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December 29, 1982

[REDACTED]  
Argonne National Lab  
Environmental Impact Studies  
Building 214  
Argonne, Illinois 60429

Dear [REDACTED]:

Attached is Bechtel's compilation of environmental baseline data for the sections covering Geology, Hydrology, Seismology and Water Quality for NEPA documentation for the Niagara Falls Site.

Please refer any question to [REDACTED]

Very truly yours,

[REDACTED]  
Project Manager-FUSRAP

DRC:bh

**CONCURRENCE**

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✓	✓				

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**GEOLOGIC AND HYDROLOGIC DATA  
COMPILEATION FOR THE  
NIAGARA FALLS STORAGE SITE**

**BY  
BECHTEL NATIONAL, INC.**

## 1.0 GEOLOGIC AND SOIL DISCUSSION OF THE NIAGARA FALLS STORAGE SITE (NFSS) AND SURROUNDING AREA

### 1.1 Topography

The Niagara Falls Storage Site (NFSS) is located on the Ontario Plain south of Lake Ontario and north of the Niagara Escarpment. The Ontario Plain is relatively flat, featureless, and slopes down toward Lake Ontario at an average of six feet per mile. Due to the flat topography and fine-grained soils, poorly drained areas are common.

The Ontario Plain is drained by streams flowing directly into Lake Ontario. Fourmile, Sixmile, Twelvemile, and Eighteen-mile Creeks are the major streams in the vicinity of NFSS. Natural drainage from the NFSS was modified during construction of the Lake Ontario Ordnance Works. The resulting series of canals and ditches currently diverts all surface drainage to Fourmile Creek (See figure 2.1)

The ground elevation in the general area ranges from approximately 185 m (610 ft), along the crest of the Niagara Escarpment, to approximately 79 m (260 ft) at Lake Ontario. Elevations within the NFSS range from approximately 96-99M (315-325 ft).

Prominent features in the general area include the Niagara Escarpment, Lake Ontario, Niagara Gorge and Falls, and an ancient beach ridge which is south and southeast of Ransomville. This ridge was formed by Lake Iroquois which was a predecessor of Lake Ontario.

### 1.2 Structure and Stratigraphy

The NFSS lies within the Central Lowland Physiographic Province of the Interior Lowlands Physiographic Division. This region, is characterized by a topography which is

developed on essentially undeformed sedimentary rocks. These rocks have a regional dip of less than one degree and occupy a broad basin sloping southward from the neighboring crystalline terrains of the Canadian Shield and the Adirondack Dome.

The stratigraphy of the region consists of relatively undeformed flat-lying sedimentary rocks ranging in age from Ordovician to Silurian. These rocks were deposited between 400 and 500 million years ago. The predominant rock types are limestone, dolomite, sandstone, shale, mudstone, and minor gypsum. A metamorphic basement composed of gneiss has been found in deep wells at depths varying from approximately 2,000 to 3,000 feet (Fisher et al., 1961). Surficial deposits of glacial origin cover most of the area.

The bedrock of the Ontario Plain is the Queenston Formation (a shale or mudstone). To the south, the Niagara Escarpment is formed from rocks of the Medina Group (sandstone, siltstone, shale), the Clinton Group (limestone, dolomite, shale), and the Lockport Group (dolomite, limestone). The Lockport Formation is the cap rock of the Niagara Escarpment. Farther south, near Buffalo, the Lockport Group is overlaid by the Salina Group (shale, gypsum).

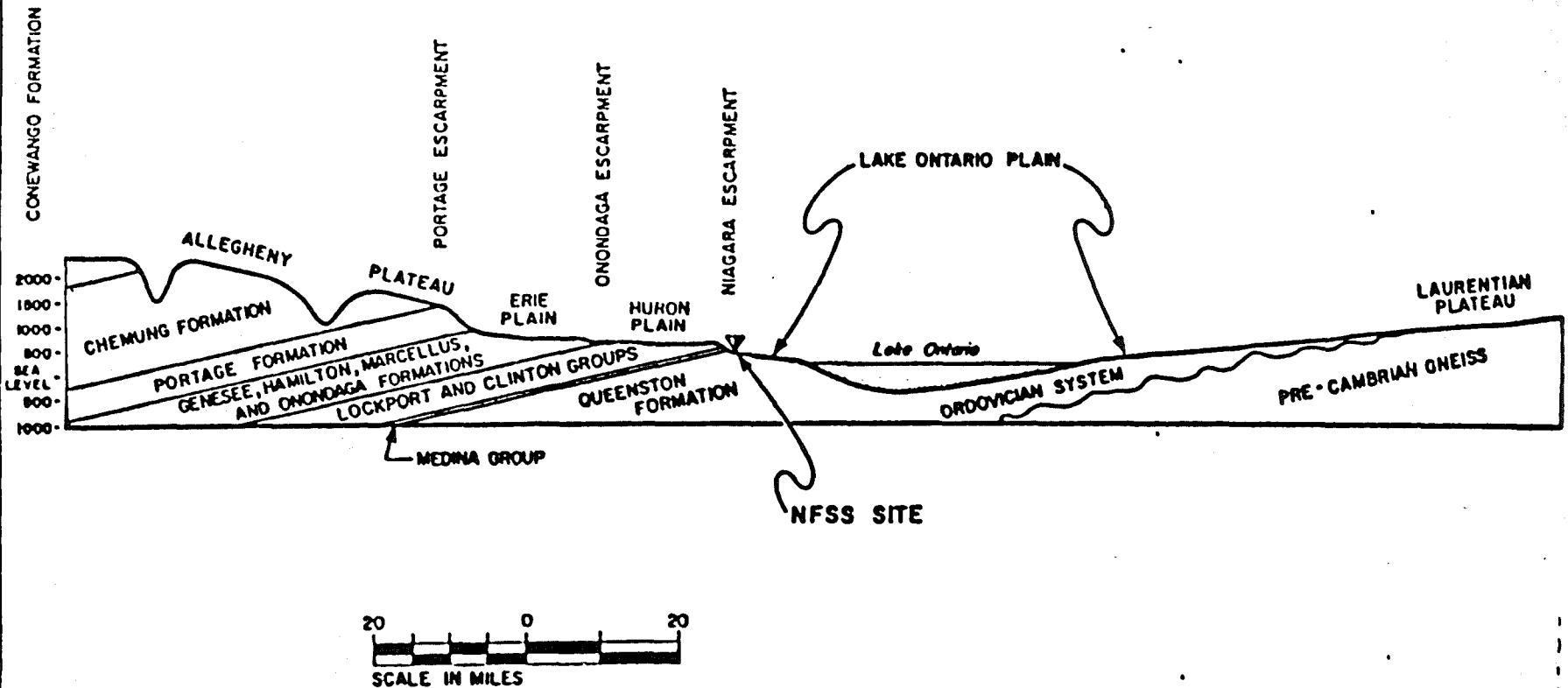
The bedrock of the region is highly susceptible to erosion. The area was intensely modified by glaciers during the Pleistocene. Variable erosional resistance of the bedrock resulted in a series of east-west trending escarpments and low plains (Figure 1.1)

The surficial deposits of the Niagara County area, are described and mapped in detail by Kinkead and Taylor (1913). The deposits of Quaternary age belong almost

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(MODIFIED FROM KINOLE AND TAYLOR, 1913)

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NIAGARA FALLS STORAGE SITE	BECHTEL
ALLEGHENY PLATEAU TO LAURENTIAN PLATEAU NORTH - SOUTH SECTION	JOB 14501
	FIGURE 1.1

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entirely to the Pleistocene Series (approximately 12,000 years before present) and include glacial drift and associated lacustrine deposits. With the exception of minor exposures of bedrock, these deposits cover almost the entire area.

The glacial deposits consist of till in various forms, principally from the most recent (Wisconsin) glaciation, and stratified drift in the form of kames, eskers, and sheets of outwash sand and gravel. The lacustrine deposits were laid on the bottoms and around the shores of glacial lakes.

The stratigraphy of the site has been reported previously (Acres American, Inc. 1981). This information was developed from an onsite subsurface investigation. The Acres American report (1981) is the basis for the following discussion of site stratigraphy.

The stratigraphy of the NFSS includes 40 to 50 feet of soil deposits overlying a thick sequence of sedimentary rocks. These soil deposits are glacially derived sediments which include glaciofluvial sands and gravel, dense tills, and glacial lacustrine clays. Beneath the soil deposits are shales, siltstones and mudstones of the Queenston Formation.

Six major stratigraphic units were identified within the interval from zero to 100 feet below ground surface (Figure 1.2). In order of increasing depth, these units are: surficial soils and fill, brown clay, gray clay and silt, brown sand and gravels, red silt, and bedrock (the Queenston Formation). Geologic and stratigraphic cross-sections for the transects indicated in Figure 1.3 may be found in Acres American (1981, pgs. 45 and 46). Detailed descriptions of these stratigraphic units are presented below.

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### 1.2.1 Surficial Soils and Fill

This soil is generally a brown or yellowish silt with organics usually present in the upper six inches (root zone). Gravel and sand are usually present but rarely constitute more than 40 percent of soil. The thickness of these silts ranges between zero and five feet, with the average being one to two feet. The unit is generally dry, although frequently wetted by precipitation. Relative density is in the range of loose to medium.

### 1.2.2 Brown Clay

Brown or reddish brown clay predominates in this stratigraphic unit although significant amounts of sand and silt are usually present. Gravel is dispersed throughout but constitutes a lesser percentage than the other grain sizes. In general, the unit ranges in classification from a clayey silt to a silty clay. Sandy gravel or gravelly sand lenses are common, especially in the basal area of the soil where they may equal up to 1/3 of the total thickness of the unit. This soil is generally dry and of medium relative density. Beneath the site, this unit varies in thickness from 6 to 23 feet. As a result of localized changes in depositional environments, this soil grades from brown clay to clayey silt, to silty sand. The basal zone of this soil has localized coarser sediments.

The brown clay is thought to be predominately a ground moraine. This unit exhibits some lamination which indicates that it was probably deposited in shallow water that may have been pooled. Sandy or gravelly zones were deposited in a relatively high energy alluvial environment, probably glacial outwash channels.

Please find enclosed the following RIR/BRA reference documents:

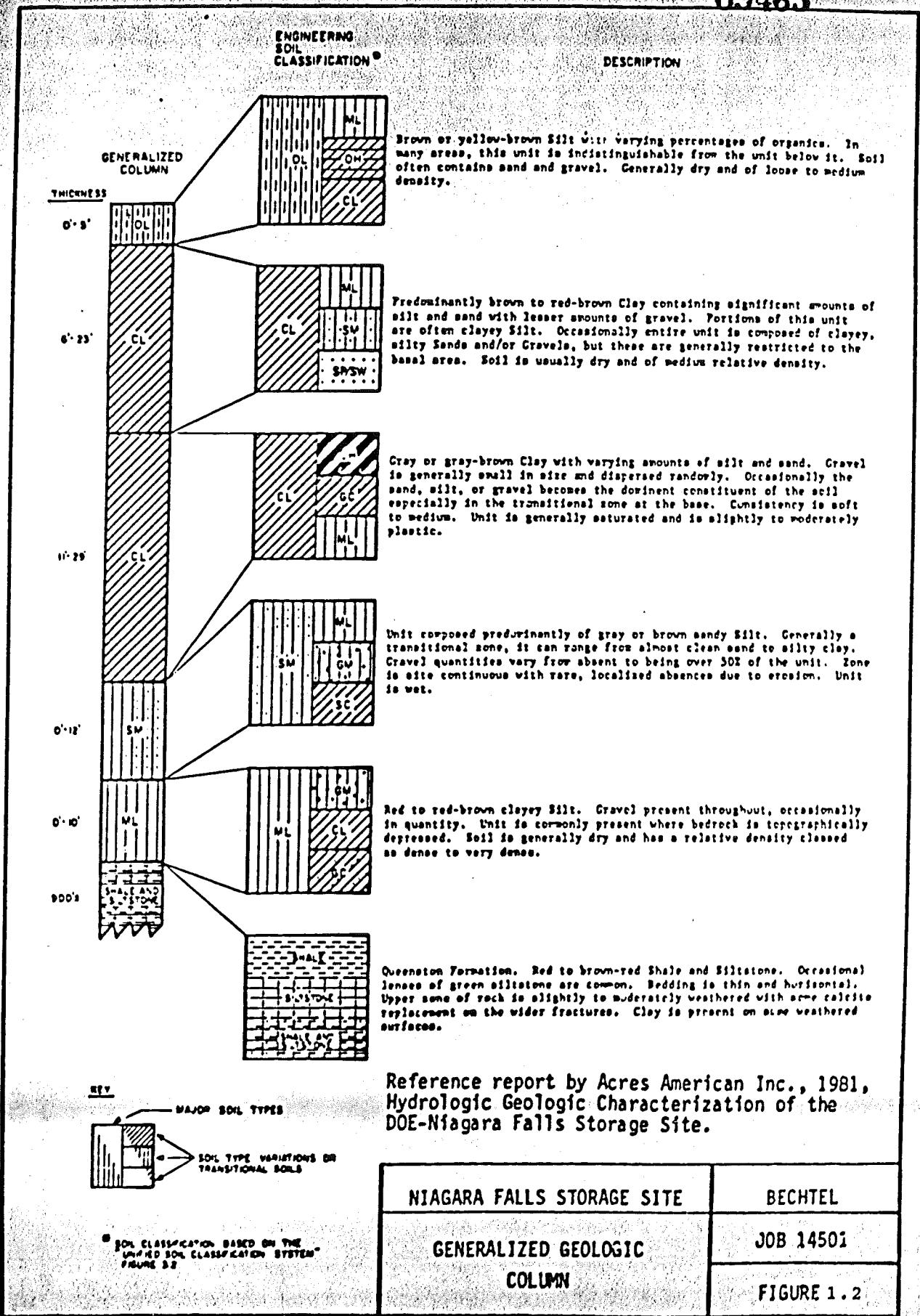
RIR Reference:

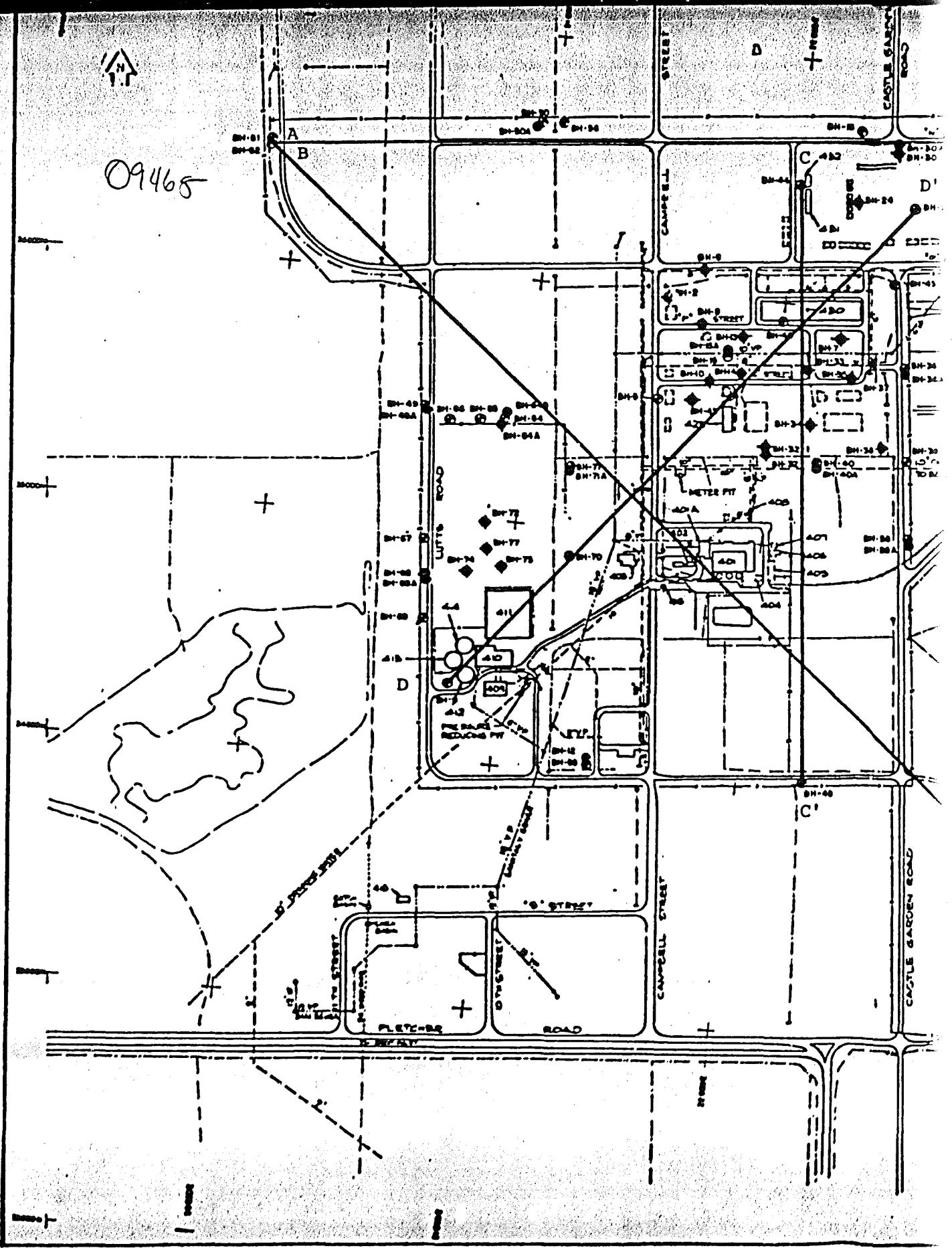
2. BNI 1984a. "Niagara Falls Storage Site South Dike Piping Plan and Schedule", Drawing No. 15-DD19-C-06, Rev. 2. Prepared for USDOE, August 3, 1984. Map.

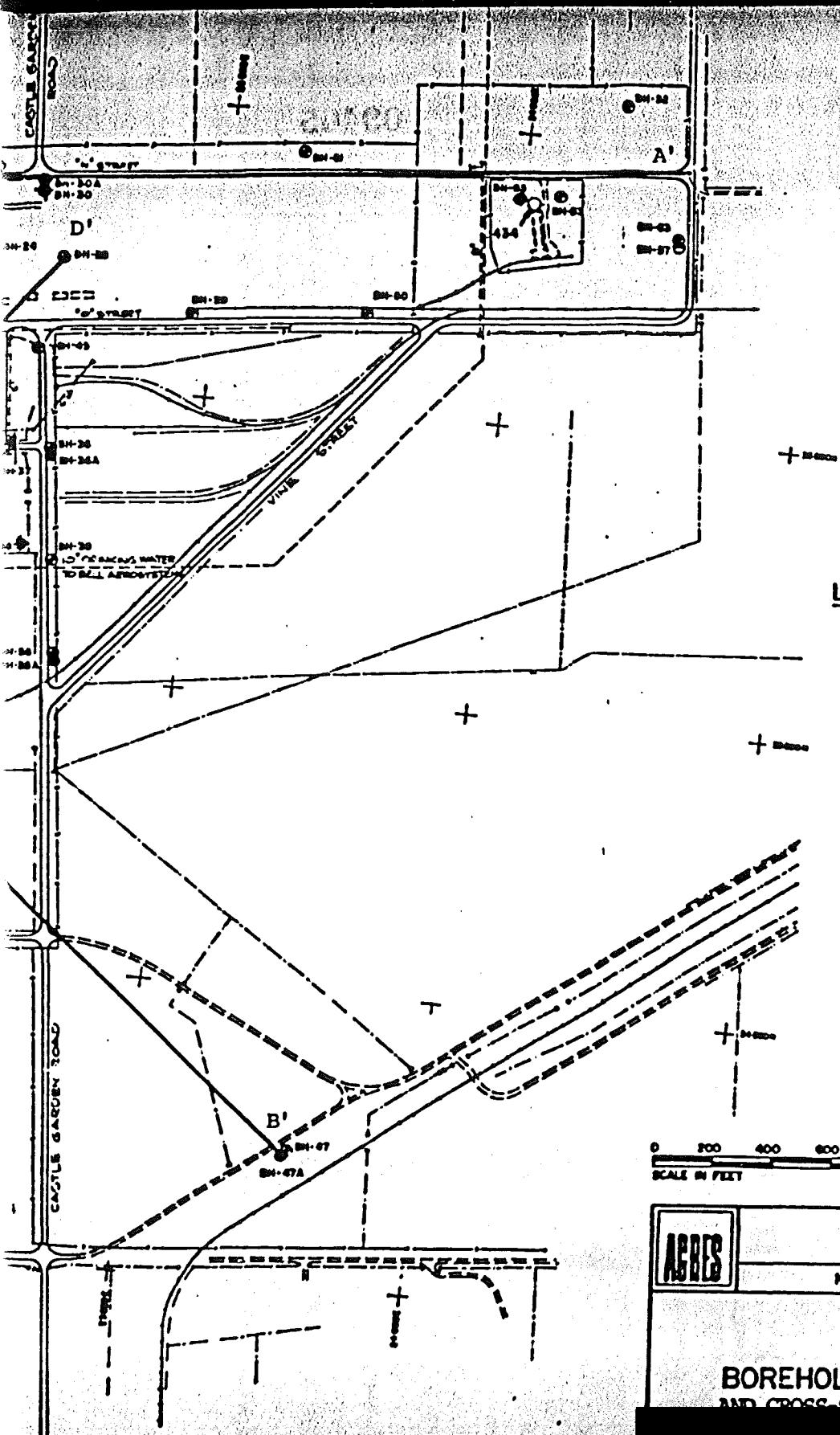
BRA Reference:

9. Young, S. M. and T. W. Weldy. 2004. *New York Natural Heritage Program Rare Plant Status List*. May 2004. New York Natural Heritage Program. Albany, New York. 90 pp. (on CD)

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## LEGEND

- ◆ SOIL BORING
  - DEEP SOIL MONITORING WELL
  - SHALLOW SOIL MONITORING WELL
  - ROCK MONITORING WELL

## **LIST OF STRUCTURES**

- 401 - DISMANTLED BOILER &  
       (BORON) PLANT BLDGS.  
 402 - INFIRMARY BLDG.  
 403 - OFFICE & GARAGE  
 408 - COOLING TOWER BLDG.  
 409 - ORIGINAL FIRE RESERVOIR  
       (UNUSED)  
 410 - F-32 & MIDDLESEX SAND  
       STORAGE  
 411 - L-30 RESIDUE STORAGE  
 412 - ACCELERATOR BLDG.  
 413 - L-50 RESIDUE STORAGE  
 414 - L-50 RESIDUE STORAGE  
 416 - GATE HOUSE  
 423 - MOTOR VEHICLE GARAGE  
 430 - SUPPLIES WAREHOUSE  
 434 - SILO

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## **NFSS - SITE CHARACTERIZATION**

**FIGURE 1.3**  
**BOREHOLE LOCATION MAP**  
**AND CROSS-SECTIONS**

SEPTEMBER 30, 1981

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1.2.3 Gray Clay

This unit is the thickest soil unit within the NFSS and is characterized by gray clay which occasionally grades to a silt and clay mixture. Within the clay unit, lenses of fine to medium grained sand are common, together with varying quantities of gravel. The gravel is usually fine to medium-sized and dispersed throughout. Sands and gravels become the predominant constituent of the unit near the base where they sometimes are clean and lighter in color.

The overall consistency of this unit ranges from soft to medium. The clay is saturated, and the gravel and/or sand lenses are wet to very wet. The soil exhibits slight to high plasticity.

This is the most homogenous unit on the site. There are some lateral facies changes but they are of a minor nature and typically consist of an increase in silt content.

The gray clay appears to be of lacustrine origin and was deposited in a low-energy environment. Some erosion of this unit occurred later, as evidenced by channeling and filling by coarse-grained material within the unit.

1.2.4 Sands and Gravels

This unit is commonly present below the gray clay. It is absent only in areas where the gray clay is exceptionally thick or bedrock rises in elevation. This unit consists of a mixture of the coarser grained sediments including sands and gravels with silt. Onsite, this unit ranges from a clean silt to a sandy gravel. The unit is normally wet to very wet and has a

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loose to medium relative density. In general, the thickest portions of this unit are present where depressions in the bedrock surface occur. These coarse gravel sediments are thought to be of glacial-fluvial origin.

#### 1.2.5 Red Silt

This unit is easily distinguished from the other units because of its red color and its very dense nature. Typically, it is composed of clayey, gravelly silt with lesser amounts of sand. Gravel found within the unit consists of both rounded gravel and angular fragments of bedrock. This unit is generally dry to moist with a relative density ranging from medium to very dense.

The topography of this unit varies with that of the bedrock surface. The red silt has been eroded away to a relatively uniform elevation with local deeper erosion caused by channeling of glacial melt waters. In some site locations this unit is absent.

Poorly sorted and unstratified units such as the red silt are classified as a till. The presence of angular fragments of bedrock in the sandy silt matrix suggests that this till was locally derived and emplaced as a lodgment till. Generally, this type of till is very dense and overconsolidated.

#### 1.2.6 Queenston Formation

The underlying bedrock consists of red shales and siltstones of the Queenston Formation. Within this formation, occasional lenses of green siltstone and shale occur in the rock mass. The bedrock is slightly to moderately weathered near the soil interface.

### 1.3 Soil Parameters

The data used in compiling this summary was taken from Acres American Inc. (1981) unless indicated. A tabulation of the soils data is contained in Table 1.1.

#### 1.3.1 Soil Profile (Stratigraphy)

The soil profile at NFSS as indicated in section 1.2.1-1.2.6 consists of six major units: (1) surficial soils and fill, (2) brown clay, (3) grey clay ana silt, (4) brown sand and gravels, (5) red silt, and (6) bedrock. The two major units as related to foundations and containment of surficial deposits are the brown clay and the gray silt and clay. The laboratory and field testing, which has been performed (Acres American Inc. 1981), was mainly centered around these two layers. The data summarized in the following sections will differentiate between these two units where possible.

#### 1.3.2 Soil Moisture

Brown clay:

Mean Moisture: 20.7%  
Std. Deviation: 7.5%

Gray silt and clay:

Mean Moisture: 24.6%  
Std. Deviation: 4.4%

#### 1.3.3 Density

Brown clay:

Dry Density ( $\gamma_d$ )

Range 94-122 PCF (lb/ft<sup>3</sup>)  
Mean 109.8 PCF (lb/ft<sup>3</sup>)

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**FIGURE 1.6 is located in the enclosed map folder**

Finally, the Central Appalachian Fold Belt is located about 100 miles southeast of the NFSS. This wide fold belt encompasses the southern part of the New York and the western parts of Pennsylvania and West Virginia. In the NFSS area, the Central Appalachian Fold Belt is made up of relatively undeformed Paleozoic sedimentary rocks above a deeply buried and little deformed basement.

The Central Stable Region is generally considered to be tectonically stable. Earthquakes within this region have generally been of moderate intensity (modified Mercalli VI or VII) or less. An exception to this rule exists near the NFSS. Here, a small seismic area in western New York and adjoining Ontario has suggested control by an unidentified westward-trending structure about parallel to the strike of the south-dipping Paleozoic rocks of the region (Hadley and Devine, 1974). Earthquake intensities are low except for an earthquake near Attica, New York, at the eastern end of the area. This earthquake and some lesser ones nearby may be related to a buried north-trending fault that displaces the lower part of the Paleozoic sequence and probably the underlying basement. It is represented by a west-dipping monocline in the surface rocks known as the Clarendon-Linden structure. The configuration of this Attica seismic zone is not well defined. A diffuse configuration (suggested by the historic seismicity of Figure 1.7) is shown in Figure 1.6. A possible alternate interpretation would restrict the most damaging earthquakes of this area to the vicinity of Attica itself and, thus, exclude the NFSS.

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The other principal region of historic earthquakes near the site is located in northeastern New York and adjoining parts of Quebec. It extends northwestward beyond Ottawa and northeastward beyond Quebec City. The region has an exceptionally long history of earthquakes, with records dating to the 17th century. Several of these earthquakes (beyond a 200 mile radius of the NFSS, and therefore, not discussed in the historical seismicity section below nor shown in Figure 1) have been rated as intensity IX or higher on the basis of contemporary but obviously rather limited accounts. The western limit of this zone occurs in the St. Lawrence Lowland portion of the site region.

Earthquake activity in the remaining portion of the 200 mile radius surrounding the NFSS, including, site region portions of the Canadian Shield, Adirondack Uplift, and Central Appalachian Fold Belt, has been scattered and of moderate to small size. This activity does not contribute significantly to the earthquake potential of the NFSS relative to the Attica seismic zone and the St. Lawrence Lowland area.

#### 1.4.2 Historic Earthquakes

A compilation was made of all earthquakes of magnitude 3.0 or greater occurring within a 200 mile radius of the NFSS. A number of sources were reviewed. Ultimately, a data base for the United States portion of the site region (Chiburis) and another for the Canadian part of the site region were combined to give a complete and homogeneous data base. Both data sets appear in a seismic hazard analysis study by Tera Corporation (1979).

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**FIGURE 1.7 is located in the enclosed map folder**

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The first data set contains northeastern U.S. earthquakes from 1534 through 1977. The primary data sources were Smith (1962, 1966), Brooks (1960), Mather and Godfrey (1927), NESA and LRSM records, and New England Seismic Network and Lamont Observatory bulletins (Tera Corporation, 1979). All data were critically reviewed. In-depth investigations into particular earthquakes were performed. Many of the original records were related and reinterpreted to produce the instrumental local magnitudes contained in the catalog. When only intensity reports were available, an equivalent magnitude was estimated as discussed below.

The second data set also contains contributions from Smith (1962, 1966) for the period 1534 through 1959. This data is supplemented by annual compilations of earthquakes published by the Earth Science Branch of the Canadian Department of Energy, Mines, and Resources from 1960 through 1975. All earthquakes with magnitudes greater than or equal to 4.0 were reviewed and recalculated. Earthquakes (in the magnitude range of 4.0 to 5.5 in source references) for which no instrumental information existed were assigned magnitudes based on the felt area of the event (Nuttli and Zollweg, 1974). Magnitudes of some larger historical earthquakes were calculated using a distance-intensity-magnitude relation developed for eastern Canada. Other earthquakes were assigned magnitudes based on epicentral intensity ( $I_0$ ) using the Gutenberg and Richter (1956) formula  $M=2/3 I_0 + 1$ . This last procedure was also adopted by Chiburis (Tera Corporation, 1979). For all larger events, a review of the macroscopic information was used to assign intensities representative of the overall effects.

The combination of the Chiburis and Basnam data sets for the (NFSS) area is listed in Table 1.6 and shown in Figure 1.7. A review of Table 1.6 indicates that the largest earthquake within 200 miles of the site is the August 12, 1929 magnitude 5.8 Attica, New York event.

This earthquake occurred approximately 40 miles from the NFSS. Other near-site events occurred on October 23, 1857 (distance about 18 miles, magnitude 5.0), April 27, 1954 (distance about 14 miles, magnitude 4.1), and a set of smaller earthquakes (November 27, 1882, November 12, 1927, March 7, 1897, April 27, 1954, August 22, 1958, and November 27, 1974) at distances of between 9 and 14 miles.

The earthquakes near Attica have been related to the Clarendon-Linden structure as discussed above. Other site-region earthquakes have not been related to known geologic structures. Some of these earthquakes may be due to stress concentrations in the crust resulting from glacial unloading of the region.

#### 1.4.3 Seismic Probabilities

In recent years, several procedures have been developed that allow formal determination to be made of earthquake probabilistic design parameters (Cornell, 1968; Corneil and Vanmarke, 1969). A number of studies have been performed incorporating these procedures (Algermissen and Perkins, 1976; Cornwell and Merz, 1975, Shah et al., 1975). In typical seismic risk studies of this kind, the region of interest is divided into seismic sources for which future earthquakes are considered equally likely to occur at any location. For each seismic source, the rate of occurrence for earthquakes larger

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TABLE 1.6 is located in the enclosed map folder.

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than a threshold level is estimated. This parameter is termed the source activity rate. The sizes of successive events for each source are assumed to be independent and exponentially distributed with the slope of the log number versus frequency relationship being estimated from the relative frequency of different sizes of events observed in the historical data. This slope, often termed the b value (Richter, 1958), is determined either for each seismic source individually or for all sources in the region jointly. Finally, the maximum possible size of earthquakes for each source zone is determined using judgment and the historical record (McGuire, 1977).

Probabilities of peak dynamic accelerations have been evaluated for the NFSS area in several recent studies. Algermissen and Perkins (1976) calculate accelerations with a 10 percent expectation during a 50-year period (approximately equivalent to the 475-year acceleration). Their results are shown in Figure 1.8. Interpolation between the 0.04 g acceleration contour and the 0.09g point in Figure 1.8 shows that the site has about a 0.07g acceleration at this probability level.

Additional studies have been performed by Milne and Davenport (1969) Donovan et al., (1970), and Basham et al. (1979). Donovan et al. found an approximate a 0.1g, 475-year effective peak acceleration at the NFSS. Milne and Davenport (1969) found find the 100-year effective peak acceleration to be 0.03g for the NFSS. Basham et al., (1979) determined that historical seismicity, not geology, controls the risk for Attica. They calculate a 1000-year acceleration event of approximately 0.12g.

The principal differences in these derived accelerations arise from the different periods (100, 475, and 1000 years) that the acceleration calculations are based upon. As would be expected, the longer time periods result in higher accelerations. Differences can also be the result of different characterizations of the source zones used in the analysis.

#### 1.4.4 Maximum Intensity and Magnitude

Several estimates of maximum site intensity (and magnitude associated with a near-site earthquake of this maximum intensity) are possible. These are maximum historical intensity, maximum probable intensity (at a specified probability) and maximum potential intensity.

A characterization of maximum historical site-region intensities appears in Figure 1.9. The NFSS lies within an area of Modified Mercalli intensity V. A review of events through 1980 indicates that no earthquakes since 1965 have resulted in a higher intensity at the NFSS. A comparison of Figures 1.6, 1.7, and 1.9 indicates that earthquakes within the Attica seismic zone (in particular the 1929 Attica earthquake) govern the maximum historical intensity. A reinterpretation of the isoseismals of the Attica earthquake (Fox and Spiker, 1977) suggests a reduction of the epicentral intensity from VIII to VII. Although not directly addressed by Fox and Spiker, this might imply a reduction in the NFSS intensity as well.

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FIGURE 1.8 is located in the enclosed map folder

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No study was found that treated maximum probable site intensity explicitly. The probabilistic accelerations noted above can be used to derive estimates of equivalent probabilistic intensities. Using the intensity-acceleration relations of Newmann (1954) and Trifunac and Brady (1975), the 0.07g-0.1g, 475-year acceleration can be associated with a VI to VI-1/2 475 year intensity while the 0.12g 1000-year acceleration can be associated with a VII 1000-year intensity.

Characterization of maximum potential site intensity depends critically on characterization of the Attica seismic source zone. A number of characterizations of this source zone have been published (Algermissen and Perkins, 1976; Basham et al., 1979, and Tera Corporation, 1980). Estimates of maximum potential site intensity from these characterizations range from extreme values of XII (Tera Corporation, 1980) to VI (implied by the recurrence of the Attica earthquake or a random intensity VI earthquake at or near the site). Preferred estimates are in the VII to VIII maximum potential intensity range.

Estimates of magnitudes associated with these intensities may be derived from magnitude intensity relations (Nuttli and Herrmann, 1978). These imply body wave magnitude of about 5.3 and 5.8 for intensities of VII and VIII.

### 1.5 Unique Geologic Features and Resources

FIGURE 1.9 is located in the enclosed map folder

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#### 1.5.1 Energy and Mineral Resources

No natural resources of importance are known to exist beneath the NFSS facility. The lacustrine clay found in the region has been used in the manufacture of brick (Kindle & Taylor 1913). This clay is located throughout Niagara County and no manufacturing facilities are known to exist adjacent to the NFSS.

The natural resources of principal economic value in the Niagara region are limestone and water (for power generation). Neither of these resources are located on or adjacent to the NFSS.

#### 1.5.2 Landforms

The principal geologic feature in the entire region is Niagara Falls which is located approximately 16 kilometers (10 miles) southwest of the NFSS. In the immediate vicinity of the site there are no unique geologic features.

#### 1.5.3 Fossil Locations

No fossil locations are known to exist in the immediate vicinity of the NFSS.

#### 1.5.4 Geologic Hazards

No significant geologic hazards exist in the site vicinity. The area is flat with little topographic relief other than the Niagara Escarpment, which is 2.5 miles to the south of the NFSS.

No rocks exist beneath the site which are susceptible to solutioning. No large withdraws of ground water, oil or gas exist in the site vicinity that could cause land subsidence.

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**SECTION 2.0**

**SURFACE WATER HYDROLOGY OF THE NIAGARA FALLS  
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SECTION 1.0

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## 2.0 SURFACE WATER HYDROLOGY

### 2.1 General NFSS Drainage Patterns

The Niagara Falls Storage Site (NFSS) is located on the Ontario Plain, about 4.5 km (2 mi) north of the Niagara Escarpment. Surface drainage from the site originally entered Fourmile, Sixmile, and Twelvemile Creeks which all flow northward to Lake Ontario.

In the 1940's, a system of ditches was installed during the construction of the Lake Ontario Ordnance Works to drain surface waters to a central drainage ditch (The Aerospace Corporation 1982). Sixmile Creek, which originally flowed through the NFSS, was diverted just outside the southwest corner of the NFSS boundary to the Southwestern Drainage Ditch. Surface waters from the area to the southeast of the NFSS, which originally flowed eastward into Twelvemile Creek, were diverted to the South-31 Ditch.

Currently, runoff from the NFSS is diverted into three major drainage ditches: the Central Drainage Ditch, the West Ditch, and the South-31 Ditch. The West and South-31 Ditches discharge directly into the Central Drainage Ditch which flows northward into Fourmile Creek and ultimately into Lake Ontario (Acres American, Inc. 1981). Sixmile and Twelvemile Creeks do not presently receive runoff from the NFSS. The drainage pattern of the NFSS is presented in Figure 2.1. A detailed diagram of the sub-drainage basins immediately surrounding the NFSS is found in Figure 2.2.

#### 2.1.1 Drainage Ditch Description

Onsite the Central Drainage Ditch is a channelized ditch approximately 3-4m (10-15 ft) deep, 3-6 m (10-20 ft) wide at the base, and 12-15 m (40-50 ft) wide at the top. The Central Ditch is 4.8 km (3 mi) in length from its origin at the south end of the NFSS to its confluence with Fourmile Creek. The West Ditch runs parallel to the Central Drainage Ditch and drains the western portion of the NFSS prior to joining the Central Drainage Ditch north of the site. It is approximately 1.5 km (0.96 mi) in length. The only major offsite contributor to flow across the site is the South-31 Ditch which flows into the Central Drainage Ditch. This ditch drains an

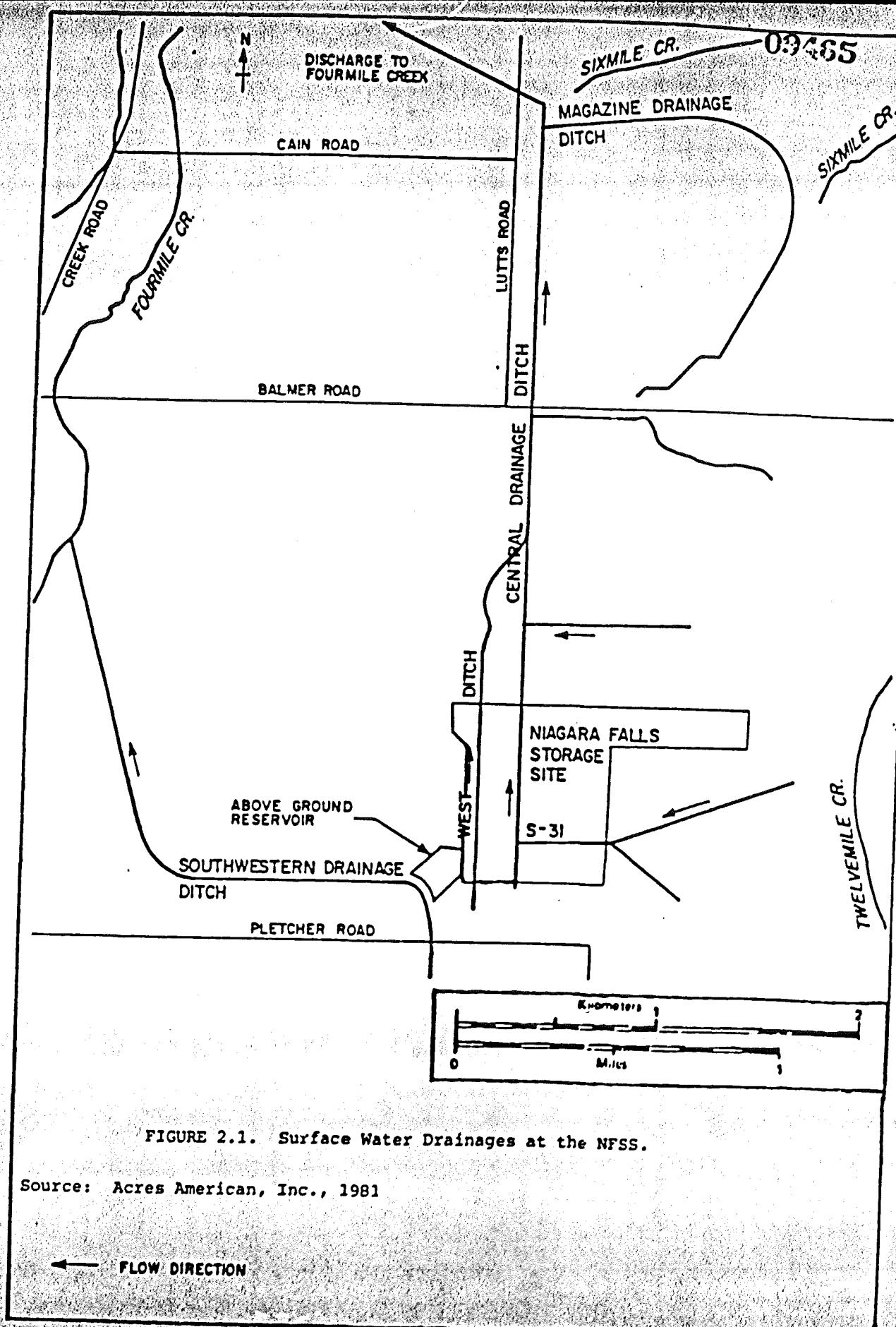


FIGURE 2.1. Surface Water Drainages at the NFSS.

Source: Acres American, Inc., 1981

← FLOW DIRECTION

offsite drainage area of approximately 200 acres and is about 421 m (1,400 ft) in length (Anderson et al. 1981). Figure 2-1 shows the locations of the drainage ditches surrounding the NFSS.

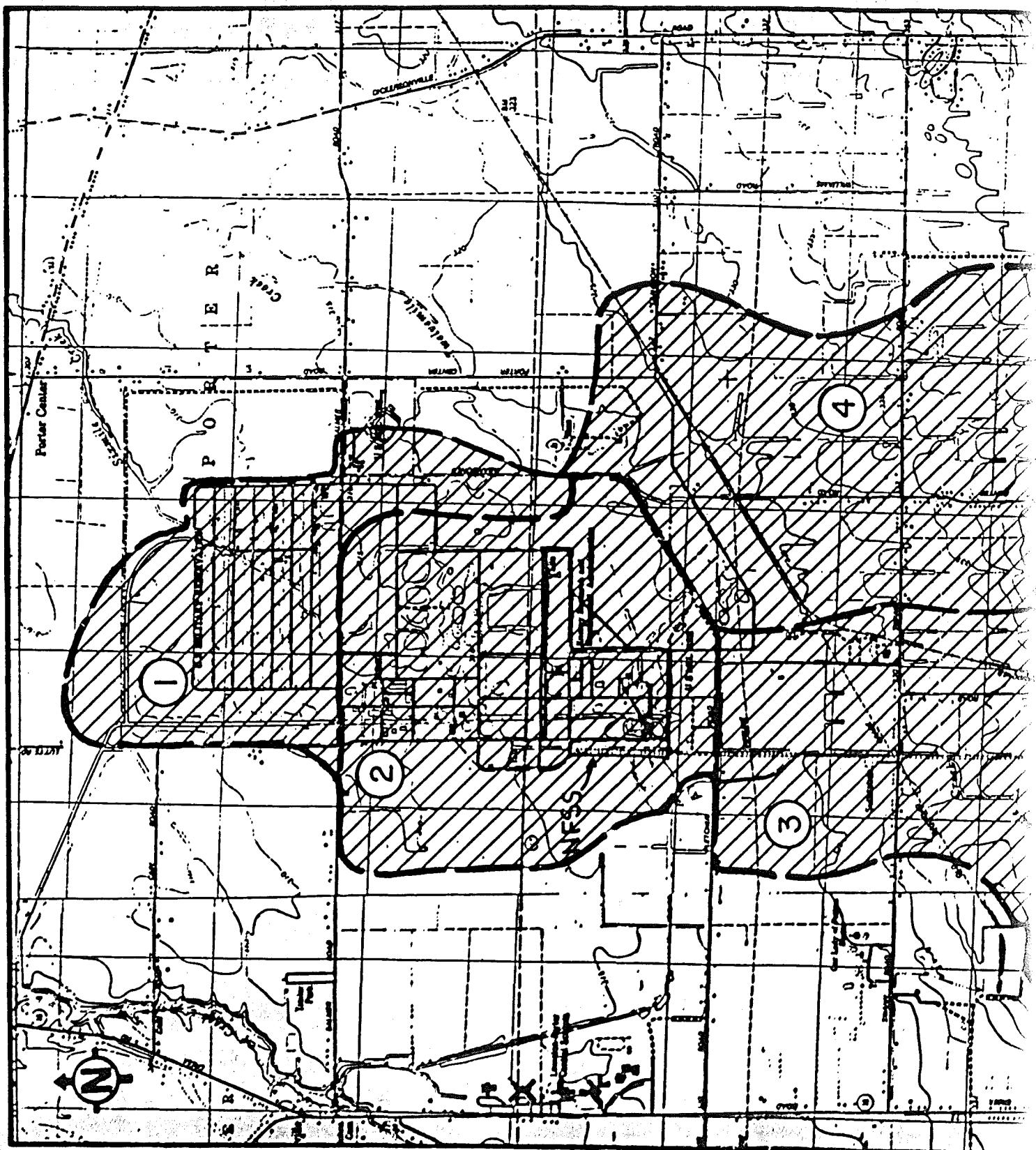
### 2.1.2 Stream Description

Based on current or historical drainage patterns, only three creeks (Fourmile Creek, Sixmile Creek, and Twelvemile Creek) could have received runoff from the NFSS. However, only Fourmile Creek is currently receiving site runoff.

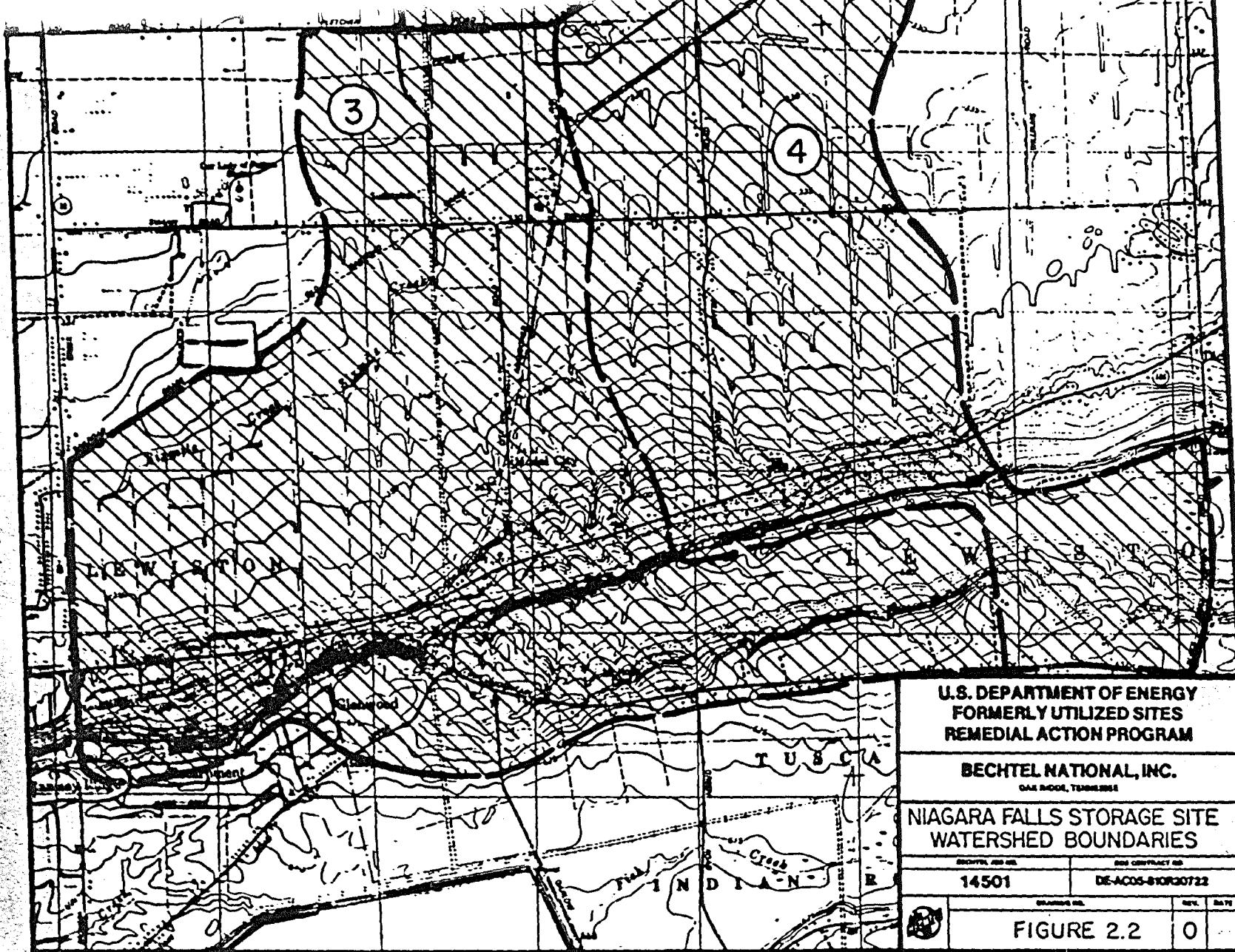
Fourmile, Sixmile, and Twelvemile Creeks are all intermittent at their upper reaches. Their streamflow consists of natural surface runoff, agricultural drainage and treated industrial and institutional waste discharges (New York State Department of Environmental Conservation 1975). Fourmile and Sixmile Creeks have a combined drainage area of 22,226 acres with Twelvemile Creek draining 23,701 acres (Erie and Niagara Counties Regulatory Planning Board, 1978). Fourmile, Sixmile, and Twelvemile Creeks are 8.4 km (5.2 mi), 4.5 km (2.8 mi), and 19.6 km (12.2 mi) in length with slopes of 0.21%, to 0.30%, and 0.13%, respectively, from their headwaters to discharge into Lake Ontario (Erie and Niagara Counties Regulatory Planning Board 1978).

