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I. INTRODUCTION

The purpose of this environmental information document (EID) is to summarize information from previous and ongoing studies of the quality of surface water and groundwater at the Western New York Nuclear Service Center (WNYNSC). This document is one of eleven EIDs designed to assess the baseline environmental conditions at the WNYNSC, an assessment needed to develop an environmental impact statement (EIS) for completion of the West Valley Demonstration Project (WVDP) and closure of the WNYNSC. It thus provides the technical data concerning water quality that will be used in preparing the EIS.

The quality of surface water and groundwater at the WNYNSC is regulated by a number of federal and state legislative, regulatory, and operational guidelines. The most specific to the WNYNSC is the West Valley Demonstration Project Act (1980), Public Law 96-368, which charges the Secretary of Energy with "preparing the required environmental impact analyses of the project" [sec. 3 (d)]. As such, the Department of Energy (DOE) is responsible for fulfilling all appropriate statutory requirements.

Under the West Valley Demonstration Project Act, the DOE is authorized to carry out high-level radioactive waste management activities and through the Atomic Energy Act (AEA) of 1954 is required to protect the health and safety of the public against radiation. Subsequent to the requirements of the AEA, the DOE has issued a series of official orders for implementation of federal legislation. The WVDP operates within the guidelines of the 5400-series of DOE orders pertaining to environmental, safety, and health protection.

The major statues and regulations affecting the WVDP are the Atomic Energy Act/DOE Orders, the National Environmental Policy Act (NEPA), the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), and the Resource Conservation and Recovery Act (RCRA).

The National Environmental Policy Act (NEPA) of 1969 establishes national policies and goals for the general protection of the environment. Section 102(2) of NEPA contains the "action forcing" provisions that direct all federal agencies, including the DOE, to give appropriate consideration to the environmental

effects of their decision making. This section also stipulates that federal agencies prepare detailed environmental statements on federal decisions that could significantly affect the quality of the environment.

The Clean Water Act (CWA) sets forth federal objectives for the prohibition of toxic discharges, the elimination of pollutant discharges, and the protection of fish and wildlife. Since the WVDP discharges wastewaters to local surface waters, it must comply with the CWA and must obtain a National Pollutant Discharge Elimination System (NPDES) permit, which is administered by the EPA or an authorized state. In the case of New York, wastewater discharges are regulated under the NPDES state equivalent, the State Pollutant Discharge Elimination System (SPDES) program, which is under the jurisdiction of the New York State Department of Environmental Conservation (NYSDEC). This permit specifies discharge standards and monitoring and reporting requirements for each point source or outfall.

The Safe Drinking Water Act (SDWA) is an environmental statute for protecting drinking water resources. The WVDP is subject to the SDWA drinking water standards for the drinking water supplied to the WVDP by the on-site water treatment facility, and the groundwater at the WVDP is subject to the SDWA standards because it is classified as a sole-source aquifer.

II. EXECUTIVE SUMMARY

Surface waters near the WVDP have been sampled and analyzed for radiological parameters since 1963, when Nuclear Fuel Services, Inc. (NFS) became the first tenant of the site. Surface waters were monitored to determine whether releases of radioactivity from nuclear fuel reprocessing operations, principally releases of radionuclide-containing wastewater from the lagoons to Erdman Brook, increased radioactivity levels in Buttermilk Creek and Cattaraugus Creek downstream of the site. Background levels of Sr-90 (<3.0 E-09 μCi/mL) and gross beta activity (3.0-6.0 E-09 μCi/mL) were established downstream of the site during pre-operational sampling in 1963, 1965, and 1966. Background levels of tritium (<1.50 E-06 μCi/mL) and Cs-137 (<2.0 E-08 μCi/mL) activity were established upstream of the site in 1967.

The surface water data suggest NFS nuclear fuel reprocessing operations from 1966-1972 increased radioactivity levels downstream of the site in both Buttermilk Creek and Cattaraugus Creek. Although data on released waste water volume is incomplete, anywhere from 26 to 91 million gallons of wastewater was released each year during fuel reprocessing operations from 1966 through 1972. A yearly average of 3,500 curies of tritium, 65 curies of gross beta, and 0.70 curies of gross alpha was released from lagoon 3 to Erdman Brook. Tritium, gross beta, and Sr-90 concentrations at Thomas Corners Bridge, 4.0 kilometers downstream of NFS, increased two orders of magnitude by 1967, a year after fuel reprocessing had begun in April 1966. Tritium, gross beta, and Sr-90 concentrations in Cattaraugus Creek also increased one to two orders of magnitude downstream of Buttermilk Creek to Lake Erie at Irving Bridge, which is approximately 67 kilometers (41.5 mi) downstream of NFS. Nuclear fuel reprocessing was terminated in March 1972, and concentrations of tritium, gross beta, and Sr-90 decreased by one to two orders of magnitude in both Buttermilk Creek and Cattaraugus Creek by 1974. Tritium activity increased one to two orders of magnitude above 1974 levels in Buttermilk Creek and Cattaraugus Creek in 1975, 1976, and 1981, coinciding with the SDA burial trench pump-out campaigns. Tritium, gross beta, and Sr-90 concentrations in Buttermilk Creek and Cattaraugus Creek decreased throughout the 1980s, reaching near background levels by 1990.

Groundwater quality at the WVDP has been investigated since 1974. Groundwater has been analyzed for radiological parameters since 1974 and for chemical parameters since 1984. The groundwater data suggests NFS plant operations affected groundwater quality immediately after nuclear fuel reprocessing began in 1966. Above-background levels of E-04 μCi/mL of tritium were first detected in 1974 from the french drain and the northeast swamp outfall, which drain the surficial sand and gravel unit. NFS began groundwater monitoring in 1974 to locate the source of the tritium, which was determined to be unlined lagoons 4 and 5. Although lagoons 4 and 5 were lined with impermeable liners in late 1974, elevated tritium levels persisted in the french drain outfall, indicating the possibility of additional sources of tritium in the surficial sand and gravel unit. NFS expanded its groundwater monitoring program by installing five wells in 1975 and an additional thirty-four wells during 1977-1979. High levels of tritium were detected at lagoon 1, an unlined surface impoundment excavated into the surficial sand and gravel unit. Above-background levels of tritium were also detected immediately downgradient of the NFS process building.

The WVDP continued to monitor NFS-installed wells from 1982 to 1985. The WVDP expanded the groundwater monitoring system in 1986 and 1990, installing more wells and analyzing additional chemical parameters, to monitor on-site waste management units. One hundred three monitoring wells and three groundwater discharge points are currently sampled to monitor groundwater quality in five water-bearing units at the WVDP: the surficial sand and gravel unit, the weathered Lavery till, the unweathered Lavery till, the till-sand, and the Kent recessional unit.

Groundwater in the surficial sand and gravel unit has been most affected by plant operations in the following areas: downgradient of the process building, the lagoon 1 area, and the area extending from the utility room to the demineralizer sludge ponds. Groundwater downgradient of the process building has elevated pH, chloride, gross beta, and tritium activity. Groundwater near lagoon 1 has elevated gross beta and tritium activity, while groundwater near the demineralizer sludge ponds has high levels of chloride, sulfate, and sodium. Elevated gross alpha activity is present in the weathered Lavery till near the NDA, and elevated tritium levels are present at the north end of the SDA. Elevated gross alpha and tritium activity is present in the unweathered Lavery till in the wastewater lagoon area. Elevated chloride concentrations and pH are present in portions of the till-sand unit. The Kent recessional unit does not appear to have been affected by plant operations.

III. TECHNICAL INFORMATION

1.0 Summary of Methodology

This water quality environmental information document describes surface water and groundwater quality in and around the WVDP from 1963 through 1991. Current and historical surface water and groundwater monitoring data from a number of sources have been compiled and incorporated in this EID and include the following:

- New York State Department of Health (NYSDOH) General Surveillance Program 1965-1967
- New York State Aquatic Ecosystem Survey 1965-1967
- Nuclear Fuel Services, Inc., Annual Environmental Checklists 1971-1981
- New York State Department of Environmental Conservation (NYSDEC) Annual Report of Environmental Radiation in New York State 1968-1981
- Pacific Northwest Laboratory, Sediment and Radionuclide Transport in Rivers, Vols. I-IV 1979-1982
- NYSDOH Annual Report of Environmental Radiation in New York State 1982-1988
- West Valley Demonstration Project (WVDP) Site Environmental Reports 1982-1991.

This large volume of data has been reduced to a more manageable amount by treating it as yearly averages that are discussed in the text in terms of qualitative, long-term, time-concentration trends at specific locations. Frequently, analytical results for a particular parameter at a sampling location may

be reported as a less-than-the-lower-limit-of- detection (LLD) value. When LLD values were present with positive detections, the LLD value was treated as a positive detection value and averaged with the other positive detection values. In those instances where results were below the LLD for the entire year, the yearly value was reported as the highest LLD value for the time-concentration chart. In those instances where LLD and positive detections were reported, the number of positive detections are specified in parenthesis next to the yearly average.

2.0 Geology and Hydrology of the Western New York Nuclear Service Center and the West Valley Demonstration Project

The WNYNSC site covers approximately 3,345 acres of former farmland located within the glaciated portion of the Appalachian Plateau province near West Valley, New York, about 48 kilometers (30 mi) south of Buffalo New York (Fig. 2-1). The Appalachian Plateau province in Western New York is a maturely dissected plateau modified by pre-Pleistocene erosion and repeated Pleistocene glaciations that deposited till, lacustrine sediments, moraines, and outwash deposits onto Devonian age bedrock. The bedrock underlying the WNYNSC reservation consists of shales and sandstones of the Upper Devonian Canadaway Group (Fig. 2-2).

The WVDP, which occupies approximately 156 acres of the WNYNSC, is subdivided into the south plateau and north plateau areas by Erdman Brook (Fig. 2-3). Pleistocene glacial and post-Pleistocene fluvial and alluvial sedimentary strata are exposed within the WVDP: the Lavery till in the south plateau and a surficial sand and gravel unit that overlies the Lavery till in the north plateau. To better understand the water quality discussion presented in this document, a summary description of the geology and hydrology of the WNYNSC and WVDP is noted below. A more detailed discussion may be found in two environmental information documents, Volume I, Geology, and Volume III, Hydrology.

2.1 Surface Waters

The WVDP and the WNYNSC are located within the Buttermilk Creek drainage basin, which is approximately 29.4 square miles in area and is part of the larger Cattaraugus Creek drainage basin (Fig.

2-4). Buttermilk Creek flows through the WNYNSC along a northwest-trending stream valley that is incised into Pleistocene glacial sediments near the WVDP and in Upper Devonian shales and siltstones of the Canadaway Group near the northwestern terminus of the WNYNSC (Fig. 2-5). Buttermilk Creek drains into Cattaraugus Creek approximately 0.33 kilometers north of the Thomas Corners Bridge, at the northwesternmost extent of the WNYNSC property (Fig. 2-6). Cattaraugus Creek flows westward into Lake Erie approximately 63 kilometers (39 mi) downstream of the Buttermilk Creek/Cattaraugus Creek confluence.

The WVDP property is drained by Quarry Creek, Erdman Brook, and Frank's Creek. (See Fig. 2-3.) Quarry Creek and Erdman Brook are tributaries to Frank's Creek, which flows into Buttermilk Creek approximately 0.75 kilometers (0.50 mi) north of the WVDP. (See Fig. 2-6.) Erdman Brook, which is the smallest of the streams, drains the central portion of the WVDP, including surface runoff from the Nuclear Regulatory Commission (NRC) - licensed disposal area (NDA) and the state-licensed disposal area (SDA). (See Fig. 2-3.) Erdman Brook also receives effluent discharged from lagoon 3, the sanitary and utility wastewater system, and the french drain system, all of which are regulated under the SPDES program. Quarry Creek is situated on the northern boundary of the WVDP and drains the northern portion of the site, including the high-level waste tank farm, the lag storage buildings, and two small wetland areas in the north plateau. Frank's Creek, which runs along the eastern portion of the WVDP, receives runoff from the east side of the WVDP, which includes the drum cell, parts of the SDA, the former construction demolition and debris landfill (CDDL), and groundwater discharge from the surficial sand and gravel unit.

2.2 Geology

2.2.1 Surficial Sand and Gravel Unit

The surficial sand and gravel unit is presently only exposed on the north plateau of the WVDP. This unit is principally a light to medium brown silty sand and gravel ranging from 1 to 10 meters (3-33 ft) in thickness, with an average textural composition of 55% gravel, 20% sand, and 25% silt and clay (West Valley Nuclear Services, Inc. 1992.) The sand and gravel unit is composed of two similar overlapping

clastic units, an older Late Wisconsinan fluvial sand and gravel unit that in turn is overlain by a Holocene post-glacial alluvial-fan deposit (Fig. 2-7). The Late Wisconsinan fluvial sands and gravels were deposited on the exposed Lavery till by glacial meltwaters as the Lavery ice margin receded from the immediate area (LaFleur 1979). The Late Wisconsinan sands were covered later by 0.60-1.5 meters (2-5 ft) of post-glacial alluvial fan deposits derived from the hillsides next to the WVDP.

Five samples of the surficial sand and gravel were analyzed via x-ray diffraction methods by Brookhaven National Laboratory to establish the mineralogy of this unit. Quartz, illite, chlorite, and plagioclase were present in all samples analyzed, while calcite and dolomite were present in two of the five samples.

2.2.2 Lavery Till

The Lavery till, which is exposed in the south plateau of the WVDP, is a calcareous clayey or silty till, ranging from 5-30 meters (16-100 ft) in thickness (LaFleur 1979). The Lavery till is thinnest near the walls of Buttermilk Creek Valley and thickens towards the center of Buttermilk Creek Valley (Fig. 2-7). The textural composition of the Lavery till is 40% clay, 48% silt, and 12% sand and gravel (Whitney 1977). Three distinct sub-units have been identified in the Lavery till: the weathered till, the unweathered till, and the till-sand.

2.2.2.1 Weathered Lavery Till

The upper 2-3 meters (6.5-10 ft) of the till is referred to as the weathered Lavery till and is physically distinct from the underlying unweathered Lavery till. In previous literature the weathered Lavery till has also been called the oxidized till. The weathered Lavery till is oxidized to a yellowish-brown color and contains numerous root tubes and intersecting horizontal and vertical fractures. The vertical fractures have been observed to extend from the ground surface into the unweathered Lavery till to depths of 4 to 8 meters (Dana et al. 1979). The weathered Lavery till is composed predominantly of illite, quartz, calcite, kaolinite, plagioclase feldspar, and dolomite, in decreasing quantities (Table 2-1).

2.2.2.2 Unweathered Lavery Till

The unweathered Lavery till is olive-gray in color and is generally unoxidized. However, fracture walls in the unweathered Lavery till are typically oxidized to a brown color and have a thin coating of iron or manganese oxide, suggesting groundwater flow along the fractures. The unweathered Lavery till is composed of quartz, illite, calcite, and kaolinite in decreasing abundance (Table 2-1).

2.2.3 Till-Sand

The till-sand is a southeast-trending, 120-245 meter-wide (400-800 ft) band of sand located within the upper 6 meters (20 ft) of the Lavery till in the north plateau of the WVDP. (See Fig. 2-2.) The till-sand ranges from 0-2.75 meters (0-9 ft) in thickness and is composed of fine to coarse sand and gravel. Structure contour mapping suggests the till-sand is a fluvial deposit presumably laid down during a hiatus within the Lavery glaciation. The till-sand extends from a point approximately 180 meters (600 ft) west of the plant southeastward to an exposure along the banks of Erdman Brook (Fig. 2-8).

2.2.4 Kent Recessional Unit

The Lavery till is underlain by the Kent recessional unit, a sequence of gravel, sand, and lacustrine strata 9-18 meters (30-60 ft) thick. (See Fig. 2-7.) Lacustrine strata composed of laminated silt and clay forms the lower 9 meters (30 ft) of the Kent recessional, which is present in the subsurface across the entire WVDP. The lacustrine sequence is interpreted as forming in a proglacial lake that formed after the recession of the Kent ice margin (LaFleur 1979). According to LaFleur, the lacustrine section of the unit is composed predominantly of quartz, illite, calcite, dolomite, and plagioclase feldspar in decreasing abundance. (See Table 2-1.) Calcite and dolomite together make up 12% to 20% of the lacustrine section of the Kent recessional by weight percent.

The lacustrine section in the eastern portion of the WVDP is overlain by upwards of 9 meters (30 ft) of sand and gravel believed to represent several kame deltas deposited over the lacustrine strata. Several of the kame deltas are exposed along Buttermilk Creek and extend into the WVDP west of the NDA and SDA.

2.3 Groundwater

2.3.1 Surficial Sand and Gravel Unit

Groundwater in the surficial sand and gravel unit flows across the north plateau in a predominantly northeastward direction from the southwestern margin of the sand and gravel unit at Rock Springs Road towards Frank's Creek (Fig. 2-9). Groundwater near the northwestern and southeastern margins of the sand and gravel unit diverges from the predominant flow direction and flows towards Quarry Creek and Erdman Brook. Flow is predominantly horizontal as the low hydraulic conductivity of the underlying Lavery till precludes any significant downward flow from the sand and gravel into the Lavery till. The overall hydraulic gradient across the north plateau from well NB-1S to well B-86-12 is 0.031, but locally steeper gradients of 0.049 exist in the southwestern portion of the sand and gravel, and flatter gradients of 0.026 exist in the northeastern portion of the north plateau. (See Fig. 2-9.)

An average groundwater velocity of 5.90 E-05 cm/s (18.6 m/year) was calculated for the sand and gravel unit using the following equation and WVDP hydrogeologic data:

$$V = -Ki/n_e$$

where V is the average linear velocity, K is the hydraulic conductivity (4.19 E-04 cm/sec), i is the hydraulic gradient (0.031), and n_e is the effective porosity (assumed 0.22).

The percentage of major cations and anions in groundwater from the sand and gravel unit is represented on trilinear diagrams (Fig. 2-10). In general, groundwater from this unit is characterized as a calcium and bicarbonate composition according to the hydrochemical facies classification scheme of Morgan and

Winner (1962). However, groundwater in the sand and gravel unit deviates from the predominant calcium and bicarbonate composition in several areas of the north plateau such as the demineralizer sludge ponds. The elevated chloride concentrations in this area result in groundwater with a calcium and chloride type of composition. Areas that deviate from the normal calcium and bicarbonate type of composition are the result of plant activities that have affected local groundwater composition. In general, though, groundwater in the sand and gravel unit is characterized as calcium and bicarbonate type with Ca^{++} comprising 50% - 78% of the cation composition and HCO_3 comprising the majority of the anion composition.

2.3.2 Lavery Till

2.3.2.1 Weathered Lavery Till

Groundwater in the weathered Lavery till flows in a north-northeasterly direction under a hydraulic gradient of 0.02 (Bergeron et al. 1987). Prudic (1982) calculated hydraulic conductivities of 6.0 E-08 to 4.0 E-05 cm/sec using the Cooper method (Cooper et al. 1967) and 2.0 E-08 to 6.0 E-06 cm/sec using the Hvorslev method (Hvorslev 1951) and bail test data from three piezometers screened in the weathered Lavery till. Two of the piezometers yielded conductivities of E-08 cm/sec, similar to the unweathered Lavery till. The third piezometer yielded a higher conductivity of E-06 and E-05 cm/sec, which was believed to reflect the piezometer screen intersecting a fracture in the weathered Lavery till. The other two piezometers probably did not intersect a fracture (Prudic 1982).

Radionuclide-contaminated n-dodecane and tributyl phosphate detected in monitoring well 82-5A on the north side of the NDA in December 1983 suggests that a significant component of lateral groundwater flow occurs in the weathered Lavery till (Fig. 2-11). The source of the n-dodecane and tributyl phosphate was traced 18 meters south of 82-5A to several 10-meter deep special burial holes (SH-10 and SH-11) that contained a mixture of n-dodecane and tributyl phosphate (West Valley Nuclear Services 1985b). (NFS had used a n-dodecane-tributyl phosphate mixture in its nuclear fuel reprocessing operation and disposed the spent solvent mixture in several special holes, including SH-10 and SH-11, in 1970.) A

minimum groundwater flow velocity of 4.39 E-06 cm/s (1.38 m/yr) was calculated for the weathered Lavery till using the migration distance of 18 meters and a travel time of thirteen years. A minimum hydraulic conductivity of 4.17 E-05 cm/sec was calculated from the flow velocity of 4.39 E-06 cm/sec.

A groundwater velocity of 4.21 E-06 cm/s (1.33 m/yr) was calculated for the weathered Lavery till using the following equation and hydrogeologic data:

$$V = -Ki/n_e$$

where V is the average linear velocity, K is the hydraulic conductivity (4.0 E-05 cm/s), i is the hydraulic gradient (0.02), and n_e is the effective porosity (assumed 0.19).

Calcium is the dominant cation in groundwater in the weathered Lavery till, while bicarbonate and sulfate are the dominant anions (Fig. 2-12). The percentage of chloride in the weathered Lavery till is very low, typically ranging from less than 1% to 3%.

2.3.2.2 Unweathered Lavery Till

Groundwater in the unweathered Lavery till flows predominantly downwards towards the underlying Kent recessional unit (Fig. 2-13) under a downward hydraulic gradient ranging from 0.95 to 1.09 and averaging 1.033 (West Valley Nuclear Services 1985b; Prudic 1986). The downward hydraulic gradients in the unweathered Lavery till also predominate near small stream valleys where local near-horizontal discharge of groundwater would be expected (Prudic 1986).

A mean downward groundwater velocity of 1.94 E-07 cm/sec (0.06 m/yr) was calculated for the unweathered Lavery till using the following equation:

$$u_v = K_v i/n_e$$

where u_v is the mean vertical velocity, K_v is the mean hydraulic conductivity, i is the mean downward hydraulic gradient (1.033), and n_e (0.17) is the effective porosity (West Valley Nuclear Services 1985b).

A small component of northeastern lateral flow exists within the Lavery till, as indicated on Fig. 2-14.

Groundwater in the unweathered Lavery till from both the north and south plateaus is characterized as predominantly calcium and bicarbonate type (Fig. 2-15). Calcium comprises 52% to 82% of the major cation concentration in groundwater from the unweathered Lavery till, which most likely originates from dissolution of calcite and dolomite in the Lavery till. Sulfate is the dominant anion type in groundwater northwest of the chemical process cell hardstand (CPC), along the northeastern and southeastern margin of lagoon 3, and at well 1105A and 1105B in the south plateau of the WVDP. The percentage of chloride in the unweathered Lavery till, ranging from less than 1% to 12%, is much lower than that observed in the overlying surficial sand and gravel unit.

2.3.3 Till-Sand

Groundwater in the till-sand flows predominantly east-southeast from the plant towards Erdman Brook under an average gradient of 0.017 (Fig. 2-16). A tentative groundwater velocity of 6.8 E-06 cm/sec (2.14 m/yr) has been calculated for the till-sand, assuming a hydraulic conductivity of 1.0 E-04 cm/sec, an effective porosity of 0.25, and a hydraulic gradient of 0.017.

Calcium and bicarbonate are the dominant cation and anions in groundwater from the till- sand (Fig. 2-17).

2.3.4 Kent Recessional Unit

The Kent recessional unit receives groundwater recharge from groundwater moving downward through the Lavery till at a velocity of 1.94 E-07 cm/sec (0.06 m/yr) (Prudic 1986). The sand and gravel portion of the Kent recessional is not saturated. However, the underlying lacustrine unit is saturated and

groundwater flows predominantly eastward towards Buttermilk Creek (Prudic 1986). Calcium is the dominant cation in groundwater from the Kent recessional; bicarbonate is the dominant anion (Fig. 2-18). The percentage of chloride is low, generally not greater than 3% of the total anion composition.

3.0 Nuclear Fuel Services, Inc. Water Quality Monitoring Program Overview

In early 1962 Nuclear Fuel Services, Inc. (NFS) requested recommendations from the Bechtel Corporation for an off-site pre-operational environmental survey program for its planned spent nuclear fuel reprocessing plant (Bechtel Corp. 1962). Bechtel's proposed environmental survey program was a radiation-level monitoring program subdivided into three broad subprograms: 1) atmospheric monitoring 2) an earth and biota monitoring program, and 3) surface water and groundwater monitoring. The program entailed continuous monitoring of radioactivity levels over time in the area surrounding the proposed NFS fuel processing plant.

Bechtel recommended that surface waters be sampled monthly from both Buttermilk Creek and Cattaraugus Creek and be analyzed for gross alpha, gross beta, and gamma isotopes. Quarterly sampling of groundwater was recommended from three wells, one each in Riceville and Springville, New York, and the third within the WNYNSC. Groundwater was to be analyzed quarterly for gross alpha, gross beta, and gamma isotopes, and semi-annually for strontium-90.

NFS developed an environmental survey program in March 1963 using Bechtel's recommendations. The NFS program included a pre-operational and a post-operational component. The first phase of the pre-operational program began in spring 1963 and was intended to establish on-site background levels of gross radiological activity. The second phase of the pre-operational program, which began in spring 1964, expanded to adjacent off-site areas and encompassed additional specific radiological analyses. The surface water and groundwater monitoring program included six surface water sampling locations and one groundwater sampling location. Surface waters were to be sampled at the following locations:

- the confluence of Quarry Creek and Frank's Creek

- Buttermilk Creek both upstream and downstream of its confluence with Frank's Creek

- Cattaraugus Creek, both upstream and downstream of its confluence with Buttermilk Creek and at Gowanda, New York

The groundwater monitoring location was on the WNYNSC south of the plant at the Rider farmstead.

In addition, in September 1963, the New York State Department of Health (NYSDOH), Bureau of Radiological Health Services, with assistance from the United States Public Health Service, outlined an environmental sampling strategy to evaluate the public health significance of any releases of radioactivity from the NFS nuclear fuel recovery operations (New York State Department of Health 1963).

NYSDOH recommended that an on-site and off-site monitoring program be developed and implemented to ensure that hazardous levels of radioactivity were not present in environmental media in the immediate area of the WNYNSC.

The NYSDOH monitoring program was to take two phases. Phase I was intended as a one-year pre-operational program to evaluate and establish background radiation levels before operations began at NFS. A total of 400 samples were to be collected during Phase I and 1,000 analyses performed. Surface water, groundwater, and drinking water were to be tested for the parameters specified in Table 3-1. Phase II, which was to be implemented during the actual operation of the facility, was intended to monitor and detect any increases in radioactivity above background levels, thereby ensuring the health and safety of individuals in the surrounding area. One thousand samples were to be collected yearly during Phase II, with 2,500 analyses performed. The media to be sampled and the analytical parameters are specified in Table 3-1.

3.1 Lagoon 3 discharges to Erdman Brook (1967 - 1991)

While NFS and NYSDOH monitoring programs recorded the levels of radioactivity dispersed to the environment, NFS routinely sampled lagoon 3, the discharge outlet to Erdman Brook for all low-level

plant liquid. From 1966-1971, all low-level wastewaters from spent fuel operations were pH-adjusted and routed in sequence to three retention basins (lagoons 1-3) before discharge to Erdman Brook. This allowed approximately 100 days decay time of the short-lived radionuclides and dilution of the waste waters with precipitation.

In May 1971, NFS began operating the low-level wastewater treatment facility (LLWTF) for removal of radionuclides (Sr-90 and Cs-137), solids, and organics from plant effluents. The construction of the LLWTF included two additional surface impoundments, lagoons 4 and 5, each with a clay liner and a 200,000-gallon capacity. Because lagoon 3 remained the final retention basin before discharge, the sediments that had accumulated on its bottom were dredged and placed in the NRC-licensed disposal area (NDA) to provide a radiologically clean storage basin for treated effluents. In 1974, lagoons 4 and 5 were retrofitted with membrane liners as part of an effort to mitigate elevated tritium concentrations in groundwater near the lagoons in the north plateau.

Lagoon 3 is a 3,300,000-gallon, unlined surface impoundment within the WVDP that receives treated wastewaters from lagoons 4 and 5. Except for the top several meters that are in the surficial sand and gravel unit, the lagoon is excavated into the Lavery till. Because of the geology immediately surrounding the basin, the lagoon leaks when the stored volume of water exceeds 80% of the design volume. Past operations have restricted the storage volume to 60% and 70% of capacity to reduce seepage into the groundwater. Current operational practices limit storage to 80% of capacity.

Lagoon 3 is presently the final retention basin in a series of four lagoons (lagoons 2-5) that store effluents originating from plant operations and, occasionally, effluents from the NDA interceptor trench and the SDA after they have been processed at the LLWTF.

3.1.1 Effluent History

The effluents discharged from lagoon 3 have varied because of operational changes and decontamination activities and have included wastewater from three SDA pump-out campaigns.

NFS routinely monitored for radiological parameters, including gross alpha, gross beta, tritium, Sr-90, Cs-137, and I-129. (NFS began collecting data on I-129 in October 1967.) The total curie levels were well below the maximum permissible concentration values noted in 10 CFR 20 and ranged from 1.0 E-03 curies on several occasions to a maximum release of 1.3 E-01 Ci in December 1970. The WVDP currently monitors for gross alpha/beta, H-3, C-14, Sr-90, I-129, gamma isotopic, Pu/U isotopic, and Am-241.

As expected, all radiological parameters listed above increased after reprocessing operations began (Fig. 3-1). In 1969, NFS released its largest quantity of radioactivity to the environment from lagoon 3. Gross alpha levels reached a maximum level of 3.67 E-01 curies, while gross beta and tritium reached maximum levels of 1.08E+02 curies and 5.29E+03 curies, respectively. According to quarterly reports, NFS reprocessed a campaign of highly enriched uranium fuel containing thorium during the first quarter of 1969, which may be responsible for the elevated levels of radionuclides. The highest annual release of Sr-90 occurred in 1970 at 1.42E+01 curies, one year after gross alpha, gross beta, and tritium peaked (See Fig. 3-1.).

Figure 3-1 also shows two periods of elevated gross alpha levels following cessation of fuel reprocessing; one in 1974, the other from 1983-1985. Personal discussions with site managers indicate that the 1974 elevation is most likely from decontamination activities associated with the proposed main plant expansion and from decontamination of the product purification cell, which contained plutonium. The high alpha levels during 1983-1985 are most likely from intense decontamination and decommissioning activities in the main plant, including decontaminating and decommissioning laboratories and glove boxes that were contaminated with plutonium.

3.1.2 SDA Pump-out Campaigns

During both NFS and DOE's occupancy of the WNYNSC, there were three SDA waste burial trench pump-out campaigns during which trench water was pumped to the LLWTF for treatment and discharge to Erdman Brook via lagoon 3. Figure 3-1 shows three episodes of elevated tritium levels after reprocessing operations ceased. These levels are directly related to the processing of SDA effluents:

The first SDA trench pump-out campaign occurred from 1975 to 1976. Yearly tritium totals for 1975 and 1976 were 1.4E+03 curies and 2.2E+03 curies. These levels are roughly two orders of magnitude higher than 1973-1974.

The SDA trenches were pumped out again in 1980-1981 with the wastewater being sent to the LLWTF before discharge via lagoon 3. During this campaign 800,000 gallons of water totaling 6 curies of gross beta and 3,600 curies of tritium were removed from the burial trenches. This activity level contributed to the 3.5E+03 curies of tritium released to Erdman Brook in 1981.

A third SDA pump-out campaign occurred in 1988. The released tritium levels were not as dramatic as in the two previous campaigns, but reached levels of 3.88E+00 and 4.40E+00 in 1989-1990. These levels were roughly one order of magnitude higher than the previous years (1985-1988).

Although the trench water was processed at the LLWTF, tritium levels were still quite elevated. This can best be explained by ion exchange capacity being specific to Sr-90 and Cs-137, allowing tritium to pass through.

3.2 Off-site Surface Water Monitoring

NYSDOH, the New York State Department of Environmental Conservation (NYSDEC), NFS, and the Pacific Northwest Laboratory collected and analyzed surface water samples from Frank's Creek, Buttermilk Creek, and Cattaraugus Creek at various times during the NFS operation from 1963 to 1982. These various sampling programs were intended to assess the effect of releases of radioactivity from NFS on streams near the NFS site.

3.2.1 New York State Department of Health (NYSDOH) Environmental Surveillance Program (1965 - 1967)

NYSDOH sampled surface water from Buttermilk Creek and Cattaraugus Creek between 1965 and 1967 to determine the radioactivity levels in these creeks before, during, and after the start-up of the NFS

nuclear fuel processing operations in April 1966 (New York State Department of Health July 1968). Buttermilk Creek was sampled at two locations (Fig. 3-2): upstream where it enters the WNYNSC property (004) and downstream where it exits the WNYNSC property (035). Cattaraugus Creek was sampled upstream of its confluence with Buttermilk Creek at Springville and at three locations downstream of the Buttermilk Creek confluence at Springville Dam (042), Gowanda (060), and Irving Bridge (065). Sr-90 was the only radiological parameter analyzed in 1965. Analysis for gross beta was added in 1966, and both Cs-137 and tritium were added to the parameter list in 1967. The sampling results are found in Table 3-2.

The highest concentrations of Sr-90, Cs-137, gross beta, and tritium were found along Buttermilk Creek downstream of NFS; they decreased progressively downstream towards Irving Bridge on Cattaraugus Creek (Table 3-2.) In 1965 the Sr-90 activities measured at all sampling locations were below 3 pCi/L (3.0 E-09 μCi/mL), a value comparable to Sr-90 activities across New York State. In 1966 the Sr-90 activity in the upstream sampling locations in both creeks remained at the 1965 activity levels, but increased to a maximum of 265 pCi/L (2.65 E-07 μCi/mL) downstream of NFS at Springville Dam on Cattaraugus Creek.

The 1966 gross beta activity was similar to the Sr-90 trend, ranging from 2 to 3 pCi/L (2.0 -3.0 E-09 μCi/mL) in the upstream samples to a maximum of 1,387 pCi/L (1.38 E-06 μCi/mL) at Springville Dam. Buttermilk Creek was not sampled downstream of NFS during the latter half of 1966. In 1967 the downstream sampling locations continued to show activity levels that were one to two orders of magnitude higher than those measured upstream.

Tritium activity at the downstream Buttermilk Creek sampling location was nearly six orders of magnitude higher than the New York State average in 1967 and was approximately 11,000 times higher at Irving Bridge than the statewide average. Sr-90 and Cs-137 activities were one to three orders of magnitude greater than the New York State average. (See Table 3-2.)

An upstream sample (Bigelow Bridge) and a downstream sample (Springville Dam) from Cattaraugus Creek were analyzed for uranium and plutonium isotopes in 1966 and 1967. The activity of Pu-238, Pu-239, and U-235 in the upstream and downstream sampling locations were not significantly different.

However, the activity of U-234 and U-238 at Springville Dam was greater than at Bigelow Bridge (Table 3-3).

The increased levels of all radiological parameters detected immediately downstream of NFS indicated that surface waters were affected by the NFS operations shortly after they began in April 1966. The NYSDOH study indicated that radionuclide concentrations along one mile of Frank's Creek and Erdman Brook and nearly two miles of Buttermilk Creek within the restricted WNYNSC site exceeded the 10 CFR Part 20 concentration limits. Releases of process wastewater from lagoon 3 and from the two holding lagoons at the SDA were considered the source for the elevated radionuclide activity downstream of NFS. The lagoon 3 discharges were considered the single largest source of radioactivity to Buttermilk Creek and Cattaraugus Creek. The burial site holding lagoons stored water pumped from the open burial trenches that was later pumped to Erdman Brook. The water in these lagoons contained radionuclides derived from previously disposed containers that had been crushed during disposal and that subsequently leached out concentrations of radioactive materials. Based on the NYSDOH findings, the Atomic Energy Commission informed NFS that significant reductions should be made in the levels of radioactivity discharged to the surrounding watershed.

NYSDOH also concluded that Sr-90 contributes a significant portion of the total gross beta activity, that Cs-137 prefers to adsorb to silt-sized material but Sr-90 prefers the dissolved state, and that the activity ratio of Cs-137 to Cs-134 is four to one.

3.2.2 New York State Department of Environmental Conservation, Environmental Radiation Monitoring Program (1968 - 1981)

NYSDEC's Bureau of Radiological Health routinely monitored the radioactivity content in surface waters in and around the WNYNSC from 1968 through 1981. Buttermilk Creek was sampled upstream of NFS at Fox Valley Road (004) and downstream at Thomas Corners Bridge (035). Cattaraugus Creek was sampled at five locations: upstream of the Buttermilk Creek confluence at Bigelow Bridge (007) and downstream of the confluence at Felton Bridge (032), Springville Dam (042), Gowanda (60), and Irving Bridge (065). (See Fig. 3-2.) Water samples were analyzed for Sr-90, Cs-137, gross beta, tritium, and

gross alpha. NYSDEC reported its results for each sampling locality as yearly averages and as a minimum and maximum value. Values below the lower limit of detection (LLD) were incorporated in the yearly averages by assuming the concentrations were at the detection limit. The yearly average was reported as a less-than value if any of the analyses that included a less-than value were used in determining an average.

The 1965 - 1967 NYSDOH program results and the 1968 - 1982 NYSDEC program results for the above named sampling locations are shown on Figures 3-3 through 3-9. Specific details of the sampling programs at each sampling location are discussed below.

3.2.2.1 Buttermilk Creek at Fox Valley Road (Fig. 3-3) and Cattaraugus Creek at Bigelow Bridge (Fig. 3-4)

The sampling location at Buttermilk Creek at Fox Valley Road (004) is located upstream of the former NFS facility where Buttermilk Creek enters the WNYNSC reservation. Bigelow Bridge (007) is located on Cattaraugus Creek approximately 3.2 kilometers (2 mi) upstream of the confluence of Buttermilk Creek and Cattaraugus Creek. Both sampling locations are considered representative of background water quality conditions in each of these streams and so are discussed together.

- Sr-90. Sr-90 concentrations in Buttermilk Creek were measured from 1965 through 1971 and from 1965 through 1976 at Bigelow Bridge. Sr-90 concentrations in these two streams were $\leq$ 3.0 E-09 μCi/mL for all sampling rounds from 1965 through 1976.

- Cs-137. Cs-137 activity was measured at both of these sampling locations from 1967 through 1971. Cattaraugus Creek was resampled in 1978. Cs-137 concentrations in both of these streams were <3.0 E-08 μCi/mL for all sampling rounds from 1967 through 1971 and 1978.

- Gross Beta. Gross beta activity was measured in both creeks from 1966 through 1981. Gross beta activity ranged from 3.0 E-09 to 8.0 E-09 μCi/mL in Buttermilk Creek and averaged 5.18 E-09 μCi/mL during this period of time. Gross beta activity in Cattaraugus Creek ranged from 2.5 E-09 μCi/mL to 1.17 E-08 μCi/mL and averaged 6.09 E-09 μCi/mL from 1966 through 1981.

- Tritium. Tritium activity was measured at both locations from 1966 through 1981. Tritium activity in both creeks was near or below the LLD for tritium, which was 1.0 E-06 μCi/mL from 1966 through 1970, 5.0 E-07 μCi/mL from 1971 through 1973, and 3.0 E-07 μCi/mL from 1974 through 1981.

- Gross Alpha. Gross alpha was measured from 1971 through 1981. Gross alpha activity was near or below the LLD in all sampling events in both creeks during this time period.

3.2.2.2 Buttermilk Creek at Thomas Corners Bridge (Fig. 3-5.)

The Thomas Corners Bridge sampling location (035), which is the downstream sampling location nearest to the former NFS processing plant, is approximately 4 kilometers (2.5 mi) downstream of the WVDP and 0.33 kilometers (0.2 mi) upstream of the confluence of Buttermilk Creek and Cattaraugus Creek. Surface water has been sampled at this location since 1965.

- Sr-90. Sr-90 was analyzed from 1965 through 1976. Pre-operational concentrations in 1965 at Thomas Corners Bridge were below the detection level of 3.0 E-09 μCi/mL through 1966. Sr-90 concentrations rose by two orders of magnitude to 3.35 E-07 μCi/mL by 1967 and increased each year, reaching a maximum concentration of 6.57 E-07 μCi/mL in 1970. Sr-90 concentrations began to decline in 1971 and continued to decline through 1976, the last year of analyses for this parameter, when the concentration had decreased to 8.0 E-09 μCi/mL. The decrease of two orders of magnitude is attributed to construction of the low-level waste treatment facility, termination of fuel processing activities at NFS in March 1972, and the cessation of disposal of radioactive waste in the two burial areas at the site.

- Cs-137. Cs-137 activity was monitored continuously from 1967 through 1978. The concentration of Cs-137 was already above the LLD by 1967, with a yearly average activity of 1.12 E-07 μCi/mL. Cs-137 activity increased progressively in the following years, reaching a maximum of 1.76 E-07 μCi/mL in 1970. Cs-137 activity began to decline in 1971 and continued to decrease until 1975 when an increase to 1.54 E-07 μCi/mL was observed. Cs-137 activity decreased to levels of 1.0 E-08 μCi/mL from 1976 through 1978.

- Gross Beta. Gross beta activity at Thomas Corners Bridge ranged from 5.8 E-09 to 2.73 E-06 μCi/mL from 1966 through 1981. An activity of 5.8 E-09 μCi/mL was measured during the first four months of 1966 before the start-up of nuclear fuel reprocessing by NFS. This figure is virtually identical to the background activities detected at Buttermilk Creek-Fox Valley Road and Cattaraugus Creek-Bigelow Bridge. Gross beta activity at Thomas Corners Bridge increased progressively from 1967 onwards, reaching a maximum activity of 2.73 E-06 μCi/mL in 1971. Gross beta activity began to decline beginning in 1972, reaching levels of 1.5 E-08 μCi/mL by 1981.

  The decrease in gross beta activity at Thomas Corners Bridge can be attributed to the construction and operation of the low-level waste treatment facility and the suspension of nuclear fuel reprocessing operations in 1972.

- Tritium. Tritium activity at Thomas Corners Bridge was analyzed from 1967 through 1981. Tritium concentrations were well above background levels by 1967, with a yearly average concentration of 3.20 E-04 μCi/mL. A maximum yearly average activity of 4.09 E-04 μCi/mL was recorded in 1971 at Thomas Corners Bridge. Tritium activities fluctuated from 1972 through 1981. Tritium activity declined during 1972 and 1973 and increased progressively from 1974 through 1976, reaching a yearly average concentration of 8.29 E-05 μCi/mL in 1976. Tritium concentrations remained at levels of E-05 μCi/mL from 1976 through 1978, followed by declines in 1979 and 1980. Tritium activity increased two orders of magnitude to an average yearly concentration of 7.72 E-05 μCi/mL in 1981. Increases in tritium activity at Thomas Corners Bridge coincided with the SDA burial trench pump-out campaigns in 1975, 1976, and 1981.

- Gross Alpha. Gross alpha activity was monitored from 1971 through 1981. Gross alpha activity ranged from a minimum of 1.0 E-09 μCi/mL to a maximum of 7.1 E-08 μCi/mL in 1974. In general, gross alpha activity ranged from 1.0 E-09 μCi/mL to 9.2 E-09 μCi/mL from 1971 through 1981.

3.2.2.3 Cattaraugus Creek at Felton Bridge (Fig. 3-6)

Felton Bridge (032) is approximately 0.8 kilometers (0.5 mi) downstream of the confluence of Buttermilk Creek with Cattaraugus Creek. The Felton Bridge location was sampled from 1968 through 1970 and then again from 1977 through 1981.

- Sr-90. The concentration of Sr-90 at Felton Bridge was measured in 1968, 1969, 1980, and 1981. The highest Sr-90 activity was measured at 2.31 E-07 μCi/mL in 1968. The concentration of Sr-90 at Felton Bridge declined during the 1970s to 8.0 E-10 μCi/mL by 1981.

- Cs-137. Cs-137 activity at Felton Bridge was measured from 1968 through 1970 and from 1977 through 1981. The highest activity of 3.58 E-07 μCi/mL was measured in 1968; it then declined to 8.60 E-08 μCi/mL by 1970. Cs-137 activity was below the 1970 level (7.00 E-09 μCi/mL) when sampling resumed in 1977 and remained below the LLD in subsequent years.

- Gross Beta. Surface water was analyzed for gross beta activity from 1968 through 1970 and from 1977 through 1981. Gross beta activity was already two orders of magnitude above background levels by 1968. A maximum gross beta activity of 3.27 E-07 μCi/mL was measured at Felton Bridge in 1969, which declined slightly to 1.76 E-07 μCi/mL in 1970. A similar decline was observed in gross beta activity at the Thomas Corners Bridge sampling location, approximately 1.40 kilometers (0.85 mi) upstream of Felton Bridge.

- Tritium. Tritium activity was measured at Felton Bridge during 1968, 1969, and 1977 through 1981. Tritium concentrations were already two orders of magnitude above background levels in 1968, with an average yearly concentration of 1.19 E-05 μCi/mL. Tritium activity increased to

a yearly average of 1.06 E-05 μCi/mL in 1978 and decreased to near background levels of 2.13 E-07 to 4.40 E-07 μCi/mL during 1979-1980.

- Gross Alpha. Surface water at Felton Bridge was analyzed for gross alpha activity from 1978 through 1981 and was not detected above the LLD, which ranged from less than 1.0 E-09 to less than 5.0 E-09 μCi/mL during this period.

3.2.2.4 Cattaraugus Creek at Springville Dam (Fig. 3-7)

Springville Dam (042) is located approximately 4 kilometers (2.5 mi) downstream of the confluence of Buttermilk Creek and Cattaraugus Creek. The sampling location was in the Springville Reservoir approximately 150 meters (500 ft) upstream of the spillway. The Springville Dam location was sampled continuously from 1965 through 1981.

- Sr-90. Sr-90 activity at Springville Dam was measured continuously from 1965 through 1981. The activity of Sr-90 was less than 3.0 E-09 μCi/mL before the start-up of fuel processing in 1965 and quickly rose to 6.2 E-08 μCi/mL during the first eight months of NFS operations in 1966. Sr-90 activity reached a maximum of 1.48 E-07 μCi/mL in 1970. Activity levels began to decrease in 1971 and nearly reached pre-operational levels of 4.0 E-09 μCi/mL by 1973. The activity levels continued to decrease to levels of 1.2 E-09 μCi/mL by 1980.

- Cs-137. Cs-137 activity at Springville Dam has been monitored from 1967 through 1975 and during 1978, 1979, and 1981. Initial levels in 1967 were less than 2.0 E-08 μCi/mL, which rose to a maximum of 1.97 E-07 μCi/mL in 1970. Cs-137 activity began to decrease in 1971, reaching a concentration of less than 5.0 E-09 μCi/mL in 1974. Activity increased during 1975 only to decrease to levels of less than 7.0 E-09 μCi/mL by 1979.

- Gross Beta. Gross beta activity was measured on a continuous basis from 1966 through 1981. Above-background levels of 1.16 E-07 μCi/mL were present at Springville Dam in 1966. Gross beta activity reached a maximum of 2.34 E-07 μCi/mL in 1970 and began to decrease in 1971.

Gross beta activity at Springville Dam decreased to near background levels of 9.5 E-09 μCi/mL by 1981.

- Tritium. Tritium was monitored on a continuous basis from 1967 through 1981. Tritium activity at Springville Dam was already two orders of magnitude above background levels at 3.07 E-05 μCi/mL during the first year of sampling in 1967. The highest average yearly tritium activity of 3.32 E-05 μCi/mL was measured in 1971. Tritium activity began to decrease in 1972 and reached near background levels of 2.18 E-07 μCi/mL by 1980. Tritium activity rose sharply in 1975, 1976, and 1981 coinciding with the SDA trench pump-out campaigns that occurred during those years.

- Gross Alpha. Gross alpha activity at Springville Dam was measured on a continuous basis from 1971 through 1981. Gross alpha activity ranged from 1.0 E-09 μCi/mL to 8.40 E-09 μCi/mL during this period.

3.2.2.5 Cattaraugus Creek at Gowanda (Fig. 3-8)

The Gowanda sampling location was located approximately 34 kilometers (21 mi) downstream of the Springville Dam and approximately 24 kilometers (15 mi) upstream from Lake Erie. The Gowanda location was sampled during the 1965 pre-operational program and from 1967 through 1971.

- Sr-90. Sr-90 concentrations at Gowanda were measured in 1965 as part of the pre-operational monitoring program and from 1967 through 1971. Pre-operational levels of Sr-90 were less than 3.0 E-09 μCi/mL. Sr-90 activity at Gowanda had increased by an order of magnitude by 1969 and reached a maximum of 3.6 E-08 μCi/mL in 1970.

- Cs-137. Cs-137 concentrations were measured from 1968 through 1971. In general, Cs-137 concentrations were near the lower limit of detectability of less than 3.0 E-08 μCi/mL, ranging from 2.0 E-08 to 3.6 E-08 μCi/mL.

- Gross Beta. Surface water at Gowanda was analyzed for gross beta from 1967 through 1971. Gross beta activity in 1967 was 5.2 E-08 μCi/mL and progressively increased to a maximum activity of 1.34 E-07 μCi/mL in 1969. Gross beta concentrations began to decline in 1970 and continued to decline through 1971.

- Tritium. Tritium activities were measured at Gowanda from 1967 through 1971. Tritium activities were already two orders of magnitude above background levels at Gowanda by 1967. Tritium concentrations remained at levels around 1.0 E-05 μCi/mL from 1967 through 1971 except in 1968, when tritium activities dropped to levels of 1.46 E-06 μCi/mL.

- Gross Alpha. Surface water analyses at Gowanda do not include gross alpha.

3.2.2.6 Cattaraugus Creek at Irving Bridge (Fig. 3-9)

Irving Bridge (065), which is the Conrail railroad bridge (formerly the New York Central), is located approximately 1.2 kilometers (4,000 ft) upstream from the mouth of Cattaraugus Creek at Lake Erie. The Irving Bridge location was sampled during the 1965 pre-operational program and from 1967 through 1980.

- Sr-90. Surface water at Irving Bridge was analyzed for Sr-90 during the 1965 pre-operational study and from 1969 through 1971. Sr-90 concentrations increased from <3.0 E-09 μCi/mL in 1965 to a maximum of 3.0 E-08 μCi/mL in 1970. Sr-90 levels showed a small decline to 1.7 E-08 μCi/mL in 1971.

- Cs-137. Cs-137 concentrations at Irving Bridge were analyzed from 1968 through 1971. Cs-137 concentrations at Irving Bridge were below the LLD during two of the four sampling years and were near the LLD during the two other years.

- Gross Beta. Gross beta activity at Irving Bridge was monitored from 1967 through 1980. The highest gross beta activities were measured at Irving Bridge during 1969 and 1970, with activities of 1.12 E-07 μCi/mL and 1.06 E-07 μCi/mL, respectively. Gross beta activity began to decline in 1971 and continued to decline to levels of 4.0 E-09 μCi/mL by 1980.

- Tritium. Surface water at Irving Bridge was analyzed for tritium on a continuous basis from 1967 through 1980. The maximum concentration of tritium was detected in 1967, at an average annual activity of 2.47 E-05 μCi/mL. This average concentration was two orders of magnitude greater than background levels. Tritium concentrations declined to levels of 8.53 E-06 to 9.15 E-06 μCi/mL in 1969 and 1970, but then increased to 2.01 E-05 μCi/mL in 1971. Tritium levels began to decline in 1972 and continued to decline through 1974. Tritium levels increased in 1975 and 1976, coinciding with the SDA burial trench pump-out campaigns, reached a secondary high of 5.65 E-06 μCi/mL in 1976, and began to decline in 1979 to near background levels of 1.85 E-07 by 1980.

- Gross Alpha. Gross alpha activity was measured in 1971, 1972, 1974, 1976, and 1978 through 1980. Gross alpha activity during all sampling events was below the LLD, which ranged from <1.0 E-09 μCi/mL to <6.0 E-09 μCi/mL.

3.2.3 New York State Aquatic Ecosystem Survey (1965 - 1967)

NYSDOH funded an aquatic ecosystem survey in the immediate area of the NFS during 1965-1967. The survey attempted to identify and evaluate biological organisms that would be indicators of environmental radioactivity above background levels (Sax et al. July 1969).

Although the aquatic survey concentrated on stream flora and fauna, water samples were collected from both Buttermilk Creek and Cattaraugus Creek and were analyzed for the radiological parameters noted on Table 3-4. The data indicated that from 1966 to 1967 NFS operations raised the dissolved concentrations of gamma-emitting isotopes downstream of NFS by one to three orders of magnitude.

3.2.4 U.S. Department of Health, Education, and Welfare Survey (1969)

The U.S. Department of Health, Education, and Welfare (HEW) collected water and suspended sediment samples from Buttermilk Creek and Cattaraugus Creek both upstream and downstream of NFS during June and November 1969. The water samples were analyzed for the radiological parameters specified in Table 3-5.

The HEW data illustrate the effect that radiological discharges from the NFS plant had on radionuclide concentrations in Buttermilk Creek and Cattaraugus Creek. Tritium concentrations at the upstream Buttermilk Creek sampling station were on the order of 1.0 E-06 μCi/mL and increased by three orders of magnitude to a maximum of 4.0 E-04 μCi/mL at the Bond Road Bridge downstream of the confluence of Frank's Creek and Buttermilk Creek. The concentration of tritium in Buttermilk Creek decreased downstream towards the confluence with Cattaraugus Creek. Tritium concentrations were further diluted downstream of the confluence of Buttermilk Creek and Cattaraugus Creek, as tritium concentrations of 3.0 E-05 μCi/mL were measured at Felton Bridge and further downstream at Springville Dam. Similar trends were noted for the other radionuclides measured in this study. In general, concentrations of dissolved radionuclides in Buttermilk Creek were an order of magnitude greater than those measured in Cattaraugus Creek.

Dissolved radionuclide concentrations were significantly lower in November compared to those measured in June (Tables 3-6 and 3-7). The decrease was attributed to the effect of dilution from greater streamflow discharge in November than in June. Radionuclide concentrations in the suspended samples showed an opposite trend to that of surface water, having higher radionuclide concentrations in the November sampling event. This increase is probably related to the increased sediment load being transported by these streams during periods of higher streamflow discharge.

3.2.5 Nuclear Fuel Services, Inc. Environmental Program (1963, 1967, 1971-1981)

3.2.5.1 1963 Sampling (Table 3-8)

NFS began its environmental monitoring program in July 1963 with a pre-operational monitoring program to determine background gross alpha, gross beta, and Sr-90 activity at and in the vicinity of the WNYNSC. Cattaraugus Creek was sampled upstream at Bigelow Bridge and downstream at Felton Bridge. The Felton Bridge location is approximately 0.8 kilometers (0.5 mi) downstream of the confluence of Buttermilk Creek and Cattaraugus Creek (Fig. 3-2). Erdman Brook was sampled upstream and downstream of the burial area. Pre-operational activity was as follows: gross alpha — 8.0 E-09 μCi/mL at all locations; gross beta — 1.0 E-08 μCi/mL at all locations; Sr-90 — 6.0 E-10 μCi/mL at all locations.

3.2.5.2 1967 Sampling (Tables 3-8 and 3-9)

Samples were collected during the first nine months of 1967 from Cattaraugus Creek at Bigelow Bridge and Felton Bridge and from Erdman Brook upstream and downstream of the burial area. NFS analyzed the samples for gross beta, gross alpha, and tritium activity. The Western New York Nuclear Research Center (WNYNRC) at S.U.N.Y. Buffalo also analyzed a smaller number of samples for the same parameters and for Sr-90 at the same locations, in addition to Frank's Creek and Cattaraugus Creek at Springville Dam. The analytical results of the 1967 NFS sampling are presented in the Environmental Report of 1967 (Nuclear Fuel Services, Inc. 1968.)

Felton Bridge and both Erdman Brook locations showed an increase of one to nearly three orders of magnitude in gross beta and Sr-90 activity compared to the 1963 pre-operational environmental assessment (see Tables 3-8 and 3-9), suggesting that nuclear fuel reprocessing and radioactive waste burial operations were affecting water quality downstream of NFS in Cattaraugus Creek and Erdman Brook.

3.2.5.3 1971 through 1981 Sampling (Figs. 3-10, 3-11, and 3-12)

NFS collected water samples from Buttermilk Creek at Thomas Corners Bridge and Cattaraugus Creek at Bigelow Bridge and Felton Bridge. Samples from Thomas Corners Bridge were analyzed quarterly for gross alpha, gross beta, and tritium. Bigelow Bridge was analyzed monthly for gross alpha, gross beta, and tritium. Samples from Felton Bridge were analyzed monthly for gross alpha, gross beta, tritium, Sr-89, Sr-90, Ru-106, I-129, Cs-134, and Cs-137. The analytical results from these sampling stations are found in the NFS yearly environmental check lists, which are on file in the EIS Library. Detailed discussion of Sr-89, Ru-106, I-129, and Cs-134 activity at Felton Bridge was not included in the following remarks because the activities were almost always below the respective LLD and because these parameters were not analyzed upstream at Bigelow Bridge and Thomas Corners Bridge.

Buttermilk Creek at Thomas Corners Bridge (Fig. 3-10)

Of the three off-site locations, Thomas Corners Bridge (035) exhibited the highest radionuclide activity from 1971 through 1981. Tritium was the most abundant radionuclide detected, ranging from a maximum of 3.61 E-03 μCi/mL in 1972 to a minimum of 2.86 E-06 μCi/mL in 1979. Tritium activity dropped sharply in 1973 after nuclear fuel reprocessing operations had been suspended in April 1972 and then rose sharply in 1975, 1976, and 1981, coinciding with the SDA trench pump-out campaigns conducted during these years.

Gross beta activity was above background levels during the sampling period, ranging from a maximum of 3.04 E-06 μCi/mL in 1971 to a minimum of 1.42 E-08 μCi/mL in 1977. Gross beta activity began to decline in 1972 after fuel reprocessing operations ceased and leveled off at approximately 1.75 E-08 μCi/mL from 1977 through 1981.

Gross alpha activity was generally below the LLD for the entire sampling period. Gross alpha activity was detected above the LLD for eight months during the eleven years this location was sampled by NFS.

Cattaraugus Creek at Bigelow Bridge (Fig 3-11)

Bigelow Bridge (007), which is upstream of the Cattaraugus Creek/Buttermilk Creek confluence, had the lowest radiological activity of the three off-site surface water locations sampled by NFS. Mean annual tritium activity ranged from 6.93 E-06 μCi/mL in 1972 to 3.24 E-07 μCi/mL in 1976. In general, tritium activity was near background levels (below the LLD) from 1971 through 1977. Tritium was detected above the LLD every month from 1978 through 1981. However, this is a reflection of a lower detection limit for tritium during these years than in previous years. Tritium activity during 1978-1981 was relatively constant, in the 1.0 E-06 μCi/mL range.

Gross beta activity from 1971 - 1976 was generally below the LLD with only twenty-two positive monthly detections for gross beta during this period. Gross beta activity increased slightly during 1977 - 1981 from levels observed during 1971 - 1976.

Gross alpha activity was generally below the LLD during the entire period of sampling. Gross alpha activity was detected above the LLD in thirteen months of the eleven years this location was sampled by NFS.

Cattaraugus Creek at Felton Bridge (Fig. 3-12)

Radionuclide activity at Felton Bridge (032), downstream of NFS, was less than that observed at Thomas Corners Bridge, presumably reflecting dilution effects as Buttermilk Creek enters Cattaraugus Creek. Tritium was the most abundant radionuclide detected, ranging from a maximum of 2.78 E-05 μCi/mL in 1971 to a minimum of 1.14 E-06 μCi/mL in 1980. The 1971 maximum corresponds to the last full year of fuel reprocessing at NFS. Tritium levels began to decline in 1972 after nuclear fuel reprocessing ended in April 1972.

Increases in tritium activity during 1975-1976 and 1981 coincide with the SDA burial trench pump-out campaigns.

Gross beta activity reached a maximum of 7.46 E-08 μCi/mL in 1972 and began to decline in 1973 to consistent levels ranging from 7.0 E-09 μCi/mL to 1.5 E-08 μCi/mL from 1974 through 1981.

Gross alpha activity was generally below the LLD from 1971 through 1981, as positive gross alpha detections were only observed in twenty-one months of the eleven-year sampling period.

3.2.6 Pacific Northwest Laboratory (PNL) Sediment Transport Study (1977 - 1979)

The Battelle Memorial Institute's Pacific Northwest Laboratory (PNL) conducted a three-phased field sampling program from November 1977 through April 1979 to investigate radionuclide transport in surface waters near the WVDP for the NRC. The data collected during this study was to be used to verify the PNL sediment and radionuclide transport model SERATRA. The results of the PNL study are presented in *Sediment and Radionuclide Transport in Rivers*, Volumes 1-4 (Ecker et al. 1979; Walters et al. April 1982; Walters et al. May 1980; Walters et al. November 1982).

Surface water samples were collected at thirteen locations along 45 miles of Erdman Brook, Frank's Creek, Buttermilk Creek, and Cattaraugus Creek (Fig. 3-13). Three background sampling stations were located at Cattaraugus Creek (CC-1) at Bigelow Bridge approximately 3.6 kilometers (2 mi) upstream of its confluence with Buttermilk Creek, at Buttermilk Creek (BC-1) at the Fox Valley Road Bridge approximately one mile upstream of its confluence with Frank's Creek, and at Great Valley Creek near Great Valley (GVC). (Great Valley Creek is a not part of the Cattaraugus Creek drainage basin but of the Allegheny River drainage basin.) The water samples were analyzed for tritium, Sr-90, Cs-134, Cs-137, Pu-238, and Pu-239/240. Eighty-gallon water samples were collected at each sampling location during Phase I sampling, which was conducted from November 30, 1977 through December 5, 1977. The low radioactivity levels in Buttermilk Creek and Cattaraugus Creek required that the sample volume be increased from 80 to 400 gallons at each sampling location during Phase II sampling from September 15 through September 28, 1978 and Phase III sampling from April 26 through April 29, 1979.

The PNL report concluded that the lowest radionuclide concentrations were found at the three background sampling locations. The highest radionuclide concentrations were associated with the Frank's Creek sampling point (FC-1), which is located 45 meters (150 ft) upstream of the confluence of Frank's Creek and Buttermilk Creek. (See Fig. 3-13).) Surface water drainage from the fuel reprocessing facility and the waste disposal areas discharged to Frank's Creek. Radionuclide concentrations decreased downstream of FC-1, but remained above background levels along Buttermilk Creek and Cattaraugus Creek from its confluence with Buttermilk Creek downstream to Irving Bridge (CC-11) at Lake Erie (Fig. 3-13). Phase II and Phase III results for tritium, Sr-90, Cs-134, Cs-137, Pu-238, and Pu-239, 240 are presented in Figures 3-14 through 3-18 and are discussed below.

- Tritium (Fig. 3-14). Tritium activity was the lowest at the three background locations during Phase II and III, ranging between 1.50 E-07 μCi/mL and 2.0 E-07 μCi/mL, and was the highest at Frank's Creek (FC-1), ranging from 1.0 E-06 μCi/mL to nearly 4.0 E-06 μCi/mL. Tritium activity progressively decreased downstream of FC-1 towards Springville Dam on Cattaraugus Creek. Above-background concentrations of tritium, ranging up to 3.0 E-07 μCi/mL, were detected at Irving Bridge (CC-11) on Cattaraugus Creek, approximately, 1,200 meters (4,000 ft) east of Lake Erie.

- Sr-90 (Fig 3-15). Sr-90 activity was lowest at the background stations, ranging from between 1.0 E-10 μCi/mL to 3.0 E-10 μCi/mL, and was highest at Frank's Creek (FC-1), ranging from 1.0 E-08 μCi/mL to 2.0 E-08 μCi/mL. Sr-90 activity decreased progressively downstream of FC-1 to near background levels at Gowanda (CC-9) on Cattaraugus Creek. Sr-90 activity at Irving Bridge (CC-11) at Lake Erie was greater than that detected at background stations GVC, BC-1, and CC-1.

- Cs-134. Cs-134 was detected at five locations during Phase 1 sampling, once during Phase 2, and was not recorded at all during Phase 3. The highest Cs-134 activity detected during Phase I, approximately 1.0 E-10 μCi/mL, was detected at the Bigelow Bridge background station (CC-1). The lowest concentration of 4.0 E-12 μCi/mL was found at Frank's Creek (FC-1).

- Cs-137 (Fig. 3-16). Cs-137 was not detected in either of the three background sampling locations during Phase 2 and Phase 3 sampling. The highest Cs-137 activity, ranging from 1.0 E-10 μCi/mL to 6.0 E-10 μCi/mL, was detected immediately downstream of NFS at FC-1. Cs-137 activity progressively decreased downstream of FC-1 leveling off at 2.0 E-11 μCi/mL along Cattaraugus Creek. However, Cs-137 activity reached levels of 5.0 E-09 μCi/mL at Springville Dam on Cattaraugus Creek (CC-5) during Phase III. Above-background levels of Cs-137 were detected at Irving Bridge (CC-11) on Cattaraugus Creek at Lake Erie.

- Pu-238 (Fig 3-17). Background concentrations of Pu-238 ranged from 2.3 E-13 μCi/mL to 3.2 E-13 μCi/mL. The highest Pu-238 activity was detected at Frank's Creek (FC-1) — 1.83 E-12 μCi/mL — and at Buttermilk Creek-Thomas Corners Bridge (BC-4) — 2.31 E-12 μCi/mL.

- Pu-239/240 (Fig. 3-18). Pu-239/240 was not readily detected at every sampling location during each sampling phase. The highest Pu-239/240 activity of 8.0 E-13 μCi/mL was measured at Frank's Creek (FC-1) during Phase III sampling. Background concentrations were approximately 1.0 E-13 μCi/mL.

3.3 On-site Surface Water Monitoring (Fig. 3-19)

3.3.1 New York State Department of Environmental Conservation, Environmental Radiation Monitoring Program (1968 - 1981)

NYSDEC sampled on-site surface water for radiological parameters at eight locations from 1969 through 1981 (Fig. 3-19). Five of the stations were placed on Erdman Brook and Frank's Creek to gauge the effect that radiological releases from plant operations had on these streams. The three remaining stations were located on the north plateau, which drains into Quarry Creek and Frank's Creek downstream of Erdman Brook.

3.3.1.1 Sewage plant (Fig. 3-20)

The sewage plant sampling station (072) was the furthest upstream monitoring location sampled by NYSDEC from 1972 through 1980. Radiological activity for all parameters was the highest in 1972 and progressively decreased through 1980. Gross beta, tritium, Cs-137, and Sr-90 activities were all above background levels from 1972 through 1980. Gross beta was the largest contributor to the radiological activity at this location from 1972 through 1974, followed by tritium from 1975 through 1980. Gross beta, Sr-90, and Cs-137 decreased by two to three orders from 1972 through 1980. Gross beta activity decreased from a high of 3.99 E-05 μCi/mL in 1972 to 3.2 E-08 μCi/mL by 1980. Tritium activity decreased by one order of magnitude during this period, from 2.68 E-06 μCi/mL in 1972 to 1.9 E-07 μCi/mL in 1980. However, tritium activity increased nearly fivefold from 1975 to 1976.

The radiological activity in the sewage plant effluent may be attributed to an acid leak that occurred in the process plant off-gas cell or to storage of radiologically contaminated laundry in or outside of the laundry room: A tank in the off-gas cell containing radiologically contaminated acid leaked its contents, which seeped through cracks in the floor into the underlying soil beneath the plant. Radiologically contaminated groundwater was able to enter a sewer line leading to the sewage plant. The sewer line was encased with stainless steel in the summer of 1974 or 1975 to prevent further leakage of contaminated groundwater. Radionuclide-contaminated laundry was commonly stored outside the laundry building during NFS operation of the facility. Precipitation may have removed radiological material from the laundry, transferring it to the ground or to sewers leading to the sewage plant.

3.3.1.2 Hot and cold ditch (Fig. 3-21)

The hot and cold ditch station (073), which was sampled by NYSDEC from 1972 through 1980, was located approximately 20 meters north of the demineralizer sludge ponds. (See Fig. 3-19.) The hot and cold ditch received wastewater from the plant's utility room. The cold water discharged to the ditch originated from water backflushed through the utility room sand filters, which were used in the early stages of the water treatment process. The hot water discharged to the ditch was condensate blown off the steam traps in the utility room.

The highest gross beta, Sr-90, and Cs-137 activity was measured in 1972 and subsequently dropped two to three orders of magnitude in 1973. Gross beta activity rose by nearly one order of magnitude between 1973 and 1977 and began to decline in 1978. The highest radiological activity was associated with tritium from 1974 through 1980. Tritium activity rose by nearly two orders of magnitude to 2.63 E-05 μCi/mL from 1975 to 1976.

3.3.1.3 Burial drainage (Fig. 3-22)

The burial drainage station (076), which was sampled from 1972 through 1979, was located at the northern end of the SDA, between Erdman Brook and the SDA. (See Fig. 3-19.) Tritium was the largest contributor to radiological activity at this location, ranging from 3.3 E-04 μCi/mL to 5.9 E-07 μCi/mL during the sampling period. Gross beta activity, followed closely by Sr-90, ranged from 1.9 E-05 μCi/mL to 6.0 E-08 μCi/mL. Tritium, gross beta, and Sr-90 activities increased by two to three orders of magnitude from 1974 to 1975. This increase probably could be attributed to the flooding and overflow of SDA burial trenches 4 and 5 and the subsequent flow of radiologically contaminated water overland towards Frank's Creek and Erdman Brook. Tritium, gross beta, and Sr-90 activities had decreased to near pre-1975 levels by 1979.

3.3.1.4 Erdman Brook (Fig. 3-23)

The Erdman Brook sampling station (053) was located approximately 60 meters northwest of the SDA along Erdman Brook and would have monitored radiological releases to Erdman Brook from the SDA and NDA (Fig. 3-19). This station was monitored from 1969 through 1981, during which time radiological activity generally decreased. Tritium was the largest contributor to radiological activity at this location, ranging from 1.4 E-04 μCi/mL to 2.0 E-06 μCi/mL during this time period. Tritium activity at Erdman Brook is similar to that measured at the burial drainage site, location 076. Tritium activity increased sharply in 1975, probably due to the flooding of burial trenches 4 and 5, followed by overland flow to Frank's Creek and Erdman Brook. Tritium levels began to decrease in 1976 and returned to 1973-1974 levels by 1979.

Gross beta and Sr-90 activity closely paralleled one another from 1969 through 1981, suggesting that Sr-90 contributed a majority of the overall gross beta activity. Gross beta, Sr-90, and Cs-137 activities at Erdman Brook do not show the 1975 increases evident at the burial drainage station location (076), indicating that Sr-90 and Cs-137 may be preferentially adsorbed to clay minerals in the Lavery till during overland flow towards Erdman Brook.

3.3.1.5 French Drain (Fig. 3-24)

The french drain (075) is a 15-cm diameter perforated steel drain pipe that was installed 3 meters below grade along the northwestern side of lagoons 2 and 3 and along the northeastern side of lagoon 3 in 1965 to decrease groundwater infiltration into the lagoons 2 and 3. (See Fig. 3-19.) NYSDEC sampled the french drain from 1972 through 1980. Tritium was the most abundant radiological parameter identified during this time, ranging from 6.6 E-04 μCi/mL to 4.1 E-05 μCi/mL. Releases of tritium from lagoons 1, 4, and 5 are the probable source of the elevated tritium concentrations observed in the french drain. Tritium activity increased slightly in 1976 and is attributed to the 1975-1976 SDA burial trench pump-out project. Water pumped from the trenches was stored in lagoon 3, which was filled to 89% capacity, allowing tritium to migrate into the sand and gravel and increasing tritium concentrations. Tritium activity in the lagoon was 1.5 E-01 μCi/mL at this time (Smokowski 1977). Gross beta activity ranged from 5.57 E-06 μCi/mL to 3.72 E-08 μCi/mL. Sr-90 activities increased one order of magnitude from 1973 through 1980. Overall radiological activity in the french drain decreased from 1972 to 1981, with the exception of Sr-90.

3.3.1.6 Acid recovery tanks (Fig. 3-25)

The acid recovery tank sampling station (074A) was located on the north side of the north plateau, near where the swamp drains into Quarry Creek. This location was sampled from 1975 through 1981, with tritium contributing the highest radiological activity, ranging from a minimum of 3.33 E-07 μCi/mL in 1979 to a minimum of 3.02 E-06 μCi/mL in 1975. Gross beta activity was above background, ranging from 1.63 E-08 μCi/mL to 5.60 E-08 μCi/mL. Sr-90 activity also was above background during this period, ranging from 4.90 E-09 μci/mL to 1.40 E-08 μCi/mL.

3.3.1.7 Spring-fed swamp (Fig. 3-26)

This sampling station (074B) was located where the swamp drains into Quarry Creek, upstream of the confluence of the acid recovery tank drainage. Tritium contributed the highest radiological activity, ranging from 5.61 E-06 μCi/mL to 2.65 E-05 μCi/mL from 1975 through 1981. Tritium activity was highest in 1975 and 1976 and decreased slightly in 1976 to fairly constant levels of approximately 7.0 E-07 μCi/mL from 1977 - 1981. Gross beta activity was nearly two orders of magnitude above background, ranging 1.41 E-07 μCi/mL to 3.75 E-07 μCi/mL. Sr-90 activity was one to two orders of magnitude above background during the sampling period.

3.3.18 Northeast brook drainage (Fig. 3-27)

The northeast brook drainage sampling location (067) is located along Frank's Creek, approximately 125 meters northeast of the SDA. This station, along with the Erdman Brook station, was sampled by NYSDEC for the longest period of time, from 1969 through 1981. Tritium contributed the largest component of radiological activity at 067, ranging from a maximum of 8.4 E-06 μCi/mL in 1971 to a minimum of 3.4 E-07 μCi/mL in 1979. Gross beta activity was one order of magnitude above background, ranging from a maximum of 4.7 E-08 μCi/mL in 1971 to a minimum of 7.9 E-09 μCi/mL in 1979. Tritium and gross beta activity both increased to their maximum value in 1971, declined sharply during 1972-1973, and then continued to decline at a slower rate from 1973 through 1981.

3.3.2 Nuclear Fuel Services, Inc., Environmental Program (1971-1981)

NFS monitored on-site surface water at eight locations from 1971 through 1981, most of which were also sampled by NYSDEC during its Environmental Radiation Monitoring Program (Fig. 3-19). The analytical results from these samplings stations are found in the NFS yearly environmental checklists, which are on file in the EIS library.

3.3.2.1 Sewage plant outfall (Fig. 3-28)

The sewage plant outfall (072), which was also sampled by NYSDEC, was sampled by NFS from 1972 through 1981. Tritium showed the highest activity during the sampling period, ranging from a maximum of 1.89 E-03 μCi/mL in 1972 to a minimum of <3.03 E-07 μCi/mL in 1977. Overall tritium activity decreased from the maximum in 1972 to 1.45 E-06 μCi/mL by 1981. Tritium activity decreased from 1972 to 1977 and from 1978 through 1980. Gross beta activity, which declined progressively from 1972 through 1981, ranged from a maximum of 1.02 E-05 μCi/mL in 1972 to a minimum of 3.68 E-08 μCi/mL in 1981. Sr-90 activity, like gross beta, was one to three orders of magnitude above background, ranging from a maximum of 1.69 E-06 μCi/mL in 1973 to a minimum of 1.32 E-08 μCi/mL in 1980. Gross alpha activity was generally around background levels with the majority of monthly sampling events indicating gross alpha activity below the LLD. All parameter activities drop sharply in 1974 and 1975, coinciding with the sewer line repair work conducted at that time.

In general, the NFS data for gross beta, Sr-90, and gross alpha compared favorably with that reported by NYSDEC. (See Fig. 3-20.) However, the NFS tritium data was one to three orders of magnitude higher than the NYSDEC data in 1972, 1973, 1975, 1978, 1979, and 1980.

3.3.2.2 Condensate and cooling water ditch (Fig. 3-29)

The condensate and cooling water ditch (073) was only sampled for gross beta by NFS from 1973 through 1981. This location was also sampled by NYSDEC and was known as the hot and cold ditch. (See Fig. 3-19.) Gross beta activity ranged from a maximum of 3.29 E-08 μCi/mL in 1973 to a minimum of 7.38 E-09 μCi/mL in 1981. The magnitude of the NFS gross beta data was comparable to the NYSDEC data generated from 1972 through 1980. (See Fig. 3-21.)

3.3.2.3 Settling Basin Outfall (Fig. 3-30)

The settling basin outfall (SBO) represents the demineralizer sludge pond outfall to Erdman Brook, located approximately 40 meters southeast of the condensate and cooling water ditch (073) location.

Spent sulfuric acid and brine solutions, used to regenerate the anion and cation exchange systems in the water treatment system, were discharged to the sludge ponds. Liquid in the demineralizer sludge ponds was discharged to Erdman Brook.

NFS sampled this location for tritium, gross beta, and gross alpha from 1974 through 1981. Tritium activity at the settling basin outfall ranged from a minimum of 5.34 E-07 μCi/mL in 1977 to a maximum to 2.76 E-06 μCi/mL in 1981.

Gross beta activity ranged from a maximum of 3.52 E-08 μCi/mL in 1974 to a minimum of 7.66 E-09 μCi/mL in 1978. Gross beta activity increased in 1979 to 1.73 E-08 μCi/mL and gradually decreased to 1.13 μCi/mL by 1981.

Gross alpha activity was generally around background levels, as only eight positive gross alpha detections above the LLD were recorded during the eight years this location was sampled.

3.3.2.4 Ditch north of hull burial (Fig. 3-31)

NFS sampled a segment of Erdman Brook approximately 60 meters north of the NDA (HBD). NFS sampled this section of Erdman Brook for gross beta and tritium from 1975 through 1981. Tritium activity was above background levels during this period, ranging from a maximum of 2.96 E-06 μCi/mL in 1977 to a minimum of 1.62 E-07 μCi/mL in 1979. Gross beta activity was approximately two orders of magnitude above background levels, ranging from a minimum of 4.18 E-07 μCi/mL in 1980 to a maximum of 7.14 E-06 μCi/mL in 1977. This section of Erdman Brook showed the highest gross beta activity of all the on-site surface water stations sampled by NFS from 1971 through 1981.

3.3.2.5 Erdman Brook (Fig. 3-32)

NYSDEC and NFS both sampled this portion of Erdman Brook (053), which is located approximately 60 meters northwest of the SDA. (See Fig. 3-19.) NFS sampled this location from 1971 through 1987, with a sampling hiatus between 1974 - 1976. Tritium was the largest contributor to radiological activity

at this location, ranging from a maximum of 2.46 E-05 μCi/mL in 1971 to a minimum of 2.59 E-06 μCi/mL in 1981. In general, tritium activity declined from 1971 to 1973 and remained at constant levels of 3.0 to 4.0 E-06 μCi/mL from 1977 through 1981. It is uncertain how the flooding of SDA burial trenches 4 and 5 in 1975 affected tritium activity at this location. NYSDEC indicated an increase in activity of nearly two orders of magnitude between 1974 and 1975. (See Fig. 3-23.) Gross beta activity was constantly one order of magnitude above background levels, during the sampling period, ranging from 2.44 E-08 μCi/mL in 1971 to 2.85 E-08 μCi/mL in 1981. Gross beta activity increased sometime between 1974 and 1976, as gross beta levels are higher in 1977 than in 1973. Gross alpha activity was generally around background levels with the majority of monthly samples indicating gross alpha activity below the LLD for gross alpha.

The NFS data does not deviate significantly from the NYSDEC data, although the NFS gross beta data from 1971 through 1973 is one to two orders of magnitude less than that measured by NYSDEC. (See Fig. 3-23.)

3.3.2.6 Stream East of Waste Burial Site (Fig. 3-33)

Frank's Creek east of the SDA at location 067 was sampled by NYSDEC and NFS. (See Fig. 3-19.) NFS sampled this location for tritium, gross beta, and gross alpha from 1974 through 1981. Tritium activity ranged from a maximum of 1.92 E-06 μCi/mL in 1974 to a minimum of 4.68 E-07 μCi/mL in 1977. A large number of the NFS monthly analyses for tritium from 1974-1977 are below the LLD, unlike the NYSDEC data, which is a reflection of the higher detection levels used by NFS during its analysis. (See Fig. 3-27.) In general, the NFS tritium levels were slightly higher than those measured by NYSDEC.

Gross beta activity was above background levels and remained relatively constant during the sampling period, ranging from 1.22 E-08 μCi/mL in 1972 to 1.00 E-08 μCi/mL in 1981. The gross beta activity determined by NFS was similar to that reported by NYSDEC. Gross alpha activity was generally around background levels, with the majority of monthly samples indicating gross alpha activity below the LLD for gross alpha.

3.3.2.7 French Drain (Fig. 3-34)

The french drain outfall at 075 was sampled by NYSDEC and NFS. NFS sampled this location for tritium, gross beta, and gross alpha from 1972 through 1981.

Tritium activity was two to four orders of magnitude above background levels, ranging from a maximum of 2.36 E-03 μCi/mL in 1972 to a minimum of 4.64 E-05 μCi/mL in 1980, and progressively decreased in activity from 1972 through 1981. NYSDEC and NFS tritium values from 1972 through 1980 were quite similar to one another. Gross beta activity was one to three orders of magnitude above background, ranging from a maximum of 6.93 E-6 μCi/mL in 1972 to a minimum of 3.64 E-08 μCi/mL in 1981 and progressively decreasing in activity from 1972 through 1984. The magnitude of the NFS gross beta data was comparable to the NYSDEC data collected from 1972 through 1980. Gross alpha activity was generally around background levels, with the majority of monthly sampling events indicating gross alpha activity below the LLD for gross alpha.

3.3.2.8 Northeast ditch and east canal (Fig. 3-35)

The northeast ditch and east canal (NED) are located in the northeastern corner of the north plateau, approximately 200 meters north of the french drain outfall. Wetlands in the north plateau drained into the northeast ditch, which emptied into Frank's Creek. The east canal was built sometime between 1975 and 1978 to drain wetlands near the old hardstand. NFS sampled this location continuously for tritium, gross beta, and gross alpha from 1974 through 1981. Tritium activity at this location was one to two orders of magnitude above background levels, ranging from a maximum of 6.06 E-05 μCi/mL in 1974 to a minimum of 6.64 E-06 μCi/mL in 1980. Overall tritium activity decreased from 1972 through 1981. Gross beta activity was one to two orders of magnitude above background levels, ranging from a maximum of 3.14 E-07 μCi/mL in 1976 to a minimum of 9.42 E-08 μCi/mL in 1980. Although gross beta activity increased slightly in 1976, the overall trend has been of decreasing gross beta activity from 1972 through 1981. Gross alpha activity was generally around background levels, with the majority of monthly sampling events indicating gross alpha activity below the LLD for gross alpha.

3.4 Nuclear Fuel Services, Inc. Groundwater Monitoring

NFS began its groundwater monitoring program in 1974 to determine the source of tritium detected at above background concentrations at two of its effluent monitoring stations, the french drain (Figs. 3-24 and 3-34) and the northeast swamp drainage (Fig. 3-35). The french drain and the northeast swamp drain groundwater from portions of the surficial sand and gravel unit in the north plateau of the WVDP. The french drain discharges into Erdman Brook northeast of lagoon 3. Increasing levels of tritium over time at the french drain and the northeast swamp had prompted NFS to find the source of the tritium in the north plateau.

The source was initially believed to be wastewater lagoons 4 and 5. The lagoon system had been used by NFS from 1966 to 1971 to treat wastewater from its spent nuclear fuel reprocessing operations. The process wastewater was sent to the interceptor basin where the pH of the wastewater was adjusted and the activity of the effluent was measured. If the gross beta activity was less than 5.0 E-03 μCi/mL, the wastewater was transferred sequentially to lagoons 1, 2, and 3 over a period of approximately 100 days to allow short-lived radionuclides to decay and to allow the wastewater to be diluted with precipitation. The wastewater was then finally discharged from lagoon 3 to Erdman Brook in controlled releases. All three lagoons were unlined surface impoundments. Lagoon 1 was constructed within the surficial sand and gravel unit, while lagoons 2 and 3 were excavated through the surficial sand and gravel into the underlying Lavery till.

In 1971 NFS completed the construction of the low-level wastewater treatment facility (LLWTF) and lagoons 4 and 5. The LLWTF was built to reduce the concentration of Sr-90 and Cs-137 discharged from lagoon 3 to Erdman Brook, as these radionuclides were observed to be accumulating in stream sediment downstream of NFS. Lagoons 4 and 5 were built in the surficial sand and gravel unit and were lined with silty clay to reduce the potential for leakage into the underlying sand and gravel.

The increase in tritium activity at the french drain and the northeast swamp prompted NFS to investigate the tritium source in 1974. Twenty-five test holes were dug with a backhoe around lagoons 4 and 5 in the spring of 1974 (Fig. 3-36). Water samples were collected from these holes from June 1974 through

January 1975 and were analyzed for gross beta and tritium (Table 3-10.) Sampling was suspended by February 1975, as most of the holes had collapsed from winter freeze-thaw cycles, making water sampling difficult, if not impossible.

The June sampling indicated that the highest tritium and gross beta activities were in test holes 15, 16, 17, and 18, which were nearest lagoons 4 and 5. Tritium activity averaged 3.20 E-04 μCi/mL in holes 15 through 18, similar to the 3.09 E-04 μCi/mL measured in the french drain during June 1974. Overall tritium ranged from 4.45 E-05 μCi/mL in hole 22 to a maximum of 3.94 E-04 μCi/mL in hole 16 (Table 3-10). Gross beta activity was also the highest in holes 15 through 18, ranging from 1.82 E-07 μCi/mL in hole 15 to 1.51 E-06 μCi/mL in hole 16 (Table 3-10). The radiological results from the test pits suggested that lagoons 4 and 5 were the source of the elevated tritium in the groundwater in the lagoon area. NFS installed synthetic membrane liners in lagoons 4 and 5 during October 1974 to prevent further releases of tritium to the groundwater in the north plateau.

Test holes 15 through 18 showed a decline in both tritium and gross beta activity after the lagoons were lined in October 1974. (See Figs. 3-37 through 3-40.) Tritium activities in holes 15 through 18, which had averaged 3.20 E-04 μCi/mL in June 1974, had dropped below the LLD (<1.7 E-06 μCi/mL) by December 30, 1974 (Fig. 3-37). Similar decreases of an order of magnitude were observed in the gross beta activity during this time (Fig. 3-38.) Smaller decreases in tritium (Fig. 3-39) and gross beta activity (Fig. 3-40) were observed in test holes 19, 21, 22, and 24. The decreased tritium and gross beta activity initially suggested that the membrane liners had eliminated lagoons 4 and 5 as a source of radionuclides to the groundwater in the north plateau. However, tritium levels from the french drain, which remained at levels of 2.0 E-04 μCi/mL through March 1975, did not decrease at a rate that would suggest that the tritium source was eliminated. Greater decreases in tritium activity had been expected, considering that lagoons 4 and 5 were lined and tritium concentrations in plant waste effluent were greatly reduced because fuel reprocessing operations were no longer in operation.

In 1975 NFS expanded its groundwater investigation program to locate the source of tritium in groundwater in the north plateau. Five groundwater monitoring wells composed of 6-inch diameter pipe were installed approximately 2.75 meters (9 ft) into the surficial sand and gravel unit north and west of

lagoon 1 during May 1975. (See Fig. 3-36.) NFS sampled these wells for tritium from May 1975 through June 1977 (Table 3-11). The highest tritium activity was detected in well #5, which was located on the northern corner of lagoon 1, followed by well #3, which was located approximately 30 meters (100 ft) north of well #5. Tritium activity in well #5 increased sharply from 5.7 E-03 μCi/mL in October 1975 to 1.2 E-02 μCi/mL in July 1977 (Fig. 3-41). Tritium activity in well #3 also increased during this time (Fig. 3-41). The lowest tritium activity, although above background levels, was found in well #1, which is located in an upgradient direction from lagoon 1.

NFS renewed its efforts to locate the tritium source in the fall of 1977. The french drain was excavated at several places and plugged to isolate sections of the drain pipe. Water samples from these sections indicated that groundwater between the lagoons was contaminated with tritium. NFS installed thirty-four additional wells to identify other potential sources of tritium in the north plateau between late 1977 and March 1979. (See Fig. 3-36.) Wells A through H were excavated near lagoon 1 in late 1977. Wells J-1 through J-9 and K were installed in the fall of 1978. A third series of sixteen wells, L-1 through L-5, M-1 through M-5, N-1 through N-3, P, Q, and R were installed by March 1979. These wells were sampled annually for tritium from 1979 through 1981 (Table 3-12). The highest tritium concentrations were detected in those wells located next to lagoon 1 (Fig. 3-42). Wells G and D, located on the southeastern and northeastern corner of lagoon 1, showed the highest tritium activity, ranging from 4.42 E-04 μCi/mL to 3.70 E-02 μCi/mL in well G between 1979 and 1981 and ranging from 2.28 E-04 μCi/mL to 1.75 E-04 μCi/mL in well D.

Tritium activity was above background levels downgradient of the process plant in wells M-5, N-1, N-2, P, and Q, suggesting an additional source in the area of the process plant (Fig. 3-43). Wells M-1 through M-4, which are farther downgradient of the process building, showed lower tritium levels than did wells M-5, N-1, N-2, P, and Q (Fig. 3-44). The J wells, which were installed in an east-west trending line between the high-level waste tank farm (HLW) and the hardstand, were intended to determine whether tritium was being released from the HLW (Figs. 3-45 and 3-46). The low, near-background tritium levels (2.0 E-06 μCi/mL) in these wells suggested that the HLW tanks were not the source of tritium detected at the northeast swamp drainage in the north plateau. The consistent activity levels observed at the french drain and the northeast swamp monitoring locations, compared to the fluctuating activities at

wells D and G near lagoon 1, suggested either a dampening effect from a large groundwater reservoir between lagoon 1 and the french drain or more than one source of tritium activity (West Valley Nuclear Services May 12, 1982).

4.0 WVDP Water Quality Monitoring Program

On February 26, 1982, the Department of Energy assumed responsibility for the operation and maintenance of the former Nuclear Fuels Services, Inc. nuclear fuel reprocessing facility in accordance with the West Valley Demonstration Project Act of 1980, Public Law 96-368. The West Valley Demonstration Project Act required that the DOE develop suitable technologies to solidify the liquid high-level radioactive waste stored at the site and, once this was complete, to decommission and decontaminate the site. The West Valley Nuclear Services Company (WVNS) was retained by the DOE to implement the provisions of the West Valley Demonstration Project Act.

The WVDP evaluated the NFS french drain and groundwater monitoring program in May 1982 and determined that NFS had adequately evaluated the concentration of tritium in groundwater in the north plateau (West Valley Nuclear Services, Inc. May 12, 1982). The WVDP concluded from its review that lagoon 1 was discharging tritium into the groundwater in the surficial sand and gravel unit. Based on tritium levels observed in wells, the groundwater appeared to be migrating towards the northeast swamp.

4.1 Surface Water Monitoring - WVDP Surface Water Sampling Program (1983 - Present)

4.1.1 Off-site Surface Water Sampling (Fig. 4-1)

The WVDP has routinely sampled off-site surface water since 1983 at two locations along Buttermilk Creek and at one location along Cattaraugus Creek. Buttermilk Creek is sampled upstream of the WVDP site at Fox Valley Road (WFBCBKG) where Buttermilk Creek enters the WNYNSC and downstream of the WVDP at Thomas Corners Road (WFBCTCB), which is just upstream of the confluence of Buttermilk

Creek with Cattaraugus Creek. An automatic sampler collects a 25-mL sample every half-hour from these sampling locations. Water samples from Buttermilk Creek are composited monthly and analyzed for tritium, gross alpha, and gross beta. A quarterly composite sample is analyzed for Sr-90 and Cs-137.

The Cattaraugus Creek sampling location is at Felton Bridge (WFFELBR), downstream of the confluence of Buttermilk Creek with Cattaraugus Creek. An automatic sampler periodically collects a small volume of water at a rate of approximately 50 mL per half-hour. Water samples are collected weekly and are analyzed for tritium, gross alpha, and gross beta. The weekly samples are proportioned into a monthly composite sample based on relative stream discharge and analyzed for Sr-90 and Cs-137. The program included an additional sampling location along Cattaraugus Creek at Bigelow Bridge from 1983 through 1985. Analytical results for each of these sampling locations may be found in the annual West Valley Demonstration Project Site Environmental Monitoring Reports for calendar years 1982 through 1991.

4.1.1.1 Buttermilk Creek Upstream at Fox Valley Road (Fig. 4-2)

Tritium, gross beta, gross alpha, Sr-90, and Cs-137 activity has been monitored at Fox Valley Road (WFBCBKG) since 1983 to document background radiological activity along Buttermilk Creek upstream of the WVDP.

- Tritium. Tritium activity has been monitored at Fox Valley Road from 1983 through 1991. Tritium activity progressively decreased during this period from a maximum yearly average of 4.55 E-07 μCi/mL in 1983 to a minimum yearly average of <1.0 E-07 μCi/mL in 1990. Tritium activity at Fox Valley Road has generally been below the LLD_p as only seventeen positive monthly tritium detections have been observed during the 8.5 years of sampling at this location. The magnitude of the tritium activity at Fox Valley Road is similar to NYSDEC-derived background tritium concentrations of 3.0 μCi/mL in New York State surface waters.

- Gross Beta. Gross beta activity has been monitored from 1983 through 1991 and has been consistent during this period of time, ranging from a minimum yearly average of 2.96 E-09 μCi/mL in 1990 to a maximum of 4.92 E-09 μCi/mL in 1984. The gross beta values of 3.0 E-09

μCi/mL to 4.0 E-09 μCi/mL measured at Fox Valley Road are consistent with the background gross beta activity for New York State surface waters that NYSDOH determined in its 1965-1967 Environmental Surveillance Report (New York State Department of Health 1968).

- Gross Alpha. Gross alpha activity has been measured from 1984 through 1991 and has ranged from a minimum yearly average of 3.56 E-10 μCi/mL in 1984 to a maximum of 1.53 E-09 μCi/mL in 1991. Gross alpha activity at Fox Valley Road has generally been below the LLD, as only twenty positive monthly gross alpha detections have been observed during the eight years of sampling at this location.

- Sr-90. Fox Valley Road has been sampled for Sr-90 on a quarterly basis since 1984. Sr-90 activity has remained fairly consistent during this time, paralleling the gross beta trend, ranging from a yearly average minimum of 2.12 E-09 μCi/mL in 1991 to a maximum of 5.08 E-09 μCi/mL in 1990. The Sr-90 values of 2.0 E-09 μCi/mL to 5.0 E-09 μCi/mL measured at Fox Valley Road are consistent with the background Sr-90 activity that NYSDOH determined in its 1965-1967 General Surveillance Program for New York State surface waters.

- Cs-137. Fox Valley Road has been analyzed for Cs-137 activity on a quarterly basis since 1984. During this period Cs-137 activity has been below the LLD for all but one quarterly sampling event.

4.1.1.2 Buttermilk Creek at Thomas Corners Bridge (Fig. 4-3)

Buttermilk Creek at Thomas Corners Bridge (WFBCTCB), approximately 4 kilometers (2.5 mi) downstream of the WVDP, has been sampled for tritium, gross beta, gross alpha, Sr-90, and Cs-137 activity since 1982.

- Tritium. Tritium contributed the largest component of radiological activity at Thomas Corners Bridge from 1982 through 1991. Tritium activity progressively decreased during this period from a maximum yearly average of 7.94 E-06 μCi/mL in 1982 to a minimum yearly average of < 1.0 E-07 μCi/mL in 1991.

- Gross Beta. Gross beta activity at Thomas Corners Bridge paralleled the tritium trend from 1982 through 1991. Gross beta activity, which was highest in 1982 with a maximum yearly average of 1.78 E-08 μCi/mL, began to progressively decrease in 1983 to a minimum yearly average of 5.29 E-09 μCi/mL in 1990. Gross beta activity increased unexpectedly to an average of 1.03 E-08 μCi/mL in 1991.

- Gross Alpha. Gross alpha activity has been measured from 1982 through 1991, ranging from a minimum yearly average of <5.83 E-10 μCi/mL in 1982 to a maximum yearly average of 2.42 E-09 μCi/mL in 1991. Gross alpha activity at Thomas Corners Bridge has generally been below the LLD, as only thirty-seven positive monthly gross alpha detections have been observed during the ten years of sampling at this location.

- Sr-90. Thomas Corners Bridge has been sampled for Sr-90 on a quarterly basis since 1984. Sr-90 activity has fluctuated during this period, ranging from a yearly average minimum of 2.12 E-09 μCi/mL in 1991 to a maximum of 5.08 E-09 μCi/mL in 1990. The Sr-90 values of 2.0 E-09 μCi/mL to 5.0 E-09 μCi/mL measured at Fox Valley Road are consistent with the background Sr-90 activity that NYSDOH determined in its 1965-1967 General Surveillance Program for New York State surface waters.

- Cs-137. Thomas Corners Bridge has been analyzed for Cs-137 activity on a quarterly basis since 1984, during which Cs-137 activity has been below the LLD for all but two quarterly sampling events.

4.1.1.3 Cattaraugus Creek at Bigelow Bridge (Fig. 4-4)

Cattaraugus Creek was sampled upstream of Buttermilk Creek at Bigelow Bridge for tritium, gross beta, and gross alpha by the WVDP from 1982 through 1985.

- Tritium. Tritium activity declined from a maximum yearly average of 9.58 E-07 μCi/mL in 1982 to background levels of 1.70 E-07 μCi/mL in 1985. Positive tritium detections were observed in less than 50% of the monthly sampling events from 1983 through 1985.

- Gross Beta. Gross beta activity decreased from a maximum yearly average of 7.28 E-09 μCi/mL in 1982 to background levels of 3.85 E-09 μCi/mL in 1985.

- Gross Alpha. Gross alpha activity was around background levels during this period ranging from <4.02 E-10 μCi/mL to 6.60 E-10 μCi/mL. Gross alpha activity was below the LLD for most of the monthly sampling events since 1982, as only thirty-one monthly positive gross alpha detections have been observed since 1982.

4.1.1.4 Cattaraugus Creek at Felton Bridge (Fig. 4-5)

Cattaraugus Creek was sampled downstream of Buttermilk Creek at Felton Bridge (WFFELBR) for tritium, gross beta, gross alpha, Sr-90, and Cs-137 by the WVDP from 1982 through 1991.

- Tritium. Tritium activity has progressively decreased at Felton Bridge from 1982 through 1991, from a maximum yearly average of 1.09 E-06 μCi/mL in 1982 to a minimum yearly average of <1.0 E-07 μCi/mL in 1990. Tritium activity has generally been below the LLD and around background levels since 1984, as only ten positive monthly tritium detections have been observed since 1984.

- Gross Beta. Gross beta activity at Felton Bridge decreased from a maximum yearly average of 1.04 E-08 μCi/mL in 1982 to minimum of 3.78 E-09 μCi/mL in 1990. Gross beta activity had decreased to near background levels by 1987 at Felton Bridge. Gross beta activity at Felton Bridge is lower than that observed at Thomas Corners Bridge, presumably a result of dilution from Cattaraugus Creek waters.

- Gross Alpha. Gross alpha activity at Felton Bridge has been below the LLD for most of the monthly sampling events since 1982, as only thirty-one monthly positive gross alpha detections have been observed since 1982.

- Sr-90. Sr-90 activity at Felton Bridge has consistently been at background levels since 1982, ranging from a minimum of 1.09 E-09 μCi/mL in 1982 to a maximum of 5.73 E-09 μCi/mL in 1986.

- Cs-137. Cs-137 activity at Felton Bridge has generally been below the LLD for all but four quarterly sampling events since 1983.

4.1.2 On-site Surface Water Sampling (Fig. 4-6)

The WVDP has sampled surface waters along on-site drainage channels since 1983. Currently, eleven sampling points along drainage channels are sampled on-site to document any potential releases of radioactivity at the WVDP. Seven of these locations, which have the most easily accessible data, are discussed below.

The on-site drainage channel sampling locations have been selected at those points most likely to indicate potential releases of radioactivity from the site, such as sampling locations along Frank's Creek and Erdman Brook, which monitor releases from the NDA and SDA. One background sampling station is located upstream of the WVDP along Frank's Creek southeast of the SDA.

4.1.2.1 Frank's Creek at the WVDP Security Fence (Fig. 4-7)

This sampling location (WNSP006) is located in Frank's Creek at the WVDP security fence. WNSP006 receives surface drainage from the two disposal areas and large portions of the site, including effluent releases from the french drain, lagoon 3, the sewage plant outfall, and the demineralizer sludge ponds. The WVDP has sampled location WNSP006 for gross alpha, gross beta, and tritium since 1983. Sr-90 and Cs-137 were part of the parameter list from 1984 through 1987. Tritium activity has generally been above 1.0 E-06 μCi/mL since 1983. Gross beta activity has been at least one order of magnitude above background levels since 1983, ranging from 4.34 E-08 μCi/mL to 1.0 E-07 μCi/mL. Similarly, Sr-90 and Cs-137 concentrations were also above background concentrations from 1984 through 1987. Gross alpha activity at WNSP006 was below the LLD for most of the monthly sampling events. However, a noticeable increase in gross alpha activity was observed from 1984 through 1986 when gross alpha was detected above the LLD in greater frequency than in previous years.

Tritium, gross beta, Sr-90, and Cs-137 activity at WNSP006 is generally one order of magnitude higher than at Thomas Corners Bridge.

4.1.2.2 Erdman Brook (Fig. 4-8)

The WVDP has sampled Erdman Brook at location 053 for tritium, gross beta, and gross alpha since 1982. Tritium activity decreased to near background levels from 1982 to 1991, ranging from a maximum of 1.57 E-06 μCi/mL in 1982 to a minimum of 1.36 E-07 μCi/mL in 1990. Gross beta activity has remained relatively constant since 1982, ranging from a yearly average of 2.18 E-08 μCi/mL to 3.52 E-08 μCi/mL, an order of magnitude above background levels. Gross alpha activity has generally been around background levels since 1982, as only twenty-eight positive monthly detections above the LLD have been recorded since 1982.

Since this station has been sampled, beginning in 1969, tritium levels have decreased two orders of magnitude, from a maximum of 5.73 E-05 μCi/mL in 1969 (see Fig. 3-23) to near background levels of 1.75 E-07 μCi/mL in 1991 (Fig. 4-8). Gross beta activity has decreased nearly two orders of magnitude from a maximum of 1.86 E-06 μCi/mL in 1971 to a minimum of 2.18 E-08 μCi/mL in 1991. (See Fig. 3-23.)

4.1.2.3 Frank's Creek at Sampling Location 067 (Fig. 4-9)

The WVDP has sampled Frank's Creek at location 067 for tritium, gross beta, and gross alpha since 1982. Tritium activity has decreased to background levels during this time, ranging from a maximum of 8.85 E-07 μCi/mL in 1982 to non-detectable levels of <1.0 E-07 μCi/mL in 1991. Tritium activity has generally been below detectable levels since 1982, as only forty-four positive monthly detections were recorded since 1982. Gross beta activity has decreased from a yearly average of 9.01 E-09 μCi/mL in 1982 to near background levels of 5.22 E-09 μCi/mL in 1991. Gross alpha activity has generally been around background levels since 1982, as only thirty-one positive monthly detections above the LLD have been recorded since 1982.

In general, tritium levels at 067 have decreased by more than an order of magnitude since 1969, from a maximum of 8.38 E-06 μCi/mL in 1971 (see Fig. 3-27) to background levels of < 1.00 E-07 μCi/mL in 1991 (Fig. 4-9). Gross beta activity has decreased nearly two orders of magnitude from a maximum of 1.86 E-06 μCi/mL in 1971 to a minimum of 2.18 E-08 μCi/mL in 1991. (See Fig. 3-23.)

4.1.2.4 French Drain (Fig. 4-10)

The french drain (WNSP008) was sampled by the WVDP for gross alpha, gross beta, and tritium from 1982 through 1991. However, gross alpha and gross beta were not sampled during 1985-1986. Tritium levels at the french drain were one to two orders of magnitude above background during this period and have declined from 3.52 E-05 μCi/mL in 1982 to 4.49 E-06 μCi/mL in 1991. Gross beta activity has

been consistently one order of magnitude above background, ranging from 1.17 E-08 μCi/mL to 4.77 E-08 μCi/mL during this period. Gross alpha activity has been at background levels, as only six positive detections above the LLD have been recorded during the eight years the french drain was sampled.

Overall, tritium activity at the french drain has declined from a maximum of 2.36 E-03 μCi/mL in 1972 (see Fig. 3-34) to a minimum of 4.49 E-06 μCi/mL in 1991. Gross beta activity has not declined as much as tritium. The highest gross beta activity was measured at 6.93 E-06 μCi/mL in 1972 (see Fig. 3-34), which declined to levels of 4.0 E-08 μCi/mL by 1978 and has remained at these levels up through 1991. Gross alpha activity has been at background levels since 1972.

4.1.2.5 Sewage Treatment Outfall (Fig. 4-11)

The sewage treatment outfall (WNSP007) is located at the equalization basin and combines liquid effluent discharged from the sewage treatment plant and the demineralizer sludge ponds. Tritium activity decreased from a maximum of 8.36 E-07 μCi/mL in 1983 to background levels of 1.0 E-07 μCi/mL by 1986. Gross beta activity has fluctuated by two orders of magnitude since 1983, ranging from a maximum of 5.68 E-07 μCi/mL in 1991 to a minimum of 5.75 E-09 μCi/mL in 1986. Gross alpha activity has been below the LLD since 1985.

4.1.2.6 Lagoon 3 (Fig. 4-12)

The lagoon 3 outfall (WNSP001) has been sampled for gross alpha, gross beta, tritium, Cs-137, and Sr-90 since 1982. Tritium activity in lagoon 3 water has ranged from a minimum yearly average of 1.67 E-05 μCi/mL in 1987 to a maximum yearly average of 3.17 E-04 μCi/mL in 1982. Overall, from 1983 to 1991 the average tritium activity discharged from lagoon 3 has declined. Gross beta activity has fluctuated slightly since 1983, ranging from 8.07 E-07 μCi/mL to 1.57 E-06 μCi/mL. Cs-137 activity has been variable, ranging from a maximum yearly average of 1.33 E-05 μCi/mL in 1986 to a minimum of 1.41 E-07 μCi/mL in 1989. In general, Cs-137 has ranged from 1.41 E-07 to 1.33 E-05 μCi/mL.

Sr-90 activity has fluctuated between 5.97 E-08 μCi/mL and 2.01 E-07 μCi/mL levels since 1982. Gross alpha activity has ranged from a maximum yearly average of 3.47 E-07 μCi/mL in 1985 to a minimum yearly average of 9.78 E-09 μCi/mL in 1991.

4.1.2.7 Northeast Swamp Drainage (Fig. 4-13)

WVNS has sampled the northeast swamp (WNSWAMP) for tritium since 1983. Tritium levels have progressively decreased from a maximum yearly average of 4.0 E-06 μCi/mL in 1983 to a minimum of 5.12 E-07 μCi/mL in 1991. Tritium levels at the northeast swamp drainage have decreased two orders of magnitude from a maximum yearly average of 6.06 E-05 μCi/mL in 1974 to a minimum of 5.12 E-07 μCi/mL in 1991. (See Fig. 3-35.)

4.2 WVDP Groundwater Monitoring

4.2.1 Comprehensive and Special Monitoring Program (1982-1991)

The WVDP's first action upon occupying the former NFS site was a review of pre-1982 NFS groundwater monitoring activities. Two separate areas of elevated tritium in the north plateau, which were attributed to two different sources (West Valley Nuclear Services May 12, 1982), were identified. One source was lagoon 1; the other source area was located between the plant and the high-level waste tank farm. Lagoon 1 was determined to be the largest source of tritium to the groundwater in the north plateau. Tritium was migrating northeast of lagoon 1 via the french drain and also northward towards discharge points located along the margins of the north plateau.

The WVDP followed up its historical investigation with groundwater sampling in October 1982 to verify interpretations derived from the historical investigation (Marchetti December 17, 1982). Forty-six on-site monitoring wells and nine off-site private drinking water wells were sampled for gross alpha, gross beta, tritium, and gamma-emitting isotopes. Of the forty-six on-site wells, thirty-three were NFS wells installed between 1977 and 1979 and the remaining thirteen were U.S. Geological Survey (USGS) 1980-series monitoring wells.

The WVDP also began to monitor groundwater in the south plateau in November 1983 after a mixture of radioactively contaminated n-dodecane and tributyl phosphate was detected in monitoring well 82-5A at the NRC-licensed disposal area (NDA).

In 1984 the WVDP modified its on-site and off-site groundwater monitoring program, including ten shallow dug wells located immediately north of the plant and near lagoon 1, six USGS 80-series wells in the north plateau, and five USGS 82-series well clusters at the NDA. In addition, another well was added to the off-site monitoring program, bringing the number of off-site drinking water wells sampled around the perimeter of the WNYNSC to ten: Most of the NFS wells were removed from the monitoring network. The off-site wells were sampled once a year for gross alpha, gross beta, and tritium. The on-site wells were sampled twice a year for gross alpha, gross beta, and tritium.

In 1986 the groundwater monitoring program was expanded again to detect both radiological and nonradiological groundwater contamination and to meet the intent of the Resource Conservation and Recovery Act (RCRA) hazardous waste permitting program. The shallow dug wells were removed from service and ten new monitoring wells, the B-86 series of wells, were added to the groundwater monitoring program. Off-site wells continued to be sampled once a year for gross alpha, gross beta, and tritium. On-site wells were sampled quarterly for gross alpha, gross beta, and tritium and were also sampled for the chemical water quality parameters specified in Table 4-1.

Under the expanded program the low-level wastewater lagoon system, the high-level radioactive waste tank complex, and the NRC-licensed disposal area (NDA) were identified as waste management areas to be monitored. Fourteen groundwater monitoring wells, a groundwater seep, and the french drain outfall (WNSP008) were designated to monitor the three waste management areas. Of the fourteen wells, five were existing USGS 80-series monitoring wells and the remaining nine were the B-86 wells installed by the WVDP in 1986. The monitoring network was situated such that one monitoring point was located upgradient of the waste management unit, with the remainder located downgradient to detect any releases from the waste management units.

The low-level wastewater lagoon system was monitored by the french drain outlet (WNSP008), groundwater seepage point WNGSEEP, and by six wells: 86-3, 86-4, 86-5, 86-6, 80-5, and 80-6 (Fig. 4-14). The high-level waste tank complex was monitored by the northeast swamp drainage outlet WNDMPNE and by five wells: 80-2, 86-7, 86-8, 86-9, and 86-12. All wells monitoring the lagoon system and the high-level tank farm were screened in and monitored the surficial sand and gravel unit. The NDA was monitored by wells 83-1D, 86-10, and 86-11, which were screened in the unweathered Lavery till. Analytical results for each of these groundwater sampling locations may be found in the annual West Valley Demonstration Project Site Environmental Monitoring Reports for calendar years 1982 through 1991.

Well 80-2 is used to establish background groundwater quality conditions in the sand and gravel unit in the north plateau because it is upgradient of plant operations and the other wells monitoring the tank farm and lagoon area.

4.2.1.1 Radiological Groundwater Monitoring

Off-site Radiological Groundwater Monitoring (Table 4-2; Fig. 4-15)

The WVDP began sampling private drinking water wells located outside the WNYNSC reservation in 1982 to establish baseline activity for gross alpha, gross beta, tritium, and gamma isotopes. Nine wells were initially sampled in 1982 and a tenth well was added to the off-site monitoring program in 1984. The off-site wells are located anywhere from 1 to 4.33 kilometers from the perimeter of the WVDP. All of the wells were sampled annually, except during 1985 through 1988, when half of the wells were sampled bi-annually on alternating years (Table 4-2). All wells are currently being sampled each year. The analyte list was expanded in 1989 to include testing for pH and specific conductivity.

In general, gross alpha, tritium, and Cs-137 activity in off-site groundwater was at background levels, either below or near the lower limit of detection (LLD) for these parameters. Gross beta activity was representative of background levels, ranging from <7.25 E-10 μCi/mL to 5.90 E-09 μCi/mL.

On-site Radiological Groundwater Monitoring: North Plateau - Sand and Gravel Unit

- Gross Alpha (Figs. 4-16 — 4-18)

Gross alpha activity in wells from the north plateau were generally below the LLD from 1984 through 1991. The highest gross alpha activity in the north plateau during this period, associated with well B-86-5 near the former lagoon 1, ranged from a yearly average of 3.47 E-09 μCi/mL in 1986 to 1.12 E-08 μCi/mL in 1991 (Fig. 4-16). Gross alpha activity above the LLD was detected during twenty-two of the thirty-two sampling events conducted at well B-86-5 from 1986 through 1991. The gross alpha activity at B-86-5 is most likely the result of radiological material remaining after the closure of lagoon 1.

- Gross Beta (Figs. 4-19 — 4-21)

The lowest gross beta activity in the north plateau was associated with background well 80-2, ranging from 5.48 E-09 μCi/mL in 1984 to 1.28 E-09 μCi/mL in 1988. The highest gross beta activity, detected in well 86-5 near former lagoon 1, ranged from 1.65 E-05 μCi/mL in 1986 to 2.76 E-05 μCi/mL in 1990 (Fig. 4-19).

The highest gross beta activity appears to be associated with the lagoon area. Well 86-5 has remained at levels of about 2.0 E-05 μCi/mL since sampling began in 1986, and activity in well 86-4, which is located approximately 25 meters west of lagoon 4, has increased by more than two orders of magnitude from 1987 to 1991. Releases of radionuclides from lagoon 1 are the apparent source of beta activity in well 86-5, while the process building, which is upgradient of well 86-4, may be the source of the activity in 86-4. Gross beta activity in the french drain (WNSP008), 86-3, and 86-6 has remained fairly constant since 1984.

Gross beta activity varies considerably in wells monitoring the tank farm (Fig. 4-20). Wells 80-3 and 86-9 have shown gross beta activity in excess of 1.0 E-07 μCi/mL since 1984, a value ten to fifty times higher than that of the other wells monitoring the tank farm. The activity in well

86-9, which is located less than 50 meters north and downgradient of the process building, has been increasing since 1986. Well 80-3, which is near the northeast swamp, has consistently shown gross beta activity of 2.0 E-07 μCi/mL from 1984 through 1990. Gross beta activity appears to be increasing over time in wells monitoring the tank farm.

Gross beta activity in wells and seeps at the northeastern corner of the north plateau were slightly above background levels, ranging from 2.22 E-09 μCi/mL to 8.29 E-09 μCi/mL from 1986 through 1990 (Fig. 4-21). Sampling point WNDMPNE, however, has consistently shown an activity of 1.0 E-07 μCi/mL.

- Tritium (Figs. 4-22 — 4-24)

Tritium activity nearly parallels gross beta activity from 1984 through 1991. The lowest tritium activities, ranging from 1.00 E-07 μCi/mL to 1.86 E-07 μCi/mL, were measured in background well 80-2, while the highest activity was measured in well 86-5, ranging from 1.61 E-05 μCi/mL to 2.64 E-05 μCi/mL (Fig. 4-22).

The highest tritium activity in the north plateau is associated with the lagoon area, where the french drain (WNSP008) and wells 86-3, 86-4, and 86-5 had tritium activity of one to two orders of magnitude above background levels (Fig. 4-22). Releases of tritium from lagoon 1 are the most likely source of the tritium in well 86-5 and WNSP008. Releases of tritium from the process building may be the source of tritium in wells 86-3 and 86-4, which are downgradient of the process building. Tritium levels in wells monitoring the lagoons have decreased slightly from 1986 through 1991.

Tritium activity in wells 80-3, 80-4, and 86-7, which monitor the tank farm, were slightly above background levels (Fig. 4-23). Tritium concentrations in wells 86-9 and 86-8, however, were nearly one order of magnitude higher. Well 86-8 is located approximately 25 meters northeast and downgradient of the tank farm. (See Fig. 14.) The process building may be the source of the tritium in wells 86-8 and 86-9.

Tritium activity was well above background levels in all wells and seeps at the northeastern corner of the north plateau (Fig. 4-24). Well 86-12 had the highest tritium levels, ranging from 2.02 E-06 μCi/mL to 4.96 E-06 μCi/mL from 1986 through 1991.

Tritium activity in the sand and gravel generally decreased from 1984 to 1991, with the exception of well 80-5, which increased nearly one order of magnitude from 1986 through 1990. This increase is difficult to explain, as tritium in wells 86-12, 80-6, and seepage point WNGSEEP, which are located within 70 meters of 80-5, decreased during this period.

4.2.1.2 On-site Nonradiological Groundwater Monitoring: North Plateau - Sand and Gravel Unit

The WVDP monitors for nonradiological parameters only at on-site locations. The program for nonradiological analyses for chemical contamination indicators began in 1986 and was modeled after the Resource Conservation and Recovery Act (RCRA) type of groundwater monitoring program.

- pH (Figs. 4-25 — 4-27)

The highest mean annual pH in the north plateau, ranging from 7.74 to 7.92 from 1986 through 1990, was measured in background well 80-2; the lowest pH, ranging from 6.21 to 6.42, was measured at seepage point WNGSEEP.

The pH at each waste management unit is quite variable. In general, slightly acidic groundwater occurs around the margins of the north plateau in the area of lagoons 2 and 3, in wells 86-5, 86-6, and WNSP008, in the french drain outfall (Fig. 4-25), in wells 86-7 and 86-8 at the tank farm (Fig. 4-26), and at WNGSEEP, WNDMPNE, and well 80-6 in the northern portion of the north plateau (Fig. 4-27). Slightly alkaline groundwater occurs in a northeast-trending zone extending from the plant in wells 86-3, 86-4, 80-3, 80-4, 80-5, and 86-12, including well 80-2. The zone of alkaline groundwater appears to decrease in width near well 86-12, as nearby well 80-6 and WNGSEEP are slightly acidic.

- Specific Conductance (Fig. 4-28 — 4-30)

Background well 80-2 had the lowest mean annual specific conductance, ranging from 305 to 464 μmhos/cm @ 25°C from 1986 through 1990; the highest conductance was measured in well 86-6, ranging from 1621 to 2584 μmhos/cm @ 25°C (Fig. 4-28).

Well 86-6 is located near the demineralizer sludge ponds and equalization pond. (See Fig. 4-14.) The demineralizer sludge ponds received dilute sulfuric acid and brine solutions that had been used to regenerate the anion and cation exchange systems in the plant's water treatment facility. Sediment sampling in the sludge pond area indicates elevated concentrations of chloride, sulfate, and various metals, which when dissolved would elevate the specific conductance of nearby groundwater. (Table 4-3.)

With the exception of well 86-6, specific conductance does not vary significantly between wells in the lagoon area (Fig. 4-28), the tank farm (Fig. 4-29), or the northeastern corner of the north plateau (Fig. 4-30). In general, specific conductance increased across the north plateau from 1984 to 1991.

- Total Organic Carbon (Figs. 4-31 — 4-33)

The highest total organic carbon (TOC) concentration was associated with well B-86-5 in the lagoon area and ranged from a minimum of 8.50 mg/L in 1988 to 18.00 mg/L in 1987 (Fig. 4-31). Well 80-2 and WNGSEEP had the lowest TOC concentrations from 1986-1990, ranging from <1.00 mg/L to 3.98 mg/L (Fig. 4-33). In general, TOC concentrations in the sand and gravel were less than 5 mg/L during this period. TOC concentrations in the north plateau show a regular alternating annual increase and decrease from 1986 through 1989.

- Total Organic Halogens (Figs. 4-34 — 4-36)

The WVDP sampled groundwater for total organic halogens (TOX) from 1988-1991. The average yearly concentration of TOX was generally less than 0.020 mg/L. However, TOX concentrations increased to 0.140 mg/L in well 86-6 in 1991 (Fig. 4-34) and to 0.130 mg/L in well 86-12 in 1990 (Fig. 4-36).

- Chloride (Figs. 4-37 - 4-39)

Monitoring wells 86-7 and 86-5 had the lowest mean annual chloride concentration of all wells monitoring the north plateau from 1984 through 1990, ranging from 6.4 mg/L to 30 mg/L (Figs. 4-37 and 4-38). The highest mean chloride concentrations, ranging from 368 mg/L to 721 mg/L, were associated with well 86-6, located approximately 75 meters southwest of 86-5 (Fig. 4-37). The demineralizer sludge ponds, which received spent chloride-rich solutions used to recharge the plant's water softener, are the most likely principal source of the elevated chloride in well 86-6.

A second area of elevated chloride exists immediately west of lagoons 4 and 5 in wells 86-3 and 86-4 (Fig. 4-37). Road salt that had been stored in the open near the maintenance shop may be the source of chloride in these wells. Chloride concentrations were lowest in the immediate area of the tank farm in wells 86-7, 86-8, and 86-9 (Fig. 4-38.) The chloride concentration in background well 80-2 exceeded that of three downgradient monitoring wells — 86-5, 86-7, and 86-9. Road salting operations may explain the elevated chloride concentrations in 80-2, which is next to the WVDP parking area.

In general, chloride concentrations increased in almost every well monitoring the sand and gravel unit from 1986 to 1991.

- Sulfate (Figs. 4-40 — 4-42)

Mean annual sulfate concentrations were lowest in background well 80-2, ranging from 9.50 mg/L to 25 mg/L from 1986 through 1990 (Fig. 4-40). The highest sulfate concentrations, ranging from 131 mg/L to 227 mg/L, were measured in wells 86-7 and 86-8, which monitor the tank farm (Fig. 4-41).

Sulfate concentrations remained fairly constant over time in the lagoon area, with the exception of wells 86-5 and 86-6, which increased two- to nearly three-fold from 1986 through 1991. (See Fig. 4-40.) The demineralizer sludge ponds, which receive spent sulfuric acid recharge solutions used to regenerate the plant's cation-exchange system, may be the source of the sulfate in these wells.

The highest sulfate concentrations were detected in the tank farm areas in wells 86-7 and 86-8 (Fig. 4-41). A source for the sulfate in these wells is not known at this time. However, it should be noted that sulfate concentrations have generally decreased from 1986 to 1991.

Sulfate concentrations in the northeast corner of the north plateau generally ranged from 40 to 60 mg/L, with the exception of well 80-6, which ranged from 288 to 125 mg/L from 1986 through 1990 (Fig. 4-42). The difference in concentration between well 80-6 and monitoring points 80-5, 86-12, and WNGSEEP, which are located within 75 meters of 80-6, is difficult to explain.

- Nitrate (Figs. 4-43 — 4-45)

Mean annual nitrate concentrations in the sand and gravel unit ranged from <0.1 mg/L to a maximum of 7.30 mg/L from 1986 to 1991. Wells 86-7 and 86-9 in the tank farm area had the highest nitrate levels during this period (Fig. 4-44), while wells in the northeast corner of the north plateau had the lowest concentrations (Fig. 4-45). The highest annual nitrate concentrations were reached in 1987 and dropped to levels below 2 mg/L from 1988 through 1990.

- Fluoride (Figs. 4-46 — 4-48)

The WVDP sampled for fluoride from 1986 through 1990. Fluoride levels in all wells were below the LLD (0.10 mg/L) every year with the exception of 1987, when sudden increases of up to 0.58 mg/L were detected in all wells monitoring the lagoons, tank farm, and the northeast corner of the north plateau.

- Phenol (Figs. 4-49 — 4-51)

The WVDP analyzed for total phenols from 1986 - 1991. Phenol concentrations were generally below the LLD during this period, although a number of positive detections were recorded, most noticeably in well 86-6 (Fig. 4-49).

- Arsenic (Figs. 4-52 — 4-54)

Arsenic concentrations were generally below the LLD (0.01 mg/L in 1986 and was 0.005 mg/L during 1987-1991) for most of the sampling events from 1986 through 1990.

- Barium (Fig. 4-55 — 4-57)

Barium was detected at mean annual concentrations ranging from 0.01 to 0.39 mg/L. The highest barium concentrations were detected in well 86-12, ranging from 0.26 mg/L to 0.39 mg/L, and increasing from 1987 through 1990 (Fig. 4-57). In general, barium concentrations in the north plateau were below 0.250 mg/L and increased slightly from 1986 through 1991.

- Cadmium (Figs. 4-58 — 4-60)

Mean annual cadmium concentrations ranged from <0.002 mg/L to 0.042 mg/L. Cadmium concentrations in all sand and gravel wells were generally below 0.010 mg/L from 1986-1990.

- Chromium (Figs. 4-61 — 4-63)

From 1986-1990 mean annual chromium concentrations in the sand and gravel unit ranged from 0.004 mg/L to 0.039 mg/L. Annual chromium concentrations in all sand and gravel wells generally did not exceed 0.030 mg/L, as chromium concentrations were below the LLD during most of the sampling events during this period.

- Iron (Figs. 4-64 — 4-66)

Mean annual iron concentrations in the sand and gravel unit ranged from 0.02 mg/L to 24.38 mg/L from 1986-1990. The majority of wells showed annual iron concentrations below 10 mg/L.

- Lead (Figs. 4-67 — 4-69)

From 1986-1990 mean annual lead concentrations in the sand and gravel unit ranged from <0.005 mg/L to 0.070 mg/L. The majority of wells showed annual lead concentrations below 0.020 mg/L.

- Mercury (Figs. 4-70 — 4-72)

Mean annual mercury concentrations in the sand and gravel ranged from <0.0002 mg/L to 0.0021 mg/L from 1986-1990. Mercury concentrations were generally below the LLD during this period.

- Manganese (Figs. 4-73 — 4-75)

Mean annual manganese concentrations ranged from a minimum of 0.003 mg/L to a maximum of 31.00 mg/L from 1986-1990. An area of high manganese concentrations was located near lagoons 1, 2, and 3 in wells 86-5, 86-6, and the french drain (WNSP008). (Fig. 4-73.) The

highest manganese concentrations were associated with well 86-8 in the tank farm (Fig. 4-74). The lowest were associated with monitoring point WNGSEEP (Fig. 4-75).

- Selenium (Figs. 4-76 — 4-78)

Selenium concentrations were generally below the LLD in all wells in the sand and gravel unit, as only sixteen positive detections above the LLD were recorded in all wells monitored from 1986-1990.

- Silver (Figs. 4-79 — 4-81)

Mean annual silver concentrations from 1986 to 1990 ranged from 0.004 mg/L to 0.051 mg/L, averaging 0.010 mg/L.

- Sodium (Fig. 4-82 — 4-84)

Background well 80-2 had the lowest sodium concentrations in the north plateau from 1986 through 1991, ranging from 3.78 mg/L to 4.95 mg/L (Fig. 4-82). The highest sodium concentrations are associated with the lagoon area. The high sodium in well 86-6, ranging from 178 mg/L to 405 mg/L, is most likely attributable to the spent brine solutions discharged to the demineralizer sludge ponds. If 86-6 is removed from the data set, sodium concentrations in the sand and gravel from 1986 to 1991 range from 3.78 mg/L to 57.00 mg/L. The remaining wells monitoring the lagoons displayed increasing sodium from 1986 to 1991. The source of the sodium in these wells may be the July 20, 1984 sodium hydroxide spill.

Sodium concentrations in wells near the tank farm are generally less than 14 mg/L and have been increasing since 1986 (Fig. 4-83). Sodium concentrations in the northeast corner of the north plateau ranged from 10 mg/L to 20 mg/L from 1987-1991 (Fig. 4-84). Overall, sodium concentrations have increased in the sand and gravel unit from 1986 to 1991.

4.2.2 Expanded Monitoring Program (1991-Present)

In 1990 ninety-six new monitoring wells were installed to monitor solid waste management units (SWMUs), as defined by the Resource Conservation and Recovery Act. The total number of wells monitoring SWMUs at the WVDP increased from seventeen to 103. Beginning in 1991, the pre-1991 monitoring network was referred to as the 1990 monitoring network, and the newly installed wells as the expanded monitoring network. The expanded monitoring network includes the new wells installed in 1990 and selected pre-1990 wells; they are monitored for the contamination indicator parameters, groundwater quality parameters, and the EPA interim primary drinking water standards specified in Table 4-4. Contamination indicator parameters are sampled eight times a year, groundwater quality parameters are sampled twice a year, and the EPA interim primary drinking water standards parameters were to be sampled a total of four times during 1991-1992.

The expanded monitoring program monitors the five different water-bearing units at the site: the surficial sand and gravel unit, the weathered Lavery till, the unweathered Lavery till, the till-sand unit, and the Kent recessional unit. A total of 103 monitoring wells and three additional groundwater monitoring points (Fig. 4-85) are sampled on a regular basis and analyzed for the indicator, radiological, and chemical parameters specified in Table 4-4. Analytical results for these groundwater monitoring points may be found in the annual West Valley Demonstration Project Site Environmental Monitoring Report for 1991.

4.2.2.1 Radiological Monitoring

Surficial Sand and Gravel Unit (Fig. 4-86)

Currently, forty-one monitoring wells screened in the alluvial sand and gravel are sampled and analyzed by the WVDP to characterize groundwