoir itself and pipelines connecting to the 1915 Pumping Station also extend into the clay, providing another potential west-to-east pathway for contaminant movement.

Utility bedding and foundation investigations should be conducted along the above-cited WTP structures to assess the presence of NAPL. There investigations should involve either test borings or shallow excavations with select sampling of fill based on NAPL identification criteria and subsequent submission of samples for analysis of S-Area specific parameters.

3) CRA/OCC further conclude (Source 55) that "from a hydrogeologic perspective of the overburden ground water, the WTP is not downgradient of the S-Area and, therefore, would not be expected to receive chemicals [presumably APL] which have migrated from the S-Area in the ground water." With the exception of that portion of the WTP property immediately adjacent to S-Area, the present distribution of hydraulic heads as measured in shallow wells on the WTP property supports this statement. Historical information on ground water levels is, however, lacking and it is not possible to determine whether the present distribution of hydraulic head varies from that between 1947 and 1975 when the S-Area Landfill was in active use. For example, resident engineer's reports during WTP construction indicate that excavations were actively dewatered. These excavations would act as ground water sinks. The presence of a ground water mound at the northwest corner of the Filtered Water Reservoir is an artificial situation and could, if leakage is eliminated or the water level in the Reservoir reduced, result in a significant change in hydraulic head distribution across the central portion of the site. It should

also be noted that any NAPL residue or organic chemicals in the soil on the WTP property will continue to act as a source of contamination.

4) The solubility, transport properties and attenuation characteristics of S-Area Survey Parameters have not been addressed in this assessment.

5) Information on the characteristics and source of fill materials is limited. As noted in Conclusion No. 1 above, the concentration pattern of S-Area Survey Parameters at the WTP is consistent with contaminant movement along linear depressions in the clay surface. Contamination associated with the fill would likely show a pattern more reflective of the progression of landfilling on the WTP property. S-Area parameters have not been identified in the eastern portion of the site, except in the immediate vicinity of the Reservoir. CRA/OCC proposes to collect samples of fill above the saturated zone from various locations on the WTP property and analyze these samples for S-Area Survey Parameters in order to better characterize the fill. Future sampling at the site should, however, be cognizant of the fact that past construction excavation and dewatering activities on the WTP property may have distributed contaminants in a random fashion over local parts of the WTP property.

MALCOLM PIRNIE

APPENDIX A

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION

SOURCE	TITLE	AUTHOR
1	City of Niagara Falls Water Treatment Plant, The Investigatory Team, July 17, 1979	City of Niagara Falls
2	Niagara Falls, New York Water Treatment Plant Investigatory Team, Progress Report No. 1, Time Period: August 9, 1979 - September 21, 1979	City of Niagara Falls
3	Niagara Falls, New York, Water Treatment Plant Investigatory Team, Progress Report No. 2, Time Period: September 24, 1979 - November 7, 1979	City of Niagara Falls
4	Niagara Falls, New York Water Treatment Plant Investigatory Team, Progress Report No. 3, December 11, 1979	City of Niagara Falls
5	Niagara Falls, New York, Water Treatment Plant Investigatory Team, Progress Report No. 4, January 29, 1980	City of Niagara Falls
6	Niagara Falls, New York,Water Treatment Plant Investigatory Team, Progress Report No. 5, March 13, 1980	City of Niagara Falls
7	City of Niagara Falls, New York, Water Treatment Plant Investigatory Team, Summary Report, May 7, 1980	City of Niagara Falls
8	Progress Report, Shallow Ground-Water Quality Investigation, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, April 1979	Leggette, Brashears & Graham, Inc.
9	Progress Report 2, Shallow Ground-Water Quality Investigation, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, May 1979	Leggette, Brashears & Graham, Inc.
10	Progress Report 3, Shallow Ground-Water Quality Investigation, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, June 1979	Leggette, Brashears & Graham, Inc.

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION (continued)

SOURCE	TITLE	AUTHOR
11	Progress Report 4, Shallow Ground-Water Quality Investigation, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, July 1979	Leggette, Brashears & Graham, Inc.
12	Progress Report 5, Shallow Ground-Water Quality Investigation, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, September 1979	Leggette, Brashears & Graham, Inc.
13	Progress Report 7, Shallow Ground-Water Quality Investigation Permeability Testing and Results, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, March 1980	Leggette, Brashears & Graham, Inc.
14	Progress Report 8, Shallow Ground-Water Quality Investigation, Regional Hydrogeologic Investigation of the Lockport Dolomite, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, March 1980	Leggette, Brashears & Graham, Inc.
15	Progress Report 9, Shallow Ground-Water Quality Investigation, Results of Supplementary Test Drilling in the S-Area, Hooker Chemicals and Plastics Corporation, Niagara Falls, New York Plant, February 1980	Leggette, Brashears & Graham, Inc.
16	Current Hydrogeological Conditions, S-Area Landfill, October 8, 1980	Leggette, Brashears & Graham, Inc.
17	Current Hydrogeological Conditions, City of Niagara Falls Drinking Water Treatment Plant, October 14, 1980	Leggette, Brashears & Graham, Inc.
18	Loadings from the S-Area Landfill Under Current Conditions, October 14, 1980	Arthur D. Little, Inc.
19	Historical Review and Plant Operations, City of Niagara Falls Drinking Water Treatment Plant, October 14, 1980	Conestoga-Rovers & Associates, Ltd.
20	Chemical Concentration Data, Water Treatment Plant - Groundwater, November 1980	Arthur D. Little, Inc.

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION (continued)

SOURCE	TITLE	AUTHOR
21	Average Hydraulic Gradients Used to Calculate Ground-Water Flow Through Clay/Till Barrier at S-Area and City Drinking Water Treatment Plant, January 26, 1981	Leggette, Brashears & Graham, Inc.
22	Conversion of Aquifer Parameter Values, January 26, 1981	Leggette, Brashears & Graham, Inc.
23	Supplementary Geologic Cross Sections in the Vicinity of the S-Area and the City Drinking Water Treatment Plant, January 26, 1981	Leggette, Brashears & Graham, Inc.
24	S-Area Soil Samples Summary of Laboratory Test Results, January 27, 1981	Woodward-Clyde Consultants
25	Loadings from the S-Area Landfill Under Current Conditions, January 28, 1981	Arthur D. Little, Inc.
26	Protocol for Examination and Description of Split-Spoon Samples used by Leggette, Brashears & Graham, Inc. Hydrogeologists, February 17, 1981	Leggette, Brashears & Graham, Inc.
27	Surficial Geology of the Niagara Falls Area, New York, March 3, 1981	Leggette, Brashears & Graham, Inc.
28	Computer Model of the S-Area Groundwater Regime, April 1981	Woodward-Clyde Consultants
29	Niagara Plant/Water Treatment Plant Survey Wells Monitoring Parameter Data, April 1981	Arthur D. Little, Inc.
30	Water Elevation Profile, Drinking Water Treatment Plant, City of Niagara Falls, June 1981	Conestoga-Rovers & Associates, Ltd.
31	S-Area Groundwater Model Supplemental Report, August 1981	Woodward-Clyde Consultants
32	Monitoring Well Installation Details, Monitoring Well Water Elevations, Hooker Buffalo Avenue Plant and Drinking Water Treatment Plant, November 20, 1981	Conestoga-Rovers & Associates, Ltd.

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION (continued)

SOURCE	TITLE	AUTHOR
33	Groundwater Elevations, "S" Area and Niagara Falls Water Treatment Plant, January 6, 1982	?
34	1977 Borehole Logs, Sludge Thickener, City of Niagara Falls Water Treatment Plant, BH-B-1 through BH-B-7, June 1982	Empire Soils Investigations, Inc.
35	Drinking Water Treatment Plant Top of Clay/Till Contours, Overburden Groundwater Contours, July 1982	Conestoga-Rovers & Associates, Ltd.
36	Hydrogeologic Conditions East of S-Area at the Drinking Water Treatment Plant and PASNY Property, August 11, 1982	Conestoga-Rovers & Associates, Ltd.
37	S-Area Hydrogeologic Evaluation, August 24, 1982	Geologic Testing Consultants, Ltd.
38	Water Elevations, S-Area and Drinking Water Treatment Plant, February 16, 1983	Conestoga-Rovers & Associates, Ltd.
39	Investigation for Ground Water Contamination for City of Niagara Falls, Niagara Falls, New York, at the City Fire Hall, April 27, 1983	Clayton Environmental Consultants, Inc.
40	Groundwater Monitoring at City of Niagara Falls Water Treatment Plant, May 12, 1983	USEPA
41	Background Chemical Concentration Levels, May 1983	Arthur D. Little, Inc.
42	Groundwater Chemical Loading from the Drinking Water Treatment Plant to the Niagara River, June 1983	Arthur D. Little, Inc. and Conestoga-Rovers & Associates, Ltd.
43	Sources of Organic Chemicals on the Water Treatment Plant Property, June 1983	Arthur D. Little, Inc.
44	S-Area Hazardous Waste Landfill and City of Niagara Falls Water Treatment Plant, Niagara Falls, New York, Two-dimensional Groundwater Flow Simulation, June 1983	Gannett Flemming Engineers and Planners

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION (continued)

SOURCE	TITLE	AUTHOR
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46	Zone 2 Groundwater Quality Assessment for City of Niagara Falls, NEw York, July 8, 1983	Clayton Environmental Consultants, Inc.
47	Ground-Water Investigation for City of Niagara Falls, Niagara Falls, New York, at The City Water Treatment Plant and Surrounding Area, June 17, 1983	Clayton Environmental Consultants, Inc.
48	Drinking Water Treatment Plant Chemical Analysis - Eastern Area, August 1983	Arthur D. Little, Inc.
49	S-Area Landfill and City of Niagara Falls, New York, Review of Reports on Groundwater Chemical Analyses of Eastern Area, April 1986	Gannett Fleming Water Resources Engineers, Inc.
50	Industrial Waste Contamination of A Water Treatment Plant Site: A Case Study	John R. Westendorf, City of Niagara Falls, New York, et al.
51	Composition of S-Area Non-Aqueous Phase Liquids	Arthur D. Little, Inc.
52	City of Niagara Falls Drinking Water Treatment Plant, assessment of Groundwater Table Contours and Geologic Conditions, June 1988	Conestoga-Rovers & Associates, Ltd.
53	City of Niagara Falls Drinking Water Treatment Plant, Pump Station, Hydrogeologic and Environmental Conditions, Collection System Design Considerations, June 1988	Conestoga-Rovers & Associates, Ltd.
54	Assessment of NAPL Migration via Underground Utility Bedding, June 1988	Conestoga-Rovers & Associates, Ltd.
55	City of Niagara Falls Drinking Water Treatment Plant, Assessment of Chemical Migration in the Overburden from the S-Area Landfill Site, June 1988	Conestoga-Rovers & Associates, Ltd.

SOURCES UTILIZED IN S-AREA HYDROGEOLOGIC EVALUATION (continued)

SOURCE	TITLE	AUTHOR
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57	City of Niagara Falls Drinking Water Treatment Plant, assessment of Overburden Chemical Migration to the Water Treatment Plant, June 1988	Conestoga-Rovers & Associates, Ltd.
58	Assessment of APL/NAPL Migration from S-Area in the Overburden Toward the Niagara River, July 1988	Conestoga-Rovers & Associates, Ltd.
59	Chemical Monitoring Program, Results of Analyses and Selection of Indicator Compounds, July 18, 1988	Occidental Chemical Corporation
60	Assessment of the Geological and Hydrogeological Characteristics of the Overburden Below the S-Area and Northern Area, August 1988	Conestoga-Rovers & Associates, Ltd.
61	Information Summary Report Vol I and II, Appendices 1 to 6, June 1988	Conestoga-Rovers & Associates, Ltd.
62	Letter from John Nichter, Occidental Chemical Corporation, to Rocco Grassi, USEPA, dated December 16, 1988	Occidental Chemical Corporation
63	Analysis of Sixteen Soil Samples from Parcel 14, April 22, 1981	Advanced Environmental Systems, Inc.
64	Test Borings, Proposed Hysen Warehouse, Buffalo Avenue, Niagara Falls, NY, April 13, 1981	Pittsburgh Testing Laboratory
65	Analysis of Three Soil Samples, June 26, 1981	Advanced Environmental Systems, Inc.
66	Phase II Investigation Report, Buffalo Avenue Site, Inactive Hazardous Waste Site Registry No. 932080B, NYPA, December 1988	Dames and Moore

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APENDIX B

B-1 CONSTRUCTION HISTORY REFERENCE LIST

B-2 SITE STRUCTURE CONSTRUCTION DETAILS

B-3 SITE PIPELINE CONSTRUCTION DETAILS

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TABLE B-1

CONSTRUCTION HISTORY REFERENCE LIST

REFERENCE NO.	REFERENCE NAME
A	Greeley and Hansen; Plans for Alterations to Existing Plant; 1953
B	Norwood Engineering Col; General Plans - Filter Plant for the City of Niagara Falls; 1909
C	Greeley and Hansen; Record Drawings for Construction of Water Treatment Plant; 1950
D	City of Niagara Falls; Plans: Plans for Building for Electrical Equipment at the Pumping Station; 1935
E	City of Niagara Falls Bureal of Engineering; Plans for the Buffalo Avenue Fire Hall; 1932
F.	City of Niagara Falls Bureau of Engineering; Record Drawings for the Extension of Filter Plant No. 1; 1934
G	Greeley and Hansen; Plans for New Pumping Station; 1950
H	Malcolm Pirnie, Inc.; Plans for Filtered Water Reservoir, Control Chamber, and Meter and Control Pit; 1943
I	Greeley and Hansen; Plans for the Construction of the New Water Treatment Plant; 1950
J	Camp, Dresser & McKee; Record Drawings for Water Treatment Plant Sludge Disposal Facility; 1978
K	Camp, Dresser & McKee; Plans for the Construction of Emergency Generator Building; 1978
L	City of Niagara Falls Bureau of Water; No. 1 System Filter Plant Plot Plan; 1945
M	Greeley and Hansen; Record Drawings for 56th Street and Pine Avenue Reinforcing Water Main; 1956
N	City of Niagara Falls Bureau of Engineering; Record Drawings for Heating Plant and Forebay Building; 1935
O	City of Niagara Falls Contract No. 280; Secondary Water Main Layout of Pipes and Valves; 1956
P	City of Niagara Falls Bureau of Engineering; Intake Tunnel for Filter Plant No.1; 1934
Q	Greeley and Hansen; Plans for Intake Structure and Tunnel; 1950

STRUCTURE CONSTRUCTION DETAILS

STRUCTURE NAME	CONSTRUCTED	AREA (1)	EXCAVATION (2)	REFERENCE
ORIGINAL PLANT B	1912	29,000	557.0 (557.6)	A,SH-9; B
OLD PUMPING STATION	1912	9,300	551.0 (551.6)	A,SH-6; C
OLD TRANSFORMER STATION	1925	700	566.0 (566.6)	D
FIREHALL	1932	5,000	552.0 (552.6)	E
PLANT B EXTENTION	1933	22,900	560.5 (561.1)	F,SH-2
FORBAY/HEATING BUILDING	1933	2,500	559.5 (560.1)	O,SH-4&7
INTAKE SHORE SHAFT	1936	70	501.0 (501.6)	G,SH-3
BEDROCK INTAKE TUNNEL	1936	9,000	501.0 (501.6)	G&P,SH-3
4 MG RESERVOIR	1943	36,100	553.5 (554.1)	H
CONTROL CHAMBER	1943	500	552.0 (552.6)	H
PLANT B FLOCCULATION BASINS	1954	9,900	562.6 (563.2)	A,SH-4
PLANT A	1954	90,000	553.0 (553.6)	I,SH-13
NEW PUMPING STATION	1954	9,200	543.8 (544.6)	G,SH-4&11
NEW TRANSFORMER STATION	1954	800	567.0 (567.6)	G,SH-37
WASH WATER TANK	1954	1,600	563.3 (563.9)	I,SH-8
6x7 PEDESTRIAN TUNNEL	1954	2,300	559.5 (560.1)	I,SH-94
INTAKE TUNNEL EXTENTION	1954	21,000	501.0 (501.6)	Q
SLUDGE PUMPING STATION	1978	2,900	543.4 (544.0)	J,SH-S3
SLUDGE THICKENER	1978	2,500	560.4 (561.0)	J,SH-S3
EMERGENCY GENERATOR BLDG.	1978	3,300	570.2 (570.8)	K

NOTES:
1. REFERS TO MAXIMUM AREA IN SQUARE FEET
2. REFERS TO DEEPEST POINT OF EXCAVATION;
   CITY OF NIAGARA FALLS DATUM (OCCIDENTAL CHEMICAL CORP. DATUM)

PIPE DESIGNATION	START POINT	END POINT	MATERIAL (1)	INVERT (2) ELEVATION	CROWN (2) ELEVATION	CONSTRUCTION PERIOD	ORIENTATION (3)	REFERENCE	ADDITIONAL COMMENTS
48-INCH STEEL PIPELINE	NIAGARA RIVER	OLD PUMP STATION	STEEL	554.0 (554.6)	558.0 (558.6)	1912	N-S	C,SH-5; L	DESIGNATED EMERGENCY INTAKE SINCE 1935 ABANDONDED NORTH OF NEW PUMP STATION IN 1955 REACTIVATED FOR USE IN 1983 DUE TO S-AREA
6-INCH SANITARY SEWER	6-INCH DRAIN	12-INCH SANITARY SEWER	TILE	563.8 (564.4)	564.3 (564.9)	1912	N-S; E-W	C,SH-5; D; L	
12-INCH SANITARY SEWER	6-INCH SANITARY SEWER	PROPERTY LINE	TILE	560.9 (561.5)	561.9 (562.5)	1912	N-S	C,SH-5; D; L	
PRIMARY ELECTRICAL SERVICE	OLD TRANSFORMER BUIDING	PROPERTY LINE	-	561.5 (562.1)	-	1912	N-S; E-W	C,SH-5; D; L	CONDUIT EXTENDED FROM WATER DEPT. TO NEWLY... CONSTUCTED TRANSFORMER BUIDING (OLD) IN 1925
36-INCH FILTERED WATER	OLD PUMP STATION	CONTROL CHAMBER	CAST IRON	553.5 (554.1)	556.5 (557.1)	1912	N-S; E-W	C,SH-5; N,SH-1	ABANDONED BY 1955
36-INCH FILTERED WATER	CONTROL CHAMBER	PLANT B	CAST IRON	564.0 (564.6)	567.0 (567.6)	1912	N-S	C,SH-5; N,SH-1	
20-INCH WASHWATER SEWER	PLANT B	NIAGARA RIVER	CAST IRON	558.3 (558.9)	560.0 (560.6)	1912	N-S	B; N,SH-1	ABANDONED BY 1935
POWER SUPPLY	OLD PUMP STATION	PLANT B	FIBER	566.6 (567.2)	566.9 (567.5)	1912	N-S; E-W	C,SH-5; N,SH-1&5	RELOCATED BY 1936
ALARM CABLE	OLD PUMP STATION	PLANT B	-	566.6 (567.2)	-	1912	N-S; E-W	C,SH-5; N,SH-1&5	
6-INCH SANITARY SEWER	OLD PUMP STATION	PROPERTY LINE	TILE	562.7 (563.3)	562.3 (563.9)	1912	N-S	C,SH-5; L	
24-INCH WATERMAIN	OLD PUMP STATION	8-INCH WATERMAIN	CAST IRON	564.3 (564.9)	566.3 (566.9)	1912	N-S	C,SH-5; L	EXTENDED WESTWARD TO 36-INCH WATERMAIN
8-INCH WATER MAIN	24-INCH WATERMAIN	8-INCH WATERMAIN	CAST IRON	566.0 (566.6)	566.7 (567.3)	1912	N-S	A,SH-8; C,SH-5	
24-INCH WATERMAIN	24-INCH WATERMAIN	36-INCH WATERMAIN	CAST IRON	564.3 (564.9)	566.3 (566.9)	1912	E-W	F, SH-8	
8-INCH WATER MAIN	36-INCH WATERMAIN	PLANT B	CAST IRON	566.0 (566.6)	566.7 (567.3)	1912	E-W	C,SH-4&5; A,SH-8	
36-INCH WATERMAIN	OLD PUMP STATION	PROPERTY LINE	CAST IRON	563.8 (564.4)	566.8 (567.4)	1912	N-S	C,SH-5;	
6-INCH SANITARY SEWER	PLANT B	6-INCH SANITARY SEWER	TILE	-	-	1912	E-W	C,SH-4; L; F,SH-1	
36-INCH FILTERED WATER	OLD PUMP STATION	CONTROL CHAMBER	CAST IRON	559.8 (560.4)	562.8 (563.4)	1912	N-S; E-W	C,SH-5; N,SH-1	EAST-WEST SECTION ABANDONED BY 1955
36-INCH FILTERED WATER	CONTROL CHAMBER	PLANT B	CAST IRON	561.5 (562.1)	564.5 (565.1)	1912	N-S	C,SH-5; N,SH-1	
4-INCH DRAIN	CONDUIT MANHOLE	6-INCH SANITARY SEWER	TILE	560.9 (561.5)	561.2 (561.8)	1912	E-W	C,SH-4; F,SH-1	
4-INCH DRAIN	WATERMAIN MANHOLE	6-INCH SANITARY SEWER	TILE	560.9 (561.5)	561.2 (561.8)	1912	E-W	C,SH-4; F,SH-1	
4-INCH DRAIN	WATERMAIN MANHOLE	12-INCH SANITARY SEWER	TILE	560.9 (561.5)	561.2 (561.8)	1912	E-W	C,SH-4; F,SH-1	
4-INCH WATERMAIN	8-INCH WATERMAIN	PLANT B	TILE	-	-	1912	N-S; E-W	C,SH-5; N,SH-1	
36-INCH WATERMAIN	36-INCH WATERMAIN	PROPERTY LINE	CAST IRON	563.8 (564.4)	566.8 (567.4)	1923	E-W	C,SH-5; L; O	
24-INCH WATERMAIN	OLD PUMP STATION	36-INCH WATERMAIN	CAST IRON	564.3 (564.9)	566.3 (566.9)	1923	E-W	C,SH-6; N,SH-1; O	

BASED ON WATER TREATMENT PLANT SITE PLAN - CIRCA 1985

PIPE DESIGNATION	START POINT	END POINT	MATERIAL (1)	INVERT (2) ELEVATION	CROWN (2) ELEVATION	CONSTRUCTION PERIOD	ORIENTATION (3)	REFERENCE	ADDITIONAL COMMENTS
6-INCH DRAIN	OLD TRANSFORMER BUIDING	6-INCH SANITARY SEWER	TILE	563.8 (564.4)	564.1 (564.7)	1925	N-S	D	
24-INCH SANITARY SEWER	FOREBAY/HEATING BUILDING	PROPERTY LINE	TILE	560.4 (561.0)	562.4 (563.0)	PRE-1936	N-S	C,SH-4; O,SH-1	
36-INCH RAW WATER LINE	OLD PUMP STATION	48-INCH RAW WATER LINE	CAST IRON	565.6 (566.2)	568.6 (569.2)	1936	N-S; E-W	C,SH-5; O,SH-1	EAST-WEST SECTION ABANDONED BY 1955
54-INCH STEEL PIPELINE	SHORE SHAFT	WATER DEPARTMENT	STEEL	550.6 (551.2)	555.1 (555.7)	1936	N-S	C,SH-6; O,SH-1	ABANDONED BY 1955
36-INCH RAW WATER LINE	OLD PUMP STATION	48-INCH RAW WATER LINE	CAST IRON	565.6 (566.2)	568.6 (569.2)	1936	N-S; E-W	C,SH-5; O,SH-1	EAST-WEST SECTION ABANDONED BY 1955
8-INCH SANITARY SEWER	YARD DRAIN	6-INCH SANITARY SEWER	TILE	562.7 (563.3)	563.4 (564.0)	1936	E-W	C,SH-5; L	
6-INCH SANITARY SEWER	6-INCH SANITARY SEWER	12-INCH SANITARY SEWER	TILE	562.7 (563.3)	562.2 (562.8)	1936	E-W	C,SH-5; L	
2-INCH DRAIN	CONDUIT MANHOLE	8-INCH SANITARY SEWER	CAST IRON	564.0 (564.6)	564.7 (565.3)	1936	E-W	C,SH-5; L	
8-INCH SANITARY SEWER	2-INCH DRAIN	24-INCH SEWER	TILE	564.0 (564.6)	564.7 (565.3)	1936	N-S	C,SH-5; N,SH-1	ABANDONED BY 1955
4-INCH DRAIN	CONDUIT MANHOLE	12-INCH SEWER	CAST IRON	562.0 (562.6)	562.3 (562.9)	1936	E-W	C,SH-4	
2-INCH WATERMAIN	8-INCH WATERMAIN	PLANT B	CAST IRON	566.0 (566.6)	566.1 (566.7)	1936	N-S; E-W	C,SH-6; O,SH-1	
8-INCH SANITARY SEWER	FIREHALL	24-INCH SEWER	TILE	561.9 (562.5)	562.6 (563.2)	1936	E-W	C,SH-4	
4-INCH WATERMAIN	PROPERTY LINE	PLANT B	CAST IRON	569.0 (569.6)	569.3 (569.9)	1936	N-S	C,SH-6; F,SH-7	
24-INCH WASHWATER SEWER	PLANT B	NIAGARA RIVER	CAST IRON	562.0 (562.6)	564.0 (564.6)	1936	N-S	J,SH-1; F,SH-7	SECTIONS REPLACED BY REINFORCED CONCRETE BY 1955
20-INCH AUXILLIARY INTAKE	SHORE SHAFT	WATER DEPARTMENT	CAST IRON	564.2 (564.8)	565.8 (566.4)	1936	N-S	H	ABANDONED BY 1955
48-INCH HIGH SERVICE SUCTION	WATER DEPARTMENT	CONTROL CHAMBER	REINF. CONC.	554.0 (554.6)	558.0 (558.6)	1945	E-W	H	ABANDONED BY 1955
48-INCH FILTERED WATER	RESERVOIR	CONTROL CHAMBER	REINF. CONC.	554.0 (554.6)	558.0 (558.6)	1945	E-W	H	ABANDONED BY 1955
48-INCH FILTERED WATER	CONTROL CHAMBER	RESERVOIR	REINF. CONC.	556.0 (556.6)	560.0 (560.6)	1945	E-W	H	ABANDONED BY 1955
66-INCH RAW WATER LINE	SHORE SHAFT	PUMPING STATION	STEEL	546.5 (547.1)	552.0 (552.6)	1955	E-W	6,SH-3; O	SUSPENDED USE IN 1983 DUE TO CONTAMINATION
60-INCH FLOOD RELIEF SEWER	PUMPING STATION	NIAGARA RIVER	REINF. CONC.	560.9 (561.5)	565.9 (566.5)	1955	N-S	6,SH-11; O	
48-INCH SEWER	PLANT A	60-INCH FLOOD SEWER	REINF. CONC.	559.9 (560.5)	563.9 (564.5)	1955	E-W	6,SH-11; O	
42-INCH LOW SERVICE DISCHARGE	PUMPING STATION	PLANT A	REINF. CONC.	568.8 (569.4)	572.3 (572.9)	1955	N-S; E-W	C,SH-6; O	
42-INCH LOW SERVICE DISCHARGE	PUMPING STATION	PLANT A	REINF. CONC.	568.8 (569.4)	572.3 (572.9)	1955	N-S; E-W	C,SH-6; O	
48-INCH HIGH SERVICE SUCTION	PLANT A	PUMPING STATION	REINF. CONC.	550.5 (551.1)	554.5 (555.1)	1955	E-W	C,SH-6; O	
48-INCH HIGH SERVICE SUCTION	PLANT A	PUMPING STATION	REINF. CONC.	550.5 (551.1)	554.5 (555.1)	1955	E-W	C,SH-6; O	
42-INCH WATERMAIN	PUMPING STATION	36-INCH WATERMAIN	REINF. CONC.	568.8 (569.4)	572.3 (572.9)	1955	N-S	C,SH-6; O	

BASED ON WATER TREATMENT PLANT SITE PLAN - CIRCA 1985

PIPE DESIGNATION	START POINT	END POINT	MATERIAL (1)	INVERT (2) ELEVATION	CROWN (2) ELEVATION	CONSTRUCTION PERIOD	ORIENTATION (3)	REFERENCE	ADDITIONAL COMMENTS
42-INCH WATERMAIN	PUMPING STATION	36-INCH WATERMAIN	REINF. CONC.	564.0 (564.6)	567.5 (568.1)	1955	N-S	C,SH-6; O	
ELECTRICAL CONDUITS	PUMPING STATION	PLANT A	REINF. CONC.	572.1 (572.7)	573.2 (573.8)	1955	N-S; E-W	C,SH-6; O	
12 kV PRIMARY SERVICE	PUMPING STATION	OLD PUMP STATION	REINF. CONC.	570.1 (570.7)	571.7 (572.3)	1955	N-S	C,SH-6	
8-INCH SANITARY SEWER	PUMPING STATION	12-INCH SANITARY SEWER	CAST IRON	569.0 (569.6)	569.7 (570.3)	1955	N-S; E-W	C,SH-6; O	
10-INCH WATERMAIN	42-INCH WATERMAIN	PLANT A	CAST IRON	570.6 (571.2)	571.4 (572.0)	1955	E-W	C,SH-5; O	
16-INCH WASHWATER LINE	PLANT A	PLANT A	CAST IRON	564.3 (564.9)	565.7 (566.3)	1955	N-S	C,SH-5; O	
48-INCH FILTERED WATER	PLANT A	RESERVOIR	REINF. CONC.	552.0 (552.6)	556.0 (556.6)	1955	N-S; E-W	C,SH-5; O	
36-INCH FILTERED WATER	PLANT A	CONTROL CHAMBER	REINF. CONC.	556.5 (557.2)	559.5 (560.7)	1955	N-S	C,SH-5; O	
48-INCH RAW WATER LINE	PLANT A	36-INCH RAW WATER LINES	REINF. CONC.	568.2 (568.8)	572.2 (572.8)	1955	N-S	C,SH-5; O	
8-INCH SANITARY SEWER	PLANT A	12-INCH SANITARY SEWER	CAST IRON	568.2 (568.8)	568.9 (569.5)	1955	N-S; E-W	I,SH-7; O	
24-INCH WASH WATER LINE	PLANT A	WASH WATER TANK	REINF. CONC.	568.0 (568.6)	570.0 (570.6)	1955	E-W	I,SH-7; O	
18-INCH WASH WATER LINE	PLANT B	24-INCH WASH WATER LINE	CAST IRON	566.8 (567.4)	568.3 (568.9)	1955	N-S	A,SH-3; O	
4-INCH DRAIN	CONDUIT MANHOLE	12-INCH SANITARY SEWER	CAST IRON	568.3 (568.9)	568.6 (569.2)	1955	N-S	C,SH-5; O	
12-INCH SANITARY SEWER	(2) 8-INCH SEWERS	PROPERTY LINE	CAST IRON	562.9 (563.5)	563.9 (564.5)	1955	N-S	C,SH-5; O	
48-INCH RAW WATER LINE	36-INCH RAW WATER LINES	PLANT B	REINF. CONC.	560.0 (560.6)	564.0 (564.6)	1955	E-W	A,SH-3; O	
8-INCH TANK OVERFLOW	WASH WATER TANK	24-INCH WASH WATER SEWER	CAST IRON	567.0 (567.6)	567.7 (568.3)	1955	E-W	J,SH-C1, O	
42-INCH WATERMAIN	42-INCH WATERMAIN	PROPERTY LINE	REINF. CONC.	560.8 (561.4)	564.3 (564.9)	1956	E-W	M; O	
12-INCH BACKWASH FORCEMAIN	PLANT B	SLUDGE PUMPING STATION	DUCTILE IRON	561.6 (562.2)	562.6 (563.2)	1979	E-W	J,SH-C1	
30-INCH WASTEWATER DRAIN	PLANT B	SLUDGE PUMPING STATION	DUCTILE IRON	561.2 (561.9)	563.8 (564.4)	1979	E-W	J,SH-C1	
20-INCH OVERFLOW LINE	SLUDGE PUMPING STATION	24-INCH WASH WATER SEWER	DUCTILE IRON	563.0 (563.6)	564.7 (565.3)	1979	E-W	J,SH-S1	
6-INCH WATERMAIN	SLUDGE PUMPING STATION	PROPERTY LINE	DUCTILE IRON	-	-	1979	N-S	J,SH-C1	
6-INCH WATERMAIN	42-INCH WATERMAIN	GENERATOR BUILDING	DUCTILE IRON	570.5 (571.1)	571.0 (571.6)	1979	N-S	K	

NOTES:
1. REINF. CONC. = REINFORCED CONCRETE
2. CITY OF NIAGARA FALLS DATUM (OCCIDENTAL CHEMICAL CORP. DATUM - ADD 0.6 FEET TO CNF DATUM)
3. N-S = NORTH-SOUTH; E-W = EAST-WEST

BASED ON WATER TREATMENT PLANT SITE PLAN - CIRCA 1985

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APPENDIX C

SUMMARY OF PREVIOUS INVESTIGATIONS

Brief Descriptions of Contents of
Sources Used in S-Area Hydrogeologic Evaluation

Sources 1-7:

- description of water plant construction history.
- description of contamination of potable water supply discovered in 1978, and actions taken to remediate system.
- sampling data for raw and finished river water, and sediment, in river intake system.
- regional overburden and bedrock ground water contour maps presented (from LBG, date unknown).
- sample results primarily for finished water.

Sources 8-15:

- well construction details.
- boring logs.
- geologic cross-sections.
- water table and bedrock ground water contour maps (maps constructed with data from two days, however).
- pH, alkalinity, chloride, conductivity, TOC data as they wait for wells to "stabilize".
- both Hooker (S-Area) and WTP are addressed.
- recovery well system described.
- sieve analyses.
- pumping test data, including transmissivity and permeability calculations.
- discussion of regional hydrogeology of Lockport Dolomite.
- isopach map of confining clay and till.
- contour maps of geologic units.
- geology and hydrogeology of area are covered.

Source 16:

- no new data from what are presented in sources 8-15.
- ground water contour maps based on July 18, 1980, data, but these data are not presented.
- S-Area is focus.
- geology and hydrogeology are covered.
- hydrologic mass balance of S-Area is calculated.

Source 17:

- essentially identical to Source 16, except one or two cross-sections are different.
- ground water contour maps based on July 18, 1980, data, but these data are not presented.
- WTP is focus.
- geology and hydrogeology are covered.
- hydrologic mass balance of WTP is calculated.

Source 18:

- describes loading calculations of organic chemicals from S-Area site through N, S, E & W boundaries of S-Area in overburden, as well as loading from overburden into bedrock.
- average overburden concentrations in 5 overburden wells and 3 bedrock wells are presented and used in loading calculations.
- effect of chemical migration on water quality in the mixing zone of the Niagara River.
- maximum contaminant concentrations in Niagara River 5, 10, and 20m from shore are given.
- data on river water quality 55 ft from shore, 500 ft west of 53rd Street, are given, meant to characterize Niagara River concentrations due to flow from WTP property.

Source 19:

- provides history of construction of WTP, similar to that given in Source 1.

Source 20:

- presents ground water analytical data on samples collected by Hooker, EPA or NYS (analyzed by 6 different laboratories) for several wells at WTP.
- no attempt to interpret results.

Source 21:

- average hydraulic gradients calculated using a grid format over Hooker and WTP areas, so that ground water flow through clay/till unit may be calculated.

Source 22:

- units which LBG uses to express permeability and transmissivity are explained (gpd/ft^2 and cm/sec, and gpd/ft and cm^2/sec, respectively); conversion formulas are given.

Source 23:

- four north-south geologic cross-sections through Hooker and the WTP are given.
- cross-sections are supplemental to those presented in Sources 16 and 17.
- no interpretation given, other than the observation that the subsurface conditions are similar in both areas.

Source 24:

- six soil samples from S-Area are analyzed for natural water content, liquid limit, plastic limit, and permeability; some are also analyzed for unit dry weight, specific gravity and grain size.

Source 25:

- similar to Source 18; appears to be recalculation of organics loading (estimates now slightly higher although data identical to that presented in Source 18) and additional calculation of metals loading.

Source 26:

- gross description of four lithologic units encountered at Hooker, WTP, and Robert Moses Parkway (fill, sand and silt, clay, till).
- protocol used to describe recovered split spoon samples is presented.

Source 27:

- description of depositional history of overburden sediments in the area, and relation of regional deposition to what kinds of sediment are seen at Hooker and the WTP.
- discussion of location of old shoreline on Hooker and WTP properties, and effect on thicknesses of naturally deposited sediments in those areas.
- five references on regional surficial geology cited.

Source 28:

- computer model was used to simulate the effects on the S-Area water table aquifer of 1) barrier wall, 2) clay cap, and 3) tile drain to south, west, and east of S-Area.
- calculated were the drop in water level, how much of the water in storage was removed, the head direction, and when the system reaches hydraulic stabilization.

Source 29:

- limited chemical data collected for overburden and bedrock wells at Hooker, WTP and Robert Moses Parkway; sampling conducted from December 1978 to March 1980, to determine whether wells had stabilized; parameters analyzed are pH, chloride, conductivity, alkalinity, total organic carbon, and total organic halides.

Source 30:

- ground water elevation data for April 3, 1981, for wells on WTP property; plant water elevations in reservoirs, tanks, and piping also included; Niagara River elevation included.

Source 31:

- addendum to Source 28, presenting input data upon which initial computer model was based, and a model simulation which assumes that the till discontinuity in the southwest corner of the S-Area is not sealed; the initial model had assumed it was sealed.
- the new simulation showed that, at steady state after the remedial program is initiated, there is an upward head from bedrock to overburden; the absence of a seal would not adversely affect the containment capability of the remedial program.

Source 32:

- some monitoring will installation details for wells installed on Hooker and WTP properties.
- nineteen sets of water level elevations for those wells, but sixteen of those sets collected over period of several days.

Source 33:

- water level data from some of wells located at Hooker, WTP, and Robert Moses Parkway.

Source 34:

- boring logs for seven boreholes installed at WTP in 1977, not as part of S-Area investigation.

Source 35:

- elevation of top of clay/till layer at WTP given; this information also contoured.
- ground water contour map for overburden aquifer at WTP on May 11, 1982, is included.

Source 36:

- brief presentation of past and present drilling programs at the WTP and PASNY properties.
- 1958 shoreline indicated.
- geologic stratigraphy on the areas described.
- permeabilities, ground water levels measured and included in discussion of hydrogeology.
- ground water contour map showing divides (suspect) presented.

Source 37:

- interpretation of geology, hydrogeology, and contaminant migration at Hooker and WTP, based on existing data collected by other consultants.
- evaluation of the reliability of much of the data is included.
- permeability data.
- indicated which wells are screened across overburden and bedrock.
- some water quality data.
- ground water contour maps are presented, but with data collected on more than one day.

Source 38:

- ground water levels for January 19, 1983, for wells at Hooker and WTP.
- overburden ground water contour map constructed with these data for WTP.

Source 39:

- two monitoring wells installed next to fire hall located on WTP property, northeast of S-Area.
- fire hall basement sediment and these two wells sampled and analyzed.
- air samples in fire hall basement collected and analyzed.
- some of components exceeded standards, especially in well closest to S-Area.
- source of contamination unidentified, as it was outside the scope of the investigation.

Source 40:

- EPA observed and commented on CEC's sampling procedures for Wells B-1 to B-12 on the WTP property.
- split samples were taken and analyzed by EPA's laboratory.
- two sets of data are included and compared.
- very minimal interpretation of results is included.

Source 41:

- surface concentrations and ambient air quality of various locations in world are presented, and health data associated with those levels for specific groups of chemicals are discussed; these data are then applied to chemical concentration criteria proposed in the S-Area health and safety program.

Source 42:

- ground water flow to Niagara River from WTP and the relative chemical loading are estimated.
- only average ground water chemical concentrations from these designated regions of the WTP and adjacent Niagara River are presented.

Source 43:

- evaluation of the sources of chemical contamination of the WTP concludes that some of the chemicals that are there do not stem from the S-Area (namely, polynuclear aromatic hydrocarbons and phthalates).
- average well concentrations given, no dates, no information on number of samples averaged.

Source 44:

- a two-dimensional ground water flow model is developed for the S-Area and is compared to previous models developed by Woodward-Clyde and NYSDEC.
- numerous data sources used but not completely documented.
- model designed for use in analyzing effectiveness of remedial measures, gradients, stabilization times, etc.
- approximate overburden permeability data presented in graph format.

Source 45:

- recommendations made for additional indicator parameters based on knowledge of materials disposed at S-Area, composition of S-Area NAPL, and average well concentrations.
- original primary list (to be analyzed monthly or tri-monthly) included pH, conductivity, TOC, TOH, monochlorobenzoic acids, monochlorobenzene, trichlorobenzenes, tetrachlorobenzenes, hexachlorobenzene, hexachlorobutadiene, octachlorocyclopentene, hexachlorocyclohexanes, and perchloropentacyclodecane.
- additional primary parameters include benzene, carbon tetrachloride, phenolic compounds, bis (2-ethylhexyl) phthalate, lead, and mercury.
- additional secondary parameters (to be analyzed semi-annually or annually) are toluene, trichloroethylene, 1,1,2,2-tetrachloroethylene, cadmium, copper, and chromium.
- optional list (semi-annual or annual analysis) includes anthracene/phenanthrene, fluoranthene, pyrene, chrysene, benzo (a) anthracene, benzo (b) fluoranthene, benzo (a) pyrene, indeno (1,2,3-c,d) pyrene, and benzo (g,h,i) perylene.

Source 46:

- focus is on "Zone 2" of WTP (central portion).
- evaluation of sources of contamination at WTP.
- chlorinated benzenes and related chloro-organics originate from S-Area.
- metals originate from S-Area, but possibly also from WTP fill.
- polycyclic aromatic hydrocarbons not linked to S-Area and could be from WTP fill.
- average well concentrations given.

Source 47:

- twelve monitoring wells installed (B-1 to B-12) at WTP.
- ground water samples collected December 7, 1982, and January 23, 1983.
- some heavy metals exceeded standards.
- low levels of organic solvents, pesticides, and phthalates were detected.
- S-Area and fill material identified as possible contamination sources, but no firm conclusions drawn.
- soil and ground water analytical data are presented.

Source 48:

- Wells B-1 to B-12 at WTP resampled on July 21, 1983, and analyzed for priority pollutant organics and metals as well as S-Area indicator parameters.
- water level data during four-day period of bailing.
- analytical results included; one field blank.

Source 49:

- EPA evaluation of validity of chemical data from several previous sampling events (by CEC, EPA, and ADL).
- CEC, EPA, and ADL used different sampling and preservation techniques, analytical protocols, and quality assurance; therefore, it is difficult to draw any comparisons between these results.
- two potential contamination sources are S-Area and WTP fill.
- whether remediation of Eastern Area is necessary is uncertain.
- additional sampling and analysis is recommended.
- analytical results are presented.

Source 50:

- history of WTP, the discovery of contamination in the drinking water system, and remedial measures taken to correct it and avoid future contamination.

Source 51:

- composition (by percent) of NAPL at S-Area (8 samples).

Source 52:

- WTP construction history presented.
- geology and hydrogeology of WTP discussed.
- ground water contour maps produced.
- ground water elevations for several dates are given.
- ground water mounds exist near Filtered Water Reservoir and 100 feet west of Filtration Plant B.
- immediately west of Filtration Plant B is ground water sink.
- buildings and 80 percent of underground utilities are below water table.
- overall ground water flow at WTP is toward south.

Source 53:

- geology and hydrogeology of pump station area at WTP are discussed.
- permeability test data are presented.
- remedial actions are discussed.

Source 54:

- excavations of underground utility bedding performed to determine whether they have served as conduits for NAPL migration.
- report written before investigation complete; Hooker area investigated, but not yet WTP.
- no chemical data presented.
- cite that many of utilities are above NAPL plume, do not intersect plume, and were backfilled with compacted native soil.
- therefore concluded that most of utilities are not pathways for NAPL migration.
- three beddings containing NAPL are thought to be easily remediated by planned/modified remedial action plan.

Source 55:

- assessment of chemical migration through overburden onto WTP from S-Area
- identify that S-Area parameters are present in soil and ground water at WTP.
- NAPL is at extreme western limit of WTP.
- concentrations of S-Area parameters decrease toward west.
- lack of continuity (east-west) in APL plume, interpreted as not indicative of chemical migration from S-Area to central portion of WTP.
- WTP not hydrogeologically downgradient of S-Area and, therefore, would not have been contaminated by S-Area ground water.
- observed fill materials on WTP.
- portions of remedial collection systems now deemed unnecessary.
- soil and water quality data are presented.

Source 56:

- provides review of studies conducted to date in bedrock to assess amount of chemical migration from S-Area.
- APL and NAPL have migrated into bedrock from S-Area, including under the Niagara River.
- deepest NAPL detected was 163 feet below ground surface, below which is an aquitard.
- major portion of APL plume is within NAPL plume.
- deepest APL detected was 171 feet below ground surface.
- analytical data given, dates unknown, samples collected during drilling.
- no remedial action proposed yet.

Source 57:

- identical to Source 55.

Source 58:

- assess APL/NAPL migration in overburden to Niagara River from S-Area.
- analytical data included.
- S-Area parameters were found in overburden adjacent to Niagara River.
- parameters are migrating via APL.
- generally no S-Area parameters detected east of 53rd Street.
- concludes that some APL and NAPL have migrated in overburden toward Niagara River into area not addressed by proposed S-Area containment system.

Source 59:

- contains analytical results for selection of S-Area indicator chemicals.
- selection based on presence in NAPL, frequency of occurrence in APL, APL concentration, and Koc.
- indicator chemicals selected include vinyl chloride monomer, 1,2-dichloroethene (total), trichloroethylene, tetrachloroethylene, chlorobenzene, chlorobenzoic acids, 1,2,3-trichlorobenzene, 1,2,4-trichlorobenzene, 1,2,3,4-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene, hexachlorobutadiene, hexachlorocyclopentadiene, and octachlorocyclopentene.

Source 60:

- assesses Hooker geology and hydrogeology.
- contains ground water elevations.
- S-Area has confining layer discontinuity which has been defined.
- modelling of remedial design on ground water.
- all permeability test results on confining clay layer were less than the $1x10^{-7}$ cm/sec criteria for a confining layer.
- permeability test results.
- grain size analyses.

Source 61:

<u>Volume 1</u>
- history of site.
- monitoring well and soil boring installation procedures.
- pump testing procedures.
- identification of NAPL.
- utility bedding investigation (as in Source 54).
- analytical results in soil and ground water.
- description of area geology and hydrogeology.
- report meant to describe field procedures and results; no interpretations or conclusions.

<u>Volume 2</u>
- plates.

Source 61: continued

Appendix 1
- overburden well and boring logs.
- overburden well construction details.
- utility bedding excavation logs.

Appendix 2
- bedrock well logs.
- bedrock well construction details.
- pump test results.

Appendix 3
- boring and well logs and construction details from previous investigations.
- water level data.

Appendix 4
- documentation of well development.
- temperature, pH, and conductivity during development and stabilization.

Appendix 5
- grain size analysis, Atterberg limits, and permeability test results.

Appendix 6
- analytical results for soil and ground water samples.

Source 62:

- boring logs for three holes are enclosed.

Source 63:

- analytical results from sixteen soil samples collected from six soil borings on the PASNY property are included; trichlorobenzenes, tetrachlorobenzenes, hexachlorobutadiene, and hexachlorocyclopentadiene were analyzed and found present in thirteen of the samples; a boring location map is provided.

Source 64:

- boring logs and location map for the six borings cited in Source 63 are presented.

Source 65:

- analytical results from three soil samples from additional boring (additional to series of six borings which were installed and analyzed two months earlier) on PASNY property are included; trichlorobenzenes, tetrachlorobenzenes, and hexachlorobutadiene were analyzed and found to be present in two of the three samples; a boring location map is provided.

Source 66:

- contour maps of chromium and barium concentrations in overburden aquifer at the PASNY property are provided.
- logs and location maps for three borings and fifteen wells are included.
- location maps included for thirteen shallow soil sampling points and nine USGS test borings from 1982 - 1983.

MALCOLM PIRNIE

APPENDIX D

SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

MALCOLM PIRNIE

D-1

SUMMARY OF TEST BORINGS/MONITORING WELL DATA FOR WATER TREATMENT PLANT PROPERTY

D-1 summarizes research efforts for the various wells, boreholes, and excavations on, or near, the Water Treatment Plant property. Each section of D-1 presents the following information for the sampling point. Included are the type, location, and material sampled for each point. In addition, the depth of material sampled, ground elevation, and chemical analyses information is included. The sources and comments of water quality sampling dates comprise the remainder of D-1.

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
WS-16	Well	Hooker	Bedrock	31-36	570.7	Yes	No	3/1/79	LBG	8,18,25,32, 33,37,36,38, 45,52,56,58, 60,61	(See B-1); pumping test data; average value from 7 samples between 2/16/79 and 9/27/79; (metals, 3 samples); ?1980, ?1982 averages; 4/11/79,4/18/79, 6/12/79, 9/6/79; permeability test data
WS-16a	Well	Hooker	Fill, Till	6-26	570.8	Yes	No	1/22/79	LBG	8,13,18,25, 32,33,35,36, 37,38,52,58, 60,61	(See B-1); permeability test data; average value from 8 samples between 2/16/79 and 9/27/79 (metals,2 samples); ?1980, ?1982 averages
WS-17	Well	Hooker	Bedrock	33-38	572.0	Yes	No	2/28/79	LBG	8,18,24,25, 32,33,37,45, 56,58,60,61	(See B-1); average value from 8 samples between 2/16/79 and 9/27/79 (metals, 3 samples); physical testing data; ?1980, ?1982 averages; 4/18/79,6/12/79, 7/12/79, 9/6/79, 9/26/79,9/27/79; permeability test data
WS-17a	Well	Hooker	Fill, Clay	7-22	572.3	Yes	No	1/22/79	LBG	8,18,25,32, 33,35,36,37, 38,52,58,60, 61	(See B-1); average value from 8 samples between 2/16/79 and 9/27/79 (metals, 3 samples); ?1980, ?1982 averages; permeability test data
WS-18	Well	Hooker	Bedrock	33-38	571.6	Yes	No	2/22/79	LBG	8,18,24,25, 32,33,37,56, 58,60,61	(See B-1); value from 1 sample between 2/16/79 and 9/27/79; physical testing data; ?1980, ?1982 averages; permeability test data
WS-18a	Well	Hooker	Fill	2-17	571.9	Yes	No	1/23/79	LBG	8,18,25,32, 33,35,36,37, 38,52,58,60, 61	(See B-1); average value from 7 samples between 2/16/79 and 9/27/79 (metals, 2 samples); ?1980, ?1982 averages; permeability test data
WS-44a	Well	Off Buffalo Avenue	Silt, Clay	4.5-9.5	573.5	No	No	6/7/79	LBG	10,11,32,36, 38,58,60,61	(See B-1); pumping test data; permeability test data
WS-45a	Well	Hooker	Fill, Sand, Clay	4.5-19.5	571.9	No	No	5/17/79	LBG	9,10,11,12, 32,35,36,38, 52,58,60,61	(See B-1); pumping test data; permeability test data
WS-46a	Well	Hooker	?Fill, Clay	5.5-16	573.0	No	No	6/1/79	LBG	10,11,32,33, 35,36,38,52, 58,60,61	(See B-1); pumping test data; permeability test data
WS-47a	Well	Hooker	Fill, Sand	7-27	572.3	No	No	6/5/79	LBG	10,11,32,33,	(See B-1); pumping test data; permeability test data

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
										35,36,38,52, 58,60,61	
CW-1	Well	53rd Street	Bedrock	32.5-37.5	570.9	Yes	No	4/6/79	LBG	8,30,32,33, 35,38,56,58, 59,60,61	(See B-1); pumping test data; permeability test data; 3/7/88
CW-1a	Well	53rd Street	Fill	3-13	569.9	Yes	No	3/28/79	LBG	8,20,30,32, 33,35,36,37, 38,46,52,53, 58,60,61	(See B-1); pumping test data; 4/11/79,4/18/79,4/19/79, 6/12/79,9/26/79;?1980,?1982 averages;averages,unknown dates; permeability test data
CW-1b	Well	53rd Street	Sand	14-24	569.9	Yes	No	3/28/79	LBG	8,13,20,30, 32,33,35,37, 38,46,52,53, 58,60,61	(See B-1); pumping test data; permeability test data; 4/18/79,4/19/79,6/12/79,9/26/79;?1980,?1982 averages; averages,unknown dates
CW-2a	Well	WTP	Fill, Sand, Clay	4.5-19.5	570.5	Yes	No	3/13/79	LBG	8,30,32,33, 35,36,37,38, 46,52,53,58, 60,61	(See B-1); 3/21/79,4/18/79,4/19/79,6/12/79,7/11/79, 7/12/79,9/26/79;?1980,?1982 averages; averages, unknown dates; permeability test data
CW-3a	Well	WTP	Fill, Clay	0-10	571.2	Yes	No	3/9/79	LBG	8,20,30,32, 33,35,36,37, 38,46,52,53, 55,57,58,60, 61	(See B-1); 3/21/79,4/18/79,4/19/79,6/12/79,9/26/79; ?1980,?1982 averages; 3/24/88; averages, unknown dates; permeability test data
CW-4a	Well	WTP	Fill, Clay	3.5-8.5	571.5	Yes	No	3/9/79	LBG	8,20,30,32, 33,35,36,37, 38,46,53,58, 60,61	(See B-1); 3/21/79,4/18/79,4/19/79,6/12/79; ?1980,?1982 averages;averages, unknown dates; permeability test data
CW-5	Well	WTP	Bedrock	37-42	576.1	Yes	No	3/12/79	LBG	8,20,30,32, 33,35,37,38, 56,58,60,61	(See B-1); 3/21/79,4/11/79,4/18/79,4/19/79,6/12/79, 9/6/79,9/26/79; ?1980, ?1982 averages; permeability test data
CW-6	Well	WTP	Clay, Till, Bedrock	34-37	575.4	No	No	5/8/79	LBG	9,10,11,30, 32,33,35,38, 52,58,60,61	(See B-1)
CW-6a	Well	WTP	Fill	6-16	575.4	Yes	No	3/8/79	LBG	8,20,30,32, 33,35,36,37, 38,46,52,55,	(See B-1); 3/21/79,4/11/79,4/18/79,4/19/79,6/12/79, 7/11/79,7/12/79,9/26/79; ?1980,?1982 averages; 3/7/88; averages, unknown dates

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
										57,58,60,61	
CW-6b	Well	WTP	Fill, Sand, Silt, Clay	17-22	575.4	Yes	No	3/8/79	LBG	8,30,32,33, 35,37,38,46, 52,53,55,57, 58,60,61	(See B-1); 3/10/88; ?1980,?1982 averages; averages, unknown dates; permeability test data
CW-7	Well	WTP	Bedrock	30.5-35.5	570.7	Yes	No	3/9/79	LBG	8,20,30,32, 33,35,37,38, 52,58,59,60 61	(See B-1); 3/21/79,4/18/79,4/19/79,6/12/79,9/6/79, 9/26/79; ?1980,?1982 averages; 3/2/88
CW-7a	Well	WTP	Fill, Clay	3.5-13.5	570.7	Yes	No	3/9/79	LBG	8,20,30,32, 33,35,36,37, 38,46,52,53, 55,57,58,60, 61	(See B-1); 3/21/79,4/18/79,4/19/79,6/12/79,9/26/79; ?1980,?1982 averages; 3/2/88; averages, unknown dates; permeability test data
CW-8a	Well	WTP	?Fill	13.5-33.5	577.2	Yes	No	3/12/79	LBG	8,20,30,32, 33,35,36,37, 38,46,52,53, 58,60,61	(See B-1); 3/21/79,4/11/79,4/18/79,4/19/79,6/12/79; ?1980,?1982 averages; averages, unknown dates; permeability test data
CW-9	Well	WTP	Bedrock	33-38	572.3	No	No	5/17/79	LBG	9,10,11,30, 32,33,35,38, 52,56,58,60, 61	(See B-1); permeability test data
CW-9a	Well	WTP	Fill	6.5-16.5	572.3	Yes	No	5/21/79	LBG	9,10,11,30, 32,33,35,36, 37,38,46,52, 53,55,57,58, 60,61	(See B-1); ?1980,?1982 averages; 3/3/88; averages, unknown dates; permeability test data
CW-10	Well	WTP	Bedrock	37-42	576.9	Yes	No	5/15/79	LBG	9,10,11,30, 32,33,35,38, 52,58,59,60, 61	(See B-1); 3/4/88
CW-10a	Well	WTP	Fill, Sand	6.5-26.5	576.9	Yes	No	5/15/79	LBG	9,10,11,30, 32,33,35,38, 38,52,53,55, 57,58,60,61	(See B-1); ?1980,?1982 averages; 3/4/88; averages, unknown dates; permeability test data

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
CW-11	Well	WTP	Bedrock	36-41	574.6	No	No	5/31/79	LBG	10,11,30,32, 33,35,38,58, 60,61	(See B-1); pumping test data
CW-11a	Well	WTP	Fill, Sand, Clay	11-26	574.6	Yes	No	5/24/79	LBG	10,11,30,32, 33,35,36,37, 38,46,52,53, 55,57,58,60, 61	(See B-1); pumping test data; ?1980,?1982 averages; 3/3/88; averages, unknown dates; permeability test data
CW-13	Well	WTP	Till, Bedrock	35.5-40.5	573.7	Yes	No	6/6/79	LBG	10,11,30,32, 33,35,38,56, 58,59,60,61	(See B-1); pumping test data; permeability test data; 3/2/88
CW-13a	Well	WTP	Fill	1.5-16.5	573.7	Yes	No	6/7/79	LBG	10,11,30,32, 33,35,36,37, 38,46,53,55, 57,58,60,61	(See B-1); pumping test data; ?1980,?1982 averages; 3/8/88; averages, unknown dates; permeability test data
SS-Pilot	Well	WTP	Bedrock	44.5-71	?	No	No	5/16/79	LBG	10,11,14	(See B-1); pumping test data
SS-1	Well	53rd Street	Bedrock	46.5-54.6	571.0	No	No	6/5/79	LBG	10,11,56,58, 60,61	(See B-1); pumping test data; permeability test data
SS-2	Well	53rd Street	Bedrock	55-70	570.9	No	No	6/27/79	LBG	10,11,56,58, 60,61	(See B-1); pumping test data; permeability test data
TRW-1	Well	N of Robert Moses Pkwy	Bedrock	33-69	?	No	No	?	LBG	12,14	(See B-1)
TRW-1a	Well	Hooker	Fill, Sand, Clay	?8-?19	?	No	No	?	LBG	12,13	(See B-1); pumping test data; permeability test data
TB1-08	Boring	WTP	Alluvium, Clay, Till	30	572.2	No	No	1908	Plant drawing		
TB2-08	Boring	WTP	Alluvium, Clay, Till	24.6	565.6	No	No	1908	Plant drawing		
BH-1-77	Boring	WTP	Fill, Silt, Clay and Sand	37	574.9	No	No	10/24/77	ESI	34,52,58,60, 61	
BH-2-77	Boring	WTP	Fill, Silt, Clay and Sand	20	569.9	No	No	10/24/77	ESI	34,52,58,60, 61	
BH-3-77	Boring	WTP	Fill, Silt, Clay and Sand	33	568.8	No	No	10/21/77	ESI	34,52,58,60, 61	
BH-4-77	Boring	WTP	Fill, Silt,	33.5	568.6	No	No	10/21/77	ESI	34,52,58,60,	

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
			Clay and Sand							61	
BH-5-77	Boring	WTP	Fill, Silt, Clay and Sand	34	569.2	No	No	10/21/77	ESI	34,52,58,60, 61	
BH-6-77	Boring	WTP	Fill, Silt, Clay and Sand	30	573.9	No	No	10/24/77	ESI	34,52,58,60, 61	
BH-7-77	Boring	WTP	Fill, Silt, Clay and Sand	35	575.9	No	No	10/21/77	ESI	34,52,58,60, 61	
BH-1A-08	Boring	WTP	Overburden, Bedrock	@35.5	568.9	No	No	1908	?	35,52,58,60, 61	
BH1B-43	Boring	WTP	Overburden, Bedrock	@31	568.8	No	No	1943	?	35,52,58,60, 61	
BH2B-43	Boring	WTP	Overburden, Bedrock	@33	570.2	No	No	1943	?	35,52,58,60, 61	
BH3B-43	Boring	WTP	Overburden, Bedrock	@33	569.8	No	No	1943	?	35,52,58,60, 61	
BH4B-43	Boring	WTP	Overburden, Bedrock	@30.5	569.3	No	No	1943	?	35,52,58,60, 61	
BH5B-43	Boring	WTP	Overburden, Bedrock	@31.5	568.3	No	No	1943	?	35,52,58,60, 61	
BH3-43	Boring	WTP	Overburden	@26	564.6	No	No	1943	?	35,52,61	
BH1-49	Boring	WTP	Overburden, Bedrock	@31	569.7	No	No	1949	?	35,52,58,60, 61	
BH2-49	Boring	WTP	Overburden, Bedrock	@32	568.7	No	No	1949	?	35,52,58,60, 61	
BH3-49	Boring	WTP	Overburden, Bedrock	@34	570.6	No	No	1949	?	35,52,58,60, 61	
BH4-49	Boring	WTP	Overburden, Bedrock	@42	571.7	No	No	1949	?	35,52,58,60, 61	
BH5-49	Boring	WTP	Overburden, Bedrock	@43	570.6	No	No	1949	?	35,52,58,60, 61	

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
BH6-49	Boring	WTP	Overburden, Bedrock	@43	572.5	No	No	1949	?	35,52,58,60, 61	
BH7-49	Boring	WTP	Overburden, Bedrock	@34	571.8	No	No	1949	?	35,52,58,60, 61	
BH12-25	Boring	WTP	?	?	574.2	No	No	1925	?	35	
BH12-26	Boring	WTP	?	?	573.0	No	No	1926	?	35	
BH12-27	Boring	WTP	?	?	572.1	No	No	1927	?	35	
BH12-28	Boring	WTP	?	?	576.9	No	No	1928	?	35	
BH12-29	Boring	WTP	?	?	574.7	No	No	1929	?	35	
BH12-30	Boring	WTP	?	?	558.0	No	No	1930	?	35	
BH12-31	Boring	WTP	?	?	568.0	No	No	1931	?	35	
BH1-80	Boring	S of WTP	Overburden, Bedrock	44.5	586.9	No	No	1/17/80	CRA	35,52,58,60, 61	
BH2-80	Boring	S of WTP	Overburden, Bedrock	34.3	569.0	No	No	1/21/80	CRA	35,52,58,60, 61	
BH3-80	Boring	S of WTP	Overburden, Bedrock	31	568.3	No	No	1/22/80	CRA	35,52,58,60, 61	
BH4-80	Boring	S of WTP	Overburden, Bedrock	52.5	588.4	No	No	1/23/80	CRA	35,52,58,60, 61	
BH5-80	Boring	S of WTP	Overburden	35.2	574.4	No	No	1/25/80	CRA	35,52,58,60, 61	
BH6-80	Boring	S of WTP	Overburden	35	574.3	No	No	1/25/80	CRA	35,52,58,60, 61	
BH7-80	Boring	S of WTP	Overburden	?50.9	588.1	No	No	1/29/80	CRA	35,52,58,60, 61	
B-1	Well	WTP	Sand and Silt	29-34	572.55	Yes	No	12/7/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; sand and silt sample from 25-27 ft. analyzed

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
B-2	Well	WTP	?Sand and Silt	19-24	573.43	Yes	No	12/8/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; sand and silt sample from 15-17 ft. analyzed
B-3	Well	WTP	Clay, Till	26.5-31.5	569.17	Yes	No	12/11/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 20-22 ft. analyzed
B-4	Well	WTP	Clay, Till	29-34	570.37	Yes	No	12/13/82	CEC	38,40,47,48, 49,58,60,61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 25-27 ft. analyzed
B-5	Well	WTP	Sand and Silt	5-10	572.67	Yes	No	12/11/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 10-12 ft. analyzed
B-6	Well	WTP	Sand and Silt	17-22	571.46	Yes	No	12/9/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; sand and silt sample from 20-22 ft. analyzed
B-7	Well	WTP	Clay, Till	31.5-36.5	572.93	Yes	No	12/82	CEC	38,40,47,48, 49,58,60,61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 30-32 ft. analyzed
B-8	Well	WTP	Clay, Till	29-34	570.99	Yes	No Yes- (Source 40)	12/10/82	CEC	38,40,47,48, 49,58,60,61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; ash sample from 5-7 ft. analyzed; clay and silt sample from 10-12 ft. analyzed
B-9	Well	WTP	Fill, Clay	7-12	568.89	Yes	No	12/11/82	CEC	38,40,47,48, 49,58,60,61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 10-12 ft. analyzed
B-10	Well	WTP	?Clay, Till	28-33	573.21	Yes	No	12/14/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 25-27 ft. analyzed
B-11	Well	WTP	Sand and Silt, ?Clay	5-10	572.21	Yes	No	12/14/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; sand and silt sample from 5-7 ft. analyzed
B-12	Well	WTP	Sand and Silt, Clay, Till	31-36	573.43	Yes	No	12/82	CEC	38,40,47,48, 49,52,58,60, 61	Water level data; 1/24/82; 12/7/82; 1/23/83; 1/26/83; 7/21/83; clay sample from 30-32 ft. analyzed

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
FH-1	Well	WTP	Overburden	?	?	Yes	No	1/83	CEC	39	Week of 1/23/83
FH-2	Well	WTP	Overburden	?	?	Yes	No	1/83	CEC	39	Week of 1/23/83
S-1	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
S-2	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
S-3	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
S-4	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
S-5	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
S-6	Grab	WTP	Surface Soil	?	?	Yes	No	12/82	CEC	47	
A-1	Exca-vation	53rd Street	Gravel, Sand	2	?	No	No	?1988	CRA	54,61	
A-2	Exca-vation	53rd Street	Gravel, Sand, Silt	2	?	No	No	?1988	CRA	54,61	
B-5	Exca-vation	53rd Street	Gravel, Sand	4.5	?	No	No	?1988	CRA	54,61	
B-6	Exca-vation	53rd Street and Adams Avenue	Clay, Gravel	6.5	?	No	No	?1988	CRA	54,61	
B-8	Exca-vation	Hooker	Gravel, Clay	10.5	?	?	?	?	CRA	54,61	
B-25	Exca-vation	S of Robert Moses Pkwy	Gravel	10.5	?	?	?	?1988	CRA	54,61	
B-26	Exca-vation	S of Robert Moses Pkwy	Gravel, Sand	10.5	?	?	?	?1988	CRA	54,61	
B-27	Exca-vation	S of Robert Moses Pkwy	Gravel	6.5	?	?	?	?1988	CRA	54,61	
B-28	Exca-vation	S of Robert Moses Pkwy	Gravel	6	?	?	?	?1988	CRA	54,61	
OW200	Well	WTP	Bedrock	204.3 (grouted)	572.8	Yes	No	10/5/87	CRA	56,58,59,60, 61	9/28/87;water level data; pumping test data; 6 intervals tested 8/26/87-9/28/87

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
OW201	Well	WTP	Bedrock	205.8 (grouted)	568.9	Yes	No	10/22/87	CRA	56,58,59,60	Physical testing data; grain size data; water level data; pumping test data; 5 intervals tested 10/8/87-10/14/87
OW202	Well	S of WTP	Bedrock	127-206.8	571.5	Yes	No	11/11/87	CRA	56,58,59,60	Water level data; pumping test data; 5 intervals tested 10/27/87-11/11/87
OW210	Well	Hooker	Bedrock	136.7-169.4 203.1 total	571.1	Yes	No	12/8/87	CRA	56,58,59,60	Physical testing data; grain size data; water level data; pumping test data; 6 intervals tested 11/14/87-12/3/87
OW211	Well	WTP	Bedrock	204.0 (grouted)	570.6	Yes	No	10/28/87	CRA	53,56,58,59, 60	Physical testing data; grain size data; water level data; pumping test data; 3 intervals tested 10/12/87-10/20/87
OW215	Well	WTP	Bedrock	154-171 206.0 total	575.1	Yes	No	12/21/87	CRA	56,58,59,60	Water level data; pumping test data; 4 intervals tested 12/9/87-12/16/87
OW216	Well	WTP	Bedrock	136-170.5 198.3 total	572.3	Yes	No	2/15/88	CRA	56,58,59,60	Water level data; pumping test data; 7 intervals tested 1/21/88-2/10/88
OW220	Well	WTP	Bedrock	31-61.1	572.4	No	No	11/23/87	CRA	58,60,61	Water level data
OW221	Well	S of WTP	Bedrock	33.3-63.3	570.4	No	No	7/21/87	CRA	58,60,61	Water level data
OW226	Well	WTP	Bedrock	33.4-63	571.9	No	No	12/29/87	CRA	58,60,61	Water level data
OW227	Well	WTP	Bedrock	35.6-66.1	574.0	No	No	7/13/87	CRA	58,60,61	Water level data
OW234	Well	WTP	Bedrock	32.5-63	569.8	No	No	7/13/87	CRA	58,60,61	Water level data
OW235	Well	WTP	Bedrock	32.5-67.8	570.8	No	No	7/9/87	CRA	53,58,60,61	Water level data
OW236	Well	WTP	Bedrock	39.5-69.9	577.0	No	No	7/7/87	CRA	53,58,60,61	Water level data
OW260	Well	S of WTP	Sand	19.1-24.1	568.4	Yes	No	6/10/87	CRA	52,55,57,58, 60,61	4/19/88; water level data; permeability test data
OW261	Well	S of WTP	Silt and Sand	22.8-27.8	569.5	Yes	No	6/15/87	CRA	52,55,57,58, 60,61	4/22/88; water level data; permeability test data
OW262	Well	S of WTP	Silt and Sand	27.4-32.4	574.5	Yes	No	6/12/87	CRA	52,55,57,58, 60,61	4/19/88; water level data; permeability test data
OW263	Well	S of WTP	Silt and Sand	21-26	571.0	Yes	No	6/17/87	CRA	52,55,57,58 60,61	4/22/88; water level data; permeability test data

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
OW264	Well	S of WTP	Fill, Silt and Sand	6-21	568.4	Yes	No	4/30/87	CRA	52,55,57,58, 60,61	5/3/88; water level data; permeability test data
OW265	Well	S of WTP	Silt and Sand	24.9-29.9	574.5	Yes	No	4/24/87	CRA	52,55,57,58, 60,61	4/21/88; water level data; permeability test data
OW274	Well	WTP	Silt, Clay	3.5-8.5	572.1	Yes	No	5/1/87	CRA	52,55,57,58, 60,61	3/18/88; water level data
OW275	Well	WTP	Fill, Silt and Clay	4-9	570.5	Yes	No	6/10/87	CRA	52,55,57,58, 60,61	3/15/88; water level data
OW276	Well	WTP	Fill, Silt and Clay	3.5-8.5	571.5	Yes	No	5/15/87	CRA	52,55,57,58, 60,61	3/17/88; water level data; 5/12/87 soil sample 4-8 ft.
OW277	Well	WTP	Fill, Silt and Clay	3.9-8.9	570.2	Yes	No	6/12/87	CRA	52,55,57,58, 60,61	3/14/88; water level data; 5/13/87 soil sample 4-8 ft.
OW278	Well	WTP	Fill, Silt and Clay	7.3-12.3	570.5	Yes	No	5/8/87	CRA	52,55,57,58, 60,61	3/15/88; water level data; 5/12/87 soil sample 4-10 ft.
OW279	Well	WTP	Fill, Silt and Clay	3.5-8.5	570.5	Yes	No	5/12/87	CRA	52,55,57,58, 60,61	3/24/88; water level data; 5/1/87 soil sample 2-8 ft.
OW280	Well	WTP	Clay and Silt	4.1-9.1	569.9	Yes	No	5/13/87	CRA	52,55,57,58, 60,61	3/25/88; water level data; 6/9/87 soil sample 6-8 ft.
OW281	Well	WTP	Silt and Clay	4-9	570.3	Yes	No	5/7/87	CRA	52,55,57,58, 60,61	3/22/88; water level data; 5/15/87 soil sample 4-8 ft.
OW282	Well	WTP	Fill, Silt and Sand, Silt and Clay	5.7-12.7	571.1	Yes	No	5/12/87	CRA	52,55,57,58, 60,61	3/11/87; water level data;6/11/87 soil sample 2.5-5.2 ft.
OW283	Well	WTP	Fill, Silt and Clay	8.5-13.5	571.7	Yes	No	6/4/87	CRA	52,55,57,58, 60,61	3/14/88; water level data; permeability test data; 5/7/87 soil sample 4-8 ft.
OW284	Well	WTP	Fill, Silt and Clay	4-9	569.9	Yes	No	6/1/87	CRA	52,55,57,58, 60,61	3/22/88; water level data; 6/3/87 soil sample 6-14 ft.
OW285	Well	WTP	Fill, Silt and Clay	5.3-10.3	569.8	Yes	No	5/12/87	CRA	52,55,57,58, 60,61	3/23/88; 6/1/87 soil sample 6-8ft; water level data; 5/11/87 soil sample 4-8 ft.
OW286	Well	WTP	Fill, Silt and Clay	6.2-11.2	570.7	Yes	No	5/14/87	CRA	52,55,57,58, 60,61	3/23/88; water level data; 6/5/87 soil sample 6-20.8 ft.

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
OW287	Well	WTP	Fill, Silt and Sand	9.8-20.8	574.2	Yes	No	2/19/88	CRA	52,55,57,58, 60,61	3/25/88; water level data; permeability test data; 5/8/87 soil sample 6-14 ft.
OW288	Well	WTP	Silt and Sand	8.5-13.5	572.2	Yes	No	5/12/87	CRA	52,53,55,57, 58,60,61	3/10/88; water level data; 5/15/87 soil sample 7-18 ft.
OW289	Well	WTP	Fill, Silt and Sand	8-18	573.1	Yes	No	5/18/87	CRA	52,53,55,57, 58,60,61	3/10/88; water level data; 6/15/87 soil sample 8-20 ft.
OW290	Well	WTP	Sand	14.8-19.8	574.8	Yes	No	6/17/87	CRA	52,55,57,58, 60,61	3/20/88; water level data; 6/18/87 soil sample 2-19.8 ft.
OW291	Well	WTP	Fill, Sand, Silt and Clay	8.3-20.5	574.4	Yes	No	6/23/87	CRA	52,55,57,58, 60,61	3/24/88; water level data; 5/18/87 soil sample 14-34 ft.
OW292	Well	WTP	Sand, Silt and Clay	28.3-33.3	576.0	Yes	No	5/22/87	CRA	52,53,55,57, 58,60,61	3/8/88; water level data; permeability test data; 5/19/87 soil sample 9-34 ft.
OW293	Well	WTP	Sand	25.5-30.5	575.6	Yes	No	5/22/87	CRA	52,55,57,58, 60,61	3/9/88; water level data; permeability test data; 5/27/87 soil sample 12-30 ft.; 5/28/87 soil sample 30-32 ft.
OW294	Well	WTP	Silt,Sand and Gravel	25-30	574.6	Yes	No	5/29/87	CRA	52,55,57,58, 60,61	3/9/88; water level data; permeability test data; 5/8/87 soil sample 6-12 ft.
BH100	Boring	Hooker	Overburden	33.5	571.8	No	No	2/9/87	CRA	58,60,61	Physical testing data; grain size data
BH101	Boring	Hooker	Overburden	32.5	571.2	No	No	5/27/87	CRA	58,60,61	Physical testing data; grain size data
BH102	Boring	53rd Street	Overburden	33.8	571.8	No	No	5/26/87	CRA	58,60,61	Physical testing data; grain size data
BH103	Boring	53rd Street	Overburden	34.1	572.1	No	No	5/26/87	CRA	58,60,61	Physical testing data; grain size data
BH104	Boring	53rd Street	Overburden	33.4	572.5	No	No	5/26/87	CRA	58,60,61	Physical testing data; grain size data
BH105	Boring	53rd Street	Overburden	33.1	572.1	No	No	3/9/87	CRA	58,60,61	Physical testing data; grain size data
BH106	Boring	53rd Street	Overburden	33.1	571.6	No	No	3/6/87	CRA	53,60,61	Physical testing data; grain size data
BH107	Boring	53rd Street	Overburden	33.1	571.1	No	No	3/5/87	CRA	53,60,61	Physical testing data; grain size data
BH108	Boring	53rd Street	Overburden	31.6	570.7	No	No	3/4/87	CRA	53,60,61	Physical testing data; grain size data
BH109	Boring	53rd Street	Overburden	31.3	570.1	No	No	3/3/87	CRA	53,60,61	Physical testing data; grain size data

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

TABLE D-1
SUMMARY OF TEST BORING/MONITORING WELL DATA
FOR WATER TREATMENT PLANT PROPERTY

SAMPLING POINT	TYPE	LOCATION	GEOLOGY	DEPTH	GR.ELEV	ANALS	QA/QC	WHEN	BY WHOM	SOURCES	COMMENTS AND WATER QUALITY SAMPLING DATES
BH110	Boring	53rd Street	Overburden	31.4	569.5	No	No	2/27/87	CRA	58,60,61	Physical testing data; grain size data
BH111	Boring	53rd Street	Overburden	31.4	568.7	No	No	2/26/87	CRA	58,60,61	Physical testing data; grain size data
BH130	Boring	Hooker	Overburden	32.8	571.1	No	No	3/10/87	CRA	58,60,61	Physical testing data; grain size data
BH222	Boring	WTP	Overburden	20.0	575.2	No	No	3/31/88	CRA	58,60,61	
BH223	Boring	WTP	Overburden	20.0	574.8	No	No	3/31/88	CRA	58,60,61	
BH277	Boring	WTP	?	2-10	?	Yes	No	?	CRA	55,57,61	7/14/87 soil
BH286	Boring	WTP	?	4-8	?	Yes	No	?	CRA	55,57,61	5/13/87 soil
BH291	Boring	WTP	?	2-18.4	?	Yes	No	?	CRA	55,57,61	7/14/87 soil

NOTE:

CEC = Clayton Environmental Consultants, Inc.
CRA = Conestoga-Rovers Associates, Ltd.
ESI = Empire Soils Investigations, Inc.
LBG = Leggette, Brashears & Graham

WTP = Water Treatment Plant

N=North
S=South

Note: Depth and Ground Elevation in feet (1986 Occidental Datum).

MALCOLM PIRNIE

D-2

LIMITS ON TEST BORING/MONITORING WELL DATA FOR THE WATER TREATMENT PLANT PROPERTY

D-2 summarizes the well construction and chemical analyses details for the various wells, boreholes, and excavations on, or near, the Water Treatment Plant property. Each section of D-2 highlights the limits of information known for the borings/wells, including whether or not a well seal is suspect and the number of non-average chemical analyses performed on a sample.

LIMITS ON TEST BORING/MONITORING WELL DATA
FOR THE WATER TREATMENT PLANT PROPERTY

	--------------WELL CONSTRUCTION-----------------							--------CHEMICAL ANALYSES--------			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
WS-16							x			x	
WS-16a						x				x	
WS-17							x			x	
WS-17a						x				x	
WS-18							x		x	x	
WS-18a										x	
WS-44a						x		x			
WS-45a						x		x			
WS-46a						x		x			
WS-47a								x			
CW-1							x				1
CW-1a									x	x	7
CW-1b									x	x	5
CW-2a						x			x	x	10
CW-3a						x			x	x	7
CW-4a						x			x	x	5
CW-5							x			x	9
CW-6						x		x			
CW-6a									x	x	14
CW-6b						x			x	x	1
CW-7							x		x		7

	--------------WELL CONSTRUCTION-----------------							--------CHEMICAL ANALYSES--------			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
CW-7a						x			x	x	7
CW-8a									x	x	7
CW-9							x	x			
CW-9a									x	x	1
CW-10							x	x			1
CW-10a									x	x	1
CW-11							x	x			
CW-11a						x			x	x	1
CW-13						x					1
CW-13a									x	x	1
SS-Pilot		x						x			
SS-1					x			x			
SS-2					x			x			
TRW-1		x					x	x			
TRW-1a		x				x		x			
TB1-08								x			
TB2-08								x			
BH-1-77											
BH-2-77											
BH-3-77											
BH-4-77											
BH-5-77											
BH-6-77											
BH-7-77											

	--------------WELL CONSTRUCTION-----------------							--------CHEMICAL ANALYSES--------			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
BH-1A-08											
BH1B-43											
BH2B-43											
BH3B-43											
BH4B-43											
BH5B-43											
BH3-43											
BH1-49											
BH2-49											
BH3-49											
BH4-49											
BH5-49											
BH6-49											
BH7-49											
BH12-25	x		x	x							
BH12-26	x		x	x							
BH12-27	x		x	x							
BH12-28	x		x	x							
BH12-29	x		x	x							
BH12-30	x		x	x							
BH12-31	x		x	x							
BH1-80											
BH2-80											
BH3-80											

		--------------WELL CONSTRUCTION----------------						--------CHEMICAL ANALYSES--------			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
BH4-80											
BH5-80											
BH6-80											
BH7-80			x								
B-1									x		3
B-2									x		3
B-3									x		3
B-4									x		3
B-5									x		3
B-6									x		3
B-7									x		3
B-8									x		3
B-9						x			x		3
B-10									x		3
B-11						x			x		3
B-12						x			x		3
FH-1		x	x	x					x		
FH-2		x	x	x					x		
OW200											1
OW201								x			
OW202								x			
OW210								x			
OW211								x			
OW215								x			

	--------------WELL CONSTRUCTION-----------------							--------CHEMICAL ANALYSES--------			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
OW216								x			
OW220								x			
OW221								x			
OW226								x			
OW227								x			
OW234								x			
OW235								x			
OW236								x			
OW260											1
OW261											1
OW262											1
OW263											1
OW264											1
OW265											1
OW274						x					1
OW275						x					1
OW276						x					1
OW277						x					1
OW278						x					1
OW279						x					1
OW280											1
OW281											1
OW282						x					1
OW283						x					1

	WELL CONSTRUCTION							CHEMICAL ANALYSES			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
OW284						x					1
OW285						x					1
OW286						x					1
OW287											1
OW288											1
OW289											1
OW290											1
OW291						x					1
OW292						x					1
OW293											1
OW294											1
BH100											
BH101											
BH102											
BH103											
BH104											
BH105											
BH106											
BH107											
BH108											
BH109											
BH110											
BH111											
BH130											

	WELL CONSTRUCTION							CHEMICAL ANALYSES			
Boring/ Well No.	Location Unknown	Elev. Unknown	Depth Unknown	Strat. Unknown	Constr. Unknown	Screen Multi Units	Well Seal Suspect	No Analys.	Sample Date Unknown	Average Values Only	Numb. Of Non-Avg. Analys.
BH222											
BH223											
BH277	x	x		x							
BH286	x	x		x							
BH291	x	x		x							

Note: Excavations and surface soil sample series S-1 to S-6 not included.

MALCOLM PIRNIE

D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

Over the years, more than 150 monitoring wells and boreholes have been installed on or near the Water Treatment Plant property for the purpose of defining local geology, hydrogeology, and soil conditions. Table D-3 summarizes the stratigraphic data base obtained from the various well and borehole installations. Each section of the table presents depth and elevation of each stratigraphic unit encountered and observations of NAPL.

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
WS-16	570.7	24	546.7	7.5	563.2	--		--		--	24	546.7	7	31	539.7	31	539.7		
																36	534.7		
WS-16a	570.8	24	546.8	7.5	563.3	--		--		--	24	546.8	3	--		6	564.8		
																26	544.8		
WS-17	572	21	551	9	563	--		21	551	10	31	541	2	33	539	33	539	10	562
																38	534	12	560
WS-17a	572.3	21	551.3	9	563.3	--		21	551.3	1.5	--		--	--		7	565.3		
																22	550.3		
WS-18	571.6	17.5	554.1	--		--		17.5	554.1	15.5	--		--	33	538.6	33	538.6	32	539.6
																38	533.6		
WS-18a	571.9	17.5	554.4	--		--		17.5	554.4	0.5	--		--	--		2	569.9		
																17	554.9		
WS-44a	573.5	--		--		0	573.5	9.5	564	1	--		--	--		4.5	569		
																9.5	564		
WS-45a	571.9	12	559.9	12	559.9	12	559.9	15	556.9	6	--		--	--		4.5	567.4	13.5	558.4
																19.5	552.4	15	556.9
																		19	552.9
* WS-46a	573	2	571	2	571	--		6	567	12	2	571	4	--		5.5	567.5		
																16	557		
WS-47a	572.3	12	560.3	--		12	560.3	27	545.3	1.5	--		--	--		7	565.3		
																27	545.3		
CW-1	570.9	20	550.9	8	562.9	20	550.9	--		--	28.5	542.4	3	31.5	539.4	32.5	538.4	30.5	540.4
																37.5	533.4		
CW-1a	569.9	13.5	556.4	7.5	562.4	--		--		--	--		--	--		3	566.9		
																13	556.9		
CW-1b	569.9	13.5	556.4	7.5	562.4	13.5	556.4	--		--	24	545.9	1.5	--		14	555.9		
																24	545.9		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
CW-2a	570.5	9	561.5	9	561.5	9	561.5	17.5	553	2	--		--	--		4.5	566	?yes	
																19.5	551		
CW-3a	571.2	9	562.2	1.5	569.7	--		9	562.2	3	--		--	--		0	571.2		
																10	561.2		
CW-4a	571.5	6	565.5	6	565.5	--		6	565.5	3	--		--	--		3.5	568		
																8.5	563		
CW-5	576.1	32.5	543.6	27	549.1	--		--		--	32.5	543.6	4.5	37	539.1	37	539.1		
																42	534.1		
CW-6	575.4	16	559.4	16	559.4	16	559.4	20.5	554.9	13	33.5	541.9	2.5	36	539.4	34	541.4		
																37	538.4		
CW-6a	575.4	16	559.4	16	559.4	--		--		--	--		--	--		6	569.4		
																16	559.4		
CW-6b	575.4	16	559.4	16	559.4	16	559.4	20.5	554.9	1.5	--		--	--		17	558.4		
																22	553.4		
CW-7	570.7	12	558.7	12	558.7	--		12	558.7	18.5	--		--	30.5	540.2	30.5	540.2		
																35.5	535.2		
CW-7a	570.7	12	558.7	12	558.7	--		12	558.7	1.5	--		--	--		3.5	567.2		
																13.5	557.2		
CW-8a	577.2	7.5	569.7	7.5	569.7	7.5	569.7	--		--	--		--	--		13.5	563.7		
																33.5	543.7		
CW-9	572.3	16.5	555.8	16.5	555.8	--		16.5	555.8	13.5	30	542.3	3	33	539.3	33	539.3		
																38	534.3		
CW-9a	572.3	16.5	555.8	16.5	555.8	--		--		--	--		--	--		6.5	565.8		
																16.5	555.8		
CW-10	576.9	15	561.9	12	564.9	15	561.9	26.5	550.4	9.5	36	540.9	1	37	539.9	37	539.9		
																42	534.9		
CW-10a	576.9	15	561.9	12	564.9	15	561.9	--		--	--		--	--		6.5	570.4		
																26.5	550.4		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
CW-11	574.6	18.5	556.1	18.5	556.1	18.5	556.1	25.5	549.1	10.5	--		--	36	538.6	36 41	538.6 533.6		
CW-11a	574.6	18.5	556.1	18.5	556.1	18.5	556.1	25.5	549.1	9	--		--	--		11 26	563.6 548.6		
CW-13	573.7	16.5	557.2	13.5	560.2	--		16.5	557.2	16.5	33	540.7	3	36	537.7	35.5 40.5	538.2 533.2		
CW-13a	573.7	16.5	557.2	13.5	560.2	--		--		--	--		--	--		1.5 16.5	572.2 557.2		
SS-Pilot	?	20	?	8	?	20	?	--	?	--	28.5	?	3	31.5	?	44.5 71	? ?		
SS-1	571	20	551	8	563	20	551	--		--	28.5	542.5	3	31.5	539.5	46.5 54.6	524.5 516.4	30.5	540.5
SS-2	570.9	20	550.9	8	562.9	20	550.9	--		--	28.5	542.4	3	31.5	539.4	55 70	515.9 500.9	30.5	540.4
TRW-1	?	?	?	?	?	?	?	?	?	?	?	?	?	33	?	33 69	? ?		
*TRW-1a	?	12	?	?	?	12	?	15.5	?	2.5	--		--	--		?8 ?19	? ?		
TB1-08	572.2	--		--		0	572.2	2.8	569.4	25.9	28.7	543.5	1.3	30	542.2	?	?		
TB2-08	565.6	--		--		0	565.6	6	559.6	16	22	543.6	2.6	24.6	541	?	?		
BH-1-77	574.9	17	557.9	17	557.9	--		17	557.9	27	--		--	--		37	537.9		
BH-2-77	569.9	9	560.9	9	560.9	9	560.9	17.5	552.4	2.5	--		--	--		20	549.9		
BH-3-77	568.8	3.5	565.3	3.5	565.3	3.5	565.3	9.5	559.3	10.5	29.5	539.3	3.5	--		33	535.8		
BH-4-77	568.6	7	561.6	7	561.6	7	561.6	7.5	561.1	21.5	29	539.6	4.5	--		33.5	535.1		
BH-5-77	569.2	6.5	562.7	6.5	562.7	6.5	562.7	8.5	560.7	20.5	29	540.2	5	--		34	535.2		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL		BASE OF GARBAGE		TOP OF ALUVIUM		TOP OF CLAY		THICKNESS OF CLAY (Feet)	TOP OF TILL		THICKNESS OF TILL (Feet)	TOP OF BEDROCK		BASE OF BORING/ SCREENED INTERVAL		NAPL	
		Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.		Depth	Elev.		Depth	Elev.	Depth	Elev.	Depth	Elev.
BH-6-77	573.9	16	557.9	16	557.9	16	557.9	--		--	--		--	--		30	543.9		
BH-7-77	575.9	18	557.9	18	557.9	18	557.9	--		--	33	542.9	2	--		35	540.9		
BH-1A-08	568.9	4.5	564.4	--		--		4.5	564.4	25	29.5	539.4	2	31.5	537.4	35.5	533.4		
BH-1B-43	568.8	-		--		0	568.8	6.5	562.3	21.5	28	540.8	0.5	28.5	540.3	31	537.8		
BH-2B-43	570.2	10	560.2	10	560.2	10	560.2	14	556.2	15.5	29.5	540.7	1	30.5	539.7	33	537.2		
BH-3B-43	569.8	--		--		0	569.8	13	556.8	18	31	538.8	1	32	537.8	33	536.8		
BH-4B-43	569.3	-		--		0	569.3	8	561.3	21	--		--	29	540.3	30.5	538.8		
BH-5B-43	568.3	5	563.3	--		5	563.3	7	561.3	22	29	539.3	1	30	538.3	31.5	536.8		
B3-43	564.6	-		--		0	564.6	4	560.6	22.4	26	538.6	0.9	27.3	537.3	26	538.6		
BH-1-49	569.7	9	560.7	9	560.7	--		-		20	--		--	29	540.7	31	538.7		
BH-2-49	568.7	11	557.7	10.5	558.2	--		-		19	--		--	30	538.7	32	536.7		
BH-3-49	570.6	10	560.6	10	560.6	10	560.6	16	554.6	11.9	27.9	542.7	4	31.9	538.7	34	536.6		
BH-4-49	571.7	17	554.7	17	554.7	--		-		11	28	543.7	3.9	31.9	539.8	42	529.7		
BH-5-49	570.6	10	560.6	10	560.6	10	560.6	20	550.6	9.9	29.9	540.7	3.1	33	537.6	43	527.6		
BH-6-49	572.5	11.8	560.7	11.8	560.7	11.8	560.7	24.8	547.7	5	29.8	542.7	3	32.8	539.7	43	529.5		
*BH-7-49	571.8	--		--		0	571.8	-		26.5	26.5	545.3	2	28.5	543.3	34	537.8		
BH12-25	574.2	?	?	?	?	?	?	?		?	?	?	?	32	542.2	?	?		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
BH12-26	573	?	?	?	?	?	?	?		?	?	?	?	34	539	?	?		
BH12-27	572.1	?	?	?	?	?	?	?		?	?	?	?	36	536.1	?	?		
BH12-28	576.9	?	?	?	?	?	?	?		?	?	?	?	31.7	545.2	?	?		
BH12-29	574.7	?	?	?	?	?	?	?		?	?	?	?	24	550.7	?	?		
BH12-30	558	?	?	?	?	?	?	?		?	?	?	?	25	533	?	?		
BH12-31	568	?	?	?	?	?	?	?		?	?	?	?	25.2	542.8	?	?		
BH-1-80	586.9	39	547.9	39	547.9	39	547.9	--		--	42	544.9	2	44	542.9	44.5	542.4		
BH-2-80	569	19	550	19	550	19	550	--		--	22	547	11	33	536	34.3	534.7		
BH-3-80	568.3	21	547.3	21	547.3	21	547.3	--		--	22	546.3	8	30	538.3	31	537.3		
BH-4-80	588.4	37	551.4	37	551.4	37	551.4	--		--	45	543.4	6.5	51.5	536.9	52.5	535.9	21 36	567.4 552.4
BH-5-80	574.4	29	545.4	29	545.4	--		--		--	29	545.4	6	--		35.2	539.2		
BH-6-80	574.3	21	553.3	21	553.3	21	553.3	--		--	28	546.3	7	--		35	539.3		
BH-7-80	588.1	42	546.1	42	546.1	--		--		--	42	546.1	8	--		50.9	537.2		
B-1	572.6	7	565.6	?	?	7	565.6	--		--	35.5	537.1	3	--		29 34	543.6 538.6		
B-2	573.43	12	561.43	12	561.43	12	561.43	--		--	--		--	--		19 24	554.43 549.43		
B-3	569.2	9	560.2	?	?	--		9	560.2	20.5	29.5	539.7	3	--		26.5 31.5	542.7 537.7		
B-4	570.4	8	562.4	?	?	--		8	562.4	22	30	540.4	4.5	--		29 34	541.4 536.4		
B-5	572.7	--		--		0	572.7	7	565.7	5	--		--	--		5	567.7		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL		BASE OF GARBAGE		TOP OF ALUVIUM		TOP OF CLAY		THICKNESS OF CLAY (Feet)	TOP OF TILL		THICKNESS OF TILL (Feet)	TOP OF BEDROCK		BASE OF BORING/ SCREENED INTERVAL		NAPL	
		Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.		Depth	Elev.		Depth	Elev.	Depth	Elev.	Depth	Elev.
B-6	571.5	12	559.5	--		12	559.5	--		--	--		--	--		10 17 22	562.7 554.5 549.5		
B-7	572.93	15	557.93	?	?	15	557.93	22	550.93	11.5	33.5	539.43	6	--		31.5 36.5	541.43 536.43		
B-8	571	7	564	7	564	--		7	564	24	31	540	6	--		29 34	542 537		
B-9	568.9	7	561.9	?	?	--		7	561.9	5			--	--		7 12	561.9 556.9		
B-10	573.21	--		--		--		?0	573.21	27	27	546.21	7	--		28 33	545.21 540.21		
B-11	572.21	--		--		0	572.21	7	565.21	5	--		--	--		5 10	567.21 562.21		
B-12	573.43	16	557.43	?	?	16	557.43	30	543.43	3	33	540.43	6	--		31 36	542.43 537.43		
FH-1	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?		
FH-2	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?		
OW200	572.8	3	569.8	--		3	569.8	8	564.8	18	26	546.8	3	29	543.8	204.3	368.5		
OW201	568.9	7	561.9	7	561.9	--		7	561.9	21.5	28.5	540.4	1	29.5	539.4	205.8	363.1		
OW202	571.5	20	551.5	20	551.5	20	551.5	--		--	26.5	545	10.5	37	534.5	127 206.8	444.5 364.7		
OW210	571.1	9	562.1	1	570.1	9	562.1	11	560.1	19.5	--		--	32.5	538.6	136.7 169.4	434.4 401.7		
OW211	570.6	19	551.6	19	551.6	19	551.6	19.5	551.1	8.5	28	542.6	3	31	539.6	204	366.6		
OW215	575.1	17	558.1	17	558.1	17	558.1	19	556.1	11.5	30.5	544.6	6.5	37	538.1	154 171	421.1 404.1		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
OW216	572.3	2	570.3	--		2	570.3	7	565.3	17.5	24.5	547.8	6	30.5	541.8	136 170.5	436.3 401.8		
OW220	572.4	1	571.4	--		1	571.4	8	564.4	22	30	542.4	0.1	30.1	542.3	31 61.1	541.4 511.3		
OW221	570.4	20	550.4	20	550.4	20	550.4	--		--	28	542.4	3.5	31.5	538.9	33.3 63.3	537.1 507.1		
OW226	571.9	8	563.9	8	563.9	--		8	563.9	24.5	32.5	539.4	5	32.7	539.2	33.4 63	538.5 508.9		
OW227	574	17	557	17	557	17	557	--		--	30	544	4	34	540	35.6 66.1	538.4 507.9		
OW234	569.8	8	561.8	8	561.8	--		8	561.8	11	29	540.8	3.5	32.5	537.3	32.5 63	537.3 506.8		
OW235	570.8	9	561.8	9	561.8	9	561.8	14	556.8	15.5	29.5	541.3	2	31.5	539.3	32.5 67.8	538.3 503		
OW236	577	18	559	18	559	18	559	29.5	547.5	4.5	34	543	3.5	37.5	539.5	39.5 69.9	537.5 507.1	15 23	562 554
OW260	568.4	13	555.4	13	555.4	13	555.4	24	544.4	2	26	542.4	2.5	28.5	539.9	19.1 24.1	549.3 544.3		
OW261	569.5	20	549.5	20	549.5	20	549.5	--		--	28	541.5	3.5	--		22.8 27.8	546.7 541.7		
OW262	574.5	17.5	557	17.5	557	17.5	557	--		--	32.5	542	1.5	--		27.4 32.4	547.1 542.1	10 16	564.5 558.5
OW263	571	20	551	20	551	20	551	--		--	--		--	--		21 26	550 545		
OW264	568.4	16.5	551.9	12.5	555.9	16.5	551.9	--		--	21	547.4	11.5	32.5	535.9	6 21	562.4 547.4	15	553.4

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL		BASE OF GARBAGE		TOP OF ALUVIUM		TOP OF CLAY		THICKNESS OF CLAY (Feet)	TOP OF TILL		THICKNESS OF TILL (Feet)	TOP OF BEDROCK		BASE OF BORING/ SCREENED INTERVAL		NAPL	
		Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.		Depth	Elev.		Depth	Elev.	Depth	Elev.	Depth	Elev.
OW265	574.5	16.5	558	16.5	558	16.5	558	--		--	30	544.5	6.5	--		24.9 29.9	549.6 544.6		
OW274	572.1	2	570.1	--		2	570.1	7	565.1	17	24	548.1	8.5	--		3.5 8.5	568.6 563.6		
OW275	570.5	7	563.5	6	564.5	--		7	563.5	20.5	27.5	543	4.5	32	538.5	4 9	566.5 561.5		
OW276	571.5	7.5	564	6.5	565	--		7.5	564	21.5	29	542.5	4	--		3.5 8.5	568 563		
OW277	570.2	8	562.2	8	562.2	--		8	562.2	11	29	541.2	3.5	--		3.9 8.9	566.3 561.3		
OW278	570.5	8.5	562	--		8.5	562	11	559.5	19	30	540.5	3	--		7.3 12.3	563.2 558.2		
OW279	570.5	8	562.5	--		--		8	562.5	20.5	28.5	542	3.5	31.5	539	3.5 8.5	567 562		
OW280	569.9	2	567.9	--		2	567.9	8	561.9	20	28	541.9	2	--		4.1 9.1	565.8 560.8		
OW281	570.3	--		--		4	566.3	4	566.3	11.5	25.5	544.8	4.5	--		4 9	566.3 561.3		
OW282	571.1	10	561.1	10	561.1	10	561.1	12	559.1	18	30	541.1	3	--		5.7 12.7	565.4 558.4	8	563.1
OW283	571.7	11.5	560.2	6.5	565.2	--		11.5	560.2	18.5	30	541.7	2	--		8.5 13.5	563.2 558.2		
OW284	569.6	6	563.6	--		--		6	563.6	23	29	540.6	1	--		4 9	565.6 560.6		
OW285	569.8	7	562.8	4	565.8	--		7	562.8	20.5	27.5	542.3	1	28.5	541.3	5.3 10.3	564.5 559.5		
OW286	570.7	5.5	565.2	5.5	565.2	5.5	565.2	7	563.7	21	28	542.7	3	--		6.2 11.2	564.5 559.5		

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
OW287	574.2	18	556.2	18	556.2	18	556.2	20.5	553.7	13.5	34	540.2	2	36	538.2	9.8	564.4		
																20.8	553.4		
OW288	572.2	8	564.2	5.5	566.7	8	564.2	14	558.2	17.5	31.5	540.7	2.5	--		8.5	563.7		
																13.5	558.7		
OW289	573.1	12	561.1	12	561.1	12	561.1	17.5	555.6	16	33.5	539.6	1.5	--		8	565.1		
																18	555.1		
OW290	574.8	14.5	560.3	14.5	560.3	14.5	560.3	19.5	555.3	13.5	33	541.8	3	--		14.8	560		
																19.8	555		
OW291	574.4	14	560.4	14	560.4	14	560.4	20	554.4	14	34	540.4	2.5	--		8.3	566.1		
																20.5	553.9		
OW292	576	22	554	22	554	22	554	34	542	0.1	34.1	541.9	1.9	36	540	28.3	547.7		
																33.3	542.7		
*OW293	575.6	25	550.6	25	550.6	25	550.6	31	544.6	1	34	541.6	3	--		25.5	550.1		
																30.5	545.1		
OW294	574.6	20	554.6	20	554.6	20	554.6	--		--	32	542.6	4	--		25	549.6	15	559.6
																30	544.6	17	557.6
BH100	571.8	8	563.8	8	563.8	8	563.8	8.5	563.3	22	30.5	541.3	3	33.5	538.3	33.5	538.3		
BH101	571.2	9	562.2	7.5	563.7	9	562.2	10	561.2	19.5	29.5	541.7	3	32.5	538.7	32.5	538.7		
BH102	571.8	9	562.8	9	562.8	9	562.8	13.5	558.3	19.5	33	538.8	1	34	537.8	33.8	538	7	564.8
																		12	559.8
BH103	572.1	11	561.1	6.5	565.6	11	561.1	16	556.1	17	33	539.1	1	34	538.1	34.1	538	5	567.1
																		8	564.1
																		15	557.1
BH104	572.5	13	559.5	13	559.5	13	559.5	16.5	556	15.5	32	540.5	1.5	33.5	539	33.4	539.1	14	558.5
																		16	556.5
BH105	572.1	13	559.1	12.5	559.6	13	559.1	27	545.1	5	32	540.1	1	33	539.1	33.1	539	12.5	559.6

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STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL Depth	BASE OF FILL Elev.	BASE OF GARBAGE Depth	BASE OF GARBAGE Elev.	TOP OF ALUVIUM Depth	TOP OF ALUVIUM Elev.	TOP OF CLAY Depth	TOP OF CLAY Elev.	THICKNESS OF CLAY (Feet)	TOP OF TILL Depth	TOP OF TILL Elev.	THICKNESS OF TILL (Feet)	TOP OF BEDROCK Depth	TOP OF BEDROCK Elev.	BASE OF BORING/ SCREENED INTERVAL Depth	BASE OF BORING/ SCREENED INTERVAL Elev.	NAPL Depth	NAPL Elev.
BH106	571.6	20	551.6	20	551.6	20	551.6	--		--	29	542.6	4	33	538.6	33.1	538.5	11	560.6
BH107	571.1	15	556.1	15	556.1	15	556.1	26.5	544.6	0.5	27	544.1	6	33	538.1	33.1	538	10.5	560.6
																		13	558.1
																		19	552.1
BH108	570.7	12.5	558.2	12.5	558.2	12.5	558.2	--		--	27	543.7	4.5	31.5	539.2	31.6	539.1	7.5	563.2
																		10	560.7
																		14	556.7
																		20	550.7
BH109	570.1	12.5	557.6	12.5	557.6	12.5	557.6	--		--	16	554.1	15.5	31.5	538.6	31.3	538.8	10	560.1
BH110	569.5	12.5	557	6	563.5	12.5	557	--		--	25	544.5	6.5	31.5	538	31.4	538.1	12	557.5
BH111	568.7	11	557.7	11	557.7	11	557.7	--		--	26	542.7	5.5	31.5	537.2	31.4	537.3	9	559.7
																		10.5	558.2
BH130	571.1	7	564.1	6	565.1	7	564.1	11	560.1	19	30	541.1	3	33	538.1	32.8	538.3	6.5	564.6
																		9	562.1
BH222	575.2	18	557.2	16	559.2	18	557.2	--		--	--		--	--		20	555.2		
BH223	574.8	18	556.8	18	556.8	18	556.8	--		--	--		--	--		20	554.8	15	559.8
BH277	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
BH286	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
BH291	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?

APPENDIX D-3

STRATIGRAPHIC SUMMARY FOR TEST BORINGS/MONITORING WELLS
FOR WATER TREATMENT PLANT PROPERTY

WELL #	Ground Elev.	BASE OF FILL		BASE OF GARBAGE		TOP OF ALUVIUM		TOP OF CLAY		THICKNESS OF CLAY (Feet)	TOP OF TILL		THICKNESS OF TILL (Feet)	TOP OF BEDROCK		BASE OF BORING/ SCREENED INTERVAL		NAPL	
		Depth	Elev.	Depth	Elev.	Depth	Elev.	Depth	Elev.		Depth	Elev.		Depth	Elev.	Depth	Elev.	Depth	Elev.

Notes: Clay frequently has silt, sand and gravel layers.

Stratigraphic sequence, from top to bottom, is normally fill/alluvium/clay/till/bedrock.

-- = Not encountered

* = Sequence not as usual

Depths of strata taken from original boring logs.

Elevations of strata (1986 Occidental Datum) calculated from ground elevations recorded in Source 61, except for B-1 to B-12, which were calculated from information in Sources 47 and 61.

Elevations for 1908, 1943 and 1949 borings have been corrected for present day, with exception of base of boring.

Depths and thicknesses in feet.

"Garbage" includes "cloth, bottom ash, wire, filtercake, brick, cinders, masonry, white material, coal, glass, shot rock, rebar, flyash, slag, rusted metal, cardboard, ceramic or metal fragments, fibrous material, rubber, ash, wood, precipitates, concrete, and industrial wastes".