Continuous flow records are not available for Fourmile, Sixmile and Twelvemile Creeks. The nearest continuous streamflow gauging station to the NFSS is located in Manning Muckland Creek basin near Barre Center, some 40 miles east of the NFSS. Although this creek is not located in the drainage basin containing the NFSS, information is included for comparative purposes.

Manning Muckland Creek drains an area of about 5.3 square miles at this gauging station. The mean annual discharge over a period of 4 years (June 1974 to September 1978) was estimated to be 7.3 cfs. In 1977 and 1978, flows were not gauged during the winter months. The maximum discharge for this 4 year period was 100 cfs with many days of zero flow. Table 2.1 presents mean monthly flow estimates for Manning Muckland Creek (U.S. Geological Survey 1974-1978).



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NOTES

- WATERSHEDS ① & ② FOR THE CENTRAL DITCH AND LUTTS ROAD CROSSING
- WATERSHED ② FOR THE CENTRAL DITCH AND BALMER ROAD CROSSING
- WATERSHED ③ FOR THE SIXMILE CREEK
- WATERSHED ④ FOR THE TWELVEMILE CREEK

Development at Modern Disposal located to the east of the NFSS may be expected to alter the upstream hydrology of the South-31 Ditch and increase or decrease the peak storm discharge. The actual effects on storm discharge are undetermined at this time. The current 100-year flood level within the NFSS is estimated to be approximately 97m (319 ft.) (Acres American, Inc., 1981). The NFSS lies between an elevation of 96-99m (315-325 ft.) (Anderson et al. 1981).

## 2.2 Water Quality Parameters

### 2.2.1 Fourmile, Sixmile, and Twelvemile Creeks

The U.S. Geological Survey performed chemical analyses of water from Fourmile Creek in 1948 (Arnow 1949). Locations of the sampling points are shown in Figure 2.2 and the results are tabulated in Table 2.2

Battelle Columbus Laboratories (Anderson et al. 1981) conducted radiological analyses of sediments from all natural drainages currently carrying NFSS runoff or historically having had the potential of carrying runoff. This survey included sampling in Fourmile, Sixmile, and Twelvemile Creeks. Sediment collection locations are presented in Figure 2.3 and the results are given in Table 2.3. Most Ra-226 levels in these sediment samples were at background concentrations of 0.5 pCi/g Ra-226. No concentrations were detected in excess of the U.S. EPA proposed guidelines of 5 pCi/g Ra-226 (Anderson et al. 1981).

### 2.2.2 Drainage Ditches

A radionuclide water monitoring program of the Central Drainage Ditch was conducted by National Lead of Ohio (NLO) from 1972 to 1981. Since 1982, collection and analysis of samples have been performed by Bechtel National, Inc. This water program includes two on-site and two off-site surface water sampling locations. All water samples are collected quarterly (Table 2.4).

Water samples were analyzed for gross alpha and beta activity, total uranium, U-238 activity, and Ra-226 during NLO's tenure. Currently, Bechtel conducts analyses for Ra-226 and total

TABLE 2.1.  
Mean Monthly Flow (1974-1978)  
Manning Muckland Creek Near Barre Center, N.Y.  
Drainage Area = 5.3 square miles

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<u>Month</u>	<u>Discharge (cfs)</u>
January	7.4
February	15.3
March	22.6
April	13.3
May	6.1
June	2.4
July	1.1
August	0.7
September	1.0
October	2.6
November	3.4
December	11.9

Source: U.S. Geological Survey, Water Resources for New York

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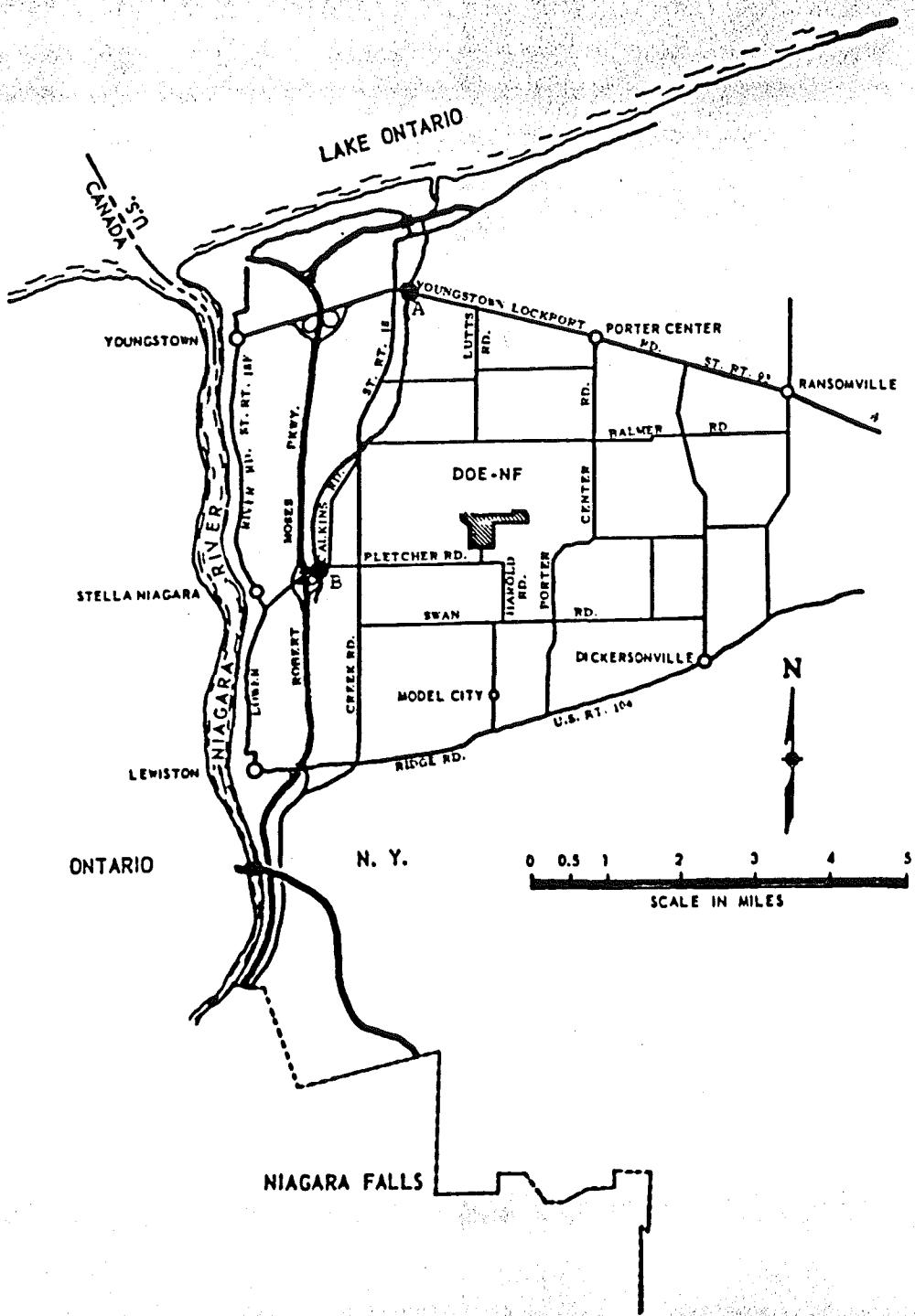


FIGURE 2.3 Fourmile Creek Sampling Points.

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TABLE 2.2  
CHEMICAL ANALYSIS - FOURMILE CREEK  
(ppm)

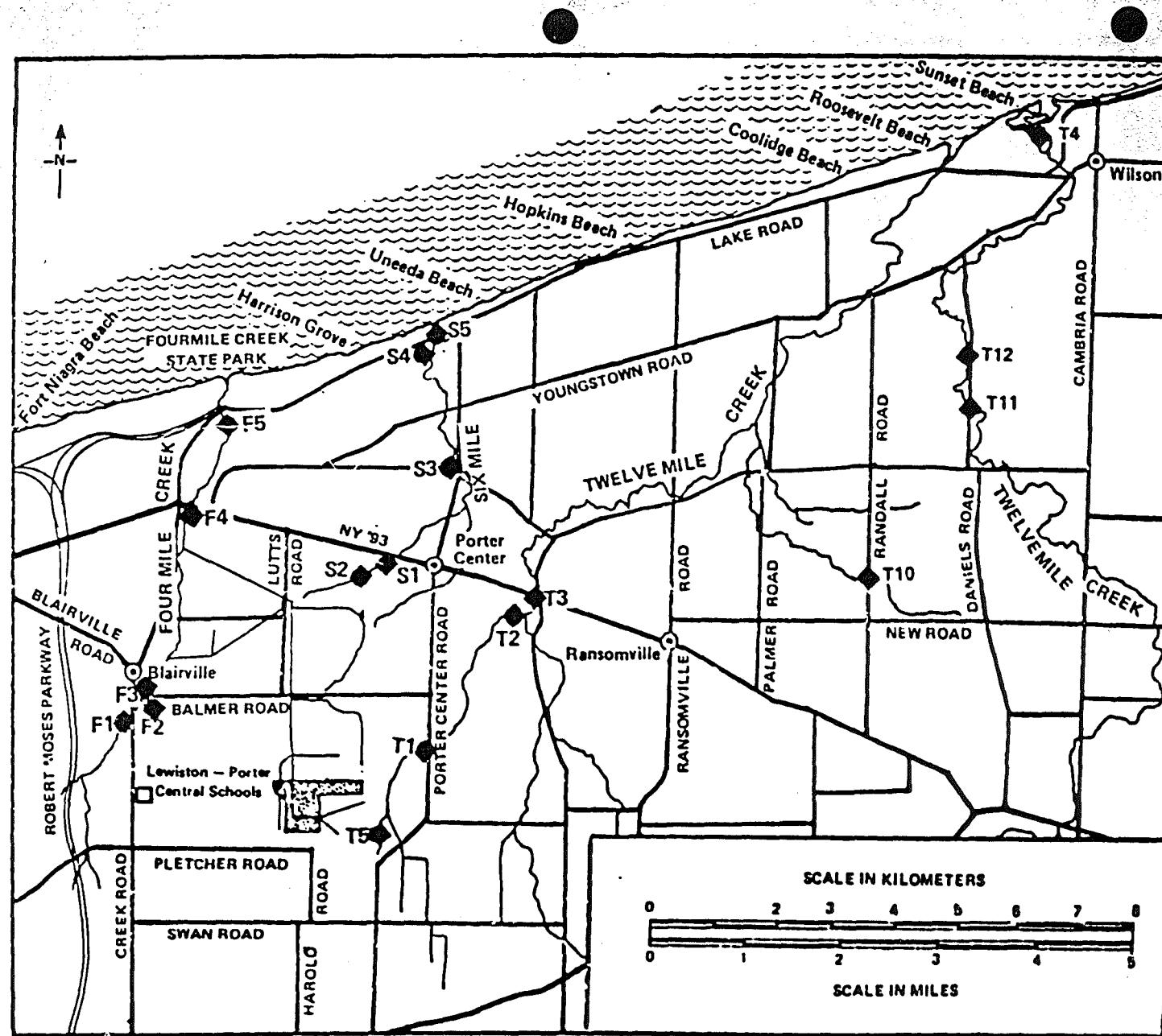
	<u>Sample</u> <u>Point A*</u>	<u>Sample</u> <u>Point B*</u>
Silica ( $\text{SiO}_2$ )	5.0	1.8
Iron (Fe)	0.02	0.02
Calcium (Ca)	62	41
Magnesium (Mg)	31	26
Sodium (Na)	19	15
Potassium (K)	3.0	2.0
Carbonate ( $\text{CO}_3$ )	16	0
Bicarbonate ( $\text{HCO}_3$ )	186	143
Sulfate ( $\text{SO}_4$ )	107	83
Chloride (Cl)	16	24
Fluoride (F)	0.2	0.2
Nitrate ( $\text{NO}_3$ )	0.5	0.6
Dissolved solids	364	280
Total hardness as $\text{CaCO}_3$	282	209
Specific conduct- ance ( $25^{\circ}\text{C}$ ) micromhos	583	467
pH	8.2	7.8
Color	6	7
Aluminum (Al)	0.4	0.3
Copper (Cu)	0	0
Zinc (Zn)	0	0
Phosphate ( $\text{PO}_4$ )	0	0
Date Collected	June 17, 1948	June 17, 1948

\*See Figure 2-2 for Sampling Locations

SOURCE: Arrow, 1949

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FIGURE 2.4 Sediment Sampling Locations in Fourmile, Sixmile, and Twelvemile Creeks.

Source: Anderson et al., 1981

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TABLE 2.3.  
Ra-226 Levels in Sediments of Fourmile, Sixmile, and Twelvemile Creeks.

Location <sup>(a)</sup>	226Ra Concentration (pCi/g)
	Screening <sup>(b)</sup>
<u>FOURMILE CREEK</u>	
F1A (c)	<4
F1B (c)	<4
F2A	<4
F2B	<4
F3A	<4
F3B	<4
F4A	<4
F4B	<4
F5A	<4
<u>SIXMILE CREEK</u>	
S1A	<4
S1B	<4
S2A	<4
S3A	<4
S3B	<4
S4	<4
S5	<5
<u>TWELVEMILE CREEK</u>	
T1A	<4
T1B	<4
T2	<4
T3B	<4
T4B	<4
T5	<4

(a) See Figure 2.3

(b) Measurement of  $^{214}\text{Bi}$  as index of  $^{226}\text{Ra}$ 

(c) A and B are duplicate samples.

Source: Anderson et al., 1981.

uranium concentrations at the same water sampling locations. Total uranium, U-238 activity, Ra-226, gross alpha and gross beta values are presented in Tables 2.5 - 2.9.

Battelle Columbus Laboratories (Anderson et al. 1981) conducted investigations of the drainage ditch sediments to determine concentrations of nuclides and metals. Sample acquisition and analysis provided data sufficient to access the levels and the depth of nuclide contamination along the lengths of the drainage ditches. From this data, the volumes of sediment above the U.S. EPA proposed guidelines of 5 pCi/g Ra-226 was estimated (Anderson et al. 1981).

Central Drainage Ditch and West Ditch on-site sediments were sampled at 15 m (50 ft) intervals while off-site sediments were sampled at 30 m (100 ft) intervals. Samples were collected along the Central Drainage Ditch to its confluence with Fourmile Creek, in the West Ditch to its confluence with the Central Drainage Ditch, and for a minimum of 300 m (1,000 ft) into every current or past tributary of these ditches. Core sampling of the Central Drainage Ditch and West Ditch was also undertaken to determine the depth of contaminated sediments.

Based upon the results of the Central Drainage Ditch sediment analyses, Battelle Columbus Laboratories (Anderson et al. 1981) concluded that there was significant radiochemical contamination in the Central Drainage Ditch, the West Ditch and South-31 Ditch (Tables 2.10-2.14). The portions of the Central Drainage Ditch and the West Ditch exceeding the proposed regulatory limit of 5 pCi/g of Ra-226 in soils are presented in Figure 2.6. The Central Drainage Ditch sediments were found to exceed the limit in all on-site areas and off-site nearly to its confluence with Fourmile Creek (Anderson et al. 1981). In the off-site section of Central Drainage Ditch, core analysis determined the contamination to be confined to the upper 0.3-0.6 m (1-2 ft) of sediment (Table 2.15 and 2.16). With one exception (at the intersection of Lutts Road and Central Drainage Ditch), no contamination greater than 5 pCi/g Ra-226 was found at or below a depth of 0.6 m (2 ft).

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TABLE 2.4

NFSS SURFACE WATER SAMPLING LOCATIONS

Sample No.	Location*	Taken From	Frequency	Remarks
<b>SURFACE WATER:</b>				
10	On-Site	Central Drainage Ditch	Quarterly	Sampled South of the former railroad bed
11	On-Site	Central Drainage Ditch	Quarterly	Sampled at North perimeter fence
12	Off-Site	Central Drainage Ditch	Quarterly	Sampled at Balmer Road
20	Off-Site	Central Drainage Ditch	Quarterly	Sampled at Lutts Road

\* See Figures 2.4 and 2.5 for on-site and off-site surface water sampling locations.

Source: Weldner, 1981.

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0 100 200 300 400 500 600  
SCALE IN FEET

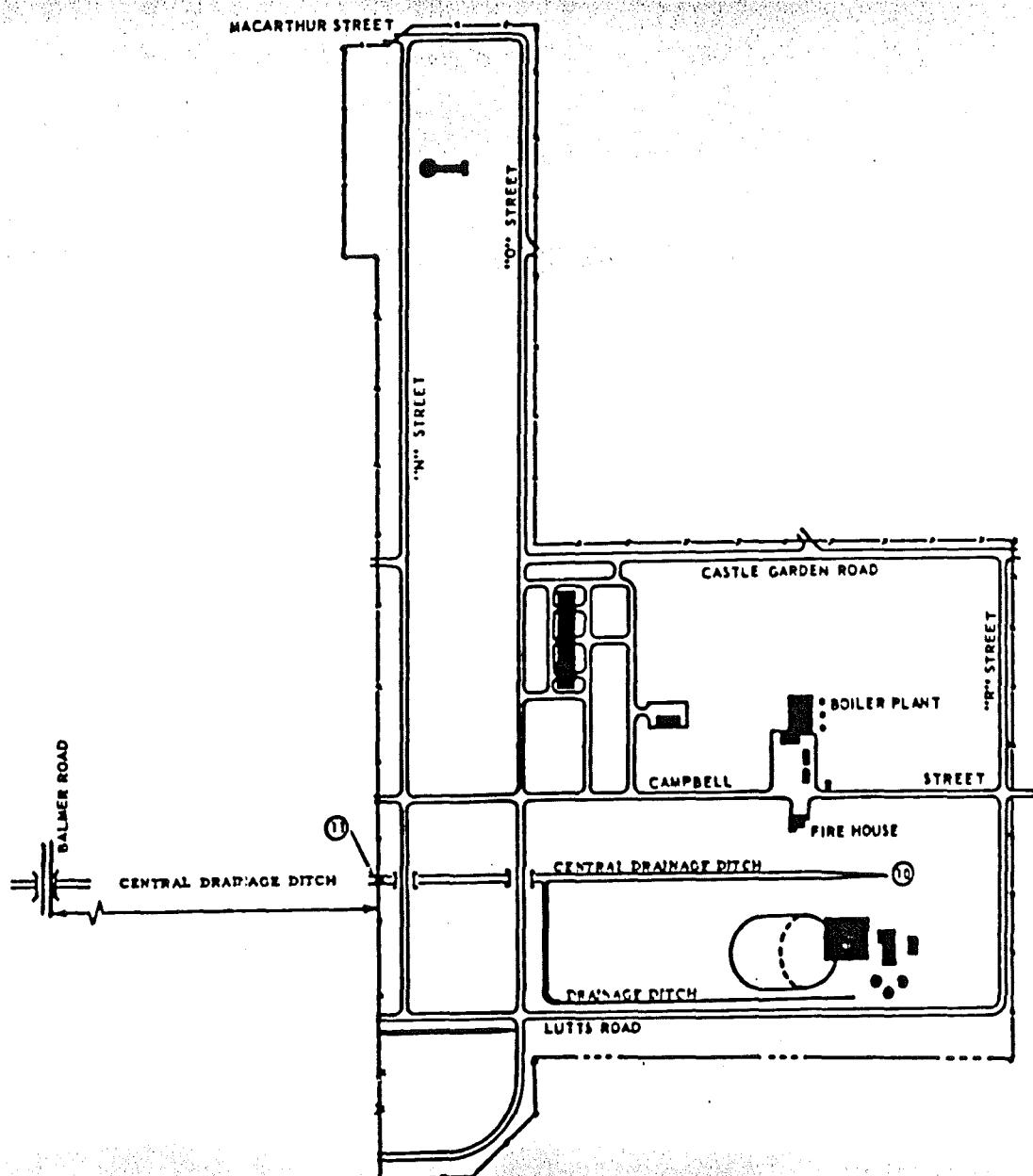


FIGURE 2-5 On-Site Surface Water Sampling Locations.

Source: Weidner, 1981

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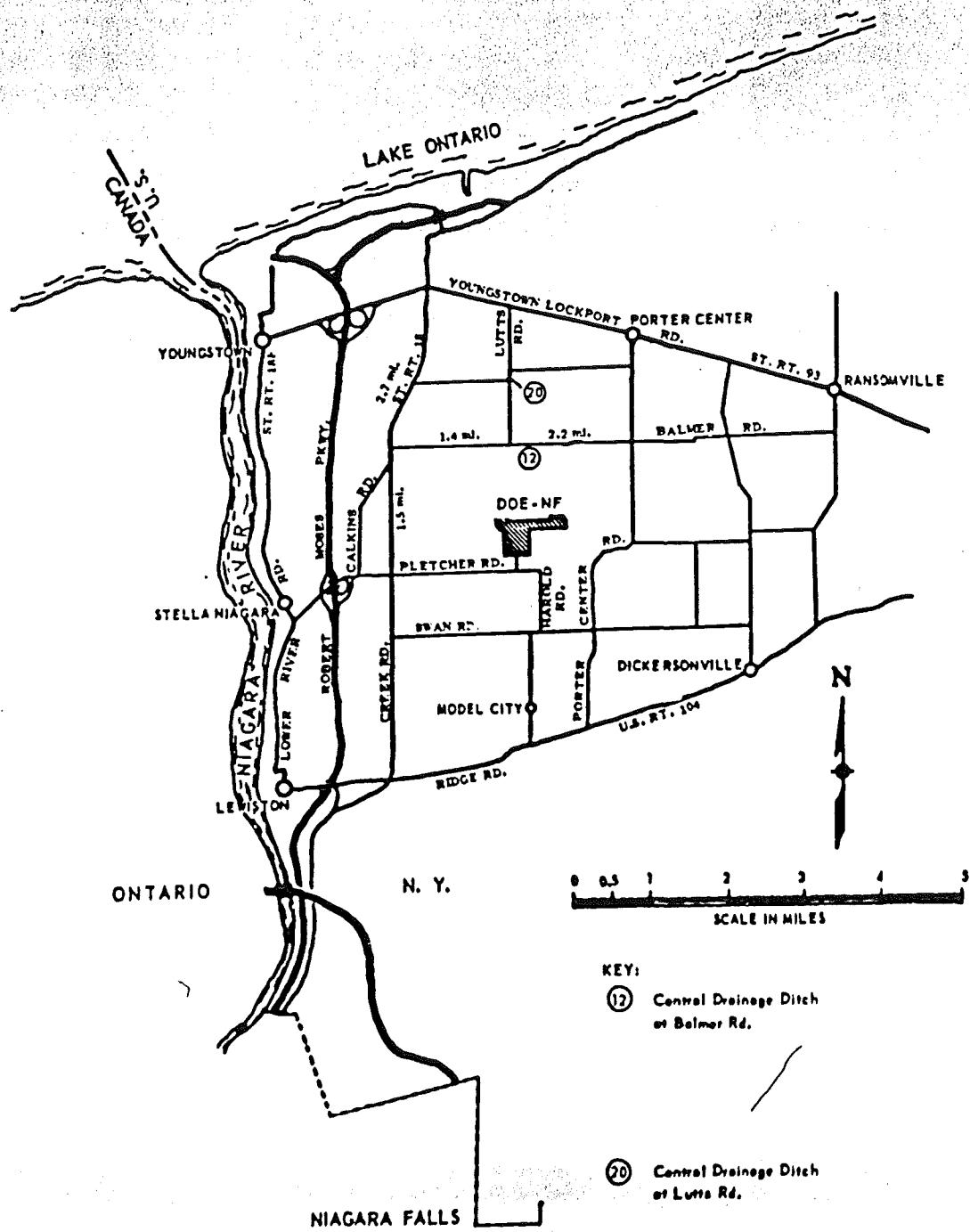


FIGURE 2.6 Off-Site Surface Water Sampling Locations.

Source: Weidner, 1981

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TABLE 2.5  
NFSS TOTAL URANIUM (mg/l) IN SURFACE WATER

Date	SAMPLING POINT			
	10	11	12	20
Jan 1977	0.58	0.63	0.16	
Apr	0.33	0.15	0.005	
Jun	8.00	4.20	0.28	
Sep	0.06	0.06	0.02	
Jan 1978	0.006	0.05	0.03	
Apr	0.06	0.11	0.03	
Jun	1.00	0.28	0.05	
Oct	0.18	0.50	0.12	
Jan 1979	0.02	0.04	0.006	
Apr	0.05	0.10	0.04	
Jun	0.62	0.28	0.08	
Oct	0.50	0.30	0.13	0.06
Jan 1980	0.05	0.07	0.004	0.02
Mar	0.01	0.07	0.02	0.02
Jun	0.65	0.17	0.13	0.01
Oct	0.31	0.94	0.14	0.02
Jan 1981	0.12*	0.34*	NS	0.02
Apr	0.03	0.05	0.03	0.02
Jun	0.11	0.08	0.01	0.01
Sep	0.12	0.27	0.01	0.06
Jan 1982	0.06	0.10	0.03	0.02
Apr	0.06	0.13	0.03	0.03
Jul	0.09	0.17	0.05	0.02

\* These samples contained a large quantity of solid material  
NS No Sample

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TABLE 2.6  
NFSS U-238 ACTIVITY (pCi/l) IN SURFACE WATER

Date	SAMPLING POINT			
	10	11	12	20
Jun 1977	2659	1396	93	
Sep	20	20	7	
Jan 1978	2	17	1	
Apr	20	37	10	
Jun	332	93	17	
Oct	60	166	40	
Jan 1979	7	13	2	
Apr	17	33	13	
Jun	206	93	27	3
Oct	167	100	43	20
Jan 1980	17	23	1	6
Mar	3	23	6	6
Jun	216	57	43	3
Oct	103	313	NS	6

NS No Sample

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TABLE 2.7

## NFSS RADIUM-226 ACTIVITY (pCi/l) IN SURFACE WATER

Date	SAMPLING POINT		
	10	11	12
			20
Apr 1972	0.9	1.4	0.9
Jun	0.9	54.0	13.5
Sep	0.9	63.1	18.0
Dec	0.5	4.5	0.9
Mar 1973	0.5	13.5	2.3
Jun	0.9	6.8	13.5
Oct	1.4	18.0	7.2
Dec	0.5	6.8	0.9
Apr 1974	0.5	2.3	0.5
Jun	0.5	12.2	11.7
Sep	2.3	12.6	9.0
Dec	0.9	9.9	18.0
Apr 1975	0.5	2.7	1.4
Jul	1.4	18.0	36.0
Sep	0.9	7.2	6.3
Dec	0.5	0.9	<0.5
Apr 1976	<0.5	1.4	0.9
Jun	0.9	5.4	2.7
Sep	1.4	6.3	4.5
Jan 1977	1.4	14.0	5.0
Apr	0.9	2.3	<0.5
Jun	1.8	15.3	9.5
Sep	<0.5	1.4	0.5
Jan 1978	<0.5	1.8	0.5
Apr	0.5	0.9	0.5
Jun	0.9	14.0	2.3
Oct	0.9	6.8	0.9
Jan 1979	0.9	7.2	1.8

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TABLE 2.7 (Cont'd)

## SAMPLING POINT

Date	10	11	12	20
Apr	0.5	3.2	1.4	
Jun	3.2	45.1	5.0	3.6
Oct	3.6	8.6	0.9	1.4
Jan 1980	1.4	2.7	0.5	1.4
Mar	0.5	1.4	0.5	0.5
Jun	1.8	9.5	2.3	0.9
Oct	5.9	1.4	1.4	1.4
Jan 1981	99.0*	265.5*	NS	22.5
Apr	0.5	2.7	0.9	0.9
Jun	5.9	5.0	0.5	0.5
Sep	0.5	4.1	0.5	1.8
Jan 1982	0.4	5.2	1.1	0.4
Apr	0.1	1.0	0.5	0.6
Jul	0.6	0.5	0.8	0.6

\* These samples contained a large quantity of solid material.

NS No Sample

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TABLE 2.8

## NFSS GROSS ALPHA (pCi/l) IN SURFACE WATER

Date	SAMPLING POINT		
	10	11	12
			20
Apr 1972	27.0	40.5	13.5
Jun	189.0	310.5	135.0
Sep	360.0	427.5	261.0
Dec	153.0	94.5	13.5
Mar 1973	NS	153.0	NS
Jun	1125.0	450.0	189.0
Oct	2565.0	1665.0	810.0
Dec	13.5	31.5	13.5
Apr 1974	13.5	58.5	9.0
Jun	2430.0	2340.0	1080.0
Sep	4860.0	3060.0	1575.0
Dec	495.0	765.0	99.0
Apr 1975	72.0	81.0	63.0
Jul	11970.0	126.0	153.0
Sep	2925.0	333.0	1350.0
Dec	63.0	220.5	117.0
Apr 1976	126.0	279.0	121.5
Jun	990.0	400.5	85.5
Sep	1035.0	450.0	171.0
Jan 1977	337.5	495.0	99.0
Apr	225.0	63.0	<4.5
Jun		3015.0	184.5
Sep		31.5	13.5
Jan 1978		40.5	2.3
Apr		81.0	31.5
Jun		234.0	36.0

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TABLE 2.8 (Cont'd)

Oct		342.0	76.5	
Jan 1979		54.0	9.0	
Apr		85.5	31.5	
Jun		414.0	90.0	
Oct		261.0	81.0	58.5
Jan 1980		72.0	9.0	22.5
Mar		58.5	18.0	18.0
Jun		90.0	76.5	13.5
Oct		585.0	130.5	27.0
Jan 1981		900.0	NS	103.5
Apr		63.0	18.0	22.5
Jun		99.0	9.0	4.5
Sep		211.5	18.0	49.5
Jan 1982	41.0	78.0	28.0	14.0
Apr*	10.0	28.0	<8.0	<8.0

\* Last sampling for gross alpha (pCi/l) by Bechtel National, Inc..

NS No Sample

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TABLE 2.9

## NFSS GROSS BETA (pCi/l) IN SURFACE WATER

Date	SAMPLING POINT		
	10	11	12
		20	
Apr 1972	22.5	31.5	13.5
Jun	90.0	117.0	67.5
Sep	58.5	162.0	63.0
Dec	36.0	18.0	13.5
Mar 1973	135.0	40.5	40.5
Jun	495.0	184.5	58.5
Oct	495.0	351.0	153.0
Dec	13.5	22.5	<13.5
Apr 1974	<13.5	22.5	<13.5
Jun	765.0	675.0	180.0
Sep	1035.0	675.0	216.0
Dec	121.5	184.5	49.5
Apr 1975	27.0	36.0	22.5
Jul	3690.0	40.5	202.5
Sep	765.0	67.5	396.0
Dec	27.0	85.5	40.5
Apr 1976	36.0	54.0	63.0
Jun	193.5	171.0	67.5
Sep	364.5	180.0	54.0
Jan 1977	72.0	99.0	54.0
Apr	31.5	13.5	<13.5
Jun		450.0	54.0
Sep		9.0	18.0
Jan 1978		18.0	13.5
Apr		22.5	31.5

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TABLE 2.9 (Cont'd)

Date	SAMPLING POINT			
	10	11	12	20
Jun		36.0	31.5	
Oct		67.5	18.0	
Jan 1979		18.0	18.0	
Apr		31.5	9.0	
Jun		135.0	45.0	
Oct		63.0	22.5	18.0
Jan 1980		27.0	9.0	13.5
Mar		22.5	13.5	4.5
Jun		81.0	36.0	13.5
Oct		292.5	85.5	31.5
Jan 1981		720.0	NS	45.0
Apr		31.5	13.5	9.0
Jun		31.5	13.5	18.0
Sep		58.5	18.0	31.5
Jan 1982	33.0	34.0	18.0	9.4
Apr*	24.0	50.0	14.0	15.0

\* Last sampling for gross beta (pCi/l) by Bechtel National, Inc.

NS No Sample

On-site contamination in the Central Drainage Ditch in excess of the proposed limit was confined to a maximum depth of 0.6 m (2 ft), except for a short distance near the R-10 residue storage and spoil pile area.

Although the sediments of the West Ditch are also in excess of the limit, they are not contaminated to the same extent as those in the Central Drainage Ditch. The greatest Ra-226 concentration detected was 75 pCi/g (Figure 2.6). From available drill core sample analysis in the West Ditch, it is estimated that contamination is limited to the first 0.3-0.6 m (1-2 feet) of sediments (Table 2.17).

Radiochemical analysis in the South-31 Ditch detected elevated Ra-226 concentrations in only a limited number of samples. These values were only slightly in excess of the 5 pCi/g limit (Table 2.18). No contamination was detected in off-site tributaries to the South-31 Ditch.

The volume of sediments exceeding the 5 pCi/g Ra-226 limit for the Central Drainage Ditch, the West Ditch, and the South-31 Ditch was estimated to be  $18,100 \text{ m}^3$  (645,200 cu ft),  $3,562 \text{ m}^3$  (127,200 cu ft), and  $504 \text{ m}^3$  (18,000 cu ft), respectively.

In addition to radiochemical analyses, the sediments of both the Central Drainage Ditch and the West Ditch were analyzed for stable elements. Detection limits were generally below or at naturally-occurring levels in soils. These results are summarized in Table 2.19. (Anderson et al. 1981). The exceptions in the Central Drainage Ditch were cobalt, nickel, copper, barium, lithium, fluorine, and cesium. In the West Ditch, sodium, cobalt, and lithium were greater than in naturally-occurring levels.

### 2.2.3 Niagara River

The Niagara Falls Storage Site drainage system does not include the Niagara River. However, information concerning the water quality of the Niagara River may be useful for comparative

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TABLE 2.10. INSTRUMENTAL READINGS AND  $^{226}\text{Ra}$  CONCENTRATIONS IN THE CENTRAL DRAINAGE DITCH

Distance from Ditch Origination, ft (m)	Instrumental Readings		$^{226}\text{Ra}$ Concentration (pCi/g)
	Gamma (1 m) ( $\mu\text{R}/\text{hr}$ ) (a)	Beta-Gamma (1 cm) ( $\mu\text{R}/\text{hr}$ ) (b)	
0	18	80	13
25	20	60	
50	15	70	6.3
75	16	100	
100(30.5)	15	90	7
125	15	100	
150	17	80	12
175	18	120	
200(61)	22	70	8.5
225	20	70	
250	19	60	5.4
275	16	70	
300	17	50	7.4
325	15	60	
350	15	60	16
375	15	60	
400(122)	15	50	12
425	21	60	
500(152.5)	22	90	22
525	20	80	
550	25	110	30
575	25	110	
600(183)	26	70	22
625	40	200	
650(f)	60	120	54
675	110	330	28
700(213.5)	211	120	140
725	500	140	1,660
750	900	1,800	210
775	1,000	2,000	670
800(244)	900	2,200	1,900
825	1,000	2,200	410
850	600	800	370
875	800	1,600	560
900(274.5)	600	1,400	760
925	500	1,700	150

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09465

TABLE 2.10. (Continued)

Distance from Ditch Origination, ft (m)	Instrumental Readings		$^{226}\text{Ra}$ Concentration (pCi/g)	
	Gamma (1 m) ( $\mu\text{R}/\text{hr}$ ) (a)	Beta-Gamma (1 cm) ( $\mu\text{R}/\text{hr}$ ) (b)	Screening (c)	Radiochemistry (d)
950	400	1,400		40
975	260	800		580
1,000(305)	400	600		99
1,025	400	900		600
1,050	260	600		273
1,075	280	700		470
1,100(335.5)	300	800		170
1,125	280	500		176
1,150	140	600		91
1,175	400	800		240
1,200(366)	160	200		64
1,225	200	320		64
1,250	150	280		405
1,275	40	150		22
1,300(396.5)	90	260		275
1,325	50	100		220
1,350	70	240		50
1,375	100	260		46
1,400(427)	140	200		190
1,425	130	240		140
1,450	90	300		40
1,475	140	260		120
1,500(452.5)	90	160		270
1,525	170	390		400
1,550	270	600		440
1,575	200	500		410
1,600(488)	100	1,100		250
1,625	220	600		340
1,650	100	360		180
1,675	200	600		160
1,700(518.5)	210	900		240
1,725	160	600		200
1,750	200	360		41
1,775	150	110		290
1,800(549)	120	190		75
1,825	100	360		150
1,850	40	220		81

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09465

09465

TABLE 2.10. (Continued)

Distance from Ditch Originination, ft (m)	Instrumental Readings			$^{226}\text{Ra}$ Concentration ( $\mu\text{Ci}/\text{g}$ )	
	Gamma (J, m) ( $\mu\text{R}/\text{hr}$ ) (a)	Beta-Gamma ( $\mu\text{R}/\text{hr}$ ) (b)	Screening (c)	Radiochemical (d)	
1.875	110	290	250		
1.900	120	470	90		
1.925	20	110	710		
1.950	16	100	24		
1.975	25	110			
2.000	40	110	140		
2.125	80	210			
2.150	50	160	50		
2.175	22	120			
2.200 (671)	16	90	2.8		
2.225	14	110			
2.250	16	90	2.2		
2.275	19	110			
2.300 (701.5)	26	70	1		
2.325	24	100			
2.350	26	60	8.5		
2.375	21	110			
2.400 (732)	22	150	61		
2.425	40	120			
2.450	26	150	110		
2.475	20	160			
2.500	26	110	9		
2.525	40	100	7.5		
2.600	50	700	60		
2.625	28	150			
2.650	26	160			
2.675	29	60	50		
2.700 (828.75)	10-20		37 (n <sup>b</sup> )		
3.700			7		
3.850 (h)	10-20				
4.700 (1.436)	10-20				
5.700 (1.739)	10-15				
5.850	10-20				
5.950	10-15				
6.700 (1) (2.044)	10-15				
6.750	10-15				
7.615 (2, 121)	10-15				
8.540 (7, 605)	10-15				
9.455 (2, 887)	10-15				

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09465

TABLE 2.10. (Continued)

Distance from Ditch Origination, ft (m)	Instrumental Readings		$^{226}\text{Ra}$ Concentration (pCi/g)	
	Gamma (1 m) ( $\mu\text{R}/\text{hr}$ ) <sup>(a)</sup>	Beta-Gamma (1 cm) ( $\mu\text{R}/\text{hr}$ ) <sup>(b)</sup>	Screening <sup>(c)</sup>	Radiochemistry <sup>(d)</sup>
10,150(3,095.75)	10-15		>5	
10,390 <sup>(j)</sup> (3,334)	10-15		>4	7.5
11,050	10-15		>4	4.4
11,890 <sup>(k)</sup> (3,626)	10-15		>4	5.1
12,090	10-15		>4	0.75
12,590(3,860)	10-15			10.4
14,340(4,374)	10-15		>5	8.4
17,650(5,383)	10-15		>4	2.6

- (a) Gamma readings taken at 1 m above sediment or surface; background 13  $\mu\text{R}/\text{hr}$ .  
 (b) Beta-gamma readings taken at 1 cm above sediment or water surface, background 60  $\mu\text{R}/\text{hr}$ .  
 (c) Measurement of  $^{214}\text{Bi}$  as index of  $^{226}\text{Ra}$   
 (d) Gamma spectroscopy, background concentration average in sediment 0.5 pCi/g ( $\pm 0.1$ )

- (e) Confluence with S31 Ditch  
 (f) Water reservoir drain pipe (from recarbonation pit running north of Building 411).  
 (g) Sample taken at the north perimeter fence.  
 (h) Sample taken 50 ft into a tributary ditch.  
 (i) Sample 100 ft north of Balmer Road  
 (j) Sample taken at Central Drainage Ditch and Magazine Drainage Ditch  
 (k) Sample just east of Lutts Road

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Source: Anderson et al., 1981.

09465

09465  
RADIONUCLIDES IN ON-SITE SEDIMENT SAMPLES OF  
THE CENTRAL DRAINAGE DITCH

ACTIVITY PCI/g

Distance from Ditch Originating, ft (m)	Total Uranium ug/g	PA-231	TH-227	RA-223	TH-234	RA-226	PB-214	BI-214	PB-210	CS-137	TH-232
0	<3.30E1	<2.40E+0	<8.00E-1	4.00E-1	1.10E+1	1.30E+1	4.70E+0	4.40E+0	2.00E+1	5.20E+0	1.20E+0
50	<3.30E1	3.00E-1	2.00E-1	8.80E+0	6.30E+0	4.40E+0	4.80E+0	2.00E+1	4.80E+0	1.50E+0	
100 (30.5)	<2.64E1	1.00E+0	<1.00E+0	<6.30E+0	7.00E+0	4.40E+0	4.40E+0	1.90E+1	4.10E+0	1.40E+0	
150	1.98E1			<6.00E-1	1.10E+1	1.20E+1	5.60E+0	4.60E+0	2.20E+1	3.10E+0	1.40E+0
200 (61)	<3.30E1	<2.40E+0	<1.30E+0	5.00E-1	1.10E+1	8.50E+0	4.60E+0	4.30E+0	1.70E+1	3.50E+0	9.00E-1
250	<2.64E1	<5.00E-1	<8.00E-1	<5.30E+0	5.40E+0	2.70E+0	3.00E+0	1.30E+1	2.50E+0	9.00E-1	
300	<4.61E1	<3.20E+0	2.10E-1	<1.10E+1	7.40E+0	4.50E+0	4.80E+0	1.10E+1	4.20E+0	1.30E+0	
350	3.30E1	<3.30E+0	6.00E-1	2.40E+1	1.60E+1	6.40E+0	5.60E+0	1.90E+1	3.00E+0	1.10E+0	
400 (122)	5.27E1	<3.00E+0	4.00E-1	5.00E-1	<1.30E+1	1.20E+1	6.70E+0	3.20E+0	3.10E+1	4.40E+0	1.70E+0
500 (152.5)	1.78E3	<9.00E+0	<1.20E+0	1.00E+0	6.70E+2	2.20E+1	1.20E+1	4.80E+1	4.80E+1	4.10E+0	2.20E+0
550	3.62E2	<1.00E+1	<6.00E-1	1.50E+2	3.00E+1	1.40E+1	1.30E+1	2.00E+1	4.00E-1	1.20E+0	
600 (183)	3.10E2	<3.30E+0	1.30E+1	1.50E+2	2.20E+1	7.50E+0	6.70E+0	1.00E+1	1.00E+1	1.00E+0	
650	1.58E2	4.40E+0	1.70E+0	5.40E+1	5.40E+1	1.40E+1	1.40E+1	4.70E+1	1.20E+0	1.60E+0	
675	3.16E2	2.90E+0	8.00E-1	1.00E+0	2.27E+2	2.80E+1	1.50E+1	4.10E+1	4.10E+1	1.50E+1	1.20E+0
700 (213.5)	5.21E2	<2.00E+1	9.30E+0	9.10E+0	1.63E+2	1.40E+2	6.60E+1	7.90E+1	2.50E+2	9.00E-1	2.80E+0
725	8.57E2	1.10E+2	1.00E+2	8.00E+1	1.90E+2	1.44E+3	9.50E+2	9.10E+2	2.30E+3	<2.00E+0	<8.00E+0
750	2.80E2	<1.50E+1	1.60E+1	<5.50E+1	2.70E+2	1.30E+2	1.30E+2	5.50E+2	1.40E+0	<3.20E+0	
775	7.91E2	3.50E+2	5.00E+1	3.60E+1	6.70E+2	4.00E+2	3.80E+2	1.06E+3	3.00E+2	<5.10E+0	
800 (244)	6.19E2	1.30E+2	1.00E+2	9.10E+1	<2.00E+2	1.90E+3	1.22E+3	2.14E+3	2.20E+3	<3.00E+0	
825	5.07E2	3.60E+1	2.30E+1	2.50E+1	<7.70E+1	4.10E+2	3.10E+2	3.10E+2	7.30E+2	<1.00E+1	<8.00E+0
850	4.15E2	4.80E+1	2.30E+1	2.50E+1	<6.40E+1	3.20E+2	2.10E+2	3.00E+2	6.30E+2	6.00E-1	3.00E+0
875	6.19E2	4.80E+1	4.00E+1	3.70E+1	1.40E+2	5.60E+2	3.70E+2	1.53E+3	7.00E-1	3.00E+0	
900 (274.5)	6.59E2	7.10E+1	5.30E+1	4.30E+1	1.40E+2	7.40E+2	4.90E+2	4.70E+2	1.53E+3	<1.00E+1	<3.00E+0
925	2.10E2	<8.30E+0	9.30E+0	8.00E+0	7.80E+1	1.50E+2	9.30E+1	8.30E+1	2.60E+2	1.40E+0	
950	2.37E2	4.00E+1	2.30E+1	2.40E+1	1.00E+2	4.00E+2	2.00E+2	2.00E+2	7.00E+2	3.00E+1	<3.40E+0
975	2.91E2	4.70E+1	4.50E+1	2.90E+1	1.10E+2	5.80E+2	3.80E+2	3.40E+2	7.20E+2	1.10E+0	
1,000 (303)	4.61E1	5.00E+0	3.70E+0	3.20E+0	<2.30E+1	9.30E+1	5.30E+1	5.60E+1	1.30E+2	1.10E+0	
1,025	<1.32E2	3.60E+1	3.70E+1	3.10E+1	6.00E+2	3.00E+2	2.00E+2	7.50E+2	<1.00E+0	<4.70E+0	
1,050	2.64E2	1.50E+2	1.80E+1	1.60E+1	1.88E+2	2.73E+2	1.44E+2	1.29E+2	3.00E+3	<4.00E+0	<4.00E+0

TABLE 2. (CONT'D)

09465

RADIOMUCLIDES IN ON-SITE SEDIMENT SAMPLES OF  
THE CENTRAL DRAINAGE DITCH

## ACTIVITY PCI/g

Distance from Ditch Origination, ft (m)	Total Uranium ug/g	PA-231	TH-227	PA-223	TH-234	PA-226	PA-214	PA-210	BI-214	PA-210	BI-210	CE-137	TH-232
1,075	3.56E2	2.30E+1	3.10E+1	<7.00E+1	4.70E+2	2.20E+2	2.10E+2	6.00E+2	<1.00E+0	3.30E+0	2.10E+2	1.30E+2	1.40E+1
1,100(335.5)	6.57E1	1.20E+1	8.70E+0	9.40E+1	4.90E+1	1.70E+2	7.60E+1	1.30E+2	1.30E+2	2.30E+1	2.10E+2	1.40E+1	2.30E+0
1,125	1.45E2	9.80E+0	1.10E+1	1.00E+1	6.50E+1	1.75E+2	9.00E+1	8.00E+1	1.00E+3	2.10E+0	4.00E+0	2.10E+0	3.00E+1
1,150	1.71E2	5.70E+0	6.20E+0	4.60E+0	4.10E+1	9.10E+1	4.90E+1	4.60E+1	1.80E+2	3.00E+1	2.10E+0	2.10E+0	2.70E+0
1,175	<1.98E2	1.50E+0	1.30E+1	1.30E+1	1.30E+1	2.40E+2	9.40E+1	9.00E+1	4.40E+2	1.10E+0	1.90E+0	1.10E+0	1.10E+0
1,200(366)	2.44E2	<6.00E+0	3.20E+0	2.00E+0	6.70E+1	6.40E+1	3.50E+1	3.30E+1	9.50E+1	2.30E+1	1.50E+1	2.30E+1	1.50E+0
1,225	2.77E2	5.20E+0	3.90E+0	4.30E+0	1.00E+2	6.40E+2	4.20E+1	4.00E+1	8.40E+1	4.20E+1	1.20E+1	4.20E+1	1.20E+0
1,250	<3.30E2	1.60E+1	2.50E+1	2.00E+1	<8.10E+1	4.05E+2	2.07E+2	2.02E+2	5.20E+2	<4.00E+0	<5.00E+0	<4.00E+0	<5.00E+0
1,275	<6.50E1	<3.20E+0	9.00E-1	1.00E+0	6.00E+0	2.20E+1	1.20E+1	1.00E+1	2.60E+1	1.00E+1	1.50E+0	1.00E+1	1.50E+0
1,300 (396.5)	7.91E1	1.70E+1	1.20E+1	1.20E+1	1.00E+1	<3.90E+1	2.25E+2	1.29E+2	1.19E+2	3.00E+2	7.00E+1	3.00E+2	7.00E+1
1,325	6.50E1	1.60E+1	1.70E+1	1.60E+1	6.00E+1	2.20E+2	1.05E+2	9.80E+1	2.30E+1	3.00E+2	2.00E+1	2.20E+1	2.20E+0
1,350	8.57E1	2.40E+0	1.90E+0	2.60E+0	3.20E+1	5.00E+1	1.90E+1	1.80E+1	9.40E+1	3.00E+1	1.30E+0	3.00E+1	1.30E+0
1,375	1.19E2	<5.20E+0	3.10E+0	3.20E+0	3.30E+1	4.80E+1	2.10E+1	1.90E+1	4.70E+1	8.00E+1	1.00E+0	8.00E+1	1.00E+0
1,400(427)	<1.45E2	6.70E+0	1.20E+1	9.30E+0	9.30E+0	7.80E+1	1.90E+2	6.40E+1	5.80E+1	2.60E+2	9.00E+2	2.30E+0	2.30E+0
1,425	<1.32E2	3.90E+0	6.10E+0	4.70E+0	<3.80E+1	1.40E+2	6.10E+1	5.50E+1	6.10E+2	6.00E+2	6.00E+2	6.00E+2	1.30E+0
1,450	<6.50E1	2.60E+0	2.40E+0	1.70E+0	1.70E+1	4.00E+1	2.60E+1	2.60E+1	2.40E+1	8.00E+1	3.00E+1	3.00E+1	1.10E+0
1,475	<1.19E2	5.10E+0	5.10E+0	5.30E+0	<3.00E+1	1.20E+2	1.20E+1	1.90E+1	1.80E+2	1.40E+2	<1.00E+1	<1.00E+1	<1.00E+0
1,500(4525)	<1.50E+0	1.40E+1	1.20E+1	1.00E+1	2.40E+1	2.20E+1	<6.20E+1	4.00E+2	2.10E+2	3.00E+2	<1.00E+0	<1.00E+0	<1.00E+0
1,525	2.64E2	1.00E+1	2.40E+1	2.20E+1	2.20E+1	<1.00E+1	1.80E+2	2.20E+2	2.20E+2	5.30E+2	<6.00E+1	<6.00E+1	<6.00E+0
1,550	1.85E2	1.90E+1	2.50E+1	2.10E+1	2.10E+1	<1.00E+2	4.40E+2	2.20E+2	2.20E+2	7.60E+2	<1.00E+0	<5.00E+0	<5.00E+0
1,575	<1.32E2	3.50E+1	2.40E+1	2.10E+1	2.10E+1	4.10E+2	4.10E+2	4.10E+2	4.10E+2	5.30E+2	5.30E+2	5.30E+2	2.20E+0
1,600(488)	<1.98E2	1.70E+1	1.40E+1	1.50E+1	1.50E+1	2.50E+2	2.50E+2	2.00E+2	2.00E+2	2.70E+2	<5.00E+1	<5.00E+1	<5.00E+0
1,625	7.91E1	1.80E+1	1.90E+1	1.00E+1	1.00E+1	2.50E+1	3.40E+2	1.50E+2	1.40E+2	4.10E+2	<1.00E+1	<1.00E+1	<1.00E+0
1,650	<1.98E2	<3.00E+1	1.60E+1	1.80E+1	1.80E+1	6.80E+2	3.80E+2	2.70E+2	2.60E+2	4.30E+2	<1.00E+0	<1.00E+0	<1.00E+0
1,675	1.71E2	1.50E+1	2.10E+1	1.80E+1	9.70E+1	3.60E+2	1.30E+2	1.20E+2	1.20E+2	7.60E+2	<7.00E+1	<7.00E+1	<7.00E+0
1,700(518.5)	<1.98E2	1.30E+1	1.20E+1	1.20E+1	1.20E+1	5.30E+1	2.40E+2	1.60E+2	1.50E+2	2.50E+2	2.50E+2	2.50E+2	<1.00E+0
1,725	<1.32E2	6.50E+0	9.00E+0	9.30E+0	<3.70E+1	2.00E+2	1.30E+2	1.20E+2	1.20E+2	2.00E+2	2.00E+2	2.00E+2	<1.00E+0
1,750	<5.27E2	2.50E+0	2.00E+0	1.30E+0	1.30E+1	4.10E+1	2.50E+1	2.40E+1	6.70E+1	6.70E+1	6.70E+1	6.70E+1	1.20E+0
1,775	<1.98E2	<2.00E+1	1.30E+1	1.40E+1	1.40E+1	<5.70E+1	2.90E+2	2.00E+2	1.90E+2	5.70E+2	<5.00E+1	<5.00E+1	<5.00E+0
1,800(549)	<9.89E1	<6.00E+0	3.20E+0	3.20E+0	3.20E+0	7.50E+1	6.10E+1	5.70E+1	5.70E+1	7.50E+1	1.40E+2	1.40E+2	1.40E+0
1,825	<2.64E2	1.50E+1	2.20E+1	1.70E+1	1.70E+1	4.80E+1	1.70E+2	1.60E+2	1.50E+2	2.50E+2	2.50E+2	2.50E+2	<3.00E+0
1,850	<1.32E2	1.30E+1	1.70E+1	1.70E+1	1.70E+1	4.80E+1	1.30E+2	1.20E+2	1.20E+2	2.40E+2	2.40E+2	2.40E+2	<3.00E+0
1,875	<5.27E2	1.70E+1	1.70E+1	1.70E+1	1.70E+1	4.80E+1	1.70E+2	1.20E+2	1.20E+2	2.40E+2	2.40E+2	2.40E+2	<3.00E+0
1,900	<9.89E1	<2.00E+1	1.30E+1	1.30E+1	1.30E+1	<5.70E+1	2.70E+2	2.00E+2	1.90E+2	5.70E+2	<5.00E+1	<5.00E+1	<5.00E+0
1,925	<3.30E2	3.00E+1	3.00E+1	3.00E+1	3.00E+1	9.00E+1	7.10E+2	7.10E+2	7.10E+2	1.40E+2	1.40E+2	1.40E+2	<3.00E+0
1,950	5.93E1	<4.00E+0	1.50E+0	1.50E+0	1.50E+0	2.40E+1	2.40E+1	2.40E+1	2.40E+1	3.50E+1	3.50E+1	3.50E+1	<3.00E+0
2,000	3.23E2	8.50E+0	8.50E+0	8.50E+0	8.50E+0	7.90E+0	9.90E+1	1.40E+2	1.40E+2	2.40E+2	2.40E+2	2.40E+2	<3.00E+0
2,150	1.91E2	2.90E+0	2.90E+0	2.90E+0	2.90E+0	3.00E+0	4.00E+1	5.00E+1	5.00E+1	8.40E+1	8.40E+1	8.40E+1	<3.00E+0

TABLE CONT'D

RADIONUCLIDES IN ON-SITE SEDIMENT SAMPLES OF  
THE CENTRAL DRAINAGE DITCH

09465

## ACTIVITY pCi/g

Distance from Ditch Origination, ft (m)	Total Uranium ug/g	PA-231	TH-227	EA-223	TH-234	EA-226	PB-214	BI-214	PB-210	CS-137	TH-232
2,225(671)	<1.32E1	<1.00E-1	<3.00E-1	<4.00E-1	4.20E+0	2.80E+0	2.20E+0	2.10E+0	6.10E+0	<1.00E-1	7.00E-1
2,250	<2.84E1	<8.00E-1	<4.00E-1	<4.00E-1	<6.50E+0	2.20E+0	1.90E+0	2.10E+0	4.80E+1	<2.00E-1	4.00E-1
2,300(701.5)	<2.64E1	<1.80E+0	<1.10E+0	<6.00E-1	5.00E+0	3.00E+0	3.40E+0	3.10E+0	4.10E+0	<2.00E-1	1.10E+0
2,350	<3.95E1	<2.60E+0		3.00E-1	4.40E+0	8.50E+0	8.20E+0	7.80E+0	1.30E+1		1.00E+0
2,400(732)	<6.59E1		3.10E+0	2.70E+0	<1.80E+1	6.10E+1	5.20E+1	4.90E+1	9.50E+1	<3.00E-1	
2,450	<1.12E2	<7.70E+0	3.60E+0	4.00E+0	<2.80E+1	1.10E+2	9.40E+1	9.30E+1	1.10E+2		
2,500	<2.64E1	<8.00E-1	<5.00E-1	<8.00E-1	<7.70E+0	9.00E+0	8.20E+0	6.40E+0	1.00E+1	<2.00E-1	8.00E-1
2,525	<3.30E1	<2.00E+0	<5.00E+1	<1.00E+1	<8.00E+0	7.50E+0	7.70E+0	7.40E+0	1.20E+1	<3.00E-1	9.00E-1
2,600	8.57E1	<1.00E+1	2.30E+0	2.00E+0	3.80E+1	4.00E+1	3.90E+1	3.90E+1	6.70E+1	<3.00E-1	1.10E+0
2,650	<5.27E1		1.90E+0	2.00E+0	<1.70E+1	5.00E+1	3.90E+1	3.80E+1	6.80E+1	<2.00E-1	<2.80E+0
2,750(838.75)(Off-Site)	<4.61E1	<3.50E+0	<1.00E+0	2.00E-1	1.40E+1	2.20E+1	2.80E+1	2.60E+1	2.30E+1	<2.00E-1	1.10E+0
? (Off-Site)	<9.23E1	<6.50E+0	5.20E+0	5.40E+0	<2.30E+1	1.07E+2	1.05E+2	1.02E+2	1.07E+2	<4.00E-1	2.50E+0

SOURCE: Anderson et al., 1981.

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TABLE 2.12. INSTRUMENTAL READINGS AND  $^{226}\text{Ra}$  CONCENTRATIONS  
IN THE WEST DITCH

Distance from Initial Sampling Point, (a) ft (m)	Instrumental Readings		$^{226}\text{Ra}$ Concentration (pCi/g)	
	Gamma(b) (micro R/hr)	Beta-Gamma(c) (milli R/hr)	Screening(d)	Radiochemistry(e)
	at 1 m above Soil Surface	at 1 cm above Soil Surface		
0			—	2.6
100(30.5)				4.2
500			23	
700(213.5)			26	
800			15	
900			15	
1,100(335.5)			6.7	
1,200			11	
1,300			3.6	
1,400			18	
1,500(452.5)			5	
1,800			75	
1,975(f)	180	3,000		
2,000(610)	40	220		
2,025	100	300		
2,050	120	360		
2,075	50	150		
2,100	40	120	59	
2,125	30	100		
2,150	22	90		
2,175	21	100		
2,200	16	80		
2,225	28	110		
2,250	40	120		
2,275	26	100		
2,300	26	60		
2,325	27	50		
2,350	27	100		
2,375	25	60		
2,400	17	70	41	
2,425	16	80		
2,450	11	50		
2,475	16	70		

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TABLE 2.12 . (Continued)

Distance from Initial Sampling Point, (a) ft (m)	Instrumental Readings		$^{226}\text{Ra}$ Concentration (pCi/g)	
	Gamma(b) (micro R/hr) at 1 m above Soil Surface	Beta-Gamma(c) (milli R/hr) at 1 cm above Soil Surface	Screening(d)	Radiochemistry(e)
2,500(g) (762.5)	14	60		
2,525	19	90		
2,550	18	70		
2,660	10-20		<4	3.1
2,700	10-20			7.8
2,760	10-20			
2,860	10-20			
2,960	10-20			
3,060(933.3)	10-20			
3,160	10-20			11.5
3,260	10-20		<4	
3,360	10-20			
3,460	10-20		<5	
3,660	10-20?		<4	3.2
3,960	10-20		>5	
4,160	10-20		>5	
4,660	10-20			19.9
4,760	10-20		>5	
4,860	10-20		>5	
4,960	10-20		>5	
5,060(1543.3)	10-20		>5	
5,160	10-20		<4	
5,260	10-20		<4	
5,360	10-20		<4	
5,460	10-20		>5	

- (a) Sampling initiated off-site in ditch due west on grid point S36W18 (see Figure 2-1).  
 (b) Gamma readings taken at 1 m above sediment or water surface; background 13  $\mu\text{R}/\text{hr}$ .  
 (c) Beta-gamma readings taken at 1 cm above sediment or water surface; background 60  $\mu\text{R}/\text{hr}$ .  
 (d) Measurement of  $^{214}\text{Bi}$  as index of  $^{226}\text{Ra}$ .  
 (e) Gamma spectrometry, background concentration average in sediment 0.5 pCi/g (10.1).  
 (f) Sample just north of Site perimeter fence on south side of West Patrol Rd. (see Figure 2-8).  
 (g) Sample 60 ft south of north perimeter fence which is at 2,560 ft (see Figure 2-1).

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Source: Anderson et al., 1981.

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TABLE 2.13

RADIONUCLIDES IN ON-SITE SEDIMENT SAMPLES OF  
THE WEST DITCH

Distance from Ditch Originat., ft (m) (a)	Total Uranium ug/g	ACTIVITY pCi/g									
		PA-231	TH-227	RA-223	TN-234	RA-226	PB-214	BI-214	PB-210	CS-137	TN-232
0(b)	2.64E1	<2.70E+0	<5.00E-1	<8.00E+0	9.90E+0	2.60E+0	1.10E+0	1.10E+0	<1.00E+1	1.40E+0	9.50E-1
100(30.5)	1.25E2	<2.00E+0	<7.00E-1	<6.00E-1	5.10E+1	4.20E+0	4.00E+0	3.90E+0	1.30E+1	3.20E+0	1.30E+0
500	6.59E1		1.00E+0	9.00E-1	2.00E+1	2.30E+1	1.60E+1	1.40E+1	2.00E+1	1.00E+0	1.30E+0
700(213.5)	5.27E1	<3.00E+0	6.00E-1	8.00E-1	2.50E-1	2.60E+1	2.00E+1	1.90E+1	2.20E+1	1.20E+0	1.20E+0
800	7.91E1	<5.00E+0	7.00E-1	8.00E-1	3.40E+1	3.50E+1	3.60E+1	3.50E+1	3.70E+1	2.10E+0	1.90E+0
900	1.25E2	5.00E-1	5.00E-1	4.00E-1	4.10E+1	1.50E+1	9.80E+0	8.60E+0	1.50E+1	<2.00E+0	1.10E+0
1,100	<3.30E1	<2.10E+0	<1.00E+0	<1.10E+0	1.00E+1	6.70E+0	5.00E+0	4.50E+0	6.10E+0	7.00E-1	1.30E+0
1,200	1.32E2	<3.00E+0	<1.00E+0	4.00E-1	4.10E+1	1.10E+1	6.50E+0	6.70E+0	1.20E+1	1.70E+0	1.20E+0
1,300	<1.98E1	<1.80E+0	<7.00E-1	<5.00E-1		3.60E+0	3.50E+0	2.40E+0	3.60E+0	2.00E-1	8.00E-1
1,400	9.23E1	<6.00E+0	<1.20E+0	<1.00E+0	3.20E+1	1.80E+1	1.70E+1	1.60E+1	2.20E+1	2.40E+0	1.70E+0
1,500(452.5)	<1.98E1	<1.60E+0		<8.00E-1	1.80E+1	5.00E+0	4.80E+0	4.60E+0	6.80E+0	7.00E-1	9.00E-1
1,600	2.97E2	<5.80E+0	2.20E+0	2.00E+0	9.00E+1	7.50E+1	3.30E+1	3.30E+1	5.50E+1	6.60E+0	2.90E+0
1,700	<2.70E2	1.20E+1	1.90E+1	1.60E+1	<6.50E+1	5.90E+2	2.00E+2	1.90E+2	6.90E+2	9.00E-1	2.00E+0
2,400	7.25E1	3.00E+0	1.70E+0	9.00E-1	<1.50E+1	4.30E+1	1.00E+1	1.70E+1	2.90E+1	2.40E+1	1.70E+0
2,700	<4.61E1		<9.00E-1	<8.00E-1	9.20E+0	7.80E+0	5.40E+0	4.80E+0	8.00E+0	2.20E+0	1.00E+0

(a) Sample taken south to north off-site every 100 ft, on-site every 25 ft.

(b) Sample starting point is off-site due west of residue storage buildings.

SOURCE: Anderson et al., 1981.

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TABLE 2.14. INSTRUMENTAL SURVEY DATA  
FROM SOUTH 31 DITCH

Location (Grid Points) (d)	Beta-Gamma (mR/hr) (a)	Gamma (mR/hr) (b)
S31W8	0.42	0.18
S31W7	0.30	0.15
S31W6	0.27	0.10
S31W5	0.20	0.06
S31W4 (c)	0.20	0.15
S31W3	0.23	0.17
S31W2	0.16	0.10
S31W1	0.18	0.07
S31E1	0.12	0.08
S31E2	0.15	0.09
S31E3	0.15	0.10
S31E5	0.13	0.06
S31E6	0.19	0.04
S31E7	0.13	0.05
S31E8	0.07	0.04
S31E11	0.11	0.05
S31E12	0.07	0.05
S31E13		

(a) Background, 0.06 mR/hr.

(b) Background, 0.01 mR/hr.

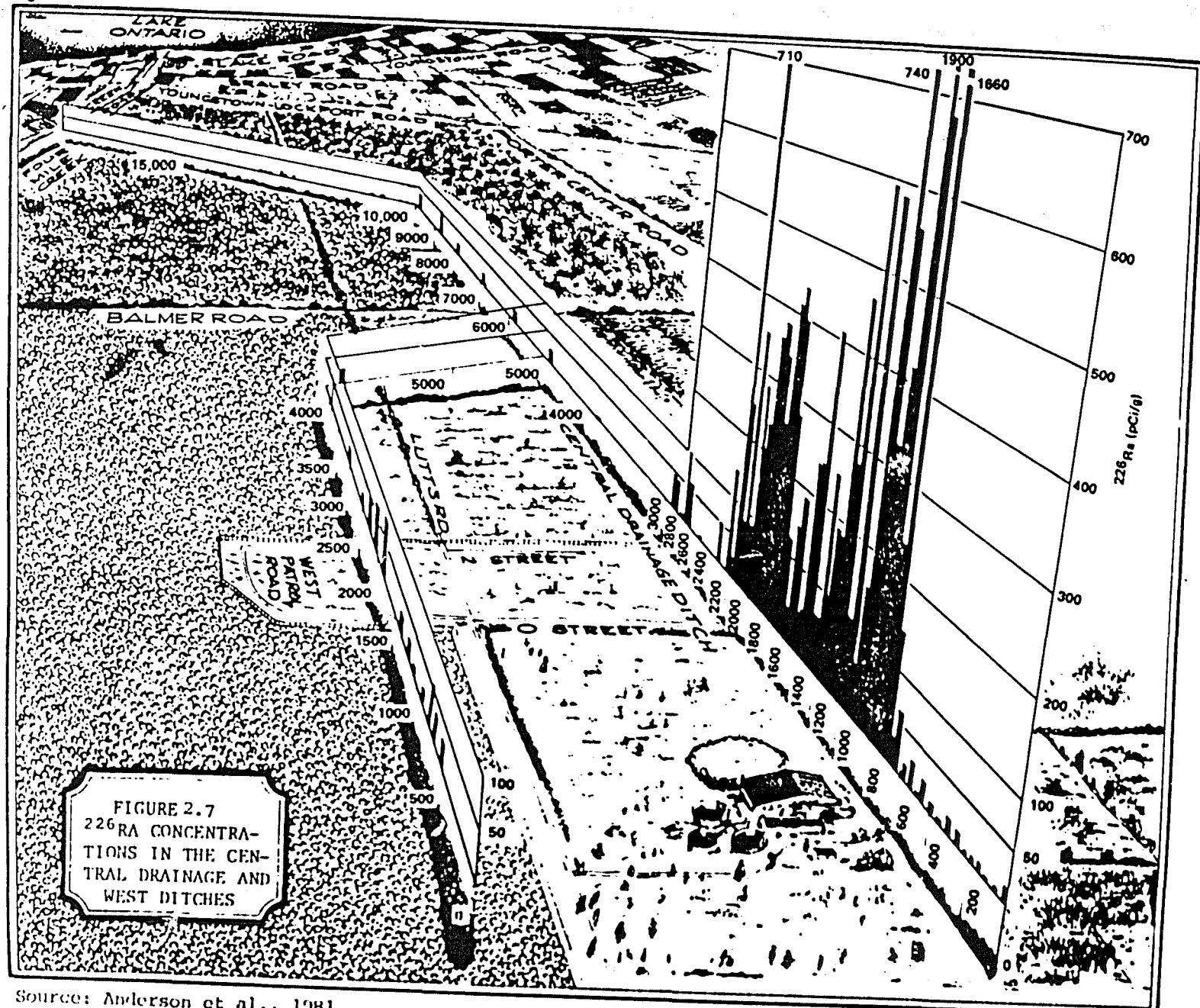
(c) Gamma spectroscopy analysis determined  
 $^{226}\text{Ra}$  concentration to be 5.0 pCi/g.

(d) See Anderson et al. (1981), Appendix I, Table I-5.

Source: Anderson et al., 1981.

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Source: Anderson et al., 1981

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TABLE 2.15  
RADIONUCLIDES IN ON-SITE DRILL CORES FROM THE CENTRAL DRAINAGE DITCH

Distance From Ditch Origination, ft	Depth (ft)	Total Uranium ug/g	231Pa	227Th	223Ra	219Rn	234Th	234Pa	226Ra	214Pb	214Bi	232Th	137Cs	210Pb
1,050	2	33.0	<2	0.2	<0.5	<0.5	11	<22	3.8	3.2	3.2	1.5	<0.2	<4
1,050	4	<52.7	<1.5	0.2	<0.5	<0.5	5.4	<12	6.9	6.5	6.4	0.7	<0.1	6
850	0	<65.9	<30	12	12	13	<9	<50	280	180	180	<5	>0.5	260
850	2	26.4	<2	<0.3	<0.3	<0.3	8.5	<20	2.1	1.4	1.3	0.8	<0.07	<3
850	6	<33.0	<2	<0.7	<0.6	<0.6	4.1	<24	1.6	1.3	1.4	1.1	<0.2	<3
750	2	<59.3	<3.7	<1	0.7	0.8	<11	<30	19	13	13	0.8	<0.3	15
750	4	<59.3	<5	<1.4	1.3	0.3	<15	<46	29	21	21	1.5	<0.3	27

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SOURCE: Anderson et al. 1981

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TABLE 2.16 (Continued)

Sample Number	Depth ft	Distance from Ditch Originatn ft	Bog/g		PCL/g		PCL/g	
			Total U	Pearl	Th273	Th274	Th275	Th276
319	2	<19.8	<0.6	<0.4	<5	--	1.4	0.9
	4	<19.8	<0.6	<0.4	<5	<28	1.1	1.1
320	2	<13.2	<0.4	<0.4	<2.4	--	0.9	0.9
	4	--	<0.4	<0.6	<4.2	--	1.1	0.1
—	324	2	<19.8	<1.3	<0.8	<0.4	<6.7	<13
	4	<26.4	<1.3	--	<0.8	<0.8	2.4	1.2
—	326	2	<26.4	--	<0.9	<0.5	<4.1	<20
	4	--	<1.3	<0.8	<0.5	<6.5	--	1.4
—	328	2	<19.8	<1.3	<0.8	<0.5	<6.5	<12
	4	<26.4	--	<0.4	<0.4	<0.4	<20	2
9,465	330	2	<26.4	<1.8	<1.1	<0.6	<6.4	<30
11,890	364	2	<33.0	<2.2	<0.8	<0.7	<8	--
	4	<92.9	<5.6	<1.6	<1.3	<1.3	--	29
	6	<19.8	<0.6	<0.3	<0.4	<1.2	--	23
	2	<26.4	<1.7	<0.5	<0.6	--	1	2.3
	4	<14.8	<1.4	--	<0.5	<5.5	--	2.1
	6	<26.4	<6.2	<1.2	<0.6	<10	<30	1.1
12,090	345	2	<26.4	<1.5	<1.0	--	--	21
	4	--	<1.3	<0.8	<0.6	<6.4	--	1.1
	6	--	<1.5	<1.0	--	--	0.3	0.4
—	348	2	<26.4	<1.5	<1.0	--	<19	1.5
	4	<19.8	<1.3	<0.8	<0.6	<6.1	<17	0.4
12,590	350	2	<26.4	<1.6	<0.6	--	7.4	--
	4	<26.4	<1.8	<0.5	<0.5	<6.7	<40	1.4
	6	--	<0.4	<0.4	<0.4	<6.7	<15	1.1
—	355	2	<26.4	<1.9	<0.4	<0.5	<6.7	<11
	4	<13.2	<2.0	<0.5	<0.6	<5.6	<26	0.0
	6	--	<0.5	<0.5	<0.5	<7.2	<26	8.4
—	356	2	<13.2	<2.0	<0.5	<0.5	<7.2	6.1
	4	<13.2	<2.1	<0.3	<0.3	<6.7	<10	1.7
	6	--	<0.4	<0.4	<0.4	<6.7	<11	5.7
—	357	2	<13.2	<2.0	<0.5	<0.5	<7.2	7
	4	<13.2	<2.1	<0.3	<0.3	<6.7	<11	5.7
—	359	2	<13.2	<2.1	<0.3	<0.3	<6.7	5.7
	4	<26.4	<1.8	<0.4	<0.5	<6.7	<19	4.5
	6	--	<0.4	<0.4	<0.4	<6.7	<19	4.5
—	361	2	<13.2	<2.2	<0.2	<0.1	<2.9	<11
	4	<26.4	<1.5	<1.0	<0.5	<6.0	<22	2.6
—	370	2	<26.4	<1.5	<1.0	<0.5	<6.0	1.9
	4	--	<1.3	<0.8	<0.5	<6.0	<22	2.6
—	17,650	2	<13.2	<2.2	<0.2	<0.1	<2.9	1.9

(a) See Table I-1 for exact distance location (Anderson, et al. 1981).

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TABLE 2.16 RADIONUCLIDES IN OFF-SITE DRILL CORES FROM THE CENTRAL DRAINAGE DITCH

Distance From Ditch Origination, ft.	Sample Number(a)	Depth (ft)	PCU/R													
			Ug/g	Totn/l/l	Pa231	Th227	Ra228	Rn223	Th234	Pa214	Ra226	Pb214	B1214	Th232	Ce137	Pb210
3,850	200	2	< 26.4	< 0.9	< 0.5	< 0.6	< 0.6	--	--	1.3	0.9	1	0.7	< 0.2	< 2	
		4	< 19.8	< 1.2	--	< 0.4	< 0.4	4.0	--	1.1	1	0.9	1	< 0.1	< 2	
		6	< 19.8	--	--	< 0.7	< 0.7	--	< 33	1.1	0.8	0.9	1	< 0.2	< 2	
	203	2	--	< 2.6	< 0.8	< 0.8	< 0.8	< 7	--	2	2	2.6	--	< 0.3		
		4	19.8	< 1.8	--	< 0.5	< 0.5	7.1	< 22	0.8	0.5	0.7	0.7	< 0.2	< 2	
		6	< 19.8	--	< 0.4	< 0.4	< 0.4	--	--	1.1	0.9	1	0.5	< 0.1	< 2	
	207	2	< 26.4	--	< 0.4	< 0.4	< 0.4	--	--	1.1	0.9	1	0.5	< 0.1	< 2	
		4	< 39.5	< 1.1	--	< 1	< 1	--	--	1.5	1	1.7	1.4	< 0.6	< 2	
		6	< 33.0	--	--	< 0.7	< 0.7	5	< 33	2.4	1.8	3.1	0.7	< 0.2		
	211	2	< 19.8	--	< 0.5	< 0.4	< 0.4	< 4.7	--	1.4	1	1.1	0.9	< 0.1	< 2	
		4	< 33.0	--	--	< 0.7	< 0.7	5	< 33	2.4	1.8	3.1	0.7	< 0.2		
		6	< 19.8	--	< 0.5	< 0.4	< 0.4	< 4.7	--	1.4	1	1.1	0.9	< 0.1	< 2	
	214	2	< 26.4	--	< 0.5	< 0.5	< 0.5	--	--	3.5	3.6	2.5	1.3	< 0.2		
		4	< 26.4	--	< 0.6	< 0.5	< 0.5	< 4.5	< 25	1.7	1.5	1.3	1.2	< 0.2	< 2	
		6	< 19.8	--	< 0.6	< 0.6	< 0.6	--	< 24	2.4	2	1.7	1.2	< 0.3		
	222	2	< 19.8	--	< 0.9	< 0.5	< 0.5	< 3.5	--	1.3	1.1	1.5	1	< 0.2	< 2	
		4	< 33.0	--	< 0.6	< 0.6	< 0.6	--	< 24	2.4	2	1.7	1.2	< 0.3		
		6	< 19.8	--	< 0.8	< 0.4	< 0.4	--	--	0.9	0.6	0.8	0.7	< 0.2		
	223.5	4	--	--	< 0.8	< 0.4	< 0.4	--	--	0.9	0.6	0.8	0.7	< 0.2		
		224	2	< 33.0	--	--	< 0.6	< 0.6	5	--	1.7	1.6	1.6	1.2	< 0.1	
		4	< 19.8	--	--	< 0.4	< 0.4	< 3.4	--	1.8	0.8	1.4	0.8	< 0.2		
	229.5	2	< 26.4	--	--	< 0.5	< 0.5	3.8	--	1.5	1.3	1.3	1	< 0.1	< 2	
		4	< 19.8	--	--	< 0.5	< 0.5	3.5	--	1.8	1.3	1.3	0.8	< 0.1		
		6	< 19.8	--	--	< 0.5	< 0.5	3.5	--	1.8	1.3	1.3	1.3	< 0.1		
6,750	300	2	< 33.0	< 1.8	--	< 0.6	< 0.6	< 7	--	1.4	1	1.2	0.7	< 0.3	< 2	
		4	< 19.8	< 1.3	< 0.5	< 0.4	< 0.4	< 3.1	--	0.6	0.8	0.8	0.8	< 0.1	< 2	
		6	< 26.4	--	< 0.8	< 0.5	< 0.5	< 5.2	--	1	0.7	0.9	0.4	< 0.1	< 2	
	302	2	< 19.8	< 1.3	< 0.5	< 0.5	< 0.5	< 3.4	--	0.8	0.7	0.7	0.7	< 0.1	< 2	
		4	< 19.8	< 1.3	< 0.5	< 0.4	< 0.4	--	< 21	1.1	0.9	0.9	0.3	< 0.1	< 2	
		6	< 19.8	--	< 0.5	< 0.4	< 0.4	--	--	1.8	1.3	1.3	0.8	< 0.1		
	304	2	< 19.8	< 1.4	< 0.4	< 0.4	< 0.4	< 3.8	--	2.2	1.7	2	1	< 0.2		
		4	< 19.8	< 1.3	< 0.5	< 0.4	< 0.4	< 3.7	--	1.1	1.4	1.2	0.8	< 0.1	< 2	
		6	< 19.8	--	--	< 0.5	< 0.5	--	--	1.6	1.2	1.6	0.9	< 0.1		
	306	6	< 26.4	--	< 0.6	< 0.5	< 0.5	4.9	< 19	0.9	0.7	1	0.6	< 0.2	< 2	
		2	< 19.8	--	< 0.9	< 0.6	< 0.6	< 5	--	1.2	1.2	1.1	1	< 0.1	< 2	
		4	< 19.8	--	< 0.4	< 0.5	< 0.5	< 5	--	1	0.7	1	1.1	< 0.1	< 2	
	308	2	< 19.8	--	< 0.9	< 0.6	< 0.6	< 5	--	1.2	1.2	1.1	1.1	< 0.1	< 2	
		4	< 19.8	--	< 0.4	< 0.5	< 0.5	< 5	--	1	0.7	1	1.1	< 0.1	< 2	
		6	< 19.8	--	--	< 0.5	< 0.5	--	--	1.1	1	1.1	0.8	< 0.2		
	312	2	< 19.7	< 1.2	< 0.6	< 0.5	< 0.5	< 6	--	1.1	1	1.1	0.7	< 0.2	< 2	
		4	< 19.8	--	< 0.4	0.1	0.1	< 6	< 25	2	2.5	1.9	0.7	< 0.2		
		6	< 13.2	--	--	< 0.1	< 0.1	< 7	< 10	1.5	0.9	1.1	1.1	< 0.1	< 2	
	316	2	< 19.8	< 1.7	< 0.5	< 0.5	< 0.5	1	< 25	1.6	1.5	1.4	0.7	< 0.1		
		4	< 19.8	< 1.6	--	< 0.5	< 0.5	< 1.7	--	1.2	0.9	1.1	0.8	< 0.2	< 2	

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TABLE 2.17 RADIONUCLIDES IN OFF-SITE DRILL CORES FROM THE WEST DITCH

Distance From Initial Sampling Point, ft.	Sample Number(a)	Depth (ft)	ug/g						PCI/g						
			Total U	Pu231	Th227	Ra223	Rn223	Th234	Pu234	Ra226	Pb214	B1214	Th232	Ca137	Pb210
2,660	400	2	<19.8	<1.3	<0.5	<0.5	<0.5	6	--	1.1	0.9	1	0.7	<0.2	<2
		4	<19.8	<1.6	<0.9	<0.4	<0.4	<4	--	1	0.9	1	0.5	<0.1	<2
2,860		6	--	<1.3	<0.8	<0.8	<5.6	--	1.8	1.2	0.7	1	<0.2		
402	2	<26.4	<1.3	--	<0.5	<0.5	<4	<17	2.2	1.8	2.2	1.1	<0.1		
	3,360		4	<19.8	<1.4	--	<0.4	<0.4	<3.4	<27	1.3	1.2	1	0.9	<0.2
—	407	2	<26.4	--	<1	<0.4	<0.4	--	--	2.1	1.9	2.1	1	<0.2	
		4	<19.8	--	<0.4	<0.4	<0.4	<3.8	<32	1.8	1.3	1	--	<0.1	<2
—	409	2	<26.4	<1.4	<0.6	<0.5	<0.5	<4.2	--	1.2	1.1	1	0.6	<0.3	<2
		4	<19.8	--	--	<0.6	<0.6	<4.7	--	1.2	0.6	1	1	<0.2	<2
—	412	2	<13.2	<1.3	<0.5	<0.2	<0.2	<2.1	--	1.1	0.8	0.8	0.6	<0.1	<2
		4	<19.8	<0.9	<0.4	<0.4	<0.4	<3.5	--	1.3	0.8	1.1	1.5	<0.1	<2
—	416	2	<19.8	--	--	<0.4	<0.4	--	--	2	1.8	1.9	1.1	<0.2	
		4	<26.4	<1.2	<0.6	<0.5	<0.5	<4.2	--	1.2	0.7	1.1	1.2	<0.2	<2
4,660	420	2	<19.8	--	<0.9	<0.5	<0.5	<6.5	<14	1.2	1.2	0.9	1.3	<0.1	<2
		4	<26.4	--	<0.6	<0.5	<0.5	--	--	1.8	1.7	1.6	1.1	<0.1	
4,860	422	2	<26.4	--	<0.9	<0.4	<0.4	--	--	1.5	0.7	1.4	0.7	<0.2	<2
		4	--	--	<0.6	<0.4	<0.5	--	<17	1.8	1.3	1.3	1	<0.2	
5,160	422.5	4	--	--	<0.6	<0.4	<0.5	--	<17	1.8	1.3	1.3	1	<0.2	
		2	<26.4	--	<0.9	<0.5	<0.5	<1.8	--	2.9	2.8	2.7	1	<0.2	
5,360	425	2	<13.2	--	<0.7	<0.5	<0.5	<3.6	--	1.2	0.9	1.1	1	<0.1	<2
		4	<19.8	<1.1	--	<0.5	<0.5	<1.5	--	1.4	1.1	1	1.2	<0.1	<2
—	427	2	<19.8	--	<0.6	<0.4	<0.4	<1.8	<21	1.3	1	1	1	<0.1	<2
		4	<19.8	<1.1	--	<0.5	<0.5	<1.5	--	1.4	1.1	1	1.2	<0.1	<2
—	429	2	<26.4	<1	--	<0.6	<0.6	5	--	1.3	1	1.2	1	<0.2	<2

(a) See Table I-3 for exact distance location (Anderson, et al. 1981). 08255

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TABLE 2.18. RADIOCHEMICAL SCREENING OF CORES IN THE SOUTH 31 DITCH

Location <sup>(b)</sup>	Depth (ft)	<sup>226</sup> Ra Concentration (pCi/g) Screening <sup>(a)</sup>
S31E18	2	<1
	4	<4
S31E15	2	<4
	4	<4
S31E4.5	2	>5
	4	<4
S31W5	2	<4
S31W7	2	<4
	4	<4
S31W8.5	2	<4
	4	<4

(a) Measurement of <sup>214</sup>Bi as index of <sup>226</sup>Ra

(b) See Anderson et al. (1981), Appendix I, Table I-9.

Source: Anderson et al., 1981.

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purposes and as an additional index describing the environment surrounding the NFSS. Niagara River water quality data may be found in Appendix A.

### 2.3 Recreational and Commercial Uses

#### 2.3.1 Fourmile, Sixmile, and Twelvemile Creeks

Fourmile, Sixmile, and Twelvemile Creeks are predominantly used for boating and fishing (New York State Department of Environmental Conservation 1975). However, at their confluence with Lake Ontario, both Fourmile and Twelvemile Creeks are designated as recreational areas with public swimming sites (Erie and Niagara Counties Regional Planning Board, 1978). Fourmile Creek recreational area is a 248 acre public water oriented park located at Porter, New York (Figure 2.7, Number 4). The Wilson-Tuscarora recreational area (390 acres) is located near Wilson, New York (Figure 2.7, Number 3).

#### 2.3.2 Niagara River

Recreational uses of the Lower Niagara River include boating and fishing. Two water oriented recreational areas are Fort Niagara recreational area (504 acres) located at Porter, New York and Joseph Davis recreational area (388 acres) at Lewiston, New York (Figure 2.7, Numbers 5 and 6, respectively) (Erie and Niagara Counties Regional Planning Board 1978). In addition, several boat launching sites are available along this segment of the river (Figure 2.7).

Commercially, the lower Niagara River is used as a discharge point in the U.S. for industrial and municipal waste water treatment plant effluents (Figure 2.8). A Canadian municipal water intake supply source is located in the town of Niagara-on-the-Lake (Figure 2.8).

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TABLE 2.19. SUMMARY OF STABLE ELEMENTS DETECTED IN DITCH  
SEDIMENT SAMPLES FROM ON-SITE DITCHES USING  
SPARK SOURCE MASS SPECTROSCOPY COMPARED  
TO NATURALLY-OCCURRING LEVELS IN SOIL

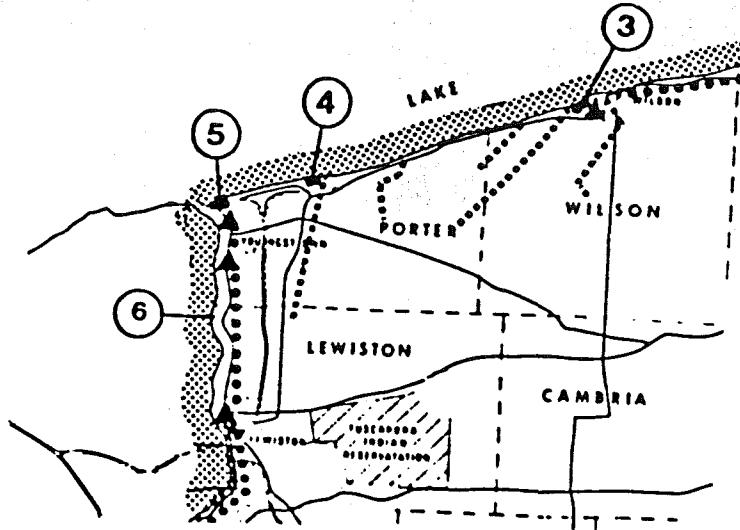
Element	Naturally Occurring in Soil (ppm)	Central Drainage Ditch (ppm)	West Ditch (ppm)
	Mean	Mean (SE)	Mean (SE)
Na	6,300	6,550 (1,535)	7,500 (3,354)
Ti	5,000	3,400 (528)	1,666 (729)
V	100	153 (100)	36 (16)
Co	8	687 (513)	66 (58)
Ni	40	828 (511)	32 (17)
Cu	20	43 (19)	19 (8)
Mn	850	54 (194)	560 (361)
Zr	300	21 (5)	26 (9)
Ba	500	733 (515)	270 (184)
Li	30	121 (30)	150 (45)
Sr	300	106 (47)	102 (51)
F	200	311 (194)	8 (3)
La	30	59 (49)	4 (1)
Ce	50	84 (51)	9 (3)
Cr	100	43 (19)	20 (4)
As	6	2 (1)	0.9 (0.5)
Pb	10	20.2 (6.4)	0.5 (0.3)

(SE) Standard Error

Source: Anderson et al., 1981.

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Figure 2.8 Major Water Oriented Recreational Areas



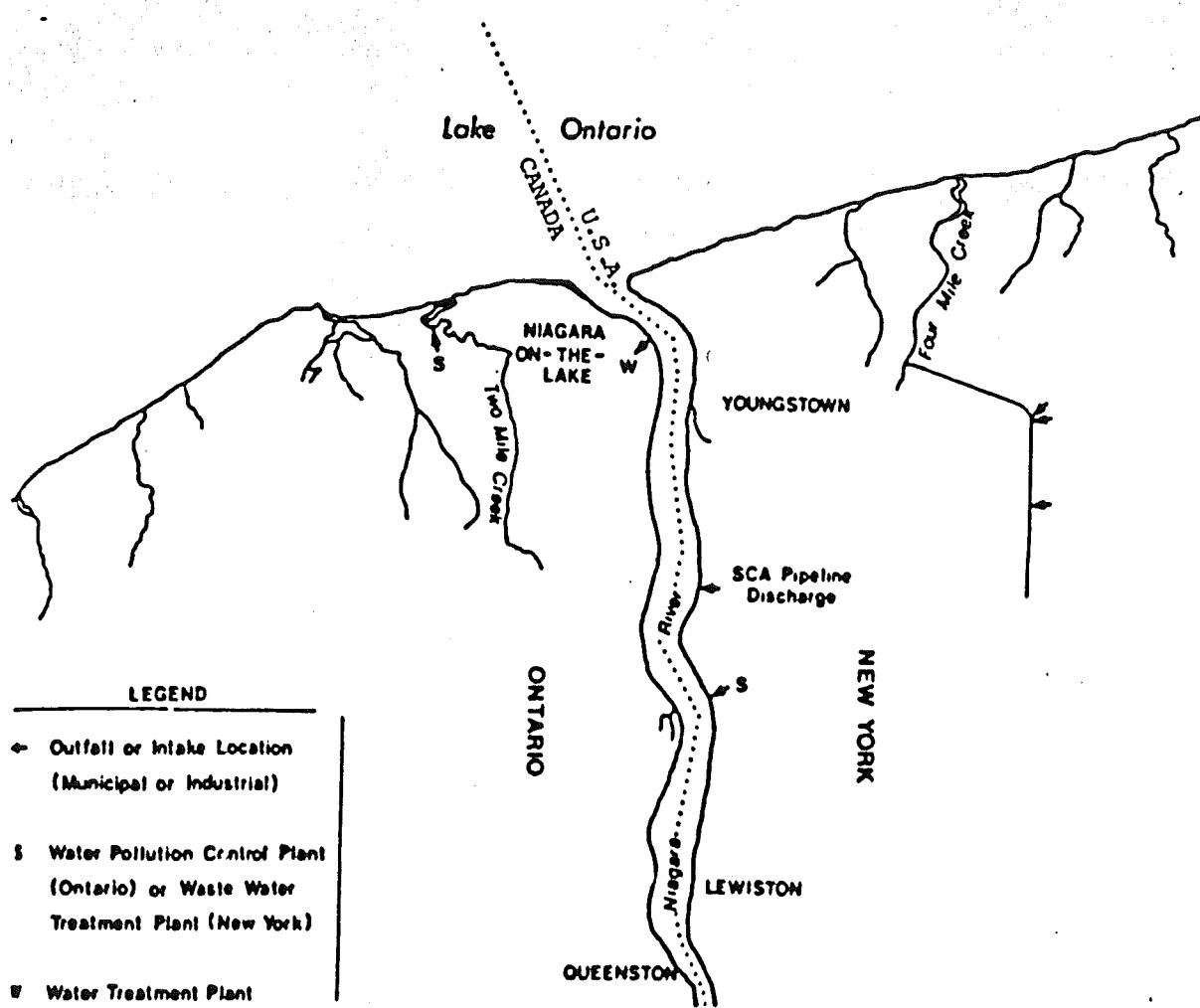
LEGEND:

- RECREATIONAL  
BOATING AND  
FISHING AREAS
- SPORT FISHING  
AREAS
- ▲ MARINAS AND/OR  
BOAT LAUNCHING SITES
- ① PUBLIC PARKS/ WATER  
ORIENTED
- PUBLIC SWIMMING  
SITES
- SCENIC AREAS/WATER  
ORIENTED

Source: Erie and Niagara Counties Regional Planning Board, 1978.

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Figure 2.9 Intakes and Outfalls in the Lower Niagara River North of Queenston.



Source: Canada-Ontario Review Board, 1981.

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**SECTION 3.0**

**GROUND WATER HYDROLOGY OF THE NIAGARA FALLS  
STORAGE SITE AND SURROUNDING AREA**

Figures 3.2 and 3.3 indicate a general northwesterly flow for the alluvial aquifer. The piezometric surface indicates that the ground water gradient across the NFSS is 0.001.

### 3.4 Ground Water Use

Approximately 10% of the population of Niagara and Erie Counties is supplied by groundwater (Erie and Niagara Counties Regional Planning Board, 1978). Domestic groundwater supply in the NFSS area is generally of low yield and poor quality. The only municipal water system dependent on groundwater in Niagara County is located in the Middleport area (eastern Niagara County) ( Erie and Niagara Counties Regional Planning Board, 1978). Location of wells and individual well records are presented in Figure 3.4 and Table 3.3, respectively. A map key (Figure 3.5) and table key (Table 3.4) are also included.

The aquifer in the unconsolidated deposits and the aquifer in the upper fractured bedrock are the only sources of groundwater on the Ontario Plain (which is the location of the NFSS). Since these aquifers produce only small quantities of water and are locally interconnected, they may be considered a sole source aquifer.

### 3.5 Groundwater Quality

#### 3.5.1 Radiological Characterization

From 1972 to 1981 radiological monitoring at the NFSS was conducted quarterly onsite and annually offsite by National Lead of Ohio (NLO) (Weidner 1981). Since 1982, this monitoring has been conducted by Bechtel National, Inc. Information about the sampling points is presented in Table 3.5

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FIGURE 3.4.  
WELL LOCATIONS.

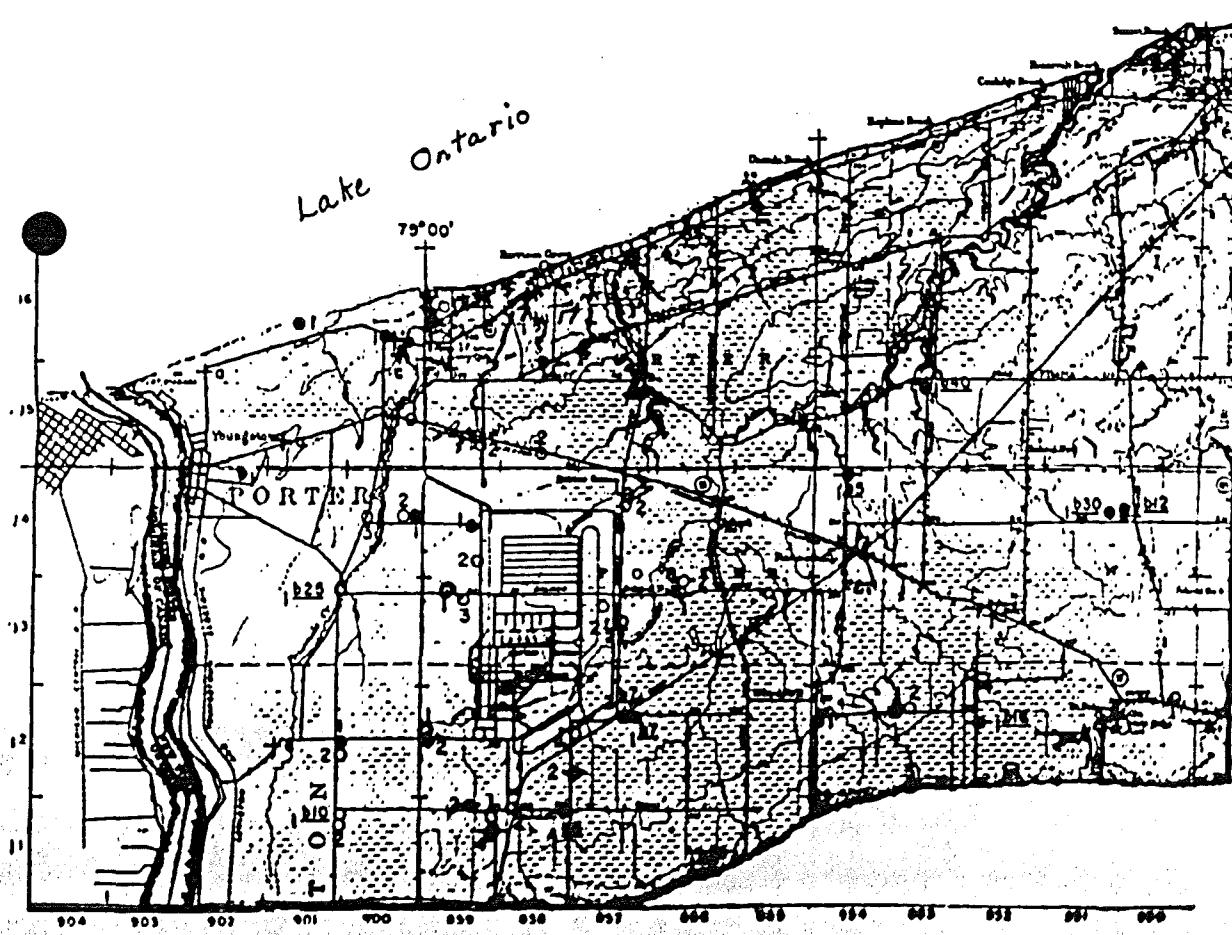
SOURCE: JOHNSON 1964

- WELL IN BEDROCK
- WELL IN UNCONSOLIDATED DEPOSITS
- SPRING (SOURCE IS BEDROCK)
- ◆ WELL YIELDING WATER CONTAINING HYDROGEN SULFIDE IN NOTICEABLE AMOUNTS
- ◆ WELL YIELDING WATER EITHER SALTY TO TASTE OR CONTAINING MORE THAN 500 PPM CHLORIDE

1—LAST DIGIT OF WELL OR SPRING NUMBER. SEE "WELL- NUMBERING SYSTEM" IN TEXT FOR EXPLANATION  
125 16 125—YIELD OF WELL IN GPM (B INDICATES YIELD FROM BAILING TEST, E INDICATES ESTIMATED YIELD, # INDICATES REPORTED YIELD).  
16—DRAWDOWN OF WATER LEVEL, IN FEET, REQUIRED TO OBTAIN STATED YIELD.  
+—TEST HOLE. LETTER IS LAST PART OF TEST-HOLE DESIGNATION. SEE "WELL NUMBERING SYSTEM" IN TEXT FOR EXPLANATION.

#### QUEENSTON SHALE

AVERAGE YIELD OF ADEQUATE WELLS IS 7 GPM. MANY WELLS HAVE BEEN ABANDONED BECAUSE OF POOR QUALITY AND INADEQUATE YIELDS. GROUND WATER OCCURS PRINCIPALLY IN FRACTURED ZONE IN TOP 1 FOOT OF SHALE. WATER IS VERY HARD AND ONE-THIRD OF WELLS YIELD SALTY WATER. WELLS IN OVERLYING GLACIAL TILL AND LAKE DEPOSITS YIELD LITTLE WATER AND ARE ADEQUATE ONLY WHEN SAND BEDS OR A "WASHED ZONE" AT TOP OF ROCK IS PENETRATED.



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TABLE 3.3. Records of Selected Wells in the Niagara Falls Area.

Source: Johnson 1964.

Well number	Owner	Year well placed	Type of well	Depth of well (feet)	Depth of casing (feet)	Diameter (inches)	Depth to bedrock (feet)	Underdraining material	Bottom of drainage level (feet)	Drilling point		Water level bottom of well (feet)	Yield (gallons per minute)	Use	Remarks	
										Description	Position					
311-054-1	E. Robbins	1958	Drill	57	—	6	700	Gravel	300	Top of casing	1.0	30.0	112/150	—	0	
311-054-2	E. Robins	1958	Drill	75	—	6	750	Gravel	400	—	1.0	30.0	112/150	—	0	
311-054-3	E. S. Atomic Energy Commission	—	Dug	10	—	30	—	Gravel	200	Top of well screen	1.7	3.0	112/150	—	0, A	
-4	E. Batty	1957	Drill	50	—	6	750	Gravel	500	Top of casing	1.0	30.0	112/150	—	0, Salty.	
311-055-1	E. Evans	—	Dug	25	—	6.5	—	Gravel	500	Bottom of well screen	1.0	4.7	112/150	—	0, Inadequate.	
-4	J. Brummitt	1956	Drill	50	—	6	—	Gravel	500	Top of casing	1.0	30.0	112/150	—	0	
-4	L. Patten	1957	Drill	65	21	6	750	Gravel	300	—	1.0	4.0	112/150	—	0, Well in E. N. Y. Water Power and Control Area.	
311-056-1	A. Scotton	1959	Drill	50	—	6	750	Gravel	300	Top of casing	1.0	30.0	112/150	—	0, Log monitor in gravel at top of rock.	
-4	M. Rauschbach	1956	Dug	25	27	6.5	75	—	Gravel	500	Top of well screen	1.0	30.0	112/150	—	0, Log.
311-056-2	J. Lefler	—	Dug	15	15	6	—	Gravel	300	—	2.0	8.7	112/150	—	0, Inadequate in fall of 1960.	
311-057-1	L. Atkin	1959	Dug	12	12	6	—	Gravel	300	—	1.0	3.0	112/150	—	0	
-4	E. Townsend	—	Dug	12	—	6.5	—	Gravel	300	—	1.0	3.0	112/150	—	0	
311-057-2	R. Morgan	1951	Drill	30	20	6	750	Gravel	300	Top of fracture pipe	1.0	32.0	112/150	—	0, Slightly salty; monitor in fractured zone at top of well.	
311-057-3	E. Bishop	1955	Drill	61	—	6	—	Gravel	300	Top of casing	1.0	11.7	112/150	—	0, Monitor; slightly salty.	
-4	E. Bishop	—	Dug	16	—	6.5	—	Gravel	300	Top of casing	1.0	16.0	112/150	—	0, 0, 0.	
-4	L. Gaud	1952	Drill	77	77	6	77	Gravel	300	Top of casing	1.0	30.0	112/150	—	0, Anhydrite monitor in fractured zone at top of shale.	
311-058-1	T. Bradford	—	Drill	35	—	6	—	Gravel	300	—	1.0	3.0	112/150	—	0, Cf 320 112/150, reported to have flowed in past.	
311-057-4	A. and V. Hayes	1959	Drill	40	37	6	750	Gravel	300	—	1.0	3.0	112/150	—	0, Reported to have flowed in past.	
311-057-5	A. and V. Hayes	1959	Drill	36	29	6	750	Gravel	300	Top of casing	1.0	6.0	112/150	—	0	
311-058-1	E. Jandy	—	Dug	25	—	27.10	—	Gravel	300	Top of casing	1.0	31.7	112/150	—	0	
-4	L. Damon	—	Dug	20	—	40.0	—	Gravel, Gr.	300	Top of well screen	1.0	3.0	112/150	—	0, Salty.	
311-059-1	E. Plotner	—	Dug	15	—	34	—	Gravel	300	Top of casing	1.0	3.0	112/150	—	0, 0, 0, 0.	
-4	E. Plotner	—	Dug	22	—	6	—	Gravel	300	Top of well screen	1.0	3.0	112/150	—	0, 0, 0, 0, 0, 0, 0.	
311-060-1	—	—	Dug	20	—	34	27.2	Gravel, Gr.	300	Top of well screen	1.0	30.0	112/150	—	0, Inadequate.	
-4	—	—	Dug	20	—	24	—	Gravel	300	Top of casing	1.0	3.0	112/150	—	0, 0.	
311-059-2	R. Potters	—	Dug	16	16	6	—	Gravel	300	Top of casing	1.0	3.0	112/150	—	0, 0.	
311-059-3	V. Baldwin	—	Dug	29	—	34	—	Gravel	300	Bottom of casing	1.0	6.0	112/150	—	0, Salty, Inadequate.	
-4	—	—	Dug	20	—	34	—	Gravel	300	Top of well screen	1.0	6.0	112/150	—	0, Salty.	
311-059-4	R. S. Army	—	Drill	29	—	8	750	Gravel	300	—	1.0	30.0	—	—	0, Log pumped at 10 gpm with 22 ft. col. monitor in gravel at top of rock.	
311-059-5	E. Bradford	1950	Dug	40	—	34.0	—	Gravel, Gr.	300	Bottom of casing	1.0	3.0	112/150	—	0, 0, Well in 22-14-0, E. N.Y. Water Power and Control Area, 60 ft. 10 in., 60 ft. 10 in., 60 ft. 10 in., 60 ft. 10 in.	
-4	E. Bradford	—	Dug	17	—	34	—	Gravel	300	—	1.0	3.0	112/150	—	0, Cf 311-059-5.	
311-059-6	—	1950	Dug	65	60	8	750	Gravel	300	—	—	—	—	—	0, Log, monitor in gravel at top of rock.	
311-059-7	E. Bradford	1959	Drill	34	20	12	750	Gravel	300	Top of fracture pipe	1.0	32.0	112/150	0.0	0, Cf 311-059-5 (sample from well Bradford and 311-059-6 monitor in fractured zone at top of rock). Estimated porosity with well 311-059-5 estimate of 30,000 gpm.	
311-060-1	do.	1950	Drill	40	32	32	750	Gravel	300	—	—	—	—	—	0, 0.	
311-060-2	R. Ward	—	Dug	21	20	6	750	Gravel	300	Top of casing	1.0	3.0	112/150	—	0, 0, Salty.	
311-060-3	R. Ward	—	Dug	17	—	34	—	Gravel	300	Top of well screen	1.0	30.0	112/150	—	0, 0.	
-4	do.	—	Dug	21	—	—	—	Gravel	300	Floor of pump house	1.0	30.0	112/150	—	0, Inadequate in floor summer.	
311-060-4	E. Gammie	1956	Drill	27	—	6	—	Gravel	300	Top of casing	1.0	3.0	112/150	—	0	
-4	E. Gammie	—	Dug	65	—	34	—	Gravel	300	Top of well screen	1.0	30.0	112/150	—	0	
311-060-5	R. Bradley	1957	Drill	70	24	16	750	Gravel	300	—	—	—	—	—	0	
-4	E. Gammie	—	Dug	19	—	34	—	Gravel	300	Top of well screen	1.0	3.0	112/150	—	0, 0, Cf 311-060-4.	
-4	E. Gammie	—	Dug	30	—	34	—	Gravel	300	Top of well monitoring	1.0	30.0	112/150	—	0, 0, Inadequate in dry summer.	
311-060-6	Frontier Farms	—	Drill	40	—	6	—	Gravel	300	Top of casing	1.0	3.0	112/150	—	0, 0, Cf 311-060-4.	
311-061-1	E. Michael	1951	Drill	40	20	6	750	Gravel	300	Top of casing	0.0	30.0	112/150	—	0, Monitor in fractured zone at top of shale.	
311-061-2	E. Eagle	1950	Drill	60	60	6	750	Gravel	300	—	1.0	3.0	112/150	—	0, 0, Slightly salty.	
-4	do.	—	Dug	12	—	34	—	Gravel	300	Top of well screen	1.0	3.0	112/150	—	0, 0	
311-061-3	E. Scholtz	—	Dug	20	—	34	—	Gravel	300	Bottom pump base	2.0	0.5	112/150	—	0, 0	
-4	J. Campfield	—	Dug	100	—	—	—	Gravel, Gr.	300	Top of well screen	1.0	3.0	112/150	—	0	
311-061-4	R. Palmer	—	Dug	35	—	34	—	Gravel	300	—	1.0	30.0	112/150	—	0, 0, Well in 30-10-0, 30-11-0, 30-12-0, 30-13-0, 30-14-0, 30-15-0, 30-16-0.	
-4	do.	—	Dug	21	—	34	—	Gravel	300	—	1.0	3.0	112/150	—	0	
311-061-5	R. McMillan	—	Dug	20	—	34	—	Gravel	300	—	1.0	3.0	112/150	—	0, Cf 311-061-4.	
311-061-6	R. Wilson	1957	Dug	7	—	44	—	Gravel	300	Bottom of well screen	1.0	3.0	112/150	—	0, 0	
311-061-7	Bigard Frontier State Park Commission	1954	Drill	100	55	6	750	Gravel	300	Top of casing	0.0	30.0	112/150	0.0	0, Log, bottom of 30 gpm well at 112 ft. col, one for 10 gpm at top of rock.	
311-061-8	E. Scholtz	—	Drill	50	—	6	750	Gravel	300	—	1.0	30.0	112/150	—	0	
311-061-9	E. Armstrong	—	Drill	70	—	6	—	Gravel	300	—	1.0	30.0	112/150	—	0, Adequate for one family.	

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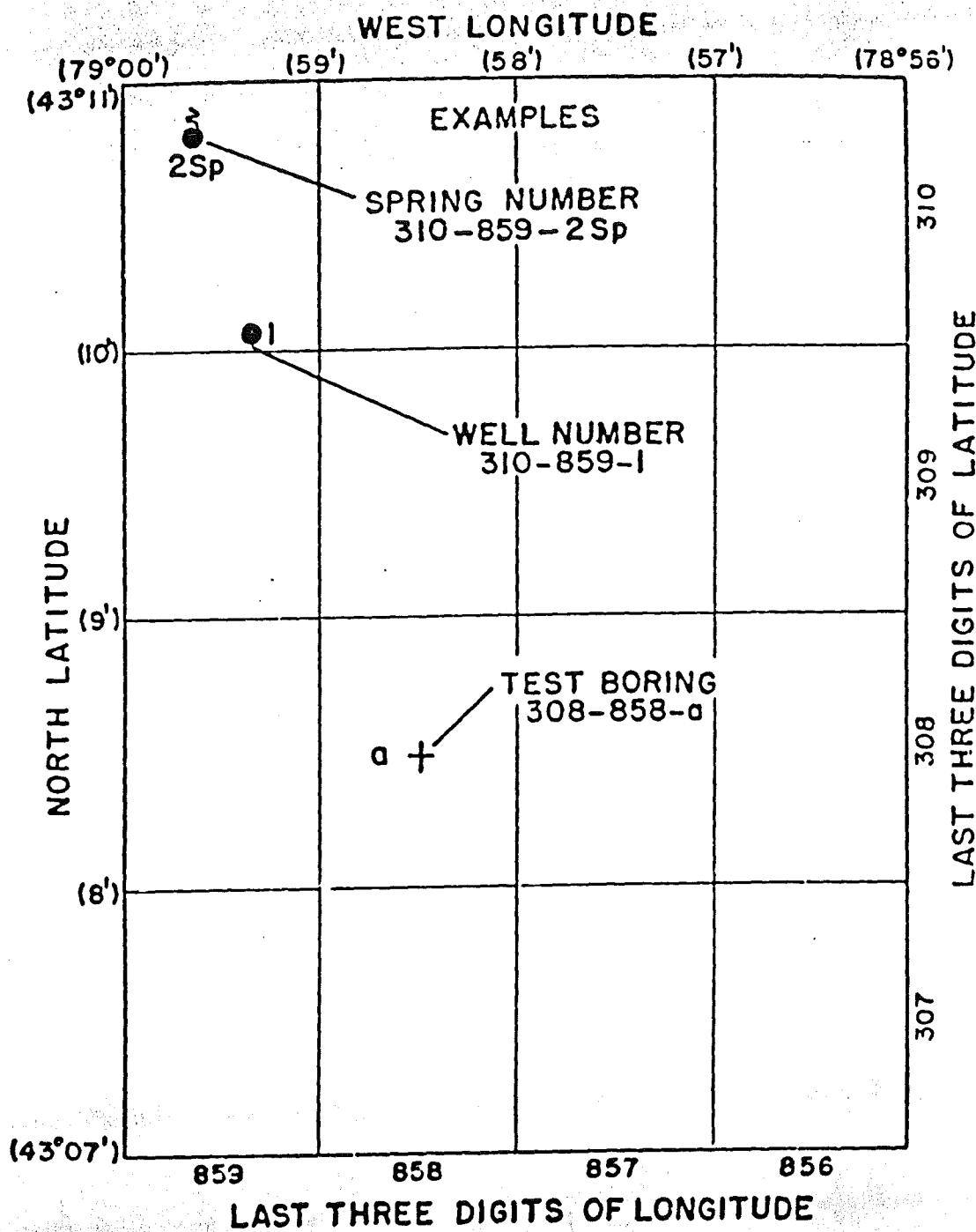


Figure 3.5--Well-numbering system.

Source: Johnson 1964.

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TABLE 3.4. Records of Selected Wells in the NFSS Area.

Well number: See "Well-Numbering System" in text for explanation.

Owner: PASNY - Power Authority of the State of New York.

Type of well: Aug = augered  
Dri = drilled  
Dug,Dri = dug and drilled

Depth of well: All depths below land surface.

a = about  
r = reported  
all others measured

Depth of casing: All depths below land surface.  
drilled wells = depth to bottom of casing or depth to top  
of slots or screen  
dug wells = depth omitted for stone-curbed wells  
= depth to bottom of tile or culvert pipe  
a = about  
r = reported

Diameter of wells: Diameters of dug wells are approximate.  
Where two or more sizes of casing were used the top and  
bottom diameters are given.

Depth to bedrock: All depths below land surface.  
a = about  
r = reported  
all others measured

Water-bearing material: Qq = Queenston Shale  
Qd = Pleistocene deposits, undifferentiated  
Qlc = Pleistocene lake deposits; silt and clay  
Qls = Pleistocene lake deposits; sand  
Qsg = Pleistocene sand and gravel  
QtI = Pleistocene glacial till  
Sa = Albion Group  
Sc = Clinton Group  
SI = Lockport Dolomite

Altitude above sea level: a = altitude of land surface measured by surveying  
instruments and given to nearest foot.  
All others estimated from topographic maps to  
nearest 5 feet.

Measuring point, position: Given in feet above land surface, except those  
preceded by a minus (-) sign which are below  
land surface.  
LS = at land surface

Water level below  
land surface:

All water levels are below land surface except those  
preceded by a plus (+) sign which are above land surface.  
r = reported  
all others measured by personnel of the U.S.G.S. or  
Uhl, Hall & Rich.  
c = water level while PASNY conduits were dewatered  
d = water level after PASNY conduits were flooded  
F = series of water-level measurements on file in U.S.G.S.  
office, Albany, N. Y.  
g = water level prior to flooding of PASNY reservoir  
h = water level after PASNY reservoir flooded to elevation  
of about 640 feet above mean sea level  
p = pumping effects probable

Yield: Yield in gallons per minute based on pumping test or continuous  
pumpage except: b = yield based on short bailing test  
e = estimated yield  
r = reported yield by owner  
> greater than  
< less than

Use: A = abandoned  
C = commercial  
D = domestic  
De = destroyed  
Dr = drainage  
Dw = dewatering  
I = Industrial  
In = institutional

Ir = Irrigation  
O = observation  
PR = pressure-relief well  
PS = public supply  
S = stock  
T = test  
U = unused

Remarks: Well number = PASNY - well number assigned by Power Authority of the  
State of New York.  
OV = observation well  
PR = pressure-relief well  
R = residential well used for observation  
WP = well finished with screened well point  
anal. = chemical analysis in this report  
Cl = chloride content in parts per million  
dd = drawdown  
gpm = gallons per minute  
H<sub>2</sub>S = noticeable odor of hydrogen sulfide  
Inadequate = reported inadequate by owner  
log = graphical log in this report  
LS = land surface

pt = pumping test data on file, U.S.G.S. office, Albany, N. Y.  
rT = temperature, in degrees Fahrenheit, reported by owner  
salty = salty to taste  
T = temperature, in degrees Fahrenheit, measured by U.S.G.S.

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TABLE 3.5.  
NFSS GROUNDWATER MONITORING SAMPLES

<u>LOCATION NO.</u>	<u>LOCATION</u>	<u>TAKEN FROM</u>	<u>FREQUENCY</u>	<u>REMARKS</u>
1-9	On-Site	Wells at 28' depth	Quarterly	Wells surrounding the R-10 residue storage area
13-14	On-Site	French drains outlet	Quarterly	Sampled from 8" concrete pipe from French drains under Building 411
15	On-Site	Drinking Water	Quarterly	Sampled from water tap on site
16	Off-Site	Well (Drinking Water)	Annual (end of March)	SCA (water tap)
17	Off-Site	Well at 25' depth	Annual (end of March)	"Wojcik" (water tap)
18	Off-Site	Water well	Annual (end of March)	"Jowdy" (water tap)
19	Off-Site	Well at 25' depth	Annual (end of March)	"Waddell" (water tap)

Source: Weidner, 1981

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0 100 200 300 400 500 600  
SCALE IN FEET  
1200

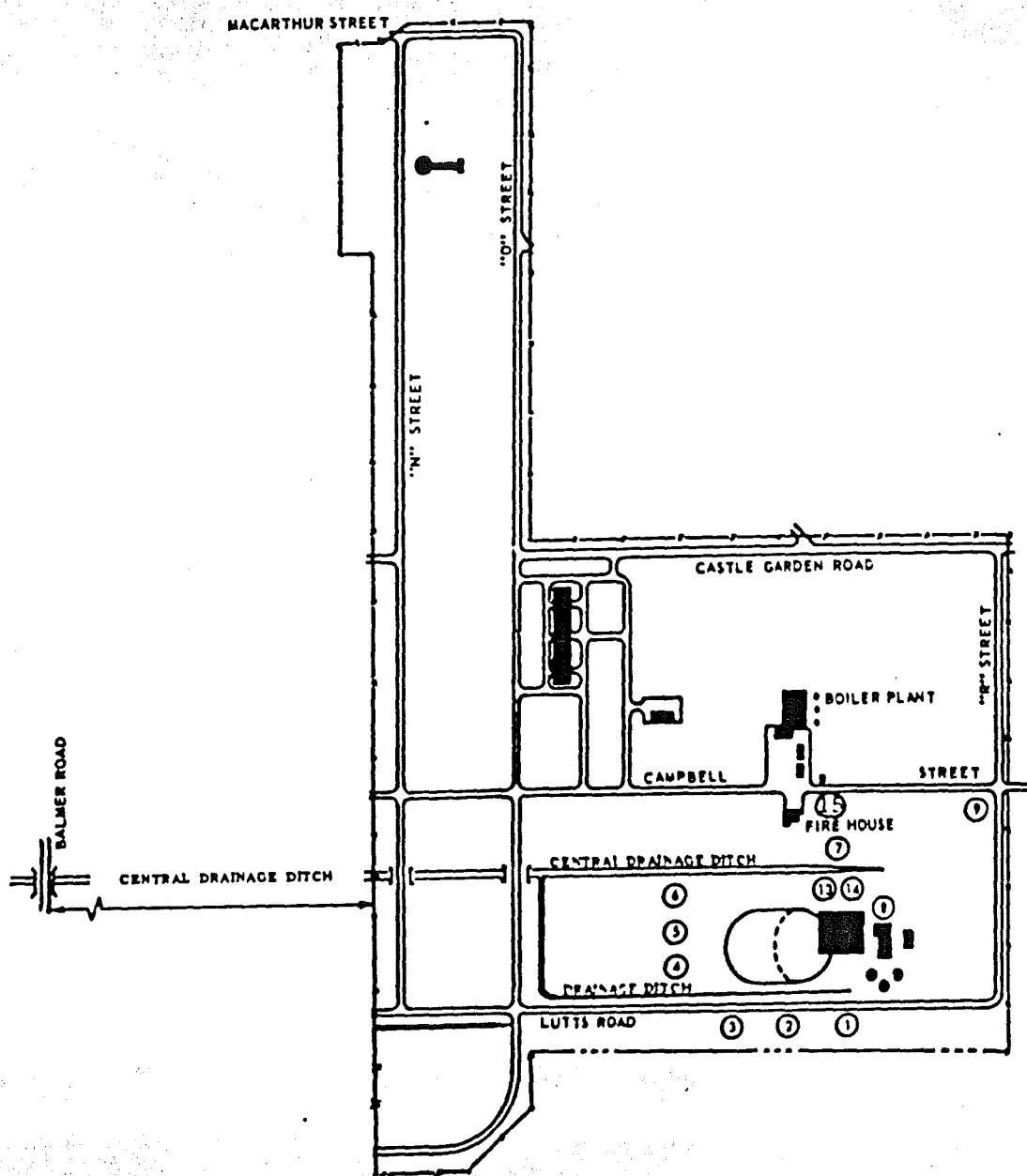


Figure 3.6. On-Site Groundwater Sampling Points

Source: Weidner, 1981

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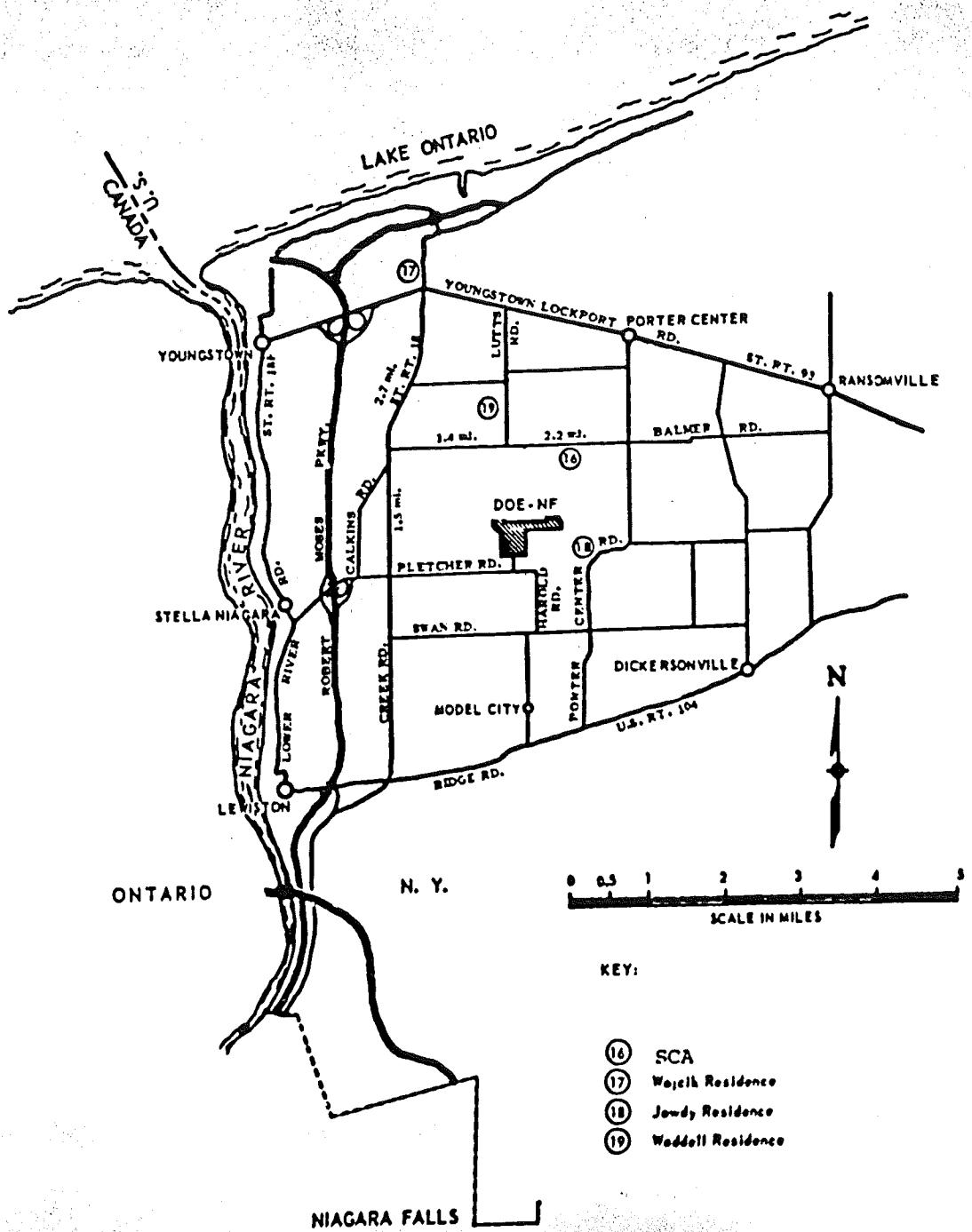


Figure 3.7. Off-Site Groundwater Sampling Locations

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with onsite and offsite locations shown in Figures 3.6 and 3.7, respectively. Groundwater is sampled at nine onsite wells around the R-10 residue storage area at a depth of approximately 28 feet (sampling points 1-9). Groundwater draining into two French drain outlets from under Building 411 is collected at points 13 and 14. Sampling point 15 is an onsite water tap served by a municipal supply while point 16 is an offsite water tap served by the same municipal main after it passes through the NFSS. Sampling points 17-19 are from offsite wells which are approximately 25 feet in depth.

Analyses were performed for total uranium, uranium-238 activity, radium-226, and gross alpha and gross beta activities by NLO. Currently, sampling is being conducted by Bechtel for total uranium and radium-226. The results of these analyses are presented in Tables 3.6-3.10. Nearly all observed radium-226 concentrations have been below the DOE guide limit of 30 pCi/l for water in uncontrolled areas. The only exception was in the samples collected from sampling points 2-4 and 6 in December 1974 (Table 3.8). The DOE concentration guide limit for uranium-238 in uncontrolled areas is 2 mg/l. Uranium concentrations have consistently been reported below this limit. Two exceptions were collections from sampling points 13 and 14 in June 1980 (Table 3.6).

In 1980, Battelle Columbus Laboratories (Anderson, et.al 1981) collected water samples from monitoring wells at the NFSS periphery and in the R-10 residue storage area. The location of these wells is shown in Figures 3.8 and 3.9. During May, June and August 1980, saturated zones (Table 3.11) were sampled and concentrations of total uranium and radium-226 in

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Table 3.6 NFSS Total Uranium (mg/l) in Groundwater

Date	Sampling Point																
	1	2	3	4	5	6	7	8	9	13	14	15	16	17	18	19	
Jun 1977	0.003	0.004	<0.003	<0.003	<0.003	0.003	0.220	0.004	0.004	0.460	0.620	<0.003					
Sep	0.007	<0.003	0.004	0.003	<0.003	0.007	0.004	<0.003	<0.003	0.100	0.120	<0.003					
Jan 1978	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.720	0.620	<0.003					
Apr	0.005	<0.003	0.004	<0.003	0.003	0.008	0.020	0.006	0.008	0.430	0.290	0.003					
Jun	0.005	0.007	<0.003	<0.003	0.008	0.006	0.004	0.008	0.009	0.780	0.640	<0.003					
Oct	0.004	0.003	0.007	0.009	0.006	0.005	0.004	0.004	<0.003	1.400	1.800	<0.003	<0.003	<0.003	<0.003	<0.003	
Jan 1979	0.009	0.008	0.005	<0.003	0.005	<0.003	0.010	0.003	0.007	1.000	1.000	<0.003					
Apr	0.020	0.003	<0.003	0.004	<0.003	<0.003	0.006	0.004	0.005	0.580	0.600	<0.003	<0.003	<0.003	0.003	<0.003	
Jun	<0.003	0.007	<0.003	<0.003	0.003	0.005	0.020	0.005	<0.003	1.100	1.000	<0.003					
Oct	0.005	0.003	0.008	0.005	0.004	0.003	0.005	0.010	0.007	0.230	0.210	<0.003					
Jan 1980	<0.003	0.004	<0.003	0.004	<0.003	<0.003	0.010	0.010	0.003	1.000	1.100	<0.003					
Mar	0.010	0.009	<0.003	<0.003	0.006	<0.003	0.009	0.005	0.003	0.900	0.750	<0.003	<0.003	<0.003	0.010	<0.003	
Jun	0.004	<0.003	0.008	0.003	0.004	<0.003	0.005	0.003	0.005	4.100	4.300	<0.003					
Oct	0.008	0.003	0.003	<0.003	<0.003	<0.003	0.007	<0.003	0.005	0.500	0.540	<0.003					
Jan 1981	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	1.400	1.400	<0.003					
Apr	<0.003	<0.003	0.003	0.003	0.004	<0.003	<0.003	<0.003	<0.003	0.260	0.260	<0.003					
Jun	<0.003	<0.003	<0.003	<0.003	<0.003	0.007	0.004	0.006	<0.003	0.080	0.090	<0.003					
Sep	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.003	<0.003	0.150	0.150	<0.005					
Jan 1982	<0.005	0.009	0.006	0.008	0.006	0.008	0.010	<0.003	0.006	0.240	0.210	<0.005	<0.005	0.013	<0.005	<0.005	
Apr	0.006	<0.003	<0.005	0.006	<0.003	<0.005	<0.005	<0.005	<0.005	0.110	<0.005	<0.005					
Jul	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005								

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Table 3.7  
NFSS U-238 Activity (pCi/l) in Groundwater

<u>Date</u>	<u>Sampling Point</u>															
	1	2	3	4	5	6	7	8	9	13	14	15	16	17	18	19
Jun 1977	1	1	1	1	1	1	73	1	1	153	206	1				
Sep	2	1	1	1	1	2	1	1	1	33	40	1				
Jan 1978	1	1	1	1	1	1	1	1	1	239	206	1				
Apr	2	1	1	1	1	3	7	2	3	143	93	1				
Jun	2	2	1	1	3	2	1	3	3	259	213	1				
Oct	1	1	2	3	2	2	1	1	1	465	598	1	1	1	1	1
Jan 1979	3	3	2	1	2	1	3	3	2	332	332	1				
Apr	7	1	1	1	1	1	2	1	2	193	200	1	1	1	2	1
Jun	1	2	1	1	1	2	7	2	1	366	333	1				
Oct	2	1	3	2	1	1	2	3	2	77	70	1				
Jan 1980	1	1	1	1	1	1	3	3	2	333	366	1				
Mar	3	3	1	1	2	1	3	2	1	300	250	1	1	1	3	1
Jun	1	1	3	1	1	1	2	1	2	1365	1432	1				
Oct	3	1	1	1	1	1	2	1	2	167	180	1				

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Table 3  
NFSS Radium-226 Activity (pCi/l) in Groundwater  
Sampling Point

Date	1	2	3	4	5	6	7	8	9	13	14	15	16	17	18	19
Apr 1972	0.9	1.4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.9	0.5	0.5
Jun	0.9	3.2	0.9	0.9	0.9	0.9	3.6	27.0	0.9	0.9	0.9	0.9	0.5			
Sep	0.9	1.4	0.9	0.9	0.5	0.9	1.4	7.2	0.5	0.9	0.9	0.9	0.5			
Dec	0.5	1.8	0.9	0.9	0.5	0.9	1.4	3.2	0.5	0.9	0.9	0.9	<0.5			
Mar 1973	2.3	0.9	0.5	0.5	0.5	0.9	0.5	4.1	<0.5	1.8	0.9	<0.5	0.9	<0.5	0.5	0.5
Jun	0.5	1.4	0.5	0.5	0.5	1.4	0.5	4.1	<0.5	1.4	1.4	1.4	<0.5			
Oct	0.5	0.9	0.5	<0.5	<0.5	1.8	0.5	2.7	<0.5	1.4	1.4	1.4	<0.5			
Dec	0.5	5.0	0.5	8.1	0.9	4.1	0.5	2.3	<0.5	1.8	2.3	<0.5				
Apr 1974	0.5	3.6	0.9	0.5	0.5	2.7	0.5	8.6	<0.5	1.4	0.9	<0.5	0.9	1.4	<0.5	0.5
Jun	0.5	0.9	0.5	0.5	<0.5	1.8	<0.5	2.7	<0.5	1.8	1.4	1.4	<0.5			
Sep	0.5	0.9	0.5	0.5	<0.5	0.5	0.5	2.3	<0.5	1.4	1.4	1.4	<0.5			
Dec	0.5	90.1	87.8	81.1	26.4	31.5	0.5	1.8	0.5	1.8	1.4	1.4	<0.5			
Apr 1975	0.5	5.4	3.2	1.4	0.9	6.3	0.5	2.3	<0.5	1.8	<0.5	<0.5	1.4	<0.5	<0.5	
Jul	0.5	0.9	0.9	0.5	0.5	1.8	0.5	2.3	<0.5	1.8	1.8	1.8	<0.5			
Sep	0.5	0.9	0.5	0.5	<0.5	1.4	2.3	0.5	<0.5	1.4	0.9	0.9	<0.5			
Dec	<0.5	0.5	0.5	<0.5	<0.5	1.4	MS	1.8	<0.5	2.3	1.8	1.8	<0.5			
Apr 1976	0.5	2.3	0.5	0.9	0.5	6.3	<0.5	0.5	<0.5	1.4	1.8	<0.5	<0.5	0.5	<0.5	<0.5
Jun	0.5	0.9	0.5	0.5	0.5	0.5	0.5	1.4	<0.5	2.3	2.3	2.3	<0.5			
Sep	2.7	3.2	0.5	<0.5	<0.5	3.6	0.5	0.5	3.2	1.4	0.9	0.9	<0.5			
Jan 1977	0.5	0.5	1.4	<0.5	<0.5	1.8	MS	1.4	<0.5	1.4	1.4	1.4	<0.5			
Apr	0.5	0.9	0.5	0.9	<0.5	3.6	0.9	1.4	0.9	2.3	2.3	2.3	<0.5	<0.5	<0.5	
Jun	0.5	0.9	0.9	<0.5	0.5	2.3	0.5	1.4	<0.5	2.3	1.8	1.8	<0.5			
Sep	0.5	0.9	0.5	0.5	0.5	0.9	<0.5	0.5	0.5	1.4	0.9	0.9	<0.5			
Jan 1978	0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	2.3	1.8	1.8	<0.5			
Apr	5.9	0.5	2.7	0.9	<0.5	10.4	0.5	<0.5	0.5	2.3	2.3	2.3	<0.5			
Jun	<0.5	0.5	0.5	0.5	<0.5	0.9	0.5	<0.5	0.5	2.7	2.7	2.7	<0.5			
Oct	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.8	2.8	2.8	<0.5	<0.5	<0.5	<0.5
Jan 1979	4.5	0.5	6.8	0.5	<0.5	<0.5	1.4	<0.5	<0.5	3.2	2.7	2.7	<0.5			
Apr	3.6	0.5	0.5	0.5	<0.5	0.5	2.3	0.5	0.5	4.1	3.4	<0.5	<0.5	<0.5	<0.5	
Jun	0.5	0.9	0.5	0.5	<0.5	1.4	1.4	<0.5	0.5	3.2	2.7	2.7	0.5			
Oct	<0.5	<0.5	4.1	0.5	1.4	<0.5	0.5	<0.5	0.5	0.9	0.9	0.9	<0.5			
Jan 1980	<0.5	<0.5	0.5	0.5	0.5	<0.5	1.4	1.4	0.5	3.2	3.2	3.2	<0.5			
Mar	1.4	1.4	1.4	<0.5	<0.5	<0.5	1.4	0.5	<0.5	2.7	3.2	<0.5	0.5	<0.5	<0.5	
Jun	0.9	0.5	0.5	0.5	<0.5	0.5	<0.5	<0.5	0.5	1.8	1.8	1.8	<0.5			
Oct	0.5	0.5	2.3	<0.5	0.9	0.9	1.4	<0.5	2.7	2.7	5.0	5.0	<0.5			
Jan 1981	0.5	<0.5	0.5	<0.5	<0.5	0.5	0.9	<0.5	<0.5	2.7	2.7	2.7	<0.5			
Apr	0.5	0.5	1.4	<0.5	0.5	0.9	1.4	0.5	0.5	3.6	2.3	<0.5	<0.5	0.5	<0.5	
Jun	0.5	0.5	13.1	<0.5	<0.5	1.4	0.9	<0.5	0.5	0.9	0.9	0.9	<0.5			
Sep	1.4	0.5	4.5	0.5	0.5	1.8	0.5	0.9	0.5	0.9	0.9	0.9	<0.5			
Jan 1982	0.2	0.4	1.1	0.8	1.0	0.4	0.5	0.3	0.2	1.1	2.1	0.1				
Apr	<0.1	0.2	0.3	0.1	0.2	0.1	0.3	0.3	0.2	0.4	0.3	0.2	0.1	0.3	0.1	0.4
Jul	0.3	0.2	0.3	0.3	0.1	0.2	<0.1	0.2	<0.1	0.5	0.7	0.4				

NS No Sample

Source: WLO Inhouse Report, Environmental Monitoring at the Mississ. Falls Discharge Site, Site Correspondence to E. W. Mautz from J. F. Englert (June 30, 1981).

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Table 3.9 MFSE Gross Alpha (pCi/l) in Groundwater

<u>Date</u>	<u>Sampling Point</u>																	
	1	2	3	4	5	6	7	8	9	13	14	15	16	17	18	19		
Apr 1972	4.5	22.5	4.5	4.5	4.5	13.5	4.5	4.5	1035	855	315	4.5	18	4.5	4.5	4.5		
Jun	18	9	4.5	9	4.5	49.5	166.5	27	9	94.5	90	4.5						
Sep	4.5	4.5	9	9	18	4.5	63	27	9	67.5	58.5	4.5						
Dec	4.5	22.5	9	4.5	4.5	4.5	45	4.5	4.5	400.5	450	4.5						
Mar 1973	9	9	<4.5	<4.5	<4.5	<4.5	103.5	9	<4.5	351	297	<4.5	18	<4.5	<4.5	<4.5		
Jun	13.5	<4.5	9	<4.5	9	9	157.5	9	<4.5	1215	1260	4.5						
Oct	<4.5	<4.5	9	22.5	13.5	22.5	99	18	22.5	162	184.5	<4.5						
Dec	<4.5	27	13.5	31.5	4.5	18	58.5	<4.5	<4.5	585	292.5	<4.5						
Apr 1974	4.5	13.5	9	13.5	9	18	49.5	<4.5	4.5	310.5	297	<4.5	9	4.5	4.5	4.5		
Jun	<4.5	<4.5	<4.5	<4.5	<4.5	27	180	18	36	1710	1485	<4.5						
Sep	<4.5	<4.5	13.5	9	18	13.5	31.5	18	13.5	720	765	<4.5						
Dec	<4.5	1012.5*	571.5*	1260*	675*	459*	135	9	4.5	945	945	<4.5						
Apr 1975	<4.5	18	18	4.5	13.5	27	49.5	4.5	9	585	585	<4.5	<4.5	<4.5	<4.5	<4.5		
Jul	13.5	4.5	4.5	4.5	18	4.5	31.5	13.5	3.5	355.5	495	<4.5						
Sep	13.5	9	<4.5	4.5	<4.5	4.5	40.5	<4.5	9	103.5	81	<4.5						
Dec	4.5	4.5	4.5	4.5	4.5	4.5	MS	4.5	4.5	585	855	4.5						
Apr 1976	<4.5	9	4.5	4.5	<4.5	63	81	31.5	13.5	265.5	27	4.5	9	<4.5	4.5	4.5		
Jun	13.5	4.5	4.5	<4.5	67.5	40.5	85.5	18	13.5	126	148.5	<4.5						
Sep	18	9	4.5	9	18	9	135	9	22.5	85.5	99	<4.5						
Jan 1977	4.5	9	4.5	<4.5	<4.5	<4.5	MS	9	9	810	810	<4.5						
Apr	9	9	4.5	40.5	18	22.5	234	36	9	112.5	153	<4.5	<4.5	4.5	4.5	<4.5		
Jun												2.7						
Sep												1.4						
Jan 1978												1.4						
Apr												1.4						
Jun												2.7						
Oct												0.9	<0.9	<0.9	6.3	0.9		
Jan 1979												0.5						
Apr												0.9	0.9	<0.9	7.2	<0.9		
Jun												2.3						
Oct												1.8						
Jan 1980												2.3						
Mar												<0.9	<0.9	0.9	13.5	1.4		
Jun												0.9						
Oct												<1.8						
Jan 1981												<1.8						
Apr												<1.8	1.4	<0.9	13.5	<0.9		
Jun												<1.8						
Sep												<1.8						
Jan 1982	<10	<10	<10	<10	<10	<10	<10	<10	<10	180	170	<10						
Apr**	<8	<60	<8	<17	<8	<9	<14	<10	<18	79	60	<9	9	<9	<10	<15		

\* Average Value

\*\* Last sampling for Gross Alpha (pCi/l) by Bechtel National, Inc.

MS No Sample

3-21

01105

09465

Table 3.10

## NFSS Gross Beta (pCi/l) in Groundwater

Sampling Point

Date	1	2	3	4	5	6	7	8	9	13	14	15	16	17	18	19	
Apr 1972	13.5	22.5	13.5	13.5	13.5	54	13.5	13.5	270	270	135	13.5	18.0	13.5	13.5	13.5	
Jun	36	36	54	45	13.5	18	67.5	31.5	13.5	36	45	18					
Sep	22.5	13.5	31.5	40.5	13.5	13.5	36	13.5	18	13.5	18	13.5					
Dec	13.5	13.5	18	45	13.5	18	31.5	13.5	13.5	117	112.5	13.5					
Mar 1973	<13.5	13.5	<13.5	<13.5	<13.5	<13.5	<13.5	22.5	<13.5	13.5	76.5	63	<13.5	<13.5	<13.5	<13.5	
Jun	<13.5	40.5	<13.5	<13.5	<13.5	<13.5	<13.5	58.5	27	13.5	675	400.5	27				
Oct	<13.5	45	18***	18	<13.5***	<13.5***	72	18	<13.5	58.5	49.5	<13.5					
Dec	13.5	<13.5	<13.5	13.5	<13.5	<13.5	31.5	<13.5	<13.5	153	76.5	<13.5					
Apr 1974	18	<13.5	22.5	<13.5	<13.5	22.5	22.5	22.5	13.5	40.5	72	18	<13.5	<13.5	<13.5	18	
Jun	<13.5	<13.5	40.5	13.5	<13.5	<13.5	<13.5	31.5	<13.5	85.5	495	495	<13.5				
Sep	<13.5	13.5	45	<13.5	22.5	31.5	<13.5	13.5	<13.5	189	202.5	<13.5					
Dec	<13.5	130.5*	103.5*	220.5*	195.8*	101.3*	31.5	<13.5	18	229.5	243	<13.5					
Apr 1975	<13.5	<13.5	<13.5	<13.5	18	<13.5	18	<13.5	22.5	202.5	157.5	<13.5	<13.5	<13.5	<13.5		
Jul	13.5	<13.5	36	22.5	<13.5	<13.5	18	18	<13.5	130.5	90	<13.5					
Sep	13.5	<13.5	<13.5	31.5	<13.5	<13.5	27	13.5	<13.5	81	45	<13.5					
Dec	22.5	<13.5	<13.5	<13.5	<13.5	<13.5	<13.5	MS	<13.5	13.5	180	139.5	<13.5				
Apr 1976	36	36	36	13.5	<13.5	22.5	31.5	49.5	22.5	99	112.5	<13.5	<13.5	<13.5	<13.5	18	
Jun	<13.5	<13.5	<13.5	<13.5	<13.5	36	31.5	36	22.5	<13.5	63	40.5	<13.5				
Sep	40.5	13.5	<13.5	<13.5	<13.5	18	36	<13.5	27	45	63	<13.5					
Jan 1977	<13.5	<13.5	<13.5	<13.5	<13.5	<13.5	MS	<13.5	<13.5	139.5	234	<13.5					
Apr	<13.5	<13.5	40.5	<13.5	<13.5	18	36	<13.5	<13.5	72	<13.5	<13.5	<13.5	<13.5	31.5		
Jun											9						
Sep											4.5						
Jan 1978											13.5						
Apr											9						
Jun											4.5						
Oct											4.5	9	9	49.5	4.5		
Jan 1979											4.5						
Apr											4.5	4.5	4.5	4.5	4.5		
Jun											9						
Oct											4.5						
Jan 1980											4.5						
Mar											4.5	4.5	4.5	13.5	180		
Jun											4.5						
Oct											13.5						
Jan 1981											9						
Apr											13.5	13.5	4.5	18	9		
Jun											9						
Sep											4.5						
Jan 1982	<6.1	<6.1	<6.1	<6.1	22	<6.1	<6.1	7.1	6.1	77	64	<6.1					
Apr**	<8	<10	<8	<7	<8	<7	<7	<10	<10	200	150	<12	<12	<12	17	<7	

\* Average Value

\*\* Last sampling for Gross Beta (pCi/l) by Bechtel National, Inc.

\*\*\* Recheck Values

MS No Sample

01108

03-45

03485

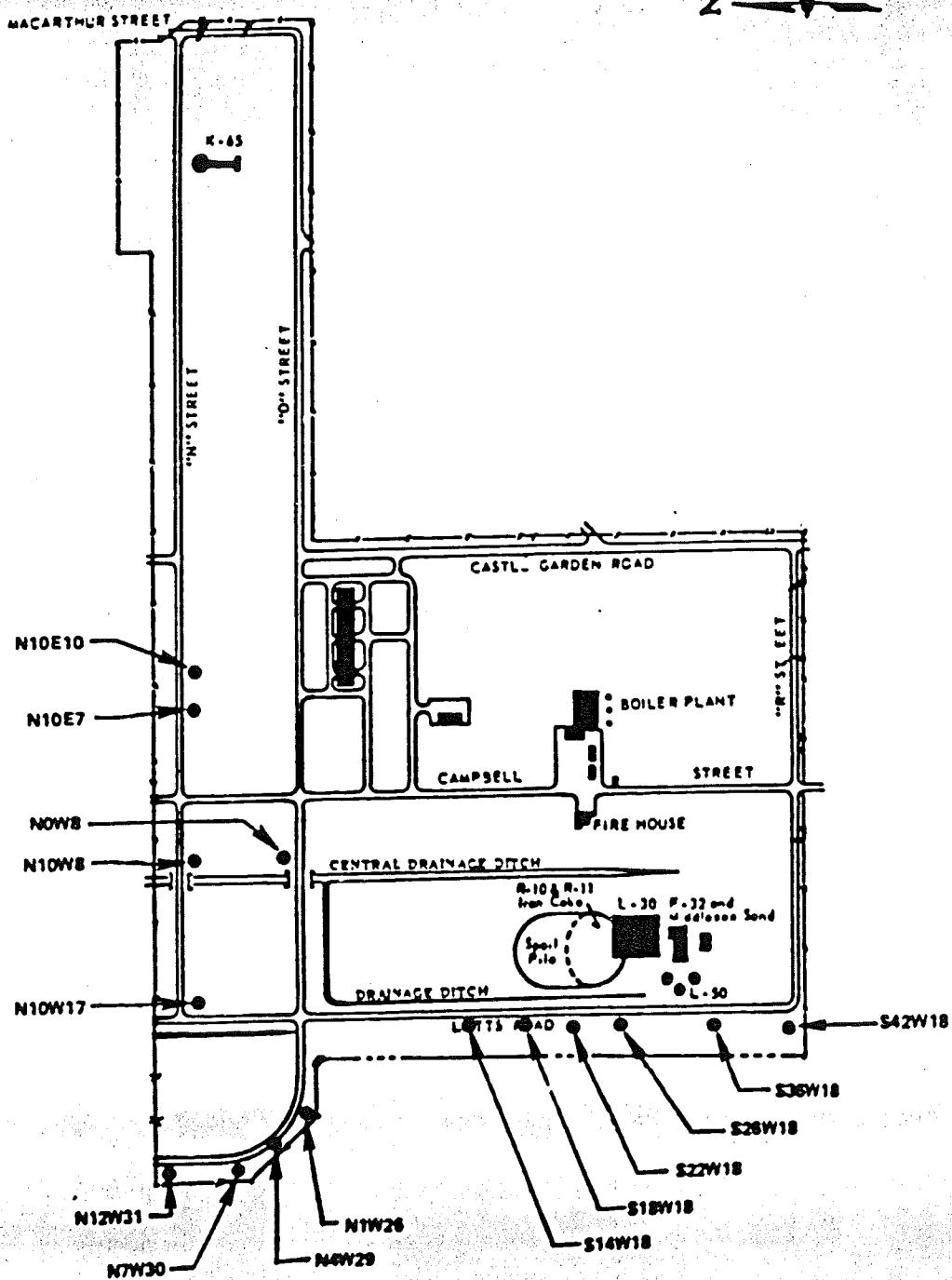


FIGURE 3.8. LOCATION OF PERIMETER WELLS

Source: Anderson et al., 1981

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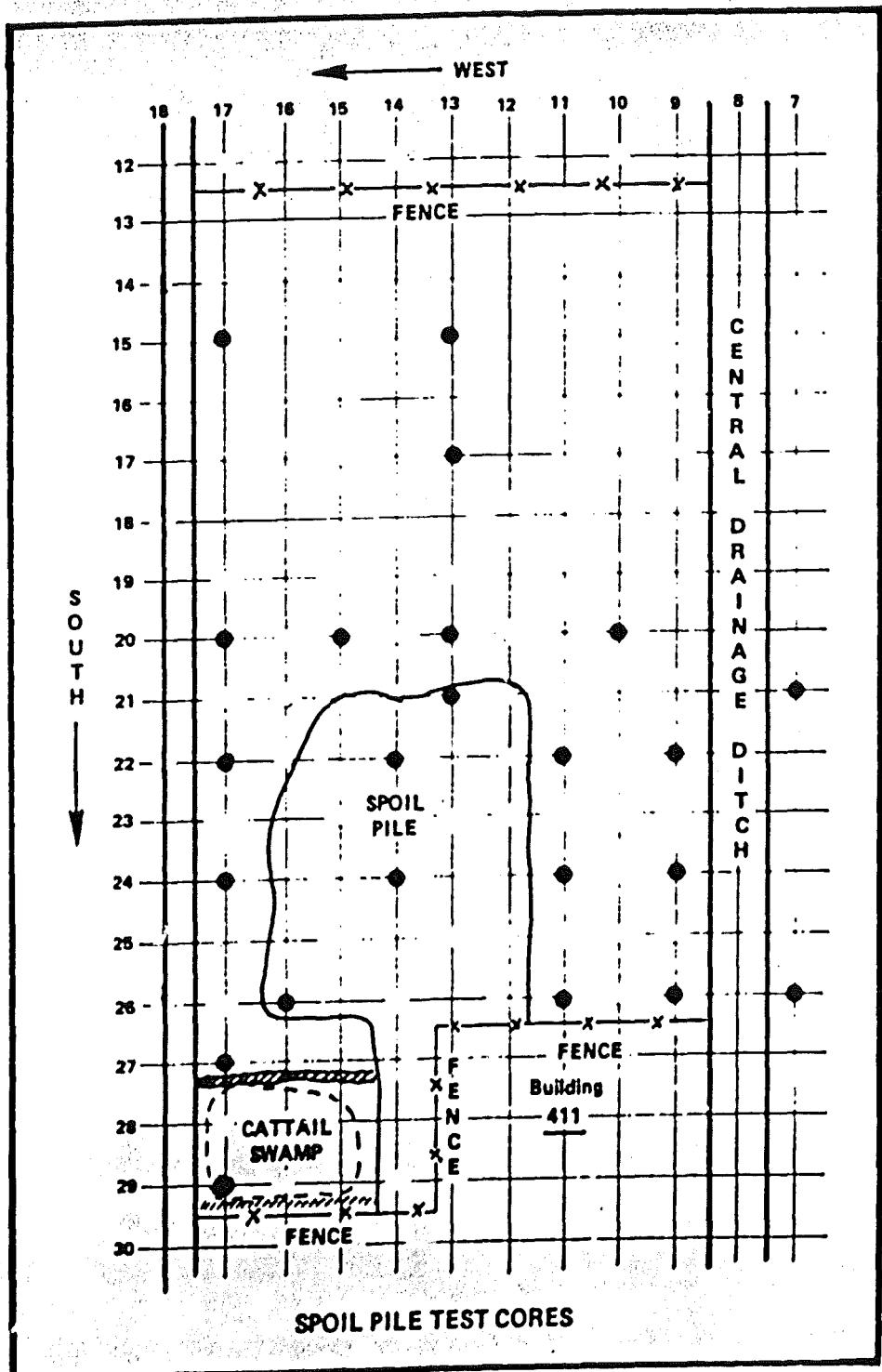


FIGURE 3.9. LOCATION OF WELLS ON THE R-10 RESIDUE  
STORAGE AND SPOIL PILE AREA

Source: Anderson et al., 1981

03465

Table 3-11.  
Depths of Saturated Zones and Wells at the NFSS

Location	Saturated Zones (ft)	Depth of Well (ft)
<b>Periphery</b>		
N10.0 E7.0	14-16	20
N10.0 E10.0	4-20	20
N 0 W8.0	14-36	42 (bedrock)
N1.0 W26.0	>20	20
N4.0 W29.0	6-20	20
N7.0 W30.0	4-20	20
N10.0 W8.0	16-26	36 (bedrock)
N10.0 W17.0	14-34	36 (bedrock)
N12.0 W31.0	10-22	24
S14.0 W18.0	14-36	40
S18.0 W18.0	8-36	40
S21.0 W7.0	--	--
S22.0 W18.0	12-16    18-20    24-28    30-32    36-40	40
S26.0 W7.0	12-18	34
S26.0 W18.0	6-10    32-36	36
S36.0 W18.0	--	--
S42.0 W18.0	8-22	22
<b>R-10 Area</b>		
S15.0 W13.0	14-16	20
S15.0 W17.0	8-20	20
S17.0 W13.0	6-20	20
S20.0 W10.0	>20	20
S20.0 W13.0	6-10    16-22	24
S20.0 W15.0	6-14    16-20	20
S20.0 W17.0	4-28	34
S21.0 W13.0	18-22	28
S22.0 W9.0	12-14	20

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TABLE 3.11 (Cont'd)

S22.0 W11.0	8-16	20
S22.0 W14.0	0-4 18-20	30
S22.0 W17.0	8-18	26
S24.0 W9.0	8-10 16-20	20
S24.0 W11.0	12-14	20
S24.0 W14.0	10-16	20
S24.0 W17.0	6-20	26
S26.0 W9.0	>20	20
S26.0 W11.0	4-8	20
S26.0 W16.0	0-2 6-30	30
S27.0 W17.0	8-22	26
S29.0 W17.0	20-22	28

Source: Anderson et al. (1981)

### 3.0 Ground Water Hydrology

#### 3.1 Characteristics of the Local Ground Water System

Within Niagara County, ground water is present within both Pleistocene surficial deposits and the underlying Silurian and Ordovician bedrock. The more productive aquifers are generally found in bedrock formations, although soil deposits are capable of supplying adequate ground water for domestic uses.

The bedrock beneath the NFSS is the Queenston Formation. The Queenston Formation consists of shales and siltstones which are generally less permeable than other surrounding bedrock aquifers. The major zone of ground water movement is the weathered and fractured zone located in the upper few feet of the formation. Well yields from the Queenston shale-siltstone are typically less than 7 gpm; however, in unweathered portions of the formation, well yields are estimated to be less than 1 gpm (Johnson 1964).

Soil deposits within Niagara County primarily consist of clays or silts with occasional sand and gravel lenses. These deposits are not considered an important source of water because of their low permeability and limited areal extent.

The two most significant water-bearing zones within the soil overburden onsite include intermittent brown sand lenses found in the brown glacial clay and the brown sand-silt with gravel found beneath the gray lacustrine clay and above the glacial till. The intermittent sand lenses are not considered a continuous aquifer. They probably represent a series of isolated lenses or a series of lenticular stream channel deposits.

Deep soil monitoring wells (approximately 50 feet in depth) are installed at the NFSS in the intermittent brown sand lenses. Shallow soil monitoring wells (29.6 - 31.5 feet in depth) are sampled in the sand-silt zone. The location of these wells is indicated in Figure 3.1. Water levels from the deep and shallow aquifers are listed in Tables 3.1 and 3.2, respectively. Contours of the piezometric surface for these units are presented in Figures 3.2 and 3.3.

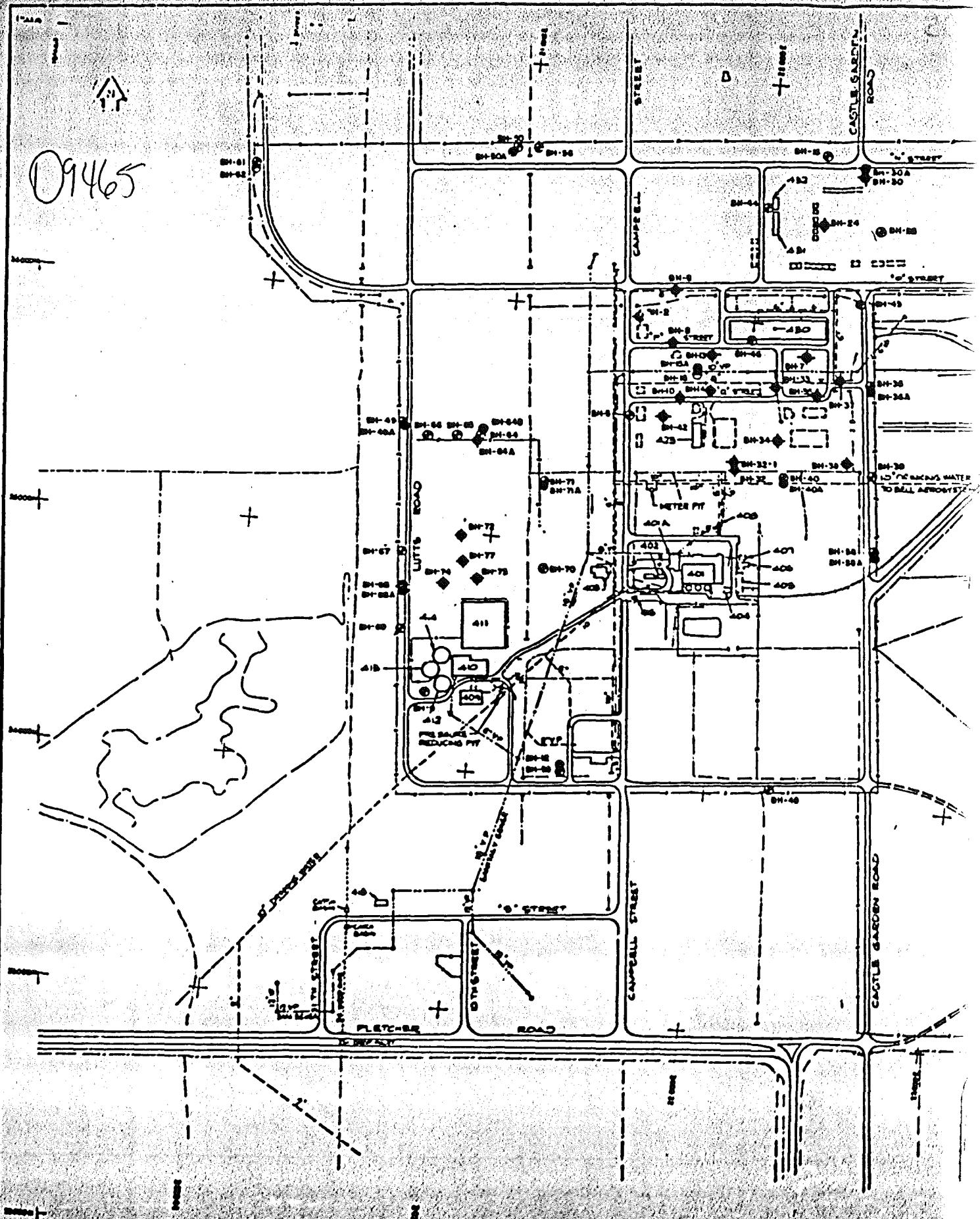
The upper brown sand unit is recharged by percolation of meteoric water. The lower gravelly sand-silt unit is confined by the overlying gray clay and the underlying red till. Recharge of this lower unit is by leakage through the overlying sediments and by upward migration of connate water from the underlying Queenston Formation, especially where the red till is not present.

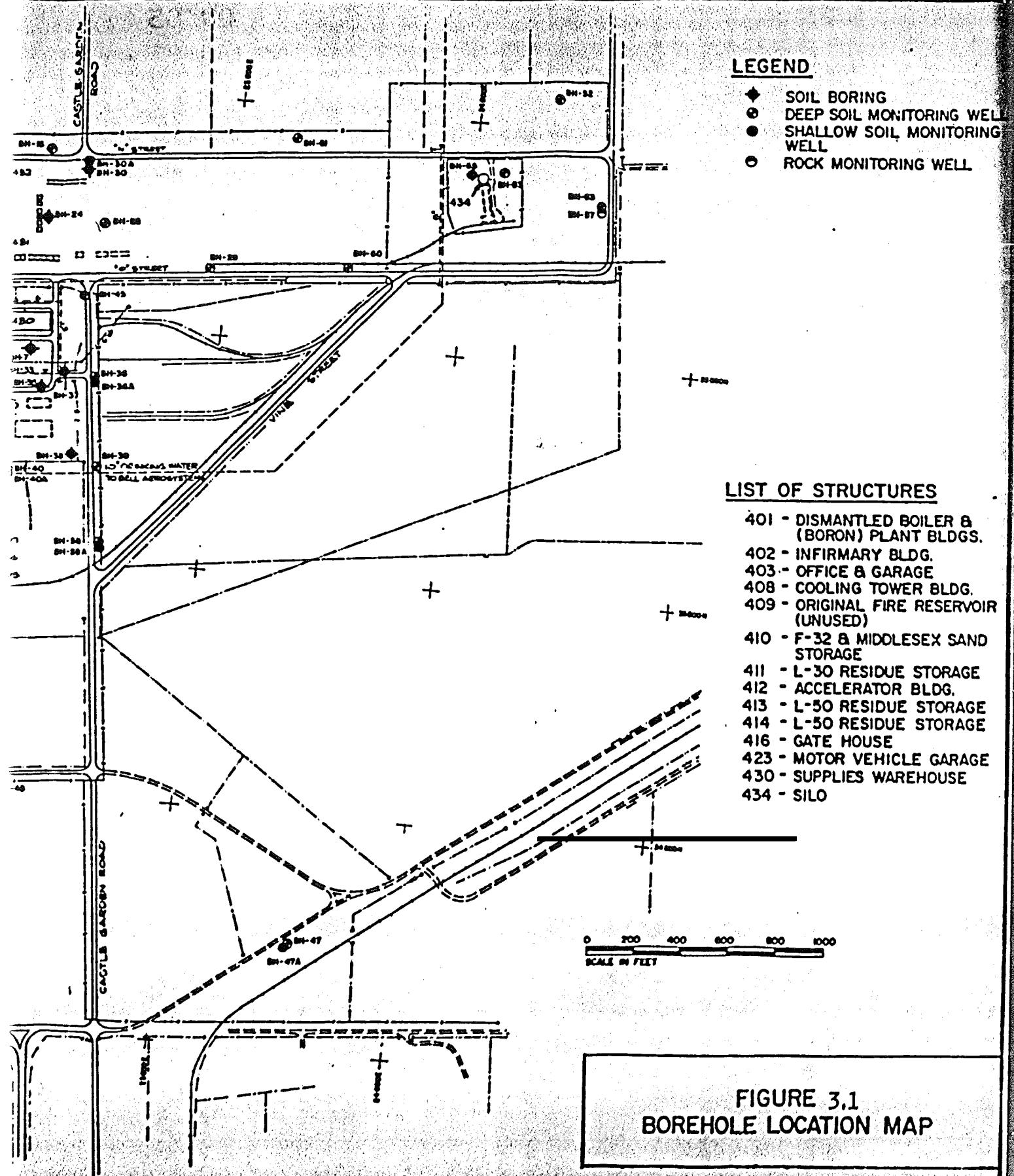
Ground water discharges to the Niagara River and Lake Ontario both of which are hydrologic sinks. In the NFSS area, the movement is generally to the northwest. Local discharge is also to streams crossing the Ontario Plain.

### 3.2 Aquifer Characteristics

Aquifers of limited extent and yield are present in both the non-indurated deposits and bedrock beneath the NFSS.

The discontinuous brown sands are present within the glacially derived brown to red-brown clay. These sands are not considered a true aquifer. They range from 1 to 9 feet thick. No information is available on the hydraulic conductivity or yield of these sand deposits. Variable head field permeability tests were conducted in these sands. Permeabilities ranged from  $2 \times 10^{-5}$  to  $2 \times 10^{-6}$  cm/sec (Acres American, Inc. 1981).





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TABLE 3.1.

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The name of the author I have omitted here will be mentioned by most lawmen, all will consider it a privilege to be associated with him.

Source: Acres American, Inc. 1981.

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TABLE 3.14. (Continued)

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ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
PRASEODYMIUM	0					17	3.45E-03	4.45E-03		
CERIUM	6	2.16E-03	4.68E-04	1.73E-03	3.03E-03	11	1.73E-03	2.04E-03		
LANTHANUM	0					17	3.45E-03	4.45E-03		
BARIUM	17	1.19E-01	8.65E-02	2.30E-02	2.96E-01	0				
CESIUM	0					17	5.19E-04	9.28E-04		
IODINE	12	5.76E-02	5.52E-02	1.73E-02	1.73E-01	5	8.63E-03	4.38E-02		
TELLURIUM	0					17	1.15E-02	1.48E-02		
ANTIMONY	0					17	3.45E-03	4.45E-03		
TIN	3	1.49E-01	2.25E-01	1.28E-02	4.09E-01	14	1.15E-02	2.43E-02		
INDIUM	0					17	1.73E-03	2.22E-03		
CADMIUM	0					17	3.45E-02	1.19E-01		
SILVER	0					17	1.73E-03	4.45E-03		
PALLADIUM	0					17	1.15E-02	2.48E-02		
RHODIUM	0					17	3.45E-03	7.41E-03		
RUTHENIUM	0					17	1.15E-02	1.48E-02		
MOLYBDENUM	6	1.24E-02	5.17E-03	6.41E-03	1.86E-02	11	5.76E-03	1.32E-02		
NIOBIUM	0					17	3.67E-03	6.19E-02		
ZIRCONIUM	0					17	5.76E-03	1.15E-02		
YTTRIUM	0					17	2.31E-03	4.39E-03		
SIRONTIUM	17	4.53E+00	3.41E+01	4.91E-01	1.04E+01	0				
RUBIDIUM	17	7.81E-03	7.66E-03	6.91E-04	2.49E-02	0				
BROMINE	17	7.31E-01	5.26E-01	9.76E-02	1.7CE+00	0				
SELENIUM	0					17	4.03E-03	3.11E-02		
ARSENIC	3	1.20E-02	6.43E-03	5.76E-03	1.86E-02	14	1.95E-03	2.19E-02		
GERMANIUM	0					17	6.12E-03	4.3AE-02		

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TABLE 3.14. (Continued)

ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
GALLIUM	1	3.07E-03	.E+00	3.07E-03	3.07E-03	16	2.88E-03	3.71E-03		
ZINC	17	1.43E+00	2.16E+00	1.15E-01	7.41E+00	0				
COPPER	17	5.36E-02	7.69E-02	6.06E-03	3.19E-01	0				
NICKEL	3	2.27E-02	1.29E-02	1.24E-02	3.71E-02	14	5.76E-03	1.46E-02		
COBALT	6	1.41E-02	2.45E-02	1.24E-03	6.39E-02	11	5.77E-04	1.15E-03		
IRON	17	3.54E-01	8.21E-01	1.48E-02	3.46E+00	0				
MANGANESE	17	9.12E-01	1.17E+00	8.85E-02	3.94E+00	0				
CHROMIUM	17	3.90E-02	1.80E-02	7.66E-03	7.93E-02	0				
VANADIUM	0					17	6.91E-04	4.45E-03		
TITANIUM	1	1.92E-01	.E+00	1.92E-01	1.92E-01	16	1.15E-02	5.76E-02		
SCANDIUM	0					17	1.15E-02	2.72E-02		
CALCIUM	17	5.89E+02	5.16E+02	1.15E+02	2.22E+03	0				
POTASSIUM	17	1.04E+01	8.87E+00	1.2AE+00	3.40E+01	0				
CHLORINE	17	3.61E+00	7.90E+00	2.60E-02	3.33E+01	0				
SULPHUR	17	6.95E+02	5.31E+02	2.45E+02	2.22E+03	0				
PHOSPHORUS	17	2.85E-02	4.02E-02	4.84E-03	1.78E-01	0				
SILICON	17	9.59E+00	1.01E+01	3.20E+00	4.42E+01	0				
ALUMINUM	11	1.24E-01	7.44E-02	3.45E-02	2.31E-01	6	1.97E-02	8.76E-02		
MAGNESIUM	17	3.39E+02	1.70E+02	5.76E+01	7.41E+02	0				
SODIUM	17	2.62E+02	1.10E+02	7.69E+01	5.11E+02	0				
FLUORINE	16	1.30E-01	1.03E-01	2.30E-02	2.96E-01	1	2.47E-02	2.47E-02		
BORON	17	1.15E-01	9.72E-02	6.40E-03	3.96E-01	0				
BERYLLIUM	0					17	1.15E-04	1.48E-04		
LITHIUM	17	2.12E-01	1.16E-01	6.91E-02	4.45E-01	0				

\*N = NUMBER OF VALUES OUT OF 17 SAMPLES.

\*\*DL = DETECTION LIMITS FOR AN ELEMENT ON A SAMPLE-BY-SAMPLE BASIS.

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TABLE 3.15. SUMMARY RESULTS OF SPARK SOURCE MASS SPECTROSCOPY OF SATURATED ZONE WATER SAMPLES FROM THE R-10 RESIDUE AREA

ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
URANIUM	9	1.52E-01	3.81E-01	5.73E-03	1.16E+00	9	5.32E-03	8.95E-03		
THORIUM	0					18	1.06E-02	1.79E-02		
BISMUTH	0					19	5.32E-03	8.95E-03		
LEAD	9	1.60E-02	5.20E-03	1.06E-02	2.50E-02	9	1.15E-02	1.40E-02		
THALLIUM	1	2.01E-01	.E+00	2.81E-01	2.81E-01	17	1.15E-02	5.00E-02		
MERCURY	0					18	2.13E-01	3.58E-01		
GOLD	0					18	5.32E-03	8.95E-03		
PLATINUM	0					18	1.06E-02	1.79E-02		
IRIDIUM	0					19	1.06E-02	1.79E-02		
OSMIUM	0					18	2.13E-02	3.58E-02		
RHENIUM	1	1.60E-01	.E+00	1.60E-01	1.60E-01	17	1.06E-02	1.79E-02		
TUNGSTEN	0					18	1.06E-02	1.79E-02		
TANTALUM	0					18	5.33E-02	6.79E-01		
HAFNIUM	0					18	1.06E-02	1.79E-02		
LUTETIUM	0					18	5.32E-03	8.95E-03		
YTTERBIUM	0					18	1.06E-02	1.79E-02		
THULIUM	0					18	5.32E-03	8.95E-03		
ERBIUM	0					18	1.06E-02	1.79E-02		
HOLMIUM	0					18	5.32E-03	8.95E-03		
DYSPROSIUM	0					18	1.06E-02	1.79E-02		
TERBIIUM	0					18	3.20E-03	5.37E-03		
GADOLINIUM	0					18	1.06E-02	1.79E-02		
EUROPIUM	0					18	1.06E-02	1.79E-02		
SAMARIUM	0					18	1.06E-02	1.79E-02		
NEODYMIUM	0					18	3.20E-02	5.37E-02		

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TABLE 3.15. (Continued)

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ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
PRASEODYMIUM	0					15	3.20E-03	5.37E-03		
CERIUM	11	2.03E-03	5.13E-04	1.72E-03	3.46E-03	7	1.60E-03	2.69E-03		
LANTHANUM	0					18	3.20E-03	5.37E-03		
BARIUM	18	1.13E-01	1.07E-01	2.38E-02	3.69E-01	0				
CESIUM	0					18	5.22E-04	8.98E-04		
IODINE	9	3.53E-02	9.80E-03	1.74E-02	4.79E-02	9	5.53E-03	3.84E-02		
TELLURIUM	3					18	1.06E-02	1.79E-02		
ANTIMONY	0					19	3.20E-03	5.37E-03		
TIN	2	5.53E-02	1.04E-02	4.79E-02	6.26E-02	16	1.06E-02	2.35E-02		
INDIUM	1	7.18E-03	.E+00	7.18E-03	7.18E-03	17	1.60E-03	2.69E-03		
CALCIUM	0					18	3.20E-02	1.13E-01		
SILVER	0					18	1.60E-03	4.21E-03		
PALLADIUM	0					18	1.06E-02	3.19E-02		
RHODIUM	0					18	3.20E-03	7.02E-03		
RUTHENIUM	0					18	5.32E-03	1.79E-02		
MOLYBDENUM	7	9.51E-03	5.62E-03	5.73E-03	1.74E-02	11	5.32E-03	8.95E-03		
NIOBIUM	0					18	3.20E-03	7.98E-02		
ZIRCONIUM	1	5.33E-02	.E+00	5.33E-02	5.33E-02	17	5.73E-03	1.40E-02		
YTTRIUM	0					18	2.35E-03	5.37E-03		
STRONTIUM	18	3.15E+00	2.83E+00	2.13E-01	1.12E+01	0				
RUBIDIUM	18	5.23E-03	6.12E-03	6.39E-04	2.01E-02	0				
BROMINE	18	5.23E-01	5.74E-01	7.99E-02	2.42E+00	0				
SELENIUM	1	1.04E+00	.E+00	1.04E+00	1.04E+00	17	6.01E-03	6.12E-02		
ARSENIC	5	7.75E-03	7.53E-03	1.74E-03	1.91E-02	13	1.60E-04	2.15E-02		
GERMANIUM	0					18	5.73E-03	4.79E-02		

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TABLE 3.15. (Continued)

ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
GALLIUM	6					18	1.60E-03	2.11E-02		
ZINC	18	1.29E+00	1.55E+00	1.23E-02	6.41E+00	0				
COPPER	18	1.92E-02	1.42E-02	2.96E-03	6.15E-02	0				
NICKEL	2	4.42E-03	2.21E-03	2.86E-03	5.99E-03	16	5.93E-03	4.43E-02		
COBALT	5	1.91E-02	3.40E-02	1.25E-03	7.98E-02	13	5.33E-04	8.95E-04		
IRON	18	6.00E-01	7.49E-01	3.13E-02	2.65E+00	0				
MANGANESE	18	1.09E+00	1.40E+00	1.67E-02	4.79E+00	0				
CHROMIUM	18	4.60E-02	3.64E-02	3.44E-03	1.11E-01	0				
VANADIUM	0					18	3.44E-04	4.79E-03		
TITANIUM	0					18	1.16E-02	1.15E-01		
SCANDIUM	0					18	1.06E-02	3.19E-02		
CALCIUM	18	5.81E+02	4.83E+02	2.66E+01	1.60E+03	0				
POTASSIUM	18	5.84E+00	5.21E+01	1.18E+00	2.39E+01	0				
CHLORINE	18	7.04E-01	9.49E-01	3.19F-02	4.11E+00	0				
SULPHUR	18	4.74E+02	5.53E+02	1.19E+01	1.97E+03	0				
PHOSPHORUS	18	2.22E-02	1.96E-02	4.58E-03	6.33E-02	0				
SILICON	18	9.18E+00	1.10E+01	4.79E-01	4.76E+01	0				
ALUMINUM	13	1.13F-01	9.25E-02	3.49E-02	2.87E-01	5	6.93E-02	1.07E-01		
MAGNESIUM	18	2.17E+02	1.38E+02	1.07E+02	6.62E+02	0				
SODIUM	18	1.58E+02	1.14E+02	1.05F-01	4.03E+02	0				
FLUORINE	18	6.00F-07	6.57F-07	2.11F-07	2.64F-01	2	2.37F-07	3.58E-07		
BORON	18	1.08E-01	1.12E-01	5.91E-03	4.76E-01	0				
BERYLLIUM	0					18	1.06E-24	1.79E-04		
LITHIUM	18	1.73E-01	1.27E-01	6.34E-02	4.79E-01	0				

\* N = NUMBER OF VALUES OUT OF 18 SAMPLES.

\*\* DL = DETECTION LIMITS FOR AN ELEMENT ON A SAMPLE-BY-SAMPLE BASIS.

Source: Anderson et al., 1981

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Table 3.16.  
pH AND ALKALINITY DATA FOR GROUNDWATER AT NFSS

Well <sup>b</sup> Number	Type of Well	Starting pH	Alkalinity (ppm)		
			Carbonate	Bicarbonate	Total <sup>a</sup>
Pumped Samples					
BH-30A	Shallow soil	7.45	0	460	460
BH-40A		7.34	0	417	417
BH-47A		7.65	36	294	330
BH-50A		7.74	26	377	403
BH-64B		7.61	36	334	360
BH-16	Deep soil	7.76	16	116	132
BH-40		7.71	10	90	100
BH-47		7.43	30	280	310
BH-50		7.91	14	64	78
BH-59		7.84	26	121	147
BH-61		7.83	14	105	119
BH-63		7.94	12	61	73
BH-64		7.71	26	311	337
BH-12	Rock	7.89	10	33	43
BH-57		7.43	12	44	56
BH-62		7.93	10.	34	44
Boiled Samples					
BH-30A	Shallow soil	7.46	36	59	95
BH-40A		7.34	0	306	306
BH-47A		8.05	8	35	43
BH-50A		7.76	20	252	272
BH-64B		7.89	10	83	93

<sup>a</sup>No hydroxide was detected in any sample.  
(ORNL, 1981)

<sup>b</sup>Data collected and analyzed by ORNL as part of research activities on the migration of low level radionuclides.

b. See Figure 3.1 . for well location.

Source: Acres American, Inc., 1981

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Table 3.17.  
GROUNDWATER QUALITY DATA AT NFSS\*

Well Number	Type of Well	Concentration (ppm)														
		Hg	Ca	Sr	Be	Na	Al	Fe	Mn	Mo	Si	P	$\text{SO}_4^{-2}$	$\text{Cl}^-$	$\text{F}^-$	K
BII-30A	Shallow soil	78	64	0.95	0.041	<0.5	<0.01	<0.01	0.13	<0.010	4.7	0.10	270	17	0.6	1.8
BII-40A		110	146	2.9	0.030	<0.5	0.12	0.01	0.003	0.016	5.7	0.21	920	13	0.2	5.0
BII-47A		74	90	2.3	0.038	120	0.02	<0.01	0.15	0.030	4.6	0.10	1,050	100	0.4	10.9
BII-50A		54	62	2.0	0.050	<0.5	<0.01	<0.01	0.25	0.013	4.0	<0.01	720	57	0.4	4.8
BII-64B		96	76	1.4	0.033	<0.5	<0.01	<0.01	0.11	<0.010	6.1	<0.01	510	19	0.2	3.2
BII-16	Deep Soil	88	100	3.5	0.058	49	0.06	<0.01	0.51	0.042	4.3	0.14	1,070	50	0.5	6.9
BII-40		70	154	5.1	0.044	<0.5	0.12	<0.01	0.12	0.021	4.8	0.06	980	72	0.3	0.4
BII-47		122	220	5.8	0.027	150	0.26	0.01	0.25	0.018	6.2	0.13	1,070	190	0.3	17.2
BII-50		86	146	4.6	0.069	20	0.09	<0.01	0.65	0.027	4.2	0.14	1,120	75	0.4	9.1
BII-59		68	76	2.8	0.052	<0.5	<0.01	<0.01	0.14	0.020	4.7	0.08	600	20	0.3	7.6
BII-61		86	144	4.6	0.053	38	0.08	<0.01	0.05	0.023	5.7	0.12	1,130	66	0.3	11.8
BII-63		96	160	4.2	0.024	56	0.12	<0.01	0.24	0.16	4.0	0.11	1,020	150	0.3	12.7
BII-64		86	68	2.4	0.040	<0.5	0.01	<0.01	0.04	0.015	5.6	0.11	480	21	0.3	8.5
BII-12	Rock	40	>300	7.2	0.020	950	0.33	<0.01	0.43	0.022	1.6	0.10	2,410	2,700	0.8	59
BII-57		46	>300	7.0	0.026	650	0.29	<0.01	0.55	0.021	1.2	0.10	1,460	2,200	0.6	56
BII-62		12	>300	6.4	0.008	200	0.22	<0.01	0.40	0.013	2.1	<0.01	2,360	180	0.7	35

(ORNL, 1981)

\* Data collected and analyzed by ORNL as part of research activities on migration of low level radionuclides.

b. See Figure 3.1. for well location.

Source: Acres American, Inc., 1981

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Observed concentrations of sodium and calcium suggest that groundwater in the soil overburden is less mineralized and softer than the groundwater in rock. Groundwater in the upper soil zones and the lower soil aquifer are similar in chemical characteristics.

However, groundwater in the deep soil zone and Queenston shale, is significantly less alkaline than groundwater in the shallow soil zone. Groundwater in the Queenston shale is more mineralized than in the soil aquifers due to high concentrations of sulfate, chloride, calcium, and sodium (Acres American, Inc. 1981).

Off-site water chemical analyses include 1977 data for the SCA Facility (formerly Chem-Trol) located north of the NFSS (Acres American, Inc. 1981), 1979 data collected at the Modern Disposal Landfill property located east of the NFSS, (Acres American, Inc. 1981) and data collected by the State of New York in the early 1960s (Johnson 1964). This information is presented in Tables 3.18-3.20. The major chemical constituents in the lower soil aquifer-Queenston Formation which are generally present in high concentrations include chloride, sulfate, iron, and manganese. The high mineral content in these waters is thought to be a result of the mixing of connate water with recharge waters from upper strata (Johnson 1964).

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TABLE 3.18.  
GROUNDWATER QUALITY DATA\* FOR THE SCA FACILITY

Parameter	Maximum Value	Minimum Value
pH	8.6	7.7
Specific Gravity	1.022	1.001
Specific Conductance (micromhos/cm @ 25°C)	4400	370
Total Carbon (ppm)	176	18
Total Inorganic Carbon (ppm)	47	5
Total Organic Carbon (ppm)	148	0
Total Dissolved Solids (ppm)	4920	420
Chemical Oxygen Demand (ppm)	426.5	<40
Chloride (ppm)	1586	34
Boron (ppm)	1.46	0.13
Cadmium (ppm)	<0.01	<0.01
Cobalt (ppm)	0.03	<0.01
Chromium (ppm)	0.03	<0.01
Copper (ppm)	1.2	<0.01
Iron (ppm)	15.4	0.14
Nickel (ppm)	0.15	<0.01
Manganese (ppm)	11.0	0.13
Zinc (ppm)	3.5	0.08
Selenium (ppm)	0.009	<0.005
Arsenic (ppm)	0.005	<0.003
Mercury (ppm)	0.001	<0.001
Sulfate (ppm)	1060	475

(WEHRAN, 1977)

- \* Samples collected from an interval which includes the lower soil aquifer, the red till and the upper portions of the Queenston Formation.

Source: Acres American, Inc., 1981

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Table 3.19.  
GROUNDWATER QUALITY DATA\* FOR THE MODERN DISPOSAL LANDFILL PROPERTY

Parameter	Maximum Value	Minimum Value
pH	8.43	7.80
Chloride (ppm)	457	16.2
Specific Conductance (micromhos/cm @ 25°C)	5480	1150
Total Organic Carbon (ppm)	430	6.5
Total Solid Iron (ppm)	0.15	0.02
Ammonia (ppm)	4.5	0.26
Nitrates (ppm)	1.14	<0.01
Nitrites (ppm)	0.01	<0.01
5-Day Biochemical Oxygen Demand (ppm)	420	4.2
Chemical Oxygen Demand (ppm)	475	32.7
Total Kjeldahl Nitrogen (ppm)	230	0.83
Sulfates (ppm)	2840	320
Aluminum (ppm)	0.4	0.2
Arsenic (ppm)	.031	<.0015
Trivalent Chromium (ppm)	<0.003	<0.002
Hexavalent Chromium (ppm)	<0.01	<0.01
Copper (ppm)	0.003	<0.002
Lead (ppm)	0.11	<0.02
Mercury (ppm)	0.5	<0.5
Potassium (ppm)	46	4.2
Sodium (ppm)	1000	20
Methylene Blue Active Substances (ppm)	3.8	<1.5
Phenols (ppm)	0.014	<0.003
Calcium (ppm)	340	40
Silver (ppm)	0.007	<0.002
Total Coliform (MPN/100 ml)	2400	<20
Alkalinity (pH = 4.5) (ppm CaCO <sub>3</sub> )	2773	68.4
Total Solids (ppm)	146000	2033
True Color (Pt/Co Units)	15	2.5
Total Hardness (ppm)(CaCO <sub>3</sub> )	6340	680
Total Phosphorus (ppm)	0.022	<0.001

(WEHRAN, 1979)

\* Samples collected from an interval which includes the lower soil aquifer, the red till and the upper portions of the Queenston Formation.

Source: Acres American, Inc., 1981

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Table 3.20. Off-Site Groundwater Chemical Analyses

Well No.	Date	Depth (ft)	Specific Capacity (gpm)	Hardness (as CaCO <sub>3</sub> )	Concentrations (mg/liter)		Remarks	
					pH	TDS		
311-059-6	6/19/68	765	8	3.0	1.0	521	65	Ca 2,000; Al 0.0; Cu 0.0; Zn 0.2; Pd 0.0
312-053-1	11/1/60	41	8	-	-	-	-	Al 0.2; Cu 0.0; Zn 0.0
-3	11/1/60	77	8	-	-	-	-	Al 0.2; Cu 0.0; Zn 0.0
312-059-1	6/18/68	15	8	1.0	.98	132	58	Ca 1,000; Al 0.2; Cu 0.0; Zn 0.0
313-059-1	6/18/68	48	0.4, 0.9	11	.75	126	145	Ca 1,000; Al 0.6; Cu 0.0; Zn 0.0; Pd 0.1
* See Figure 3.4 . for well locations.								
** See Table 3.4 . for water-bearing material identification.								

Source: Johnson, 1964

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APPENDIX A  
NIAGARA RIVER WATER QUALITY

The Niagara River flows in a northerly direction from the east end of Lake Erie to Lake Ontario, a distance of about 37 miles. The Niagara River drainage is approximately 1,700 sq. mi. Average flow of the Niagara River is about 202,000 cfs (Vincent and Franzen 1982).

Both the New York State Department of Environmental Conservation (NYSDEC, 1982) and Environment Canada (1981) have monitored the chemical quality of the Niagara River at its discharge into Lake Ontario. Figure A-1 shows the locations of these monitoring sites.

New York's monitoring site is at Fort Niagara in Youngstown, New York. The NYSDEC (1982) analyzed samples for conventional water pollutants as well as priority pollutants. Results from the conventional pollutant testing are listed in Table A-1. Of the priority pollutants tested for in 1981, only two (dichloromethane and chloroform) ever had levels above the detection limits (Personal communication, Kurcher 1982). These detection limits are listed in Table A-2.

Canada's monitoring site is at Niagara-on-the-Lake in Ontario. Environment Canada (1981) has been measuring trace metal levels in the Niagara River since 1975 (Table A-3). Copper and iron were the only metals found to frequently exceed the 1978 Great Lakes Water Quality Agreement (GLWQA) objectives (0.005 ppm and 0.3 ppm for copper and iron, respectively). Exceedences were also observed, but less frequently, for other metals such as cadmium, chromium and nickel (0.2, 50, and 25 ppb GLWQA objective limits, respectively).

PCBs, organochlorine pesticides, dioxin, hydrocarbons, and radionuclides have been monitored at the Niagara-on-the-Lake sampling site since 1979. The results of these tests are summarized in Tables A-4 - A-6. The maximum observed concentrations of PCBs, dieldrin,  $\alpha$ BHC,  $\delta$ chlordane, endrin, and HCB were higher during 1980 than in 1979 while the maximum concentrations of lindane, heptachlor epoxide, and  $\alpha$ -endosulphane were lower in 1980 than in 1979. Dioxin was not detected in any of the water samples analyzed. Maximum concentrations of alkanes, halogenated aliphatics, aromatics and halogenated aromatics were generally greater in 1980 than in 1979.

In contrast to the water samples, PCBs, pesticides, and metals were more frequently detected in suspended sediments from the river. Occurrence of these substances in suspended sediments at the Niagara-on-the-Lake sampling site are shown in Tables A-7 and A-8. Concentrations of PCBs, HCB, lead, copper, and zinc are the most significant although there are not presently any water quality objectives specifically applicable to suspended sediment.

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Table 1.1  
LABORATORY TEST DATA SUMMARY - INDEX PROPERTIES OF SOILS

* Boring Number	Sample Designation	Sample Depth Interval (ft)	Average Natural Water Content w(%)	Atterberg Limits			Plasti-city Index I <sub>p</sub>	Specific Gravity of Solids G	Unified Soil Classification Symbol	Soil Description
				Liquid Limit w <sub>L</sub>	Plastic Limit w <sub>P</sub>	Plasti-city Index I <sub>p</sub>				
BH-6	6254-80-1A	3-5	16	28	16	12	2.68	CL	Brown fine to coarse sandy clay, trace fine gravel	
	-1B	3-5	17	33	17	16				
	-3A	31-33	23	32	17	15				
	-20	31-33	22	32	17	15				
BH-9	6254-80-1B	7-9	18	33	18	15	2.75	CL	Brown silty clay, trace fine to coarse sand, trace fine gravel	
	-13C	7-9	18	36	19	17				
	-14A	17-19	27	35	19	16				
	-14B	17-19	30	39	20	19				
BH-14	6254-80-5A	29-31	34	42	22	20	2.77	CL-CH	Gray silty clay, trace fine to coarse sand	
	-5B	29-31	43	55	25	30				
	-6A	37-38.5	-	18	14	4				
BH-24	6254-80-1RA	4-6	13	18	16	2	2.67	ML	Brown clayey silt, some fine to coarse sand, trace fine gravel	
	-1RC	4-6	15	18	17	1				
BH-30	6254-80-17A	28-30	25	34	18	16	2.67	CL	Brown fine to coarse sandy silt, trace fine to coarse gravel	
	-17B	28-30	28	37	20	17				
BH-34	6254-80-7A	7-9	-	36	18	18	2.71	CL	Gray silty clay, some fine to coarse sand, trace fine gravel	
	-7C	7-9	17	37	18	19				
BH-37	6254-80-10A	10-12	19	32	17	15	2.75	CL	Brown silty clay, some fine to coarse sand, trace fine gravel	
	-10(B)	10-12	16	30	16	14				
	-12B	24-26	37	40	20	20				
	-12C	24-26	26	35	18	17				
BH-53	6254-80-20A	3-5	16	35	18	17	2.73	CL	Gray silty clay, some fine to coarse sand and gravel	
	-20C	3-5	15	36	19	17				
	-21A	13-15	19	23	14	9				
	-21B	13-15	21	31	17	14				
	-22A	23-25	27	40	23	25				
	-22C	23-25	24	40	20	20				
BH-65	6254-80-20B	2-4	16	39	17	20	2.70	CL	Brown silty clay, some fine sand, trace medium to coarse sand	
	-20A	8-10	23	38	18	20				
	-25A	14-16	23	33	18	15				
BH-71	6254-80-26A	3-5	18	41	20	21	2.70	CL	Brown silty clay, trace fine to coarse sand and gravel	
	-27B	9-11	22	36	18	18				
	-28A	13-21	22	22	15	7				
							2.67	CL-ML	Gray silty clay, trace fine to coarse sand	

\* Boring locations may be found in Figure 1.3  
Source: Acres American (1981)

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Table 1.1 Contd.  
LABORATORY TEST DATA SUMMARY - ENGINEERING PROPERTIES OF SOILS

Boring Number	Sample Designation	Sample Depth Interval (ft)	Unified Soil Classification Symbol	The Dimensional Consolidation								Void Ratio at Start of Swelling $e_s$	
				Natural Water Content w(%)	Specific Gravity of Solids G	Degree of Saturation S(%)	Initial Void Ratio $e_0$	Dry Unit Weight $\gamma$ (pcf)	Effective Overburden Stress $P_e$ (tsf)	Preconsolidation Stress $P_c$ (tsf)	Compression Index $C_c$	Swelling Index $C_s$	
BH-6	6254-B0-1A	3-5	CL	15.4	2.60	89	0.463	114	0.26	6.0	0.13	0.020	0.331
	-1B	3-5	CL	17.4	2.73	81	0.505	108	0.26	3.4	0.16	0.035	0.371
	-3A	31-35	CL	22.7	2.73	97	0.620	104	1.21	3.1	0.23	0.065	0.364
	-3B	31-35	CL	22.0	2.69	100	0.592	106	1.21	3.0	0.20	0.050	0.397
BH-9	6254-B0-13B	7-9	CL	18.5	2.75	93	0.545	111	0.44	4.6	0.16	0.045	0.389
	-13C	7-9	CL	—	—	—	—	—	—	—	—	—	—
	-14A	17-19	CL	27.1	2.73	100	0.730	99	0.77	4.0	0.20	0.040	0.547
	-14B	17-19	CL	27.3	2.73	91	0.814	94	0.77	2.7	0.30	0.075	0.464
BH-14	6254-B0-5A	29-31	CL	29.2	2.77	99	0.813	95	1.14	1.9	0.24	0.060	0.535
	-5B	29-31	CH	42.5	2.82	98	1.224	79	1.14	2.4	1.00	0.140	0.512
BH-24	6254-B0-18A	4-6	ML	13.0	2.67	95	0.384	122	0.32	5.6	0.05	0.010	0.307
	-18C	4-6	ML	14.5	2.68	90	0.429	117	0.32	4.0	0.055	0.010	0.358
BH-30	6254-B0-17A	28-30	CL	25.3	2.67	95	0.710	98	1.11	2.4	0.27	0.080	0.368
	-17B	28-30	CL	20.5	2.66	101	0.746	95	1.11	3.0	0.29	0.070	0.467
BH-34	6254-B0-7C	7-9	CL	—	—	—	—	—	—	—	—	—	—
BH-37	6254-B0-10A	10-12	CL	18.7	2.75	95	0.546	111	0.50	4.4	0.15	0.035	0.397
	-10B	10-12	CL	—	—	—	—	—	—	—	—	—	—
	-12A	24-26	CL	37.2	2.73	102	0.997	86	0.95	2.5	0.325	0.136	0.654
	-12C	24-26	CL	—	—	—	—	—	—	—	—	—	—
BH-55	6254-B0-20A	3-5	CL	15.7	2.73	80	0.406	115	0.26	5.2	0.13	0.060	0.362
	-20C	3-5	CL	—	—	—	—	—	—	—	—	—	—
	-21A	13-15	CL	—	—	—	—	—	—	—	—	—	—
	-21B	13-15	CL	19.8	2.76	96	0.567	110	0.58	2.4	0.20	0.035	0.299
	-22A	23-25	CL	23.7	2.73	100	0.647	104	0.90	2.3	0.22	0.065	0.343
	-22C	23-25	CL	—	—	—	—	—	—	—	—	—	—
BH-65	6254-B0-23B	2-4	CL	15.8	2.70	96	0.447	117	0.19	3.0	0.09	0.030	0.353
	-24A	8-10	CL	23.5	2.69	100	0.632	103	0.39	2.4	0.19	0.055	0.433
	-25A	14-16	CL	23.3	2.71	96	0.655	102	0.59	1.7	0.19	0.040	0.405
BH-71	6254-B0-26A	3-5	CL	18.8	2.70	100	0.508	112	0.26	7.0	0.19	0.060	0.381
	-27B	9-11	CL	22.9	2.67	101	0.599	104	0.45	3.0	0.16	0.085	0.393
	-28A	19-21	CL-ML	23.6	2.77	91	0.710	101	0.70	2.0	0.25	0.050	0.386

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Bulk Density ( $\gamma_t$ )

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Range 119.7-137.9 PCF (lb/ft<sup>3</sup>)  
Mean 130.4 PCF (lb/ft<sup>3</sup>)

Gray silt and clay:

Dry Density ( $\gamma_d$ )

Range 79-110 PCF (lb/ft<sup>3</sup>)  
Mean 98.2 PCF (lb/ft<sup>3</sup>)

Bulk Density ( $\gamma_t$ )

Range 112.6-131.8 PCF (lb/ft<sup>3</sup>)  
Mean 124.2 PCF (lb/ft<sup>3</sup>)

#### 1.3.4 Particle Size Distribution

A total of 33 particle size distribution tests were performed as part of the Acres American Inc. (1981) investigation. A summary of the particle size distribution for the surficial soil and brown clay are shown on Figure 1.4 and for the gray clay and red silt on Figure 1.5. The individual grain size curves are contained in Appendix F-1 of the Acres American, Inc. 1981.

#### 1.3.5 Atterberg Limits

Brown clay

Liquid Limit (LL) = 33  
Plastic Limit (PL) = 18  
Plasticity Index (PI) = 15

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Gray silt and clay

Liquid Limit (LL) = 34  
Plastic Limit (PL) = 18  
Plasticity Index (PI) = 16

Red silt

Liquid Limit (LL) = 18  
Plastic Limit (PL) = 14  
Plasticity Index (PI) = 4

1.3.6 Soil Classification

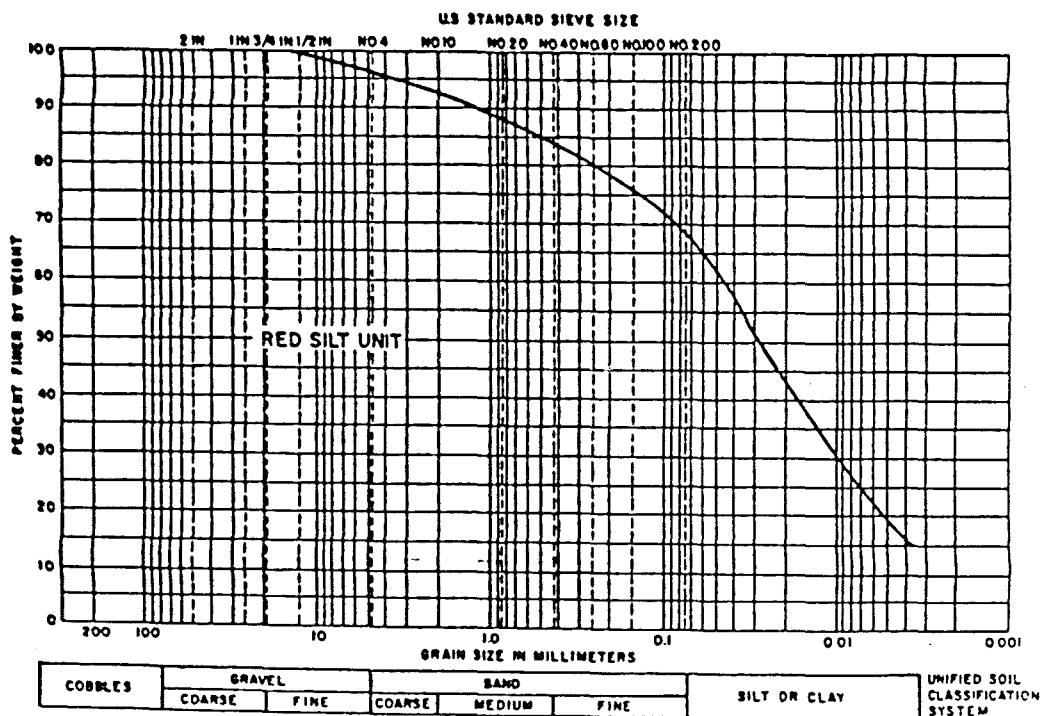
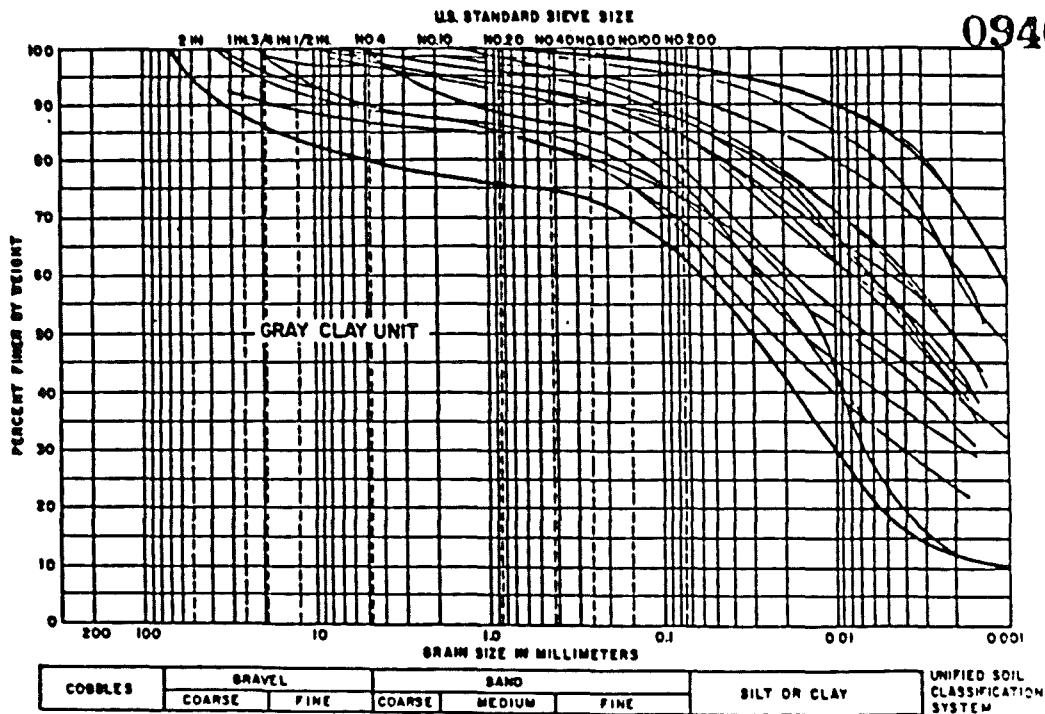
USDA:

The USDA classifications of the site surface soils according to the Soil Survey (United States Department of Agriculture, 1972) are as follows:

0"-10" Silt Loam

10"-60" Silt Clay Loam and Clay

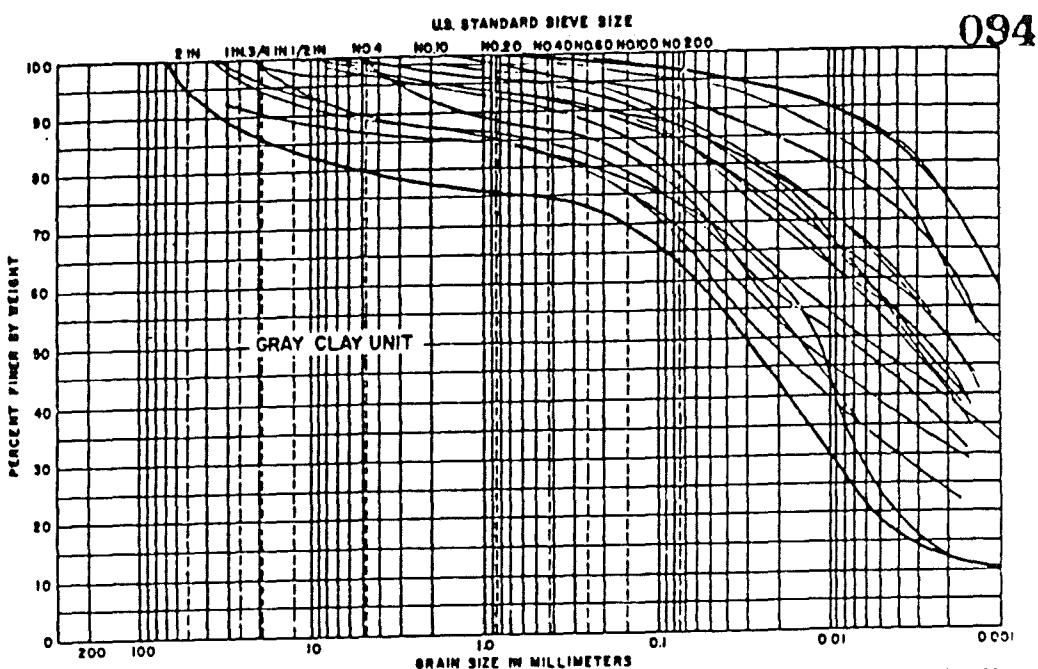
NOTE: The Soil Survey designates the NFSS as made land, it was assumed the site soils are similar to those surrounding the site.



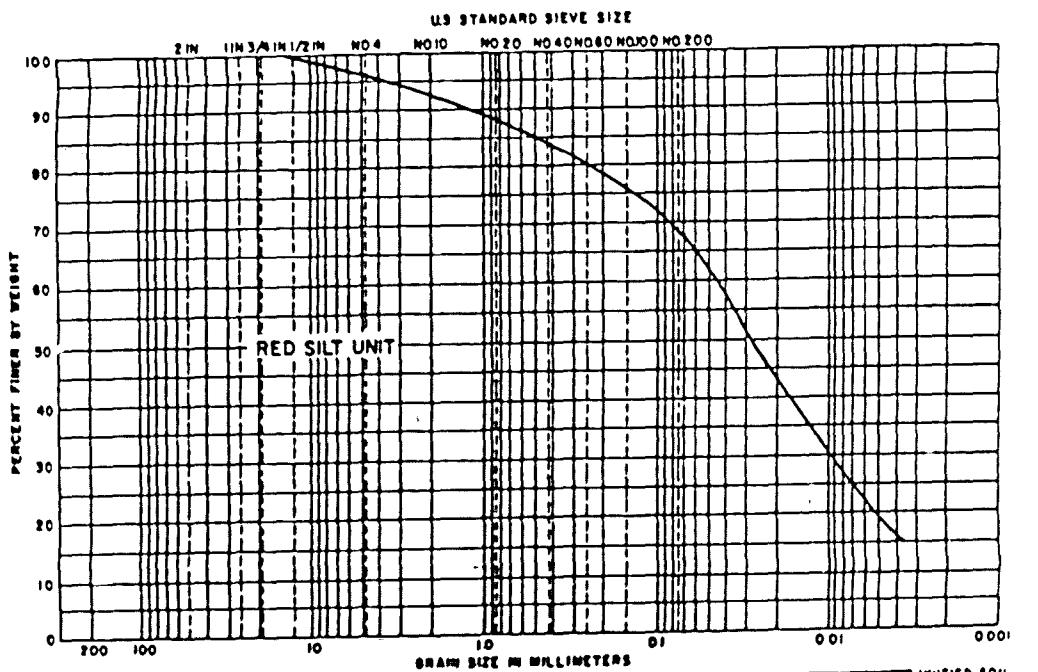
Source: Acres American (1961)

ACRES	NLO, INC
	FERNALD, OHIO
NFSS - SITE CHARACTERIZATION	
FIGURE 1.4	
PARTICLE-SIZE DISTRIBUTIONS	
FOR SELECTED SOILS	
SEPTEMBER 30, 1984	

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COBBLES	GRAVEL		SAND			SILT OR CLAY	UNIFIED SOIL CLASSIFICATION SYSTEM
	COARSE	FINE	COARSE	MEDIUM	FINE		

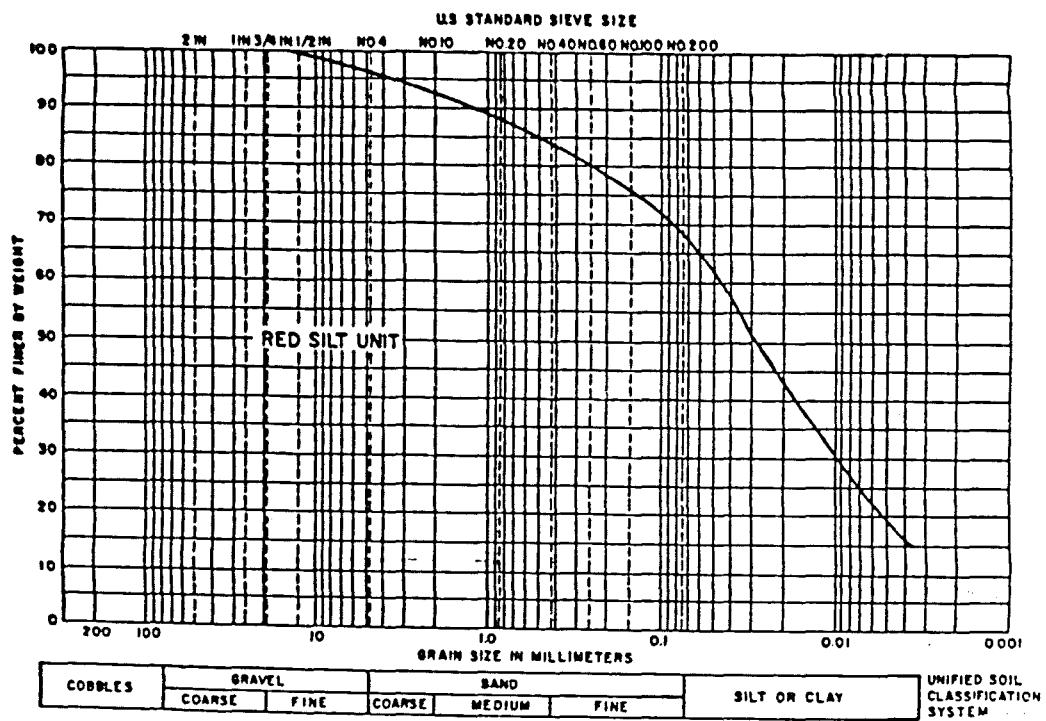
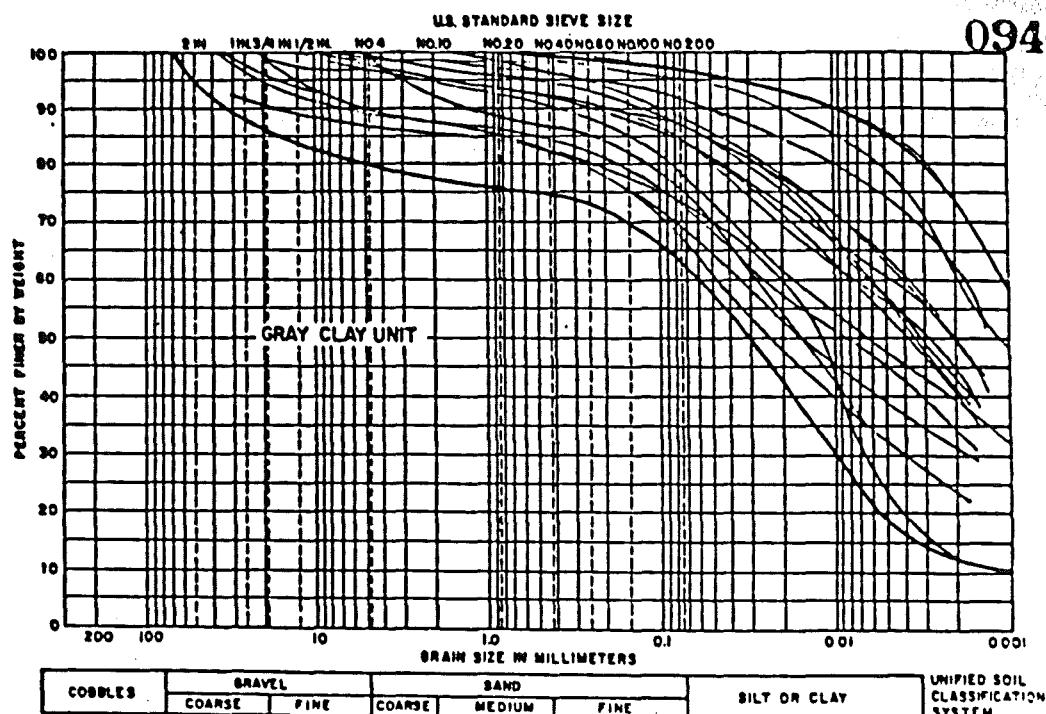


COBBLES	GRAVEL		SAND			SILT OR CLAY	UNIFIED SOIL CLASSIFICATION SYSTEM
	COARSE	FINE	COARSE	MEDIUM	FINE		

SOURCE: Acres American (1983)

ACB	NLO, INC FERNALD, OHIO NFSS - SITE CHARACTERIZATION
FIGURE 1-4 PARTICLE-SIZE DISTRIBUTIONS FOR SELECTED SOILS	
11	
SEPTEMBER 30, 1988	
DATE	

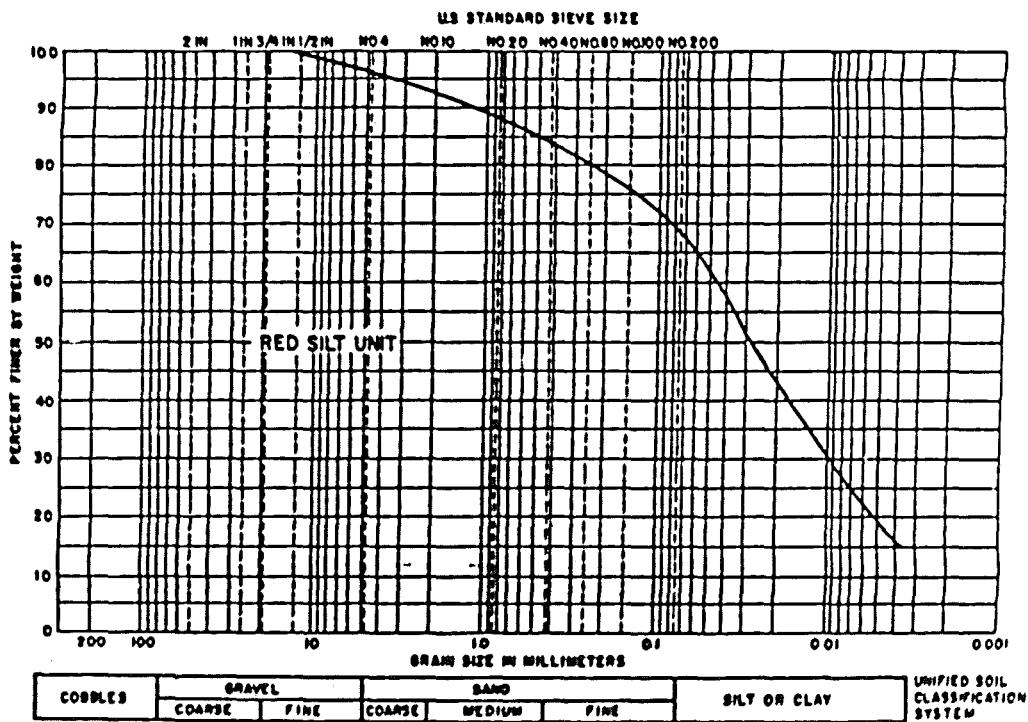
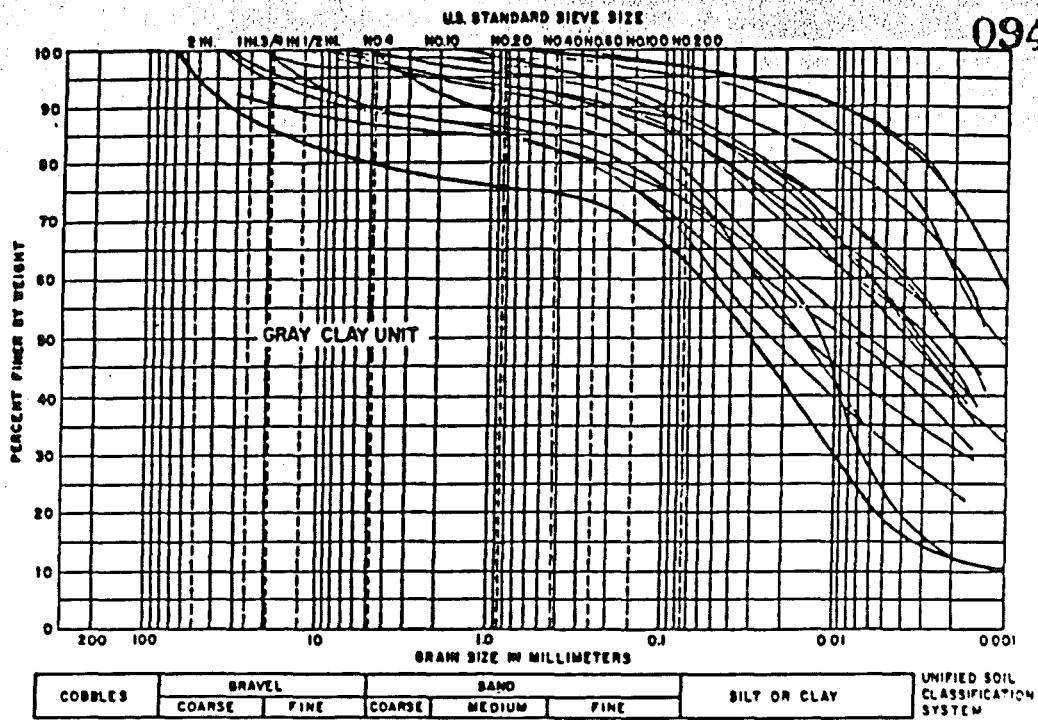
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Source: Acres American (1981)

FIGURE 1.4  
PARTICLE-SIZE DISTRIBUTIONS  
FOR SELECTED SOILS

SEPTEMBER 30, 1988  
DATE



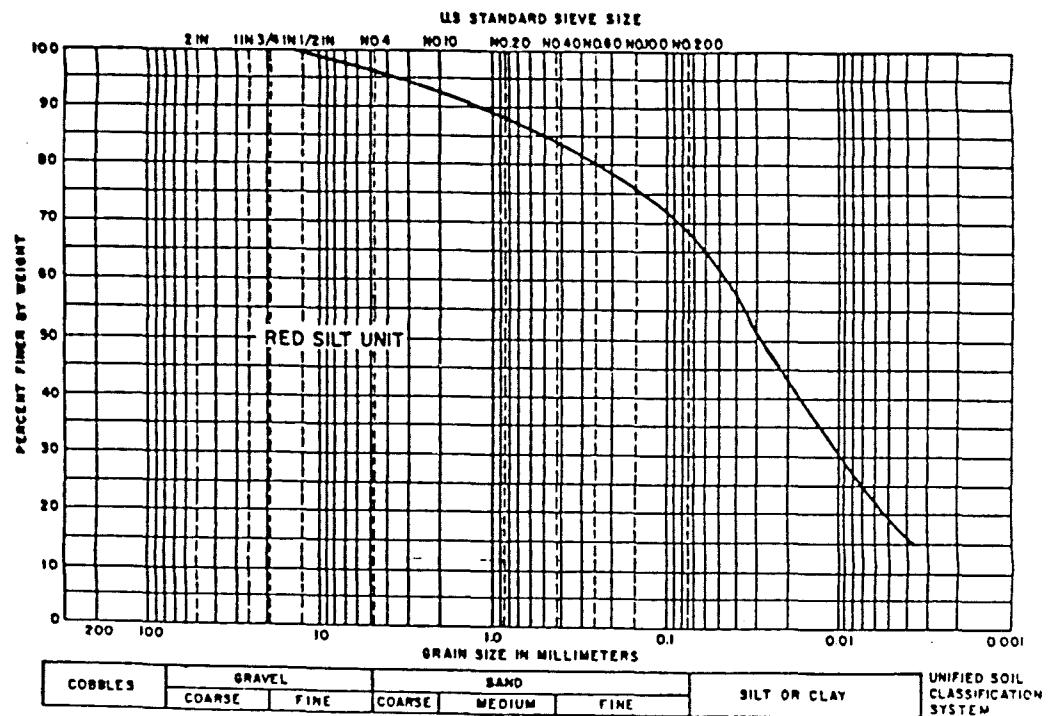
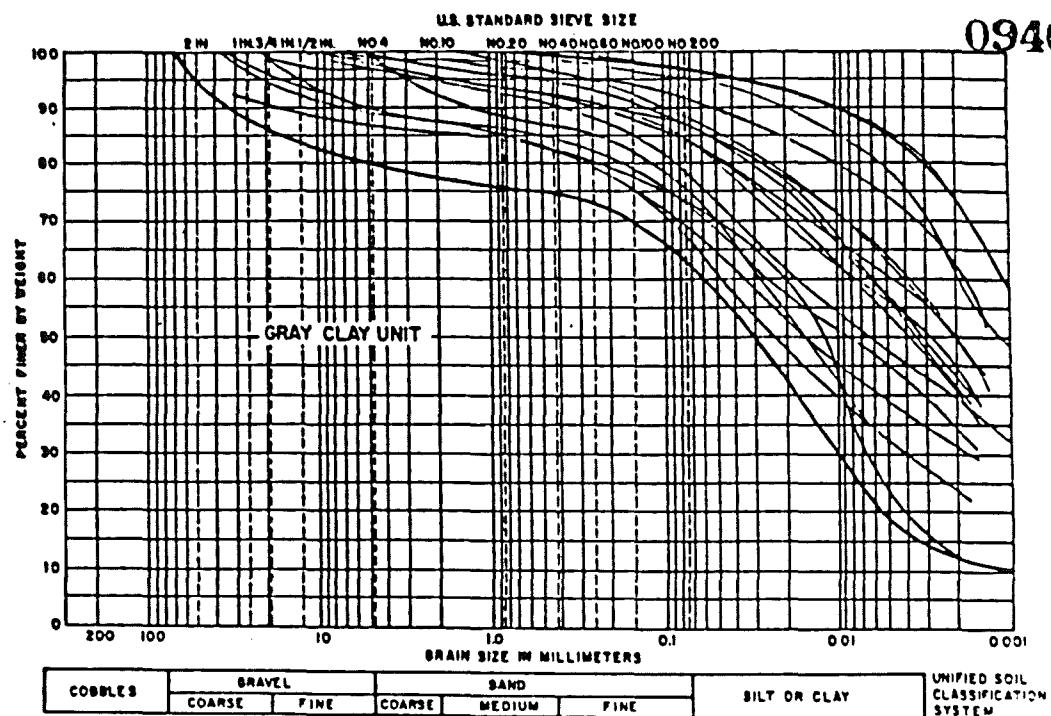
Sources: Actes American (1983)

NLO, INC  
FERNALD, OHIO  
NFS9 - SITE CHARACTERIZATION

FIGURE 1.4  
PARTICLE-SIZE DISTRIBUTIONS  
FOR SELECTED SOILS

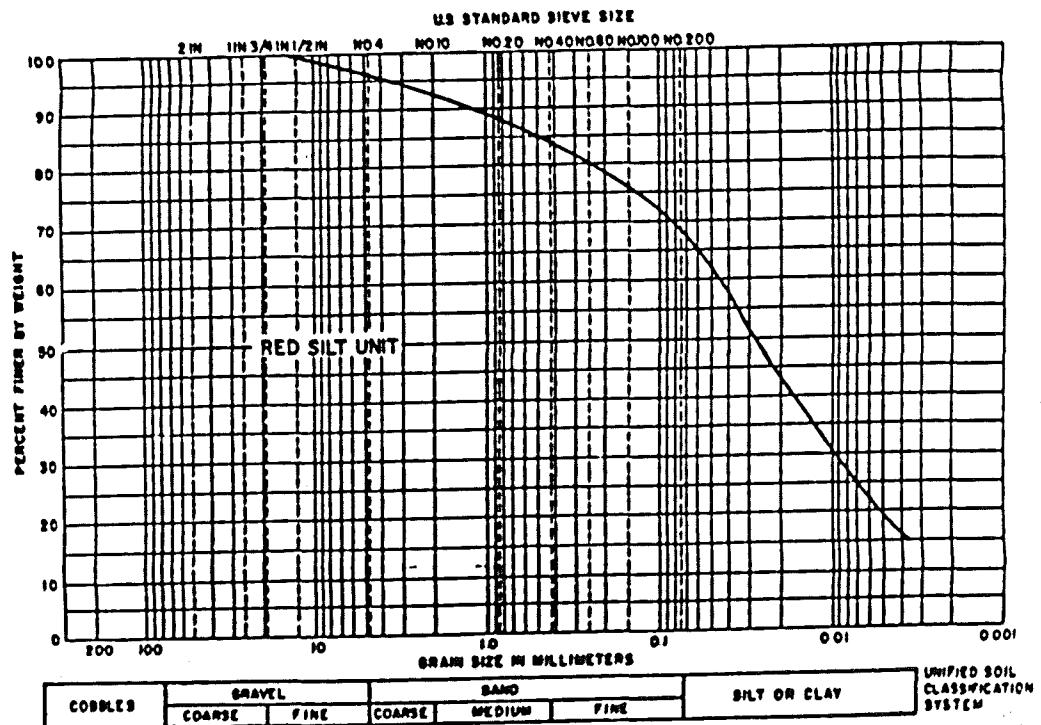
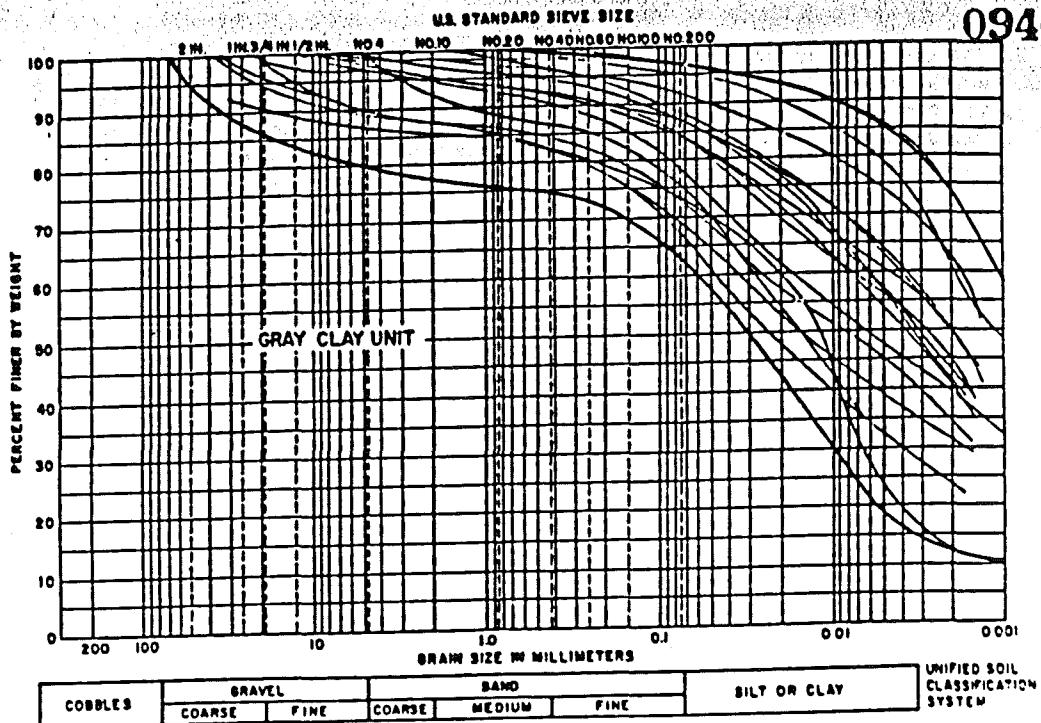
SEPTEMBER 30, 1984

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Source: Acres American (1961)

	NLO, INC FERNALD, OHIO
	NFSS - SITE CHARACTERIZATION
	FIGURE 1.4 PARTICLE-SIZE DISTRIBUTIONS FOR SELECTED SOILS
	SEPTEMBER 30, 1981
	RELEASER



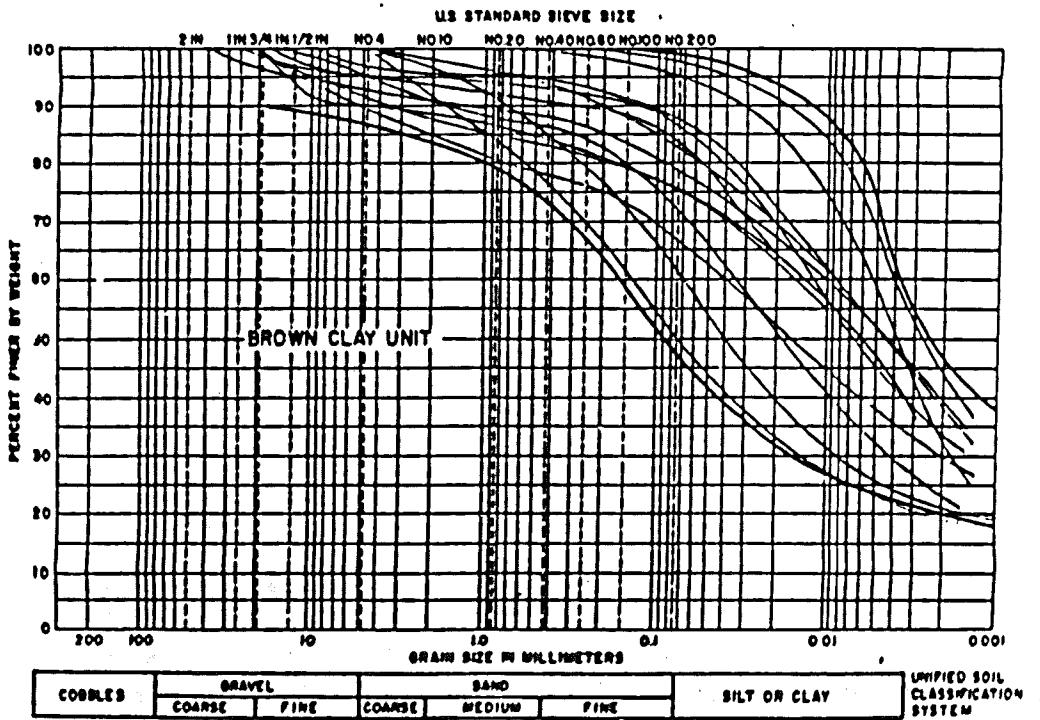
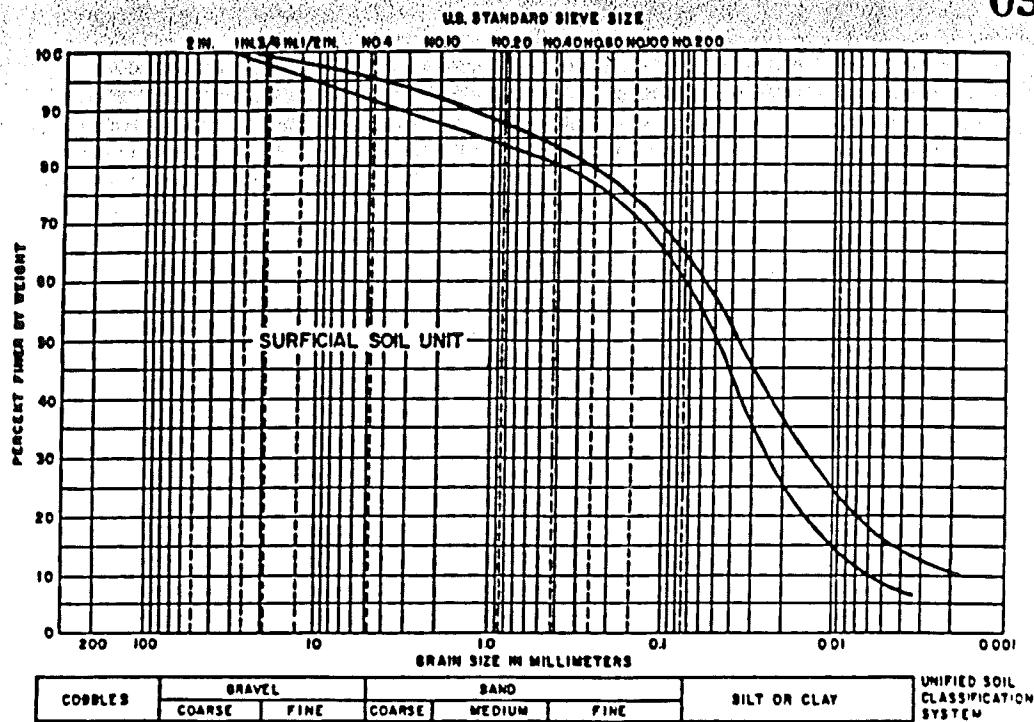
Sources: Acres American (1981)

NLO, INC  
FERNALD, OHIO  
MFSS - SITE CHARACTERIZATION

FIGURE 1.4  
PARTICLE-SIZE DISTRIBUTIONS  
FOR SELECTED SOILS

SEPTEMBER 30, 1981  
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Sources: Acres American (1983)

ACRES	HLO, INC FERNALD, OHIO NFS - SITE CHARACTERIZATION
FIGURE 1.5 PARTICLE-SIZE DISTRIBUTIONS FOR SELECTED SOILS	
PTEMBER 7, 1984	

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Unified Soil Classification System:

The USCS classifications of the NFSS soils are as follows:

Surficial soil	ML
Brown clay	CL
Gray silt and clay	CL-CH
Brown sand and gravel	GP, SP, SM, ML
Red silt	ML

1.3.7 Porosity, Specific Gravity, and Void Ratio

Brown clay

Porosity	0.355
Specific Gravity	2.71
Void Ratio	0.551

Gray silt and clay

Porosity	0.430
Specific Gravity	2.73
Void Ratio	0.753

1.3.8 Permeability

The Acres report contains data from both field and laboratory tests. The testing included both falling head and constant head permeability tests. The results of the field tests are divided between the "Upper Soil Horizons" (Table 1.2), and the "Lower Soil Aquifer" (Table 1.3). The mean permeability in the Upper Soil Horizons is:

$$2.64 \times 10^{-5} \text{ cm/sec}$$

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The mean permeability in the Lower Soil Aquifer is:

$$3.74 \times 10^{-5} \text{ cm/sec}$$

The laboratory permeability tests were divided between the brown clay and the gray silt and clay. The laboratory tests were all constant head tests with a head differential of 50 psi. The resulting average values are as follows:

Brown clay:  $3.42 \times 10^{-8} \text{ cm/sec}$

Gray silt and clay  $7.34 \times 10^{-8} \text{ cm/sec}$

#### 1.3.9 Soil Strength

The shear strength of a soil is defined by the equation:

$$S = c + \sigma \tan \phi$$

where  $c$  = cohesion

$\phi$  = angle of internal friction

For a clay soil for total stress conditions  $\phi \rightarrow 0$   
therefore, for the clayey soils at NFSS

$$S = c$$

The laboratory tests indicated the following:

Brown clay:  $S = 2900 \text{ psf}$

Gray silt and clay:  $S = 800 \text{ psf}$

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### 1.3.10 Consolidation

A total of 24 consolidation tests were performed on the site soils, 13 on the brown clay and 11 on the gray silt and clay. The results of the tests are contained in Table 1.4. The individual test results are shown in Appendix F-2. (Acres American, Inc., 1981) The test results are as follows:

#### Brown clay

Compression Index	0.15
Swelling Index	0.04
Preconsolidation Stress	4.25 TSF (Tons/ft <sup>2</sup> )
Overconsolidation Ratio	13

#### Gray silt and clay

Compression Index	0.31
Swelling Index	0.07
Preconsolidation Stress	2.42 TSF (Tons/ft <sup>2</sup> )
Overconsolidation Ratio	3

All of the compression tests were run only in initial compression and decompression (swelling) and not in recompression. As a result, recompression index values are not available. However, recompression index values are normally similar in magnitude to the swelling index.

### 1.3.11 Volume Stability

The near surface soils at the NFSS are classified basically as ML and CL soils. Soils of these types typically have medium to high potential for frost action

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TABLE 1.2  
SUMMARY OF FIELD PERMEABILITY TESTING IN THE UPPER SOIL HORIZONS

ACRES AMERICAN INCORPORATED

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Borehole Number	Test Interval (feet)	Soil Classification*	Type of Test		Permeability** cm/sec	Date of Test	Duration Hr:min.	Comments
			Rising Head	Falling Head				
BH-30A	13.1-18.0	Clay with occasional sand lenses	X		$7 \times 10^{-5}$	6/11/81	1:41	
BH-38	11.0	Silt/Clay interface		X	No take	4/22/81	17:10	
BH-40	15.2	Sand		X	No take	5/21/81	0:05	Thin lens within clay layer
BH-40	25.0	Fine to med. sand clay interface		X	$2 \times 10^{-5}$	5/22/81	0:28	Thin sand lens .2 feet
BH-40A	10.9-15.7	Clay with occasional sand lenses	X		$3 \times 10^{-5}$	6/3/81	2:07	
BH-48	11.0	Very thin sand lens in clay		X	No take	5/12/81	15:15	Very thin sand lens
BH-49	13.0	Sand/clay interface		X	$7 \times 10^{-5}$	5/19/81	0:41	
BH-49A	13.6-18.5	Clay with silty sand 15.5-17.0'	X		$2 \times 10^{-6}$	6/9/81	65:46	
BH-50A	14.1-19.0	Sand with occasional silt zones	X		$4 \times 10^{-6}$	6/10/81	49:32	
BH-58A	13.1-18.0	Clay with silt zone 12.0-13.0'	X		$7 \times 10^{-6}$	6/5/81	1:00	
BH-68A	11.6-16.3	Clay with occasional sand zones 3-7 inches thick	X		$5 \times 10^{-6}$	7/10/81	0:35	
BH-71	11.0	Silty sand		X	$3 \times 10^{-5}$	6/19/81	1:09	

\* For Detailed Soil Stratigraphy and Classification, see Boring Log Appendix A.

\*\* Permeabilities calculated according to procedures outlined in NAVFAC DM-7 (U.S. Department of the Navy, 1971).

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Source: Acres American (1981)

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Table 1.3  
SUMMARY OF FIELD PERMEABILITY TESTING IN THE LOWER SOIL AQUIFER

Borehole Number	Test Interval (feet)	Soil Classification <sup>a</sup>	Type of Test		Permeability <sup>b</sup> cm/sec	Date of Test	Duration Hr:min.	Comments
			Rising Head	Falling Head				
BII-39	27.2-41.8	Clay, silt, weathered bedrock	X		$3 \times 10^{-5}$	5/12/81	4:10	
BII-40	21.8-36.5	Clay and sand	X		$1 \times 10^{-4}$	6/2/81	1:00	
BII-45	31.6-45.4	Clay, sand, weathered bedrock	X		$2 \times 10^{-5}$	5/14/81	7:00	
BII-47	16.3-31.0	Clay, sand and silty sand	X		$4 \times 10^{-5}$	6/4/81	0:49	
BII-50	24.8-38.3	Silt, gravel, weathered bedrock	X		$5 \times 10^{-5}$	5/13/81	0:23	
BII-58	28.4-42.7	Clay, sand, silt	X		$4 \times 10^{-5}$	5/14/81	2:36	
BII-60	25.8-40.3	Clay, sand, silty sand	X		$1 \times 10^{-5}$	6/1/81	0:20	
BII-66	33.4-42.6	Clay, sand, silty sand	X		$9 \times 10^{-6}$	7/1/81	20:26	

<sup>a</sup> For Detailed Soil Stratigraphy and Classification, see Boring Logs Appendix A.

<sup>b</sup> Permeabilities calculated according to procedures outlined in NAVFAC DM-7 (U.S. Department of the Navy, 1971).

Source: Acres American (1981)

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and medium potential for shrink-swell. According to the procedure used by the Corps of Engineers, the NFSS soils would be classified either F3 or F4, which are the highest levels of frost-susceptible soils.

The swelling index of the brown clay and gray silt and clay is 0.04 and 0.07, respectively. It is important to note that both the brown clay and gray silt and clay are overconsolidated which would limit the settlement of these layers upon loading.

#### 1.3.12 Compaction Relationships

There is no information available in the existing literature regarding the compaction relationship of any of the site soils. Work currently being performed at the site in relation to the dike construction surrounding the R-10 spoils pile could provide some information regarding the compactability of the brown clay.

#### 1.3.13 Chemical and Mineral Properties

Limited data is available on the chemical and mineral properties of the site soils. The following information was taken from Anderson et al (1981).

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Table 1.4  
LABORATORY TEST DATA SUMMARY - ENGINEERING PROPERTIES OF SOILS

Boring Number	Sample Designation	Sample Depth Interval (ft)	Unified Soil Classification Symbol	Natural Water Content w(%)	Specific Gravity of Solids G	Degree of Saturation S(%)	Initial Void Ratio e <sub>o</sub>	Dry Unit Weight γ (pcf)	Effective Overburden Stress σ <sub>e</sub> (tsf)	Preconsolidation Stress P <sub>c</sub> (tsf)	Compression Index C <sub>c</sub>	Swelling Index C <sub>s</sub>	One Dimensional Consolidation		
													Consolidation		
BH-6	6254-B0-1A	3-5	CL	15.4	2.68	89	0.463	114	0.26	6.0	0.13	0.020	0.331		
	-10	3-5	CL	17.4	2.73	81	0.505	108	0.26	3.4	0.16	0.035	0.371		
	-3A	31-35	CL	22.7	2.73	97	0.628	104	1.21	3.1	0.23	0.065	0.364		
	-3B	31-35	CL	22.0	2.69	100	0.592	106	1.21	3.0	0.20	0.050	0.397		
BH-9	6254-B0-1JB	7-9	CL	18.5	2.75	93	0.545	111	0.44	4.6	0.16	0.045	0.389		
	-13C	7-9	CL												
	-14A	17-19	CL	27.1	2.73	100	0.730	99	0.77	4.0	0.20	0.040	0.547		
	-14B	17-19	CL	27.3	2.73	91	0.814	94	0.77	2.7	0.30	0.075	0.464		
BH-14	6254-B0-5A	29-31	CL	29.2	2.77	99	0.813	95	1.14	1.9	0.24	0.060	0.535		
	-5B	29-31	CH	42.5	2.82	98	1.224	79	1.14	2.4	1.00	0.140	0.512		
BH-24	6254-B0-1BA	4-6	ML	13.0	2.67	95	0.384	122	0.32	5.6	0.05	0.010	0.307		
	-10C	4-6	ML	14.5	2.68	90	0.429	117	0.32	4.0	0.055	0.010	0.358		
BH-30	6254-B0-17A	28-30	CL	25.3	2.67	95	0.710	98	1.11	2.4	0.27	0.080	0.368		
	-17B	28-30	CL	28.5	2.66	101	0.746	95	1.11	3.0	0.29	0.070	0.467		
BH-34	6254-B0-7C	7-9	CL												
BH-37	6254-B0-10A	10-12	CL	18.7	2.75	95	0.546	111	0.50	4.4	0.15	0.035	0.397		
	-10B	10-12	CL												
	-12D	24-26	CL	37.2	2.73	102	0.997	86	0.95	2.5	0.325	0.136	0.654		
	-12C	24-26	CL												
BH-55	6254-B0-20A	3-5	CL	15.7	2.73	88	0.486	115	0.26	5.2	0.13	0.060	0.362		
	-20C	3-5	CL												
	-21A	13-15	CL												
	-21B	13-15	CL	19.8	2.76	96	0.567	110	0.58	2.4	0.20	0.035	0.299		
	-22A	23-25	CL	23.7	2.73	100	0.647	104	0.90	2.3	0.22	0.065	0.343		
	-22C	23-25	CL												
BH-65	6254-B0-23D	2-4	CL	15.8	2.70	96	0.447	117	0.19	3.0	0.09	0.030	0.353		
	-24A	8-10	CL	23.5	2.69	100	0.632	103	0.39	2.4	0.19	0.055	0.433		
	-25A	14-16	CL	23.3	2.71	96	0.655	102	0.39	1.7	0.19	0.040	0.405		
BH-71	6254-B0-26A	3-5	CL	18.8	2.70	100	0.508	112	0.26	7.0	0.19	0.060	0.301		
	-27B	9-11	CL	22.9	2.67	101	0.599	104	0.45	3.0	0.16	0.085	0.395		
	-28A	19-21	CL-ML	23.6	2.77	91	0.708	101	0.70	2.0	0.25	0.050	0.306		

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Table 1.4  
LABORATORY TEST DATA SUMMARY - ENGINEERING PROPERTIES OF SOILS (Cont'd.)

Boring Number	Sample Designation	Sample Depth Interval (ft)	Soil Classification Symbol	Undrained Compressive Strength					Constant Head Permeability Tests					
				Natural Water Content w (%)	Specific Gravity of Solids G	Dry Unit Weight $\gamma$ (pcf)	Shear Strength $\frac{\sigma_u - \sigma_v}{\gamma}$ (psf)	Shear Confining Pressure $\sigma_3$ (psf)	Confining Strain Rate in/in/min	Natural Water Content w (%)	Specific Gravity of Solids G	Dry Unit Weight $\gamma$ (pcf)	Test Pressure Head $\Delta H$ (psi)	Coefficient of Permeability (cm/sec)
BH-6	6254-B0-1A	3-5	CL							15.8	2.73	-	50	$3.5 \times 10^{-8}$
	-1B	3-5	CL							21.2	2.69	107	50	$6.3 \times 10^{-8}$
	-JA	31-35	CL											$2.8 \times 10^{-8}$
	-JB	31-35	CL											
BH-9	6254-B0-1JB	7-9	CL							17.4	2.75	111	50	$9.4 \times 10^{-9}$
	-1JC	7-9	CL	17.6	2.73	10	3,720	864	0.01					
	-14A	17-19	CL	28.1	2.73	96	1,650	2,016	0.01					
	-14B	17-19	CL	30.8	2.73	93	991	4,320	0.01	31.4	2.73	91	50	$1.3 \times 10^{-8}$
BH-14	6254-B0-5A	29-31	CL							37.7	2.77	82	50	$1.4 \times 10^{-8}$
	-5B	29-31	CH											
BH-24	6254-B0-18A	4-6	ML							13.3	2.67	121	-	Invalid test
	-18C	4-6	ML											
BH-30	6254-B0-17A	28-30	CL							25.1	2.67	102	50	$3.2 \times 10^{-8}$
	-17B	28-30	CL							26.7	2.66	97	50	$5.4 \times 10^{-8}$
BH-34	6254-B0-7C	7-9	CL							16.7	2.69	121	50	$8.7 \times 10^{-9}$
BH-37	6254-B0-10A	10-12	CL							16.4	2.69	105	50	$2.2 \times 10^{-8}$
	-10B	10-12	CL											
	-12B	24-26	CL							23.6	2.73	103	50	$2.0 \times 10^{-8}$
	-12C	24-26	CL											
BH-55	6254-B0-20A	3-5	CL	16.8	2.73	113	4,268	432	0.01	16.0	2.73	103	50	$7.6 \times 10^{-9}$
	-20C	3-5	CL	14.9	2.73	119	3,739	432	0.01					
	-21A	13-15	CL	19.2	2.76	103	680	1,584	0.01	21.2	2.76	106	50	$1.3 \times 10^{-7}$
	-21B	13-15	CL											
	-22B	23-25	CL	30.9	2.73	90	962	2,736	0.01					
	-22C	23-25	CL	23.5	2.69	104	778	2,736	0.01	35.6	2.69	85	50	$4.3 \times 10^{-8}$
BH-65	6254-B0-23B	2-4	CL							17.6	2.70	114	50	$4.2 \times 10^{-9}$
	-24A	8-10	CL							23.2	2.69	101	50	$1.7 \times 10^{-8}$
	-25A	14-16	CL							24.2	2.71	92	50	$2.2 \times 10^{-7}$
BH-71	6254-B0-26A	3-5	CL							17.1	2.70	115	50	$6.6 \times 10^{-9}$
	-27B	9-11	CL							20.9	2.67	97	50	$1.9 \times 10^{-7}$
	-28A	19-21	CL-ML							20.0	2.77	109	50	$1.2 \times 10^{-7}$

\* Boring Locations may be found in Figure 1.3  
Source: Acres American (1981)

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<u>DEPTH</u>	<u>pH</u>	<u>CATION EXCHANGE CAPACITY</u>
0-2 ft.	7.9	8.28
2-4 ft.	8.3	5.73
4-6 ft.	8.4	5.12
6-8 ft.	8.4	3.82
8-10 ft	8.4	3.52
10-12 ft	8.4	3.17
14-16 ft.	8.4	2.75
16-18 ft.	8.3	3.30

#### 1.3.14 Soil Distribution Map

A surficial soils distribution map of NFSS is shown on Sheet #27 of the Niagara County, New York Soil Survey (U. S. Dept. of Agriculture, 1972). The map shows the actual site area as made land. The soil to the north, west, and south is classified as soil unit Ma (Madalin silt loam) and to the east the soil is classified as soil unit RbA (Rhinebeck silt loam, 0 to 2 percent slopes). Both units are part of the Rhinebeck-Ovid-Madalin soil association. A detailed description of this soil association can be found in the New York Soil Survey (U. S. Dept. of Agriculture, 1972).

#### 1.3.15 Soil Erosion

The soil Erosion Factor (K) - indicates the susceptibility of a soil to sheet and till erosion by water. Estimates are based primarily on percentages of silt, sand, and organic matter and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the K value, the more susceptible the soil is to sheet and rill erosion by water.

<u>Soil Layer</u>	<u>K-Factor</u>
Surficial Soil	0.40
Brown Clay	0.37
Gray Silt and Clay	0.25

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The K-factors were calculated by using the soil properties contained in (Acres American, 1981 and U. S. Dept. of Agriculture, 1977) and the Soil-erodibility nomograph developed by W. H. Wischmeier, C. B. Johnson, and B. V. Cross in 1971.

Wind Erodibility - Each wind erodibility group is made up of soils that have similar properties affecting their resistance to wind erosion. The surficial silty loam soils present at the NFSS would be part of a group of soils that would typically be highly to moderately erodible by wind action. The underlying silty clay loam and clay would be moderately erodible by wind action.

Critical Velocity - Typical critical velocities for clay soils range between 80 to 100 cm/sec. The critical velocity is that velocity at which runoff will begin to erode and transport soil particles.

#### 1.3.16 Engineering Parameters

Engineering parameters of the brown and grey clay units are indicated in Table 1.5. Additional onsite geotechnical studies are being conducted by Bechtel at NFSS. Data and/or results will be provided to Argonne when they become available.

### 1.4 Seismology

#### 1.4.1 Tectonic Provinces

The principal tectonic divisions within 200 miles of the Niagara Site are shown in Figure 1.6.

The NFSS lies within the Central Stable Region. This region has been described by Eardley (1962) as a region consisting of a veneer of sediments overlying

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Table 1.5

## RANGE OF VALUES OF ENGINEERING PROPERTIES FOR THE BROWN CLAY AND GRAY CLAY UNITS

Test Parameter	Range of Values	BROWN CLAY		GRAY CLAY	
		Median Value	Range of Values	Median Value	Range of Values
Coefficient of Permeability k (cm/sec)	$4 \times 10^{-9}$ to $2 \times 10^{-7}$	$4 \times 10^{-8}$	$1 \times 10^{-8}$ to $2 \times 10^{-7}$	$8 \times 10^{-8}$	
Dry Unit Weight $\gamma$ (lbs/cf)	108 to 122	114	79 to 107	98	
Standard Penetration Resistance - blows/ft	10 to 47	32	3 to 20	10	
Moisture Content w (%)	13.0 to 27.2	18.9	19.2 to 42.5	27.2	
Undrained Shear Strength, $T_s/2$ (PSF)	991 to 4,268	2,603	680 to 962	820	
Preconsolidation Stress, $P_c$ -Tsf	3.0 to 7.0	4.56	1.7 to 3.6	2.49	
Compression Index, $C_c$	0.05 to 0.20	0.13	0.19 to 1.00	0.30	

Source: Acres American (1981)

29650

Precambrian crystalline rocks that have been formed into arches, basins, and other structures primarily as a result of Paleozoic epeirogenic activity. The Central Stable Region extends from the eastern Appalachian Mountain Chain to the western Rocky Mountains, and from the Canadian Shield in the north to the onlapping Cretaceous and Tertiary sediments of the Coastal Plain in the south.

To the north of the site (at about 100 mile at its closest approach), the Canadian Shield is characterized by a vast expanse of Precambrian rock. Its upland surfaces are uniform in height over large areas and represent an old erosion surface. The extensive surface rises 1000 to 2000 feet above sea level north of the St. Lawrence River and Lake Superior.

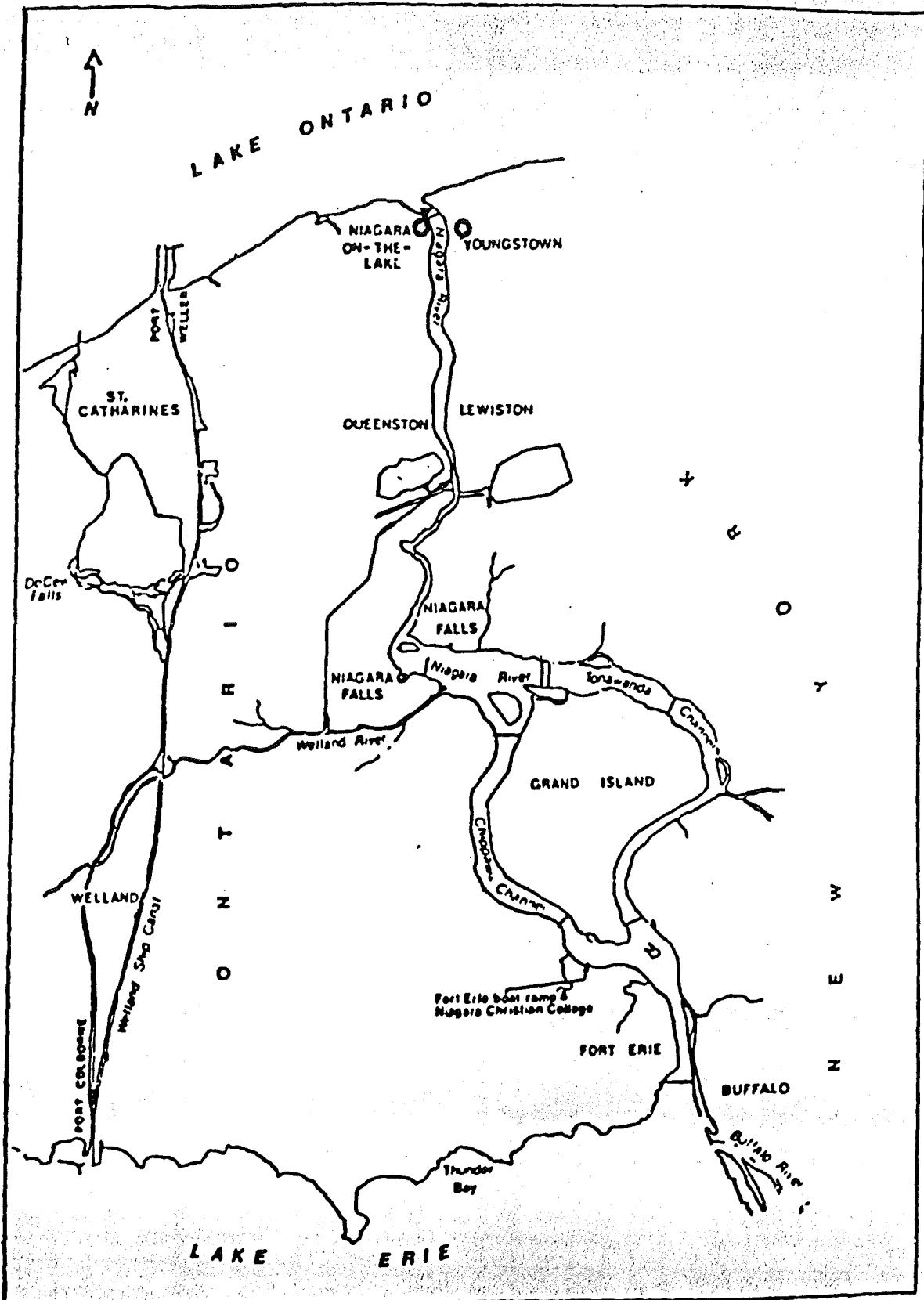
Approximately 160 miles east-northeast of the NFSS, the Adirondack uplift exposes shield-type Precambrian rocks flanked to the north and south by younger sedimentary rocks. The uplift is a zone of high-angle faulting along the southeastern edge of the Canadian Shield. This circular zone, with a radius of 75 miles, contains many faults. A west-trending fault and graben zone penetrates the shield and separates the Adirondack Uplift from the Canadian Shield.

North of the Adirondack Uplift is the western part of the St. Lawrence Lowlands. The rocks in the lowlands are Paleozoic limestones, dolomites, and sandstones. It is a rift valley in which major block faulting has occurred (Fox, 1970).

FIGURE A-1.

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## Niagara River Water Quality Monitoring Stations.



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2/8

Free Fluoride	<0.10
Ammonia	0.07
Nitrite	<5.00
Nitrate	0.30
Chloride	21.0
Phenols	<0.00
pH	7.90
Total Suspended Solid	3.00
1-Day BOD	0.40
3-Day BOD	0.80
5-Day BOD	—
7-Day BOD	1.70
Kjeldahl Nitrogen	—
Fecal Coliform (/100ML)	230.
Alkalinity	99.0
Temperature (°C)	0.00
Conductivity (micromho/cm)	295.
Dissolved Oxygen	15.8
Total Phosphate	0.03
COD	6.40

SOURCE: Department of Enviro  
at Fort Niagara, Youngstown.

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WATKINTOWN, NY

8/81 9/81 10/81 11/81 12/81

	0.100	0.200	0.100	0.100
0.030	0.020	<0.020	0.020	<0.020
0	<5.00	10.0	10.0	5.0
100	<0.100	<0.100	0.150	0.250
0	17.0	16.0	16.0	21.0
0.001	0.003	0.003	0.002	<0.001
0	6.10	6.30	—	7.40
0	10.0	4.00	7.00	6.00
00	0.100	0.100	0.200	0.200

0.600	—	0.400	1.20
—	0.700	—	—
1.40	1.50	0.700	2.00
0.330	—	—	0.320

190.	<10..0	230.	40.0
94.0	97.0	105.	97.0
21.0	14.0	—	5.00

<b>9.00</b>	<b>11.0</b>	<b>--</b>	<b>12.4</b>
<b>0.002</b>	<b>--</b>	<b>0.146</b>	<b>0.146</b>
<b>11.0</b>	<b>9.70</b>	<b>14.0</b>	<b>6.60</b>

### Line levels for the Majora River

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TABLE X-1  
NIAGARA RIVER WATER QUALITY AT YOUNGSTOWN, NY  
(ppm)

	2/81	3/81	4/81	5/81	6/81	7/81	8/81	9/81	10/81	11/81	12/81
Free Fluoride	<0.100	0.100	0.100	---	0.100	0.100	0.100	0.100	0.200	0.100	0.100
Ammonia	0.070	0.035	0.030	0.050	0.070	0.050	0.030	0.020	<0.020	0.020	<0.020
Nitrite	<5.00	<5.00	5.00	10.0	10.0	10.0	10.0	<5.00	10.0	10.0	5.0
Nitrate	0.300	0.275	0.350	0.300	0.250	0.200	0.100	<0.100	<0.100	0.150	0.250
Chloride	21.0	19.5	16.0	17.0	17.0	18.0	18.0	17.0	18.0	18.0	21.0
Phenols	<0.001	<0.001	<0.001	<0.001	<0.001	--	<0.001	0.003	0.003	0.002	<0.001
pH	7.90	7.90	7.50	8.10	8.30	8.50	8.20	8.10	8.30	--	7.40
Total Suspended Solid	3.00	4.00	8.00	5.00	6.00	1.00	4.00	10.0	4.00	7.00	8.00
1-Day BOD	0.400	0.650	0.200	1.00	0.600	0.600	0.100	0.300	0.300	0.200	0.200
3-Day BOD	0.800	0.850	1.00	--	1.20	1.70	0.800	0.600	--	0.400	1.20
5-Day BOD	--	--	--	1.70	--	--	--	--	0.700	--	--
7-Day BOD	1.70	1.25	1.80	2.10	2.10	3.30	1.50	1.40	1.50	0.700	2.00
Kjeldahl Nitrogen	--	--	--	--	0.290	--	--	0.330	--	--	0.320
Fecal Coliform (100ML)	230.	50.0	77.0	147.	350.	860.	40.0	190.	<10.0	230.	40.0
Alkalinity	99.0	102.	87.0	96.0	90.0	97.0	94.0	94.0	97.0	105.	97.0
Temperature (°C)	0.000	1.75	2.00	14.0	19.0	23.5	23.0	21.0	14.0	--	5.00
Conductivity (micromho/cm)	295.	276.	245.	--	--	--	--	--	--	--	--
Dissolved Oxygen	15.8	15.4	14.4	15.2	9.20	9.20	8.80	9.00	11.8	--	12.4
Total Phosphate	0.039	0.044	0.029	0.029	0.019	0.023	0.013	0.002	--	0.146	0.148
COD	6.40	6.20	4.80	10.0	5.60	5.60	--	13.0	9.70	14.0	8.60

SOURCE: Department of Environmental Conservation. Conventional and Priority Pollutant Levels for the Niagara River at Fort Niagara, Youngstown. Water Quality Surveillance Network. (July, 1982).

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TABLE A-2

DETECTION LIMITS FOR PRIORITY POLLUTANTS  
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Pollutant	DETECTION LIMIT (ppb)*
Chloromethane	16.
Chloroethene	18.
Chloroethane	21.
Dichloromethane	6.
1,1- Dichloroethylene	13.
Bromomethane	16.
Trans 1,2 Di Cl Ethene	13.
1,1 - Dichloroethane	16.
1,2 - Dichloroethane	-
Chloroform	3.
1,1,1 - Trichloroethane	5.
Trichlorofluoromethane	6.
Carbon Tetrachloride	4.
Bromodichloromethane	-
Benzene	4.
Toluene	11.
Ethylbenzene	3.
CIS 1,3 Dichloropropene	8.
1,2 - Dichloropropane	6.
Chlorobenzene	8.
Trichloroethylene	4.
1, 1, 2 - Trichloroethane	4.
Tetrachloroethene	4.
1, 1, 2, 2 - Tetra Cl Ethane	9.
Dibromochloromethane	6.
Bromoform	-

\* Pollutant levels were below the detection limits for all samplings done for the Niagara River at Youngstown in 1981 except dichloromethane which was present in the Oct. 1981 sample and chloroform which was present in the Sept. 1981 sample.

Source: New York State Department of Environmental Conservation.  
Conventional and Priority Pollutant Levels for the Niagara River at Fort Niagara, Youngstown. Water Quality Surveillance Network.  
(July 1982)

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TABLE A-3  
NIAGARA RIVER AT NIAGARA-ON-THE-LAKE  
MEAN ANNUAL TRACE METAL CONCENTRATIONS (ppm)

PARAMETER/YEAR	1975	1976	1977	1978	1979	1980* incomplete
NO. OBS.	19	51	48	43	39	41
ALUMINUM	.085	.100	.082	.082	.115	.155
CADMIUM	<.001	<.001	<.001	<.001	<.001	<.001
CHROMIUM	.003	.002	.003	.002	.001	.005
COPPER	.004	.007	.010	.005	.006	.003
IRON	.128	.177	.214	.282	.336	.391
LEAD	.002	.002	.002	.002	.001	.001
MANGANESE	.005	.011	.007	.015	.011	.024
NICKEL	.002	.003	.004	.002	.003	.003
ZINC	.004	.005	.007	.006	.004	.005

\* 1980 Data set includes data from Jan. 3 - Oct. 7, 1980

SOURCE: Environment Canada. Environmental Baseline Report of the Niagara River - Nov. 1981 Update. Ontario Review Board. (November 16, 1981)

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TABLE A-4  
NIAGARA RIVER AT NIAGARA-ON-THE-LAKE  
CONCENTRATION RANGE (ppb) OF PCBs, ORGANOCHLORINE PESTICIDES,  
AND DIOXIN

Parameter	1979			1980		
	N	n	Range	N	n	Range
PCBs	7	1	ND-0.020	13	2	ND-0.032
Aldrin	7	0	ND	12	0	ND
Dieldrin	7	1	ND-0.001	12	1	ND-0.005
-BHC	7	1	ND-0.003	12	8	ND-0.005
-BHC	7	0	ND	12	0	ND
Lindane (-BHC)	7	2	ND-0.002	12	4	ND-0.001
- Chlordanes	7	0	ND	12	0	ND
- Chlordane	7	0	ND	12	1	ND-0.003
DDT+metabolites	7	0	ND	12	0	ND
Endrin	7	1	ND-0.003	12	1	ND-0.009
Heptachlor	7	0	ND	12	0	ND
Heptachlor epoxide	7	1	ND-0.010	12	1	ND-0.003
Hexachlorobenzene (HCB)	7	0	ND	12	1	ND-0.005
Mirex	7	0	ND	12	0	ND

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TABLE A-4 (Cont'd)

Parameter	1979			1980		
	N	n	Range	N	n	Range
Thiodan I ( $\alpha$ -Endosulphane)	7	1	ND-0.003	12	0	ND
Thiodan II ( $\beta$ -Endosulphane)	7	0	ND	12	0	ND
Dioxin	0	-	-	11	0	ND

N = Number of samples

n = Number of samples with detectable concentration of compound.

ND = Not detected (below detection limit)

- = Not available

SOURCE: Environment Canada. Environmental Baseline Report of the Niagara River - Nov. 1981 Update. Ontario Review Board. (November 16, 1981)

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TABLE A-5  
NIAGARA RIVER AT NIAGARA-ON-THE-LAKE  
CONCENTRATION RANGE (ppb) OF HYDROCARBONS

Parameter	1979			1980		
	N	n	Range	N	n	Range
<b>Alkanes:</b>						
Hexane	9	3	ND-<0.001	14	6	ND-<0.1
Pentane	9	0	ND	14	2	ND-<0.1
<b>Alkenes:</b>						
Methyl pentene	9	0	ND	14	0	ND
<b>Aliphatics</b>						
Carbon tetrachloride	9	1	ND-<0.001	14	0	ND
Bromoform	9	0	ND	14	0	ND
Chloroform	9	5	ND-0.5	14	14	<0.001-2.4
Chlorodibromomethane	9	2	ND-(+)	14	2	ND-0.2
Dichlorobromomethane	9	2	ND-0.2	14	2	ND-0.3
Dichloroethane	9	1	ND-<0.001	14	0	ND
Trichloroethane (1,1,1-)	9	1	ND-(+)	14	3	ND-0.4
Trichlorotrifluoroethane	9	0	ND	14	0	ND
Dichloropropane	9	1	ND-<0.001	14	0	ND
Methylene chloride	9	5	ND-9.0	14	11	ND-2.1
Trichloroethylene	9	5	ND-0.184	14	6	ND-0.1
Tetrachloroethylene	9	4	ND-0.1	14	3	ND-0.1
<b>Aromatics:</b>						
Benzene	9	4	ND-0.263	14	8	ND-0.6
Ethyl benzene	9	0	ND	14	0	ND
Di-ethyl benzene	9	1	ND-0.059	14	0	ND
Toluene	9	3	ND-0.049	14	5	ND-0.3
Xylene(s)	9	2	ND-0.03	14	6	ND-0.4
Styrene	9	0	ND	14	0	ND
<b>Halogenated aromatics:</b>						
Dichlorobenzene	9	0	ND	14	2	ND-<0.1
Chlorotoluene isomer-1	9	0	ND	14	1	ND-<0.1
Chlorotoluene isomer-2	9	0	ND	14	1	ND-<0.1
m-Chlorotoluene trifluoride	9	1	ND-(+)	14	9	ND-<0.1
<b>Alcohols:</b>						
n-Butanol	9	0	ND	14	0	ND
sec-Butanol	9	0	ND	14	3	ND-<0.1
tert-Butanol	9	0	ND	14	0	ND
<b>Ethers:</b>						
Ether	9	1	ND-<0.001	14	0	ND
Di-ethyl ether	9	2	ND-(+)	14	0	ND
Methyl furan	9	0	ND	14	0	ND
<b>Aldehydes:</b>						
Butanal	9	0	ND	14	0	ND

TABLE A-5 (Cont'd)

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Isobutanal	9	0	ND	14	0	ND
Hexanal	9	0	ND	14	6	ND-<0.1
Benzaldehyde	9	0	ND	14	0	ND
<b>Ketones:</b>						
Hexenone	9	0	ND	14	0	ND
<b>Sulphides:</b>						
Carbon disulphide	9	2	ND-(+)	14	1	ND-(+)
Diethyldisulphide	9	0	ND	14	0	ND

N = Number of samples

n = Number of samples with detectable concentration of compound.

ND = Not detected (below detection limit which varies with compound, but generally is in the range of 0.2-0.5 ppb)

(+)= Present but not quantitated

SOURCE: Environment Canada. Environmental Baseline Report of the Niagara River - Nov. 1981 Update. Ontario Review Board. (November 16, 1981)

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TABLE A-6  
NIAGARA RIVER AT NIAGARA-ON-THE-LAKE  
CONCENTRATION (pCi/l) OF RADIONUCLIDES

Radionuclide	1979	1980
Gross alpha ( $\alpha$ )	-	<1
Gross beta ( $\beta$ )	-	3
Cesium-134	<30	<15
Cesium-137	<30	<15
Cobalt-60	<30	<15
Radium-226	-	0.2
Strontium-89	<0.1	<0.3
Strontium-90	0.7	1.0
Tritium	-	-

Values prefixed by "<" are detection limits  
- = Not available

SOURCE: Environment Canada. Environmental Baseline Report of the Niagara River - Nov. 1981 Update. Ontario Review Board. (November 16, 1981)

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TABLE A-7  
SUMMARY OF TRACE ELEMENT CONCENTRATION (ug/g)  
IN SUSPENDED SEDIMENT AT NIAGARA-ON-THE-LAKE

<u>PARAMETER</u>	<u>1978</u>			<u>1979-1980</u>		
	<u>MEAN</u>	<u>N.OBS.</u>	<u>MEAN</u>	<u>S.D.</u>	<u>N.OBS.</u>	<u>MEAN</u>
CADMIUM	13	2.4	0.8	35	2.4	1.3
LEAD	13	80.0	28.6	35	58.0	18.9
COBALT	13	6.6	3.3	35	6.5	2.3
COPPER	13	46.0	15.1	35	44.0	37.0
ZINC	13	177.0	44.0	35	163.0	50.0
NICKEL	13	29.0	16.0	35	24.0	12.0
CHROMIUM	13	39.0	31.0	35	30.0	12.0

SOURCE: Environment Canada Environmental Baseline Report of the Niagara River - Nov. 1981 Update Ontario Review Board. (November 16, 1981)

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TABLE A-8

## MEAN CONCENTRATIONS OF ORGANIC CONTAMINANTS (ng/g) IN SUSPENDED SEDIMENT AT NIAGARA-ON-THE-LAKE 1980

PARAMETERS	NO. OF SAMPLES	CONFIRMED DETECTIONS		
		NO.	MEAN (ng/g)	ST. DEV
PCBs (TOTAL)	24	24	642	534
ALDRIN	24	0	N.D.	--
DIELDRIN	24	21	4	2
$\alpha$ BHC	24	18	11	15
$\gamma$ BHC (LINDANE)	24	10	2	4
$\omega$ CHLORDANE	24	14	1	3
$\beta$ CHLORDANE	24	20	2	2
$\alpha$ , $\beta$ - DDT	24	8	3	5
P,P - DDT	24	18	13	16
P,P - DDE	24	24	19	10
P,P - TDE (DDD)	24	13	2	2
ENDRIN	24	1	<1	--
HEPTACHLOR	24	0	N.D.	--
HEPTACHLOR EPOXIDE	24	14	2	3
HCB (packed col)*	24 (23)	24 (23)	160 (51)	535 (58)
HCB (CAP. COL)	18	18	83	78
MIREX	24	17	6	7
$\beta$ - ENDOSULFAN	24	0	<1	--
METHOXYCHLOR	21	17	10	19
$\alpha$ ENDOSULFAN	24	1	<1	--

\* One high value eliminated

N.D. Values not detected

Data set from Jan 5 - Aug 19/1980

Detection Limit values entered as zero in mean calculations

Source: Environment Canada. Environmental Baseline Report of the Niagara River - Nov. 1981 Update. Ontario Review Board. (November 16, 1981).

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The widespread occurrence of PCBs was evident from analysis of bottom sediments collected from 9 Lower Niagara River station in 1979 (Figure A-2). Significant contamination of sediments with organochlorine pesticides was also detected. It was concluded by Vincent and Franzen (1982) that the lower river north of Queenston appears to be an accumulation point for pesticide contaminated sediments.

No chlorophenoxy acid herbicides or chlorophenols were detected in the bottom sediments. However, heavy metals were detected in all bottom sediments. Chromium, mercury, copper, lead and zinc exhibited the most significant concentrations (Table A-9).

In addition to the water quality sampling program conducted by NYSDEC and Environment Canada, the State University of New York College, Great Lakes Laboratory (Badorek and Frederick 1982) conducted ambient water quality analyses at 24 sites in the Lower Niagara River Basin north of Bloody Run Creek. Figure A-3 is a map showing the locations of the ambient water quality sampling locations in the Lower Niagara River Basin. Table A-10 lists and provides a description of each of the sites, including the reference numbers that are associated with the information that was collected for each site. Some of the sites include data from different sources which all had sampling points that were in close proximity with each other, and thus were considered to represent the same location in the river. Information on the concentrations of inorganic and organic substances analyzed for in water, sediment, and suspended sediment are presented in Tables A-11 - A-22.

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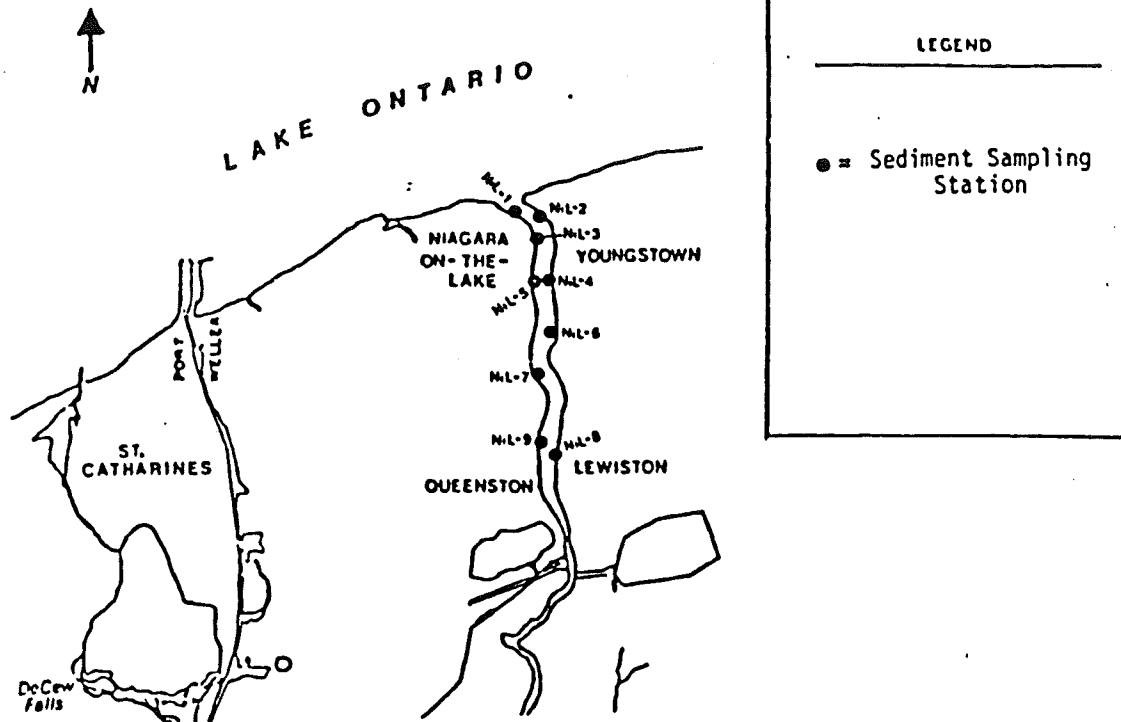


FIGURE A-2. Bottom Sediment Collection Stations.

Source: Environment Canada (1981).

TABLE A-9

SUMMARY OF 1979 ENVIRONMENT ONTARIO (MOE) ANALYTICAL RESULTS FOR PCBs,  
 ORGANOCHLORINE PESTICIDES, CHLOROPHENOXY ACID HERBICIDES AND CHLOROPHENOLS  
 (ppb - ug/kg), ARSENIC AND HEAVY METALS (ppm - ug/g)  
 IN NIAGARA RIVER BOTTOM SEDIMENTS\*\*\*

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PARAMETER	MOE Dredging Guideline	LOWER NIAGARA RIVER STATIONS								
		1	2	3	4	5	6	7	8	9
PCBs, Total	50	160	130	290	66	--	82	2700	690	490
Aldrin		ND	ND	ND	ND	--	ND	ND	ND	ND
Dieldrin		2	ND	--	ND	--	5	26	10	6
$\alpha$ - BHC		ND	6	13	ND	--	ND	110	ND	38
$\beta$ - BHC		ND	ND	ND	ND	--	ND	ND	ND	ND
Lindane ( $\gamma$ - BHC)		ND	ND	ND	ND	--	ND	ND	ND	20
$\alpha$ - Chlordane		11	14	50	--	--	ND	293	ND	61
$\gamma$ - Chlordane		6	5	35	ND	--	--	64	ND	70
$\alpha, \beta$ - DDT		ND	ND	ND	ND	--	ND	20	ND	21
p,p' - DDT		ND	ND	ND	ND	--	ND	74	ND	70
p,p' - DDE		10	9	6	5	--	4	20	5	36
p,p' - DDD		ND	ND	14	ND	--	ND	65	ND	63
$\Sigma$ DDT + metabolites		10	9	20	5	--	4	179	5	190
Endrin		ND	ND	--	ND	--	ND	13	5	7
Heptachlor		ND	ND	ND	ND	--	ND	ND	ND	ND
Heptachlor epoxide		1	1	3	ND	--	1	36	4	3
Hexachlorobenzene		45	28	32	1	--	8	250	47	31
Mirex		ND	ND	11	ND	--	4	640	6	23
Thiodan I		1	1	ND	1	--	1	15	4	12
Thiodan II		2	1	ND	ND	--	1	15	6	45

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TABLE A-9 (Cont'd)

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PARAMETER	MOE Dredging Guideline	LOWER NIAGARA RIVER STATIONS (NL)								
		1	2	3	4	5	6	7	8	9
2,4-D		ND	--	ND	ND	--	ND	ND	ND	--
2,4,5-T		ND	--	ND	ND	--	ND	ND	ND	--
2,4-D8		ND	--	ND	ND	--	ND	ND	ND	--
Silvex		ND	--	ND	ND	--	ND	ND	ND	--
2,3,4- Trichlorophenol		ND	--	ND	ND	--	ND	ND	ND	--
2,4,5 - Trichlorophenol		ND	--	ND	ND	--	ND	ND	ND	--
2,4,6 - Trichlorophenol		ND	--	ND	ND	--	ND	ND	ND	--
Pentachlorophenol		ND	--	ND	ND	--	ND	ND	ND	--
Arsenic	8	2.5	1.5	2.0	8.2	3.5	4.0	4.2	2.8	3.7
Cadmium	1	0.72	0.55	0.65	<0.40	0.45	0.88	0.88	0.60	0.72
Chromium	25	15	9.5	20	170	15	25	35	16	27
Copper	25	8.8	7.5	13	32	11	16	28	13	21
Lead	50	13	6	10	60	6.5	16	33	13	19
Mercury	0.3	0.19	0.51	0.22	0.86	0.03	0.34	3.2	0.26	0.96
Nickel	25	7.2	9.5	7.5	17	11	17	20	15	18
Zinc	100	63	47	150	170	55	96	140	79	110

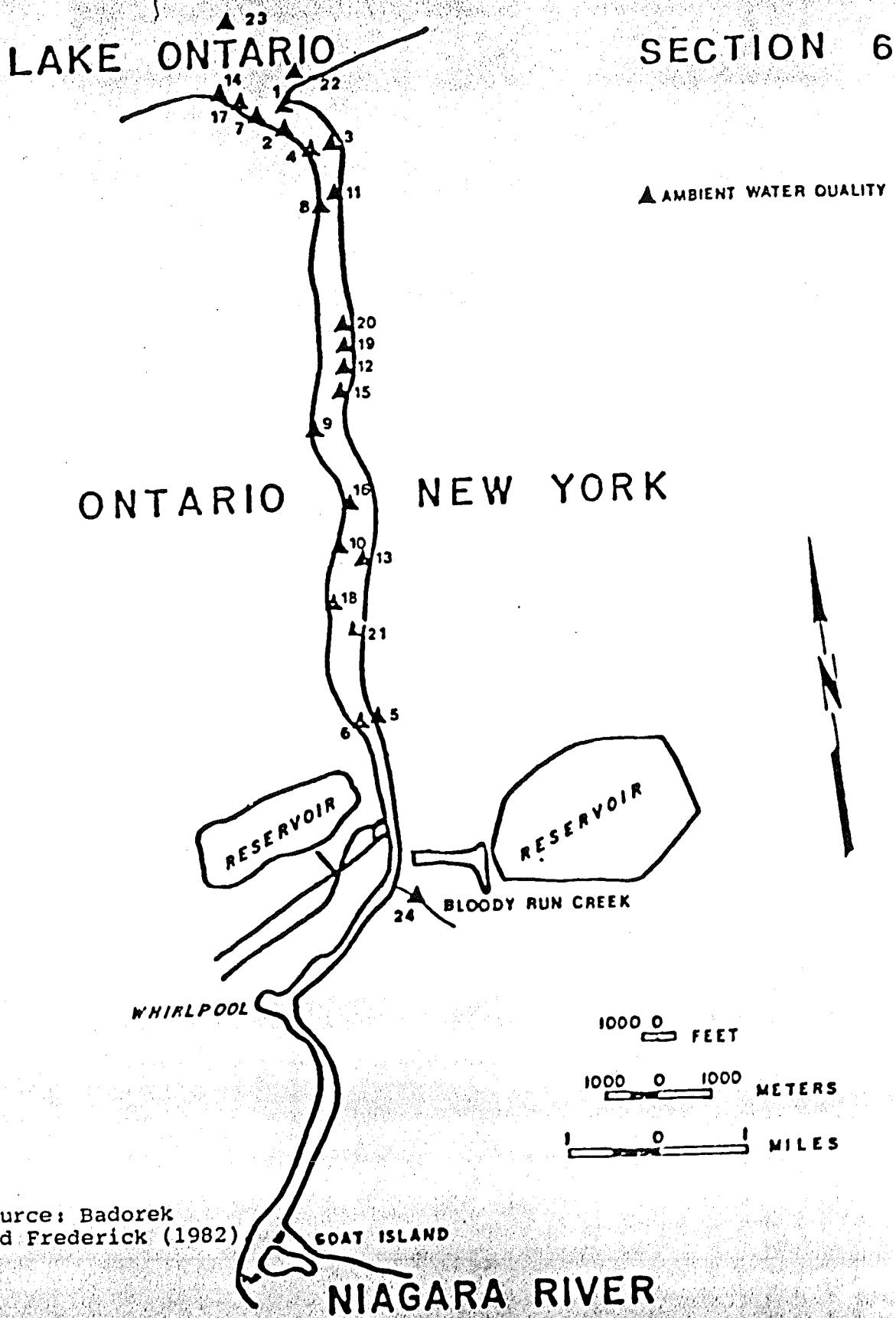
ND = below detection limit

-- = no data available

Tr = trace

\*\*\* = grab Shipek surface sediment (0 to 3 cm) composite per station

FIGURE A-3.

Map of Ambient Water Quality Site Locations in Segment 6  
02-655

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Table A-10 Listing of Ambient Water Quality Sites, Site Descriptions and Reference Numbers in Section 6.

<u>Site Number</u>	<u>Reference# Number</u>	<u>Site Description</u>
1	(7)	New York State Department Environmental Conservation, Fort Niagara, New York, Water Quality Station 01-0001-00
	(11,12,13,14)	United States Geological Survey, Fort Niagara, New York, Water Quality Monitoring Station
	(2,3,10)	Environment Ontario, Station NIL-2
2	(2,3)	Environment Canada Niagara-on-the-Lake Station
	(2,3)	Niagara-on-the-Lake WTP Intake
	(3)	Niagara River Biomonitoring Station (Algae/Clams) at Niagara-on-the-Lake/Fort George, Ontario
	(3)	Niagara River Sampling Range 1.3
3	(9)	Great Lakes Laboratory, Transect E, Niagara River Station
4	(9)	Great Lakes Laboratory, Transect E, Niagara River Station
	(2,3)	Environment Ontario Station NIL-3
5	(9)	Great Lakes Laboratory, Transect D, Niagara River Station
6	(9)	Great Lakes Laboratory, Transect D, Niagara River Station
7	(2,3,10)	Environment Ontario Station NIL-1
8	(3)	Environment Ontario Station NIL-5
9	(2,3,10)	Environment Ontario Station NIL-7
	(8)	Great Lakes Laboratory, SCA Sample Station 31
	(3)	Niagara River Biomonitoring Station (Clams) at Queenston, Ontario
10	(2,3,10)	Environment Ontario Station NIL-9
11	(3)	Environment Ontario Station NIL-4
12	(8)	Great Lakes Laboratory SCA Sample Stations 32-37
	(3)	Environment Ontario Station NIL-6
13	(3)	Environment Ontario Station NIL-8
14	(3)	Niagara River Biomonitoring Station (Algae) at Niagara- on-the-Lake/Fort Mississauga, Ontario
15	(3)	Niagara River Biomonitoring Station (Fish, Algae) at Peggy's Eddy/Joseph Davis Park, New York
16	(3)	Niagara River Biomonitoring Station (Algae) at Queenston, Ontario

Table A-10 (Continued)

<u>Site Number</u>	<u>Reference<sup>*</sup> Number</u>	<u>Site Description</u>
17	(3)	Niagara River Biomonitoring Station (Fish) at Niagara-on-the-Lake
18	(3)	Niagara River Biomonitoring Station (Fish) at Queenston, Ontario
19	(8)	Great Lakes Laboratory, SCA Sample Stations 38 and 39
20	(8)	Great Lakes Laboratory, SCA Sample Station 40
21**	(4,6)	New York State Department of Environmental Conservation - Lewiston Fish Monitoring Station
22**	(4,5,6)	New York State Department of Environmental Conservation - Fort Niagara Fish Monitoring Station
23**	(4)	New York State Department of Environmental Conservation - Niagara Bar Fish Monitoring Station
24	(1)	Bloody Run Creek Sample Stations

\* See: References - Ambient Water Quality

\*\* Approximate station locations. The area trawled is actually more expansive.

Source: Badorek and Frederick (1982).

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TABLE A-11 Ambient Water Quality Data for Segment 6 - Inorganic Substances Analyzed for at Sampling Site 1  
(U.S.G.S. Water Quality Station).

Parameter	Concentration, mean $\mu\text{g/l}^*$				
	1976 <sup>(11)</sup>	1977 <sup>(11)</sup>	1978 <sup>(12)</sup>	1979 <sup>(13)</sup>	1980 <sup>(14)</sup>
Total Arsenic	LDL	1	1	1	1
Dissolved Arsenic	LDL	1	1	1	1
Total Barium	-	-	25	LDL	LT 50
Dissolved Barium	-	-	25	17	20
Total Cadmium	1	1	1	12	20
Dissolved Cadmium	LDL	LDL	LDL	2	3
Total Chromium	LT 10	10	10	10	7
Dissolved Chromium	LT 10	1	1	LT 10	LT 10
Total Cobalt	LDL	LDL	1	LDL	LDL
Dissolved Cobalt	LDL	LDL	LDL	1	LDL
Total Copper	10	6	7	13	10
Dissolved Copper	10	3	4	13	4
Dissolved Fluoride	100*	100	114	114	133
Total Iron	80	306	150	197	170
Dissolved Iron	10	15	30	LDL	7
Total Lead	14	9	6	23	9
Dissolved Lead	5	6	3	6	4
Dissolved Magnesium	8250*	8400	8286	7857	8140
Total Manganese	10	7	10	10	10
Dissolved Manganese	0	LDL	5	3	1
Total Mercury	LT 0.5	LT 0.5	LT 0.5	LT 0.5	LT 0.1
Dissolved Mercury	LT 0.5	0.2	LT 0.5	LT 0.5	LT 0.1
Total Nickel	-	-	-	-	2
Dissolved Nickel	-	-	-	-	LDL
Total Selenium	LDL	LDL	LDL	LDL	LDL
Dissolved Selenium	LDL	LDL	LDL	LDL	LDL

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TABLE A-11 Ambient Water Quality for Segment 6 - Inorganic Substances Analyzed for at Sampling Site 1  
 (U.S.G.S. Water Quality Station). (cont.)

Parameter	Concentration, mean µg/l*				
	Sampling Date (reference)				
	1976 (11)	1977 (11)	1978 (12)	1979 (13)	1980 (14)
Total Silver	-	-	LDL	LDL	LDL
Dissolved Silver	-	-	LDL	LDL	LDL
Total Zinc	10	30	28	30	23
Dissolved Zinc	0	10	3	17	13

\* - The 1976 values represent mean of 2 samples (Nov. and Oct., 1976). The Remainder of 1976 values are taken from 1 October sample. The values for 1977 - 1980 are generally mean values for 4 or 5 samples taken between April 1 and November of the specified year.

20 LDL - Less Than Detection Limit.

- - Not analyzed or not available

LT - Less Than

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TABLE A-12 Ambient Water Quality Data for Segment 6 - Inorganic Substances Analyzed for at Sampling Site 2\*.

Parameter	<u>Concentration, mg/l</u>						
	1975 <sup>a</sup>	1976 <sup>a</sup>	1977 <sup>a</sup>	1978 <sup>a</sup>	1979 <sup>a</sup>	1980 <sup>a</sup>	1980 <sup>b</sup>
Aluminum	0.085	0.100	0.082	0.082	0.115	0.155	0.164
Arsenic	-	-	-	-	-	-	LTO.001
Cadmium	LTO.001	LTO.001	LTO.001	LTO.001	LTO.001	LTO.001	LTO.0002
Chromium	0.003	0.002	0.003	0.002	0.001	0.005	LTO.020
Copper	0.004	0.007	0.010	0.005	0.006	0.003	LTO.002
Cyanide	-	-	-	-	-	-	LTO.010
Iron	0.128	0.177	0.214	0.282	0.336	0.391	0.165
Lead	0.002	0.002	0.002	0.002	0.001	0.001	LTO.003
Manganese	0.005	0.011	0.007	0.015	0.011	0.024	-
Mercury (filtered)	-	-	-	-	-	-	LTO.0001
Nickel	0.002	0.003	0.004	0.002	0.003	0.003	LTO.020
Zinc	0.004	0.005	0.007	0.006	0.004	0.005	LTO.010

— - Not Analyzed

LT - Less Than

a - Environment Canada Niagara-on-the-Lake Station

b - Niagara River Sampling Range 1.3

\* - Data Source is Reference 3

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TABLE A-13 Ambient Water Quality Data for Segment 6 - Organic Substances Analyzed for at Sampling Site 2 and Site 4

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Parameter	Mean Concentration, $\mu\text{g/l}$						
	Site (reference)		Site 2 <sup>(2)c</sup> 1974-78	Site 4 <sup>(2)</sup> 1979	Site 2 <sup>(2)c</sup> 1979	Site 2 <sup>(3)a</sup> 1980	Site 2 <sup>(3)c</sup> 1980
PCB		ND	LTO.020	ND-0.020	LTO.020	ND-0.032	0.010
Aldrin		ND	LTO.001	ND	LTO.001	ND	LTO.001
Dieldrin		ND	LTO.001	ND-0.002	LTO.001	ND-0.002	0.001
$\alpha$ - BHC		ND	LTO.001	ND-0.003	0.004	ND-0.005	0.011
$\beta$ - BHC		ND	LTO.001	ND	LTO.001	ND	-
$\gamma$ - BHC		ND-0.030 <sup>x</sup>	LTO.001	ND-0.002	LTO.001	ND-0.001	0.004
$\alpha$ - Chlordane		ND	LTO.001	ND	LTO.001	ND	LTO.001
$\gamma$ - Chlordane		ND	LTO.001	ND	LTO.001	ND-0.003	LTO.001
$\text{o},\text{p}'$ - DDT		ND	LTO.005	-	LTO.005	-	LTO.001
$\text{p},\text{p}'$ - DDT		-	LTO.005	-	LTO.005	-	LTO.001
$\text{p},\text{p}'$ - DDE		-	LTO.001	-	LTO.001	-	LTO.001
$\text{p},\text{p}'$ - DDD		-	LTO.005	-	LTO.005	-	LTO.001
$\Sigma$ DDT + Metabolites		-	LTO.005	ND	LTO.005	ND	-
Endrin		ND	LTO.001	ND-0.003	LTO.001	ND-0.009	LTO.001
Heptachlor		ND	LTO.001	ND	LTO.001	ND	LTO.001
Heptachlor epoxide		ND	LTO.001	ND-0.010	LTO.001	ND-0.008	LTO.001
HCB		ND	LTO.001	ND	LTO.001	ND-0.005	0.001
Mirex		ND	LTO.005	ND	LTO.005	ND	LTO.001
Thiodan I		ND	LTO.001	ND-0.003	LTO.001	ND	LTO.001
Thiodan II		ND	LTO.001	ND	LTO.001	ND	LTO.001
Phenol		-	-	-	LTO.0	ND	-
Methoxychlor		-	-	-	-	-	LTO.001

— - Not analyzed or not available

ND - Not Detected

LT - Less Than

<sup>x</sup> - Lindane only detected in 1974

a - Niagara River Sampling Range 1.3

b - Environment Canada Niagara-on-the-Lake Daily Station. Data from 8 January-9 September, 1980; 31 samples analyzed.

c - Niagara-on-the-Lake Water Treatment Plant Intake.

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TABLE A-14 Ambient Water Quality Data for Segment 6 - Additional Organic Substances Analyzed for at Sampling Site 2 (Niagara-on-the-Lake Water Treatment Plant Intake).

<u>Parameter</u>	<u>Concentration, ug/l</u>		
	<u>Sampling Date (reference)</u>	<u>1978 (2)</u>	<u>1979 (3)</u>
		<u>1978 (2)</u>	<u>1979 (3)</u>
Hexane		ND	ND ~0.2
Pentane(s)		-	ND ~0.5
Methyl pentene		ND	ND
Carbon tetrachloride		ND	ND
Bromoform		ND	ND-0.4
Chloroform	ND-Trace	8.0-20.0	4.1-9.1
Chlorodibromomethane		LT0.001-(+)	1.7-5.2
Dichloro bromo methane		(+)-20.0	3.6-13.5
Dichloroiodomethane		-	ND-(+)
Dichloroethane		ND	ND
1,1,1 - Trichloroethane		ND	ND-0.001
Trichlorotrifluoroethane		-	ND
Dichloroproppane		ND	ND
Methylene chloride		ND	0.147-0.400 ND-3.0
Trichloroethylene	ND-Trace	LT0.001-0.231	ND-0.1
Tetrachloroethylene		ND	ND
Dichloropropylene		ND	-
Trimethylbenzene		ND	-
Benzene	ND-0.190	ND-0.324	ND-1.9
Ethylbenzene		ND	ND
Di-ethylbenzene	ND-Trace	ND	ND
Cumene		ND	ND
Toluene	ND-0.200	0.100-1.90	LT0.001-0.8
Ethyl Toluene		ND	ND
Xylene(s)	ND-0.250	ND-0.105	ND-0.2
Stryrene	-	ND	ND
Chlorobenzene		ND	ND
Dichlorobenzene	-	ND	ND-0.001
Chlorotoluene (Isomer 1)	ND	ND	ND-0.001
Chlorotoluene (Isomer 2)	ND	ND	ND
m-Chlorotoluene trifluoride	-	ND-(+)	ND-~0.1
n-Butanol	-	ND	ND
sec-Butanol	-	ND	ND-LT0.001
tert-Butanol	-	ND	ND
Ether	ND	ND	ND
Di-ethyl ether	ND	ND	ND
Methyl furan	-	ND	ND
Butanol	-	ND	ND
Isobutanol	ND	ND	ND-~0.1
Hexanal	-	ND	ND
Benzaldehyde	-	ND	ND
Hexonene	-	ND	ND

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TABLE A-14 Ambient Water Quality Data for Segment 6 - Additional Organic Substances Analyzed for at Sampling Site 2 (Niagara-on-the-Lake Water Treatment Plant Intake). (cont.)

Parameter	Concentration, $\mu\text{g/l}$		
	Sampling Date <u>1978</u> <sup>(2)</sup>	<sup>(reference)</sup> <u>1979</u> <sup>(3)</sup>	<u>1980</u> <sup>(3)</sup>
Carbon Disulfide	-	ND-(+)	ND~0.1
Diethyldisulfide	-	ND	ND

- - Not Analyzed

ND - Not Detected

~ - Approximately

LT - Less Than

(+) - Present but not quantitated

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TABLE A-15 Ambient Water Quality Data for Segment 6 - Arsenic, Copper, Cyanide, Mercury and Phenol in Water and Sediment Samples.

Sampling Site (reference)	Mean Concentration in Water, $\mu\text{g/l}$					Concentration in Sediments, mg/kg dry wet			
	Arsenic	Copper	Cyanide	Mercury	Phenol	Arsenic	Cyanide	Mercury	Phenol
Site 1 <sup>(7)</sup> (1976)	-	-	-	-	1.0	-	-	-	-
Site 1 <sup>(7)</sup> (1977)	-	-	-	-	2.0	-	-	-	-
Site 1 <sup>(7)</sup> (1978)	-	-	-	-	4.0	-	-	-	-
Site 1 <sup>(7)</sup> (1979)	-	-	-	-	5.0	-	-	-	-
Site 3 <sup>(9)</sup> (1980)a	-	1	LT1.0	0.11	0.5	-	-	-	-
Site 4 <sup>(9)</sup> (1980)a	-	7	LT1.0	1.03	0.9	-	-	-	-
Site 5 <sup>(9)</sup> (1980)a	-	2	LT1.0	3.90	LT 0.5	--	-	-	-
Site 6 <sup>(9)</sup> (1980)a	-	10	LT1.0	0.25	LT 0.5	-	-	-	-
Site 9 <sup>(8)</sup> (1980)b	-	-	-	-	-	4.7±0.8	0.01±0.00	1.2±0.2	0.26±0.09
Site 12 <sup>(8)</sup> (1980)b,c	LT2.0	-	9.0	0.36	6.0	3.2±0.5	0.35±0.53	1.2±0.2	0.65±0.85
Site 19 <sup>(8)</sup> (1980)b,c	-	-	-	-	-	3.2±0.3	0.06±0.07	0.22±0.17	0.46±0.31
Site 20 <sup>(8)</sup> (1980)b	-	-	-	-	-	3.4±0.1	6.69±9.07	1.22±0.99	1.63±0.54
<u>Concentration in Elutriate Water, <math>\mu\text{g/l}</math></u>									
Site 12 <sup>(9)</sup> (1980)	LT2.0	-	2±2	0.37±0.09	16±9	-	-	-	-

LT - Less Than

- - Not analyzed

a - Data represents mean values from July and August samplings.

b - Data represents values from January sampling.

c - Site values represent means and standard deviations of 2 or more pooled stations.

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TABLE A-16 Concentrations of Organic Contaminants Analyzed for in Water or Sediment at Site 24 in the Lower Niagara River - Segment 6.

No.	<u>Compound</u>	<u>Site 24*</u>
Chlorobzenes		
1	Chlorobenzene	+
2	Dichlorobzenes	+
3	Trichlorobzenes	+ <sup>b</sup>
4	Tetrachlorobzenes	8
5	Pentachlorobenzene	25
6	Hexachlorobenzene	10
		10
Chlorotoluenes		
7	Dichlorotoluenes	90
8	Trichlorotoluenes	50
9	Tetrachlorotoluenes	10
10	Pentachlortoluenes	5
11	Hexachlorotoluenes	-
12	Heptachlorotoluenes	-
Polycyclic Aromatic Hydrocarbons and Derivatives		
13	Methylnaphthalenes	-
14	C <sub>2</sub> -naphthalenes	-
15	C <sub>3</sub> -naphthalenes	-
16	Chloronaphthalene	-
17	Dichloronaphthalene	-
18	Trichloronaphthalene	-
19	Biphenyl	-
20	Phenanthrene	-
21	Chlorophenanthrene	+
22	Dichlorophenanthrene	+
23	Trichlorophenanthrene	+
24	Pyrene	+
25	Fluoranthene	-
Polychlorinated Biphenyls		
26	Dichlorobiphenyls	-
27	Trichlorobiphenyls	-
28	Tetrachlorobiphenyls	-
29	Pentachlorobiphenyls	5
30	Hexachlorobiphenyls	-

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TABLE A-16 Concentrations of Organic Contaminants Analyzed for in Water or Sediment at Site 24 in the Lower Niagara River - Segment 6. (cont.)

<u>No.</u>	<u>Compound</u>	<u>Site 24*</u>
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#### Phenols

31	Phenol	NA
32	Dichlorophenol	2
33	Trichlorophenol	5
34	(1,1,3,3,-Tetramethylbutyl)phenol	+

#### Cyclohexane Derivatives

35	BHC (hexachlorocyclohexane)	+
36	Cyclohexylcyclohexanol <sup>d</sup>	-
37	Cyclohexylcyclohexanone	-
38	Phenylcyclohexane	-

#### C<sub>7</sub>-Benzyl Derivatives

39	Benzyl alcohols (0-5C <sub>1</sub> ) <sup>d</sup>	-
40	Benzaldehydes (0-5 C <sub>1</sub> ) <sup>d</sup>	-
41	Benzoic acids (0-5 C <sub>1</sub> ) <sup>d</sup>	-
42	Benzamides (0-4 C <sub>1</sub> ) <sup>d</sup>	-

#### C<sub>14</sub>-Benzyl Derivatives

43	(Methylphenyl)phenylmethane <sup>d</sup>	+
44	Chloro(methylphenyl)phenylmethanes	+
45	Dichloro(methylphenyl)Phenylmethanes	+
46	Trichloro(methylphenyl)phenylmethanes	+
47	(phenylmethyl)benzenemethanols	-
48	(phenylmethyl)benzoic acid <sup>d</sup>	-
49	Methylbenzophenone <sup>d</sup>	-
50	Benzoylbenzoic acid <sup>d</sup>	+
51	Benzyl ether <sup>d</sup>	-

#### C<sub>21</sub>-Benzyl Derivatives

52	Methylbis(phenylmethyl)benzenes <sup>d</sup>	-
53	Chloro(methyl)bis(phenylmethyl)benzenes <sup>c</sup>	-
54	Dichloro(methyl)bis(phenylmethyl)benzenes <sup>c</sup>	-
55	Trichloro(methyl)bis(phenylmethyl)benzenes <sup>c</sup>	-
56	Tetrachloro(methyl)bis(phenylmethyl)benzenes <sup>c</sup>	-
57	Pentachloro(methyl)bis(phenylmethyl)benzenes <sup>c</sup>	-
58	Bis(methylphenyl)phenylmethane <sup>d</sup>	+

TABLE A-16 Concentrations of Organic Contaminants Analyzed for in Water or Sediment at Site 24 in the Lower Niagara River - Segment 6. (cont.)

No.	<u>Compound</u>	<u>Site 24*</u>
C <sub>28</sub> -Benzyl Derivative		
59	Methyltris(phenylmethyl)benzenes <sup>d</sup>	-
Fluorine-Containing Compounds		
60	Benzotrifluoride	+
61	Chlorobenzotrifluoride	+
62	Dichlorobenzotrifluoride	+
63	3-Aminobenzotrifluoride <sup>d</sup>	+
64	N-(3-trifluoromethyl)phenylbenzamide (0-3 C1) <sup>d</sup>	+
65	Dichloro(trifluoromethyl)benzophenone <sup>d</sup>	25
66	Dichloro(trifluoromethyl)-α,α-difluorodi-phenylmethane <sup>d</sup>	15
Miscellaneous		
67	Mirex	+
68	Phenothiazine <sup>d</sup>	-
69	Phenyl ether	+
70	DDE(1,1'-(dichloroethylidene)bis-(4-chlorobenzene)	+
71	Methoxybenzophenone <sup>d</sup>	+
72	Chloromethoxybenzophenone	+
73	Chlorohydroxybenzophenone	15
74	Aminoacetophenone	-
75	1-dodecanethiol	-
76	Trichloroethylene	+
77	Tetrachloroethylene	+
78	Hexachlorobutadiene	+
79	Furan	-

- 
- NA - Sample not analyzed for this compound.  
 + - Compound detected in water at a level of 0.1-1 ppb or in sediment at a level of 0.5-2 µg/g dry weight but was not quantified.  
 - - Compound not detected in water or sediment. Lower limits of sensitivity are 0.1 ppb in water and 0.5 µg/g in sediment.  
 b - Maximum level in µg/g dry weight in sediment. Same for all values presented.  
 c - Or another isomer.  
 d - Structure presented in paper referenced.  
 \* - Samples taken at approximately 130 and 150 meters downstream (in Bloody Run Creek) from the boundary of the Hyde Park landfill. Data source is Reference 1.

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TABLE A-17 Inorganic and Organic Contaminants Detected in Sediment in Segment 6, 1979\*

<u>Parameter</u>	<u>Concentration, ug/kg for organics; ug/g for metals (dry weights)</u>									
	<u>Site 1<sup>a</sup></u>	<u>Site 4</u>	<u>Site 7</u>	<u>Site 8<sup>b</sup></u>	<u>Site 9</u>	<u>Site 10</u>	<u>Site 11</u>	<u>Site 12</u>	<u>Site 13</u>	
Arsenic	1.5	2.0	2.5	3.5	4.2	3.7	8.2	4.0	2.8	
Cadmium	0.55	0.65	0.72	0.45	0.88	0.72	LT0.4	0.88	0.60	
Chromium	9.5	20.	15.	15.	35.	27.	170.	25.	16.	
Copper	7.5	13.	8.8	11.	28.	21.	32.	16.	13.	
Lead	6.	10.	13.	6.5	33.	19.	60.	16.	13.	
Mercury	0.51	0.22	0.19	0.03	3.2	0.96	0.86	0.34	0.26	
Nickel	9.5	7.5	7.2	11.	20.	18.	17.	17.	15.	
Zinc	47.	150.	63.	55.	140.	110.	170.	96.	79.	
PCB (total)	130.	290.	160.	-	2700.	490.	66.	82.	690.	
Aldrin	ND	ND	ND	-	ND	ND	ND	ND	ND	
Dieldrin	ND	-	2.	-	26.	6.	ND	ND	ND	
$\alpha$ - BHC	6.	13.	ND	-	110.	38.	ND	ND	ND	
B - BHC	ND	ND	ND	-	ND	ND	ND	ND	ND	
$\gamma$ - BHC (Lindane)	ND	ND	ND	-	ND	ND	ND	ND	ND	
$\alpha$ - Chlordane	14.	50.	11.	-	293.	61.	-	ND	ND	
$\gamma$ - Chlordane	5.	35.	6.	-	64.	70.	ND	-	ND	
$\alpha, p'$ - DDT	ND	ND	ND	-	20.	21.	ND	ND	ND	
$p, p'$ - DDT	ND	ND	ND	-	74.	70.	ND	ND	ND	
$p, p'$ - DDE	9.	6.	10.	-	20.	36.	ND	ND	ND	
$p, p'$ - DDD	ND	14.	ND	-	65.	63.	5.	4.	5.	
$\Sigma$ DDT + metabolites	9.	20.	10.	-	179.	190.	ND	ND	ND	
Endrin	ND	-	ND	-	13.	7.	5.	4.	5.	
Heptachlor	ND	ND	ND	-	ND	ND	ND	ND	5.	
Heptachlor epoxide	1.	3.	1.	-	36.	3.	ND	ND	ND	
Hexachlorobenzene	28.	32.	45.	-	250.	31.	1.	8.	47.	
Mirex	ND	11.	ND	-	640.	23.	ND	4.	6.	
Thiodan I	1.	ND	1.	-	15.	12.	1.	1.	4.	
Thiodan II	1.	ND	2.	-	15.	45.	ND	1.	6.	

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TABLE A-17 Inorganic and Organic Contaminants Detected in Sediment in Segment 6., 1979\* (cont.)

<u>Parameter</u>	<u>Concentration, µg/kg for organics; µg/g for metals (dry weights)</u>								
	<u>Site 1<sup>a</sup></u>	<u>Site 4</u>	<u>Site 7</u>	<u>Site 8<sup>b</sup></u>	<u>Site 9</u>	<u>Site 10</u>	<u>Site 11</u>	<u>Site 12</u>	<u>Site 13</u>
2,4 - D	-	ND	ND	-	ND	-	ND	ND	ND
2,4,5 - T	-	ND	ND	-	ND	-	ND	ND	ND
2,4 - DB	-	ND	ND	-	ND	-	ND	ND	ND
Silvex	-	ND	ND	-	ND	-	ND	ND	ND
2,3,4 - Trichlorophenol	-	ND	ND	-	ND	-	ND	ND	ND
2,4,5 - Trichlorophenol	-	ND	ND	-	ND	-	ND	ND	ND
2,4,6 - Trichlorophenol	-	ND	ND	-	ND	-	ND	ND	ND
Pentachlorophenol	-	ND	ND	-	ND	-	ND	ND	ND

— - Not Analyzed

ND - Not Detected

LT - Less Than

\* - 3-grab Shipek surface sediment (0 to 3cm) composite samples per station. Data source is Reference 3.

a - Environment Ontario Station NIL 2.

b - Environment Ontario Station NIL 5.

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TABLE A-18 Organics Analyzed for in Sediments in Segment 6.\*

<u>Parameter</u>	<u>Concentration, µg/kg wet weight</u>			
	<u>Site 9<sup>a</sup> 1980</u>	<u>Site 12<sup>b</sup> 1980</u>	<u>Site 19<sup>b</sup> 1980</u>	<u>Site 20<sup>a</sup> 1980</u>
DDE	19-31	14-50	12-21	7-22
DDD	-	6-12	8-23	4-13
DDT	32-66	7-17	2-12	4-9
Mirex	104	Trace-7	4-11	12
PCB 1242	Trace	Trace	-	-
PCB 1254	Trace	Trace	-	-
PCB 1260	Trace-413	227	-	-

- - Not Analyzed

\* - Data Source is Reference 8.

a - 1 or 2 Samples Analyzed.

b - Site values represent mean ranges of 2 or more pooled stations.

09465 TABLE A-19 Inorganic Contaminants Analyzed for in Suspended Sediment Samples Taken from Various Sites in Segment 6.

Parameter	Concentration, $\mu\text{g/g}$ dry weight					
	Site (reference)					
	Site 1 (10)a (1979)	Site 2 (3)b (1978)	Site 2 (3)b (1979-80)	Site 7 (10) (1979)	Site 9 (10) (1979)	Site 10 (10) (1979)
Cadmium	-	2.4	2.4	-	-	-
Chromium	-	39.0	3.0	-	-	-
Cobalt	-	6.6	6.5	-	-	-
Copper	-	46.0	44.0	-	-	-
Lead	-	80.0	58.0	100.0	170.0	120.0
Mercury	-	-	-	0.69	-	0.66
Nickel	-	29.0	24.0	-	-	-
Zinc	380.0	177.0	163.0	330.0	390.0	300.0

-- Not Analyzed or Not Available

a - Environment Ontario Station NIL 2

b - Environment Canada Niagara-on-the-Lake Station

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TABLE A-20 Organic Contaminants Analyzed for in Suspended Sediment in Segment 6.

Parameter	<u>Mean Concentration, ng/g dry weight</u>		
	Overall Mean - Sites 1,7,9,10 <sup>(2)</sup> 1979	Site 2 <sup>(2)a</sup> 1979	Site 2 <sup>(3)a</sup> 1980
PCB	137 ± 84	493 ± 30/1080 ± 253 <sup>b</sup>	642.
Aldrin	ND	ND	ND
Dieldrin	8 ± 7	9 ± 4	4:
α-BHC	5 ± 7	16 ± 10/74 ± 162 <sup>b</sup>	11.
γ-BHC	3 ± 4	19 ± 11	2:
α-Chlordane	4 ± 7	} 22 ± 12	1.
γ-Chlordane	15 ± 26		2.
O,p - DDT	ND	15	3.
p,p - DDT	ND	12 ± 6	13.
p,p - DDE	8 ± 2	25 ± 13	19.
p,p - TDE	3 ± 6	9 ± 5	2.
Endrin	0.3 ± 0.6	ND	LT1.
Heptachlor	ND	ND	ND
Heptachlor epoxide	5 ± 5	ND	2.
HCB (packed column)	38 ± 51	106 ± 130	160.
HCB (capillary column)	-	-	83.
Mirex	41 ± 60	30 ± 61	6.
Methoxychlor	-	19 ± 16	10.
Σ DDT + Metabolites	11 ± 16	34 ± 16	-
Thiodan I	5 ± 5	12 ± 4	LT1.
Thiodan II	13 ± 18	ND	LT1.
B-BHC	ND	-	-

LT - Less Than

- - Not Analyzed

ND - Not Detected

a - Environment Canada Niagara-on-the-Lake Station.

b - Without and with high values.

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TABLE A-21 Non-Routine Organic Contaminants Identified in Suspended Sediment Samples from Site 2\*, Segment 6, January 1980.

	<u>Compound</u>	
I	<u>Chlorinated Hydrocarbons</u>	
	Trichlorobzenes	1 isomer
	Tetrachlorobenzene	2 isomers
	Pentachlorobenzene	
	Hexachlorobenzene	
II	<u>Polyaromatic Hydrocarbons</u>	
	Naphthalene	
	Methyl naphthalenes	2 isomers
	Dimethyl naphthalenes	3 isomers
	Trimethyl naphthalenes	4 isomers
	Tetramethyl -4-propenyl-(E)-naphthalene	
	Phenathrene	
	Methyl phenanthrenes	2 isomers
	Dimethyl phenanthrenes	2 isomers
	Fluorathene	
	Pyrene	
	Methyl pyrenes or methyl fluoranthenes	4 isomers
	Chrysene or Triphenylene or Benzanthrathenes	
	Benzopyrenes or perylene or benzofluoranthenes	2 isomers
III	<u>Alkyl Benzenes</u>	
	Toluene	
	C <sub>2</sub> -alkyl benzene	1 isomer
	C <sub>3</sub> -alkyl benzene	2 isomers
	C <sub>4</sub> -alkyl benzene	6 isomers
IV	<u>Phthalic Acid Esters</u>	
	Phthalates 3-4 unidentified	

\* - Environment Canada Niagara-on-the-Lake Station. Data extracted from Reference 3 (Ministry of the Environment, Ontario 1981), Table 10.

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TABLE A-22 Quantification of Selected Residues in Suspended Sediment Samples from Site 2\*, Segment 6, March-April 1980.

I      Chlorinated Hydrocarbons (ppm)

1,2,4-T <sub>3</sub> CB (Trichlorobenzene)	Trace
1,2,4,5-T <sub>4</sub> CB (Tetrachlorobenzene)	0.003-0.010
1,2,3,4-T <sub>4</sub> CB(tetrachlorobenzene)	0.019-0.145
Pentachlorobenzene	0.023-0.115
Hexachlorobenzene	0.017-0.064

II     Polyaromatic Hydrocarbons (ppm)

Naphthalene	0.012-0.510
Acenaphthylene	0.004-0.016
Acenaphtene	0.008-0.038
Fluorene	0.010-0.042
Anthracene/Phenanthrene	0.166-1.58
Fluoranthene	0.173-0.942
Pyrene	0.141-0.824
Chrysene/Benzo(A)anthracene	0.105-1.51
Benzo fluoranthene(B&K)	0.193-1.08
Benzo pyrene(A&E)	0.190-1.10

No quantitation on the alkylated PAH due to lack of standards

III    Phthalic Acid Esters (ppm)

di-n-butyl	0.07-1.0
Butyl benzyl	Trace
Bis (2-ethyl hexyl)	5.9-107.0
Di-n-octyl	0.12-7.0

---

\* - Environment Canada Niagara-on-the-Lake Station. Data extracted from Reference 3 (Ministry of the Environment, Ontario 1981), Table 11.

## REFERENCES - APPENDIX A

Badorek, D., V. R. Frederick. Niagara River Toxics Study - Final Report on Segment 6, Lower Niagara River Section. Great Lakes Laboratory, State University of New York College at Buffalo. (July 7, 1982)

Environment Canada. Environmental Baseline Report of the Niagara River - November 1981 Update. Ontario Review Board. (November 16, 1981)

New York State Department of Environmental Conservation (NYSDEC). Conventional and Priority Pollutant Levels for the Niagara River at Fort Niagara, Youngstown. Water Quality Surveillance Network. (July 1982)

Vincent, J., A. Franzen. Overview of Environmental Pollution in the Niagara Frontier, New York. United States Environmental Protection Agency. (March 1982)

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Badorek, D., V. R. Frederick. Niagara River Toxics Study - Final Report on Segment 6, Lower Niagara River Section. Great Lakes Laboratory, State University of New York College at Buffalo. (July 7, 1982)

Environment Canada. Environmental Baseline Report of the Niagara River - November 1981 Update. Ontario Review Board. (November 16, 1981)

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PROJECT 36302

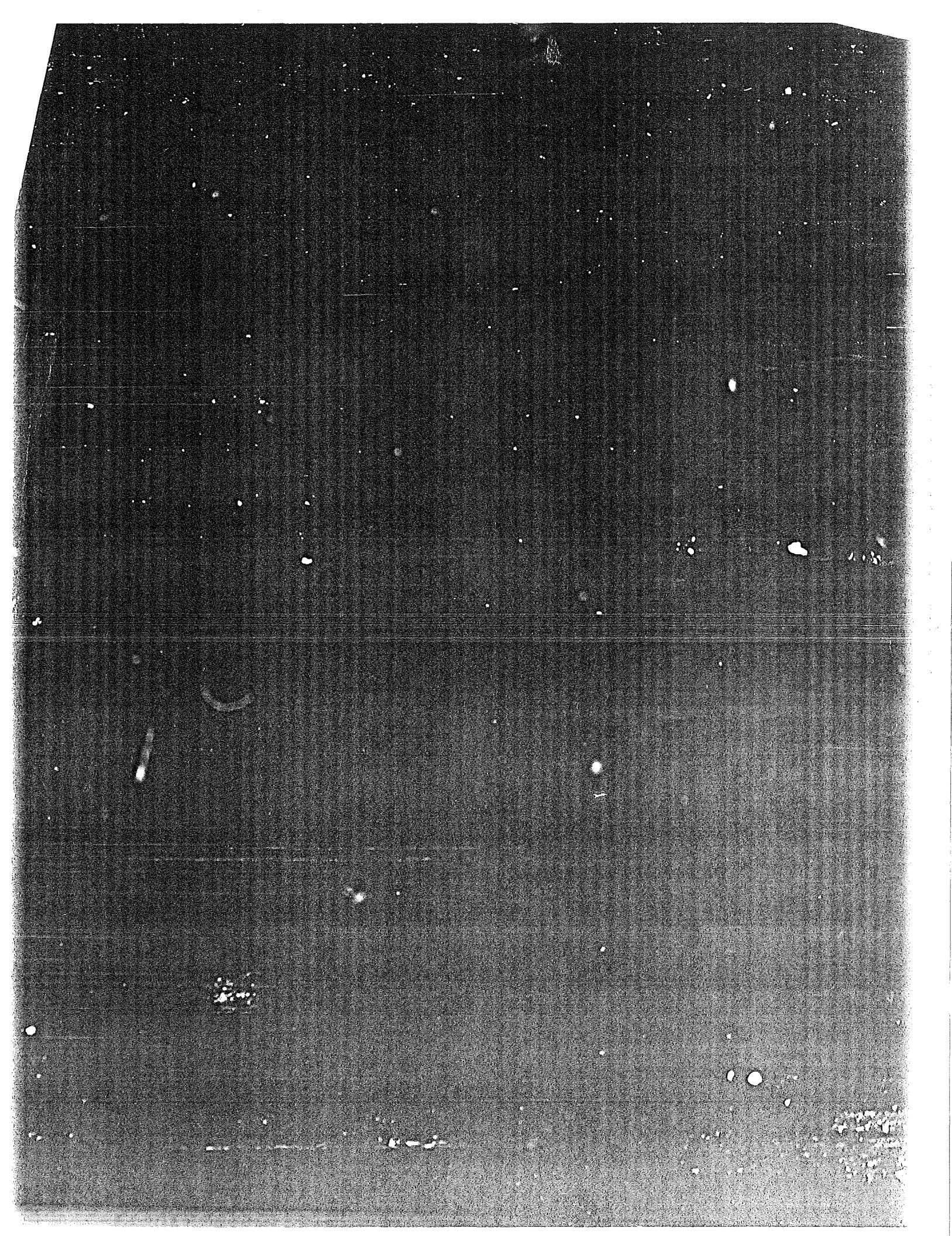
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TABLE 3.2.

## SUMMARY OF GROUNDWATER ELEVATIONS\* FOR THE UPPER SOIL AQUIFER

FEET (MSL)

Well No.	D A T E S									
	6-4-81	6-8-81	6-10-81	6-15-81	6-22-81	6-24-81	6-29-81	7-2-81	7-10-81	7-15-81
BH-15A								305.10	312.73	311.42
BH-30A		314.2		314.2	315.30	314.99		314.22	314.20	314.00
BH-36A	315.13	315.2		315.5	315.56	315.67	315.96	315.99	316.04	315.85
BH-40A	315.80	315.8		315.3	315.10	315.62	315.66	315.13	314.71	313.81
BH-47A		317.4		317.3	316.93	317.26			315.27	315.89
BH-49A		312.2		311.4	311.88	312.28		311.84	311.92	311.58
BH-50A		314.0		315.5	314.82	315.23		313.58	313.45	312.53
BH-58A	320.70			309.5			313.53	313.92	314.82	314.97
BH-64B					315.01	317.22		315.84	315.42	314.24
BH-68A									311.69	311.33
BH-71A								314.54	313.52	312.84

\* Because of the short time period in which these wells were monitored, and the fluctuations observed in some wells, monitoring should be continued to establish long-term water level fluctuations. The greatest accuracy for water level measurements is generally accepted to be  $\pm 0.04$  feet.

Source: Acres American, Inc. 1981.

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EXPLANATION

Groundwater flow paths

Elevation of piezometric surface  
in lower alluvial aquifer on  
7-15-81

NOTE:

Water level elevations from  
hydraulic and geologic characteris-  
tics of the DOE - Niagara  
Falls Storage Site, Acres  
American Inc., Sept. 30, 1981.

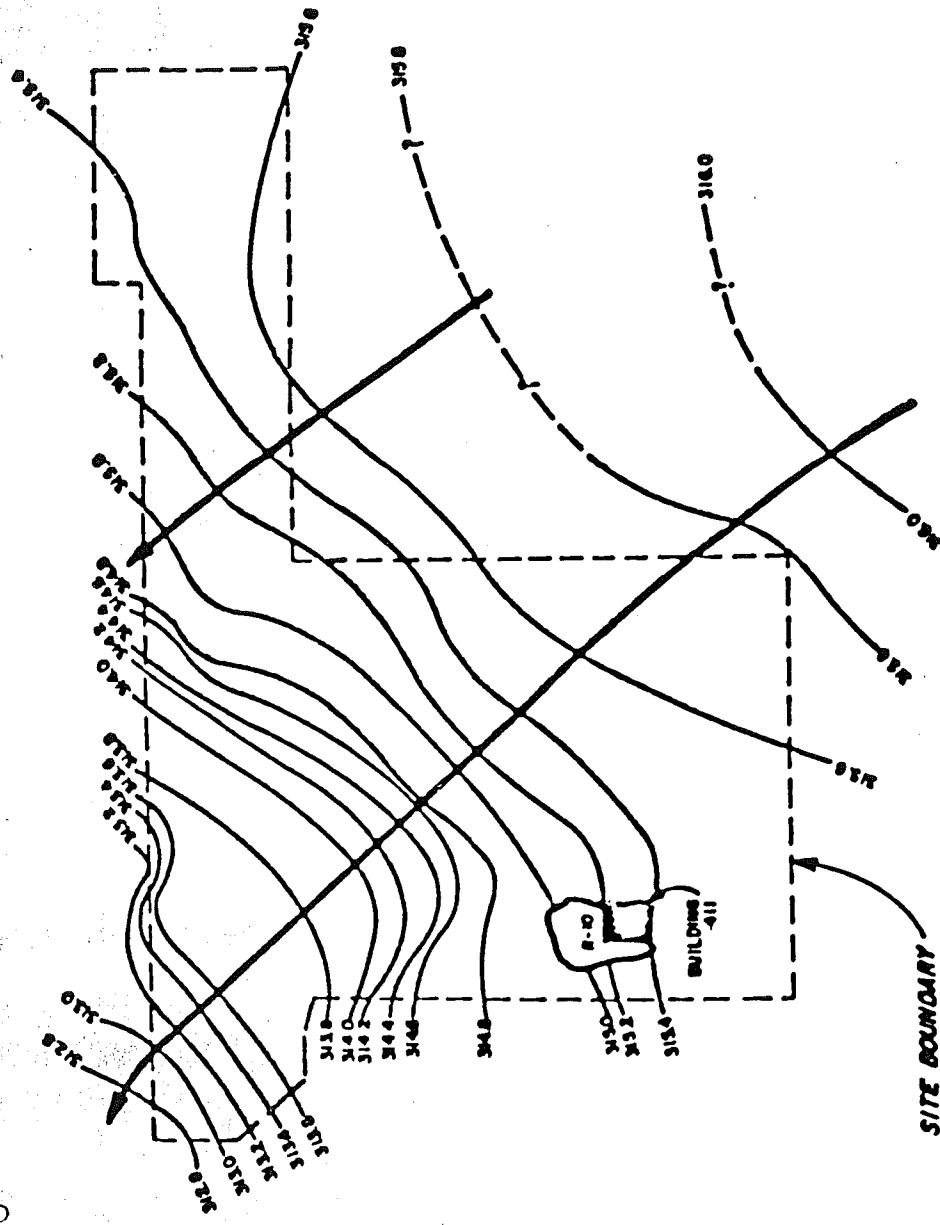


FIGURE 3.2

0 200 400 600 800  
SCALE IN FEET

PIEZOMETRIC SURFACE	ACRES	FEET
316.0	100	316.0
315.0	100	315.0
314.0	100	314.0
313.0	100	313.0
312.0	100	312.0
311.0	100	311.0
310.0	100	310.0
309.0	100	309.0
308.0	100	308.0
307.0	100	307.0
306.0	100	306.0
305.0	100	305.0
304.0	100	304.0
303.0	100	303.0
302.0	100	302.0
301.0	100	301.0
300.0	100	300.0

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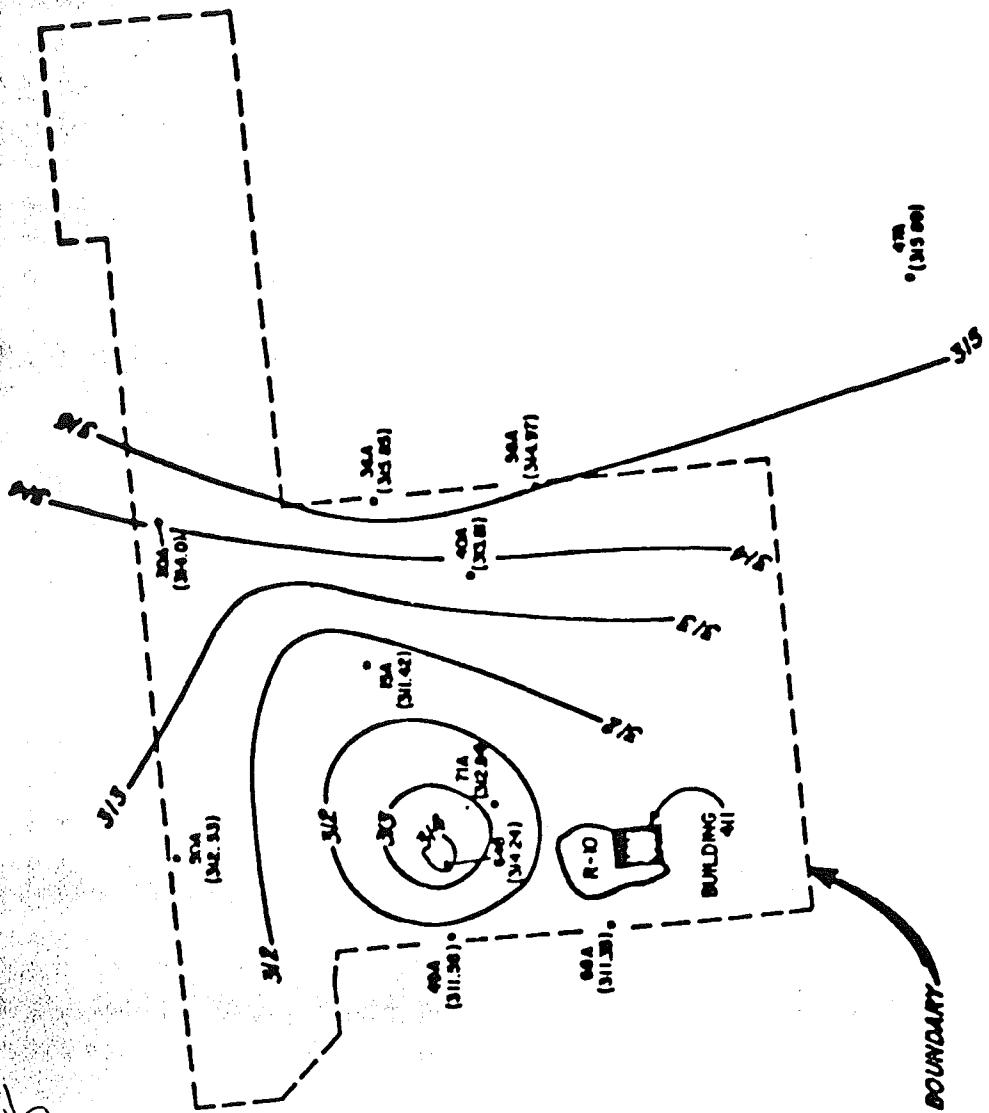
## **EXPLANATION**

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NOTE

Winter level elevations from hydrologic and geologic characterizations of the DOE - Moegara Falls 3 storage site, Acres, fence posts Inc., Sept. 30, 1981.



**FIGURE 3.3**

BIOSTRATIFICATION		MISURA DELLA STRADA SITA		MEZOBIOTRICO SURFACE		UPPER ALUMINUM ACQUAION	
		mm	m	mm	m	mm	m
1	2	3	4	5	6	7	8

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The gravelly sand-silt unit is reported to be continuous beneath the NFSS (Acres American, Inc. 1981). This aquifer is 3 to 7 feet thick and is confined, with an average piezometric surface 25 to 30 feet above the top of the unit (Acres American, Inc. 1981). Average permeability within the unit is reported to be  $1.3 \times 10^{-3}$  cm/sec (Wehran Eng. Corp., 1979).

The upper fractured portion of the Queenston Formation is a water bearing zone and is used to supply water for domestic wells. This fractured zone is probably only a few feet thick. Groundwater in the NFSS area is transmitted through fractures and solution channels in the bedrock (secondary porosity). The unfractured Queenston Formation is essentially impermeable. The average yield of wells screened in the Queenston Formation is reported to be 7 gpm (Johnson, 1964).

### 3.3 Ground water Flow Characteristics

The uppermost ground water in the unconsolidated deposits consists of locally discontinuous alluvial sand and gravel lenses within the lacustrine clays. The piezometric surface of this ground water is shown in Figure 3.3. The aquifer in the surficial deposits consists of a continuous alluvial sand unit that overlies the red clay. Where the red clay is absent, the alluvial aquifer and the underlying bedrock aquifer are in contact. The piezometric surface of the alluvial aquifer is shown in Figure 3.2. The water levels in wells installed into the bedrock coincide with the piezometric contours on this figure. Therefore at least locally, the alluvial aquifer and the weathered zone aquifer of the Queenston Formation are connected.

solution were determined. Soluble uranium and radium were detected in saturated zones in the R-10 residue storage area and in peripheral wells on the west side of the NFSS (Tables 3.12 - 3.13). The average uranium and radium-226 concentrations in the saturated zones of the R-10 storage area were 40.8 ug/l U and 2.14 pCi/l Ra-226 (Table 3.12) (Anderson et al. 1981). In the peripheral areas, average concentrations were 20.36 ug/l U and 0.26 pCi/l Ra-226 (Table 3.13) (Anderson et.al. 1981).

### 3.5.2 Nonradiological Characterization

Battelle Columbus Laboratories (Anderson et al. 1981) evaluated samples collected at the NFSS in May, 1980 for dissolved concentrations of metals and rare earths. Well locations are the same as those shown in Figures 3.6 and 3.7. Summary results of these analyses from the site periphery and R-10 residue area are given in Tables 3.14 and 3.15, respectively.

Periphery well water samples from the west side of the NFSS and from the R-10 residue storage area exhibited trace (ppb) levels of lead, barium, nickel, copper, chromium, and cobalt. In addition, selenium and zirconium were also detected in water from the R-10 residue storage area.

In addition to the Battelle study, water quality sampling was performed by the Oak Ridge National Laboratory (ORNL) in July 1981 at the NFSS and is presented in Acres American, Inc. (1981). Analyses were performed for 17 chemical parameters at each of 5 upper soil monitoring wells, 8 lower soil monitoring wells, and 3 bedrock wells on the site. Results of these analyses are presented in Table 3-16 and 3-17.

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TABLE 3.12.

RESULTS OF URANIUM AND  $^{226}\text{RA}$  ANALYSES OF SATURATED  
ZONE WATER SAMPLES COLLECTED IN MAY, JUNE, AND AUGUST  
1980 IN THE PERIPHERY WELLS OF THE NIAGARA FALLS  
STORAGE SITE

MONITORING WELL	SAMPLING PERIOD	TOTAL U		RA-226	
		$\mu\text{G/L}$	1 SD	$\mu\text{Ci/L}$	1 SD
<b>PERIPHERY</b>					
N10.0 E 7.0	MAY	2.40	.30	.14	.07
N10.0 E 7.0	JUNE	4.40	.50	.04	.12
N10.0 E 7.0	AUG	4.60	.50	.53	.11
N10.0 E10.0	MAY	.25	.03	.09	.05
N10.0 E10.0	JUNE	2.40	.40	.05	.05
N10.0 E10.0	AUG	3.00	.20	.08	.08
N 0 N 8.0	JUNE	4.00	.40	.14	.05
N 0 N 8.0	AUG	22.00	1.00	.22	.05
N 1.0 W26.0	MAY	.25	.03	.27	.08
N 1.0 W26.0	JUNE	2.00	.40	.05	.08
N 1.0 W26.0	AUG	13.00	1.30	.08	.08
N 4.0 W29.0	MAY	6.30	.60	.09	.05
N 4.0 W29.0	JUNE	4.60	.40	.03	.05
N 4.0 W29.0	AUG	1.80	.20	.05	.04
N 7.0 W30.0	MAY	.27	.03	.13	.04
N 7.0 W30.0	JUNE	15.00	1.00	.15	.15
N 7.0 W30.0	AUG	4.10	.50	.03	.08
N10.0 W 8.0	JUNE	16.00	1.00	.12	.04
N10.0 W 8.0	AUG	2.40	.20	.22	.05
N10.0 W17.0	MAY	46.00	3.00	.09	.05
N10.0 W17.0	JUNE	14.00	1.00	.08	.08
N10.0 W17.0	AUG	55.00	3.00	.0c	.09
N12.0 W31.0	MAY	6.30	.60	.56	.18
N12.0 W31.0	JUNE	5.50	.40	.00	.08
S14.0 W18.0	MAY	1.70	.40	.39	.09
S14.0 W18.0	JUNE	98.00	5.00	.32	.07
S14.0 W18.0	AUG	12.00	1.00	.19	.06
S14.0 W18.0	MAY	238.00	12.00	.13	.06
S15.0 W18.0	JUNE	45.00	2.00	.30	.07
S15.0 W18.0	AUG	28.00	1.00	.29	.06
S21.0 W 7.0	MAY	78.00	4.00	1.15	.17
S21.0 W 7.0	JUNE	8.00	.50	.18	.06
S21.0 W 7.0	AUG	10.00	1.00	.13	.04
S22.0 W18.0	MAY	9.60	1.10	1.58	.16
S22.0 W18.0	JUNE	15.00	1.00	.08	.08
S22.0 W18.0	AUG	7.00	.40	.0c	.08

Source: Anderson et al., 1981

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TABLE 3.12. (Continued)

MONITORING WELL	SAMPLING PERIOD	TOTAL U		RA-226	
		µG/L	1 SD	µG/L	1 SD
<b>PERIPHERY</b>					
S26.0 W 7.0	MAY	37.00	.40	.39	.09
S26.0 W 7.0	JUNE	15.00	1.00	.13	.06
S26.0 W 7.0	AUG	10.00	1.00	.29	.08
S26.0 W15.0	MAY	49.00	3.00	.24	.05
S26.0 W15.0	JUNE	5.30	.20	.40	.06
S26.0 W15.0	AUG	2.00	.50	.11	.04
S36.0 W15.0	MAY	1.40	.20	.30	.10
S36.0 W15.0	JUNE	25.00	1.00	.08	.08
S36.0 W15.0	AUG	25.00	1.00	1.00	.11
S42.0 W15.0	MAY	49.00	3.00	.12	.03
S42.0 W15.0	JUNE	3.10	.40	.05	.09
S42.0 W15.0	AUG	2.50	.60	.14	.04

TABLE 3.13. ANALYSES OF TOTAL URANIUM AND  $^{226}\text{RA}$  DISSOLVED  
IN WATER OF SATURATED ZONES IN R-10 RESIDUE  
STORAGE AREA DURING MAY, JUNE, AND AUGUST 1980

MONITORING WELL	SAMPLING PERIOD	TOTAL U		RA-226	
		$\mu\text{G/L}$	1 SD	$\text{PCI/L}$	1 SD
<b>R-10 AREA</b>					
S15.0 W13.0	MAY	13.00	2.00	.33	.06
S15.0 W13.0	JUNE	8.90	.50	.08	.08
S15.0 W13.0	AUG	2.40	.20	.12	.04
S15.0 W17.0	MAY	56.00	7.00	.16	.08
S15.0 W17.0	AUG	14.00	1.00	.22	.09
S17.0 W13.0	JUNE	.50	.10	.17	.05
S17.0 W13.0	AUG	.15	.06	.20	.20
S20.0 W10.0	MAY	5.00	.50	.49	.05
S20.0 W10.0	JUNE	6.60	.40	.08	.08
S20.0 W10.0	AUG	20.00	1.00	.33	.06
S20.0 W13.0	MAY	15.00	2.00	2.50	.50
S20.0 W13.0	AUG	.90	.20	.45	.07
S20.0 W13.0	MAY	1.10	.20	.73	.09
S20.0 W15.0	JUNE	14.00	1.00	.74	.09
S20.0 W15.0	AUG	6.10	.60	.67	.10
S20.0 W17.0	MAY	149.00	8.00	.33	.01
S20.0 W17.0	JUNE	21.00	1.00	.37	.06
S20.0 W17.0	AUG	1150.00	60.00	.28	.05
S21.0 W13.0	MAY	16.00	2.00	34.40	.70
S21.0 W13.0	AUG	9.10	.50	2.90	.20
S22.0 W 9.0	MAY	5.90	.70	8.10	.40
S22.0 W 9.0	JUNE	16.00	1.00	.43	.08
S22.0 W 9.0	AUG	3.60	.50	.37	.07
S22.0 W11.0	MAY	15.00	2.00	3.70	.20
S22.0 W11.0	JUNE	19.00	1.00	.43	.06
S22.0 W11.0	AUG	28.00	1.00	.17	.05
S22.0 W14.0	MAY	54.00	3.00	.79	.10
S22.0 W14.0	JUNE	6.60	.50	.19	.05
S22.0 W14.0	AUG	14.00	1.00	.09	.05
S22.0 W17.0	MAY	53.00	5.00	2.97	.18
S22.0 W17.0	JUNE	11.00	1.00	.68	.08
S22.0 W17.0	AUG	10.00	1.00	.26	.06
S24.0 W 9.0	MAY	8.10	.80	.20	.06
S24.0 W 9.0	JUNE	5.50	.40	.35	.08
S24.0 W 9.0	AUG	4.70	.60	.06	.05
S24.0 W11.0	MAY	145.00	7.00	16.60	.43
S24.0 W11.0	JUNE	67.00	4.00	1.97	.17
S24.0 W11.0	AUG	30.00	1.00	2.20	.20

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TABLE 3.13. (Continued)

MONITORING WELL	SAMPLING PERIOD	TOTAL U		RA-225	
		µG/L	1 SD	PCU/L	1 SD
S24.0 W14.0	MAY	63.00	3.00	3.80	.20
S24.0 W14.0	JUNE	5.60	.40	.34	.06
S24.0 W14.0	AUG	27.00	1.00	.92	.13
S24.0 W17.0	MAY	4.70	.60	.97	.11
S24.0 W17.0	JUNE	6.40	.40	.19	.04
S24.0 W17.0	AUG	6.60	.40	.34	.09
S26.0 W 9.0	MAY	8.90	1.10	1.12	.17
S26.0 W 9.0	JUNE	12.00	1.00	.77	.09
S26.0 W 9.0	AUG	11.00	1.00	1.00	.17
S26.0 W11.0	MAY	13.00	2.00	5.48	.24
S26.0 W11.0	JUNE	13.00	1.00	2.00	.10
S26.0 W11.0	AUG	9.80	1.00	.85	.14
S26.0 W16.0	MAY	12.00	2.00	.63	.09
S26.0 W16.0	AUG	3.60	.30	2.27	.18
S27.0 W17.0	MAY	102.00	5.00	.16	.05
S27.0 W17.0	JUNE	21.00	1.00	.61	.07
S27.0 W17.0	AUG	55.00	3.00	5.86	.24
S29.0 W17.0	MAY	38.00	5.00	.13	.06
S29.0 W17.0	AUG	20.00	2.00	.27	.05

Source: Anderson et al., 1981

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TABLE 3.14. SUMMARY RESULTS OF SPARK SOURCE MASS SPECTROSCOPY OF SATURATED ZONE WATER SAMPLES FROM THE SITE PERIPHERY

ELEMENT	VALUES ABOVE DETECTION LIMITS (PPM)					VALUES BELOW DETECTION LIMITS (PPM)				
	N*	MEAN	STD DEV.	MIN.	MAX.	N*	MIN.	DL**	MAX.	DL**
URANIUM	4	8.15E-03	2.78E-03	6.39E-03	1.23E-02	13	5.76E-03	7.31E-03		
THORIUM	0					17	1.15E-02	1.48E-02		
BISMUTH	0					17	5.76E-03	7.41E-03		
LEAD	7	1.45E-02	4.95E-03	1.15E-02	2.55E-02	10	1.15E-02	1.48E-02		
THALLIUM	0					17	1.15E-02	5.93E-02		
MERCURY	0					17	2.30E-01	2.96E-01		
GOLD	0					17	5.76E-03	7.41E-03		
PLATINUM	0					17	1.15E-02	1.48E-02		
IRIDIUM	0					17	1.15E-02	1.48E-02		
OSMIUM	0					17	2.30E-02	2.96E-02		
RHENIUM	0					17	1.15E-02	1.48E-02		
TUNGSTEN	0					17	1.15E-02	1.48E-02		
TANTALUM	0					17	3.71E-02	3.72E-01		
HAFNIUM	0					17	1.15E-02	1.48E-02		
LUTETIUM	0					17	5.76E-03	7.41E-03		
YTTERBIUM	0					17	1.15E-02	1.48E-02		
THULIUM	0					17	5.76E-03	7.41E-03		
ERDIUM	0					17	1.15E-02	1.48E-02		
HOLMIUM	0					17	5.76E-03	7.41E-03		
DYSPROSIUM	0					17	1.15E-02	1.48E-02		
TERBIUM	0					17	3.45E-03	4.45E-03		
GADOLINIUM	0					17	1.15E-02	1.48E-02		
EUROPIUM	0					17	1.15E-02	1.48E-02		
SAMAPIUM	0					17	1.15E-02	1.48E-02		
NEODYMIUM	0					17	3.45E-02	4.45E-02		

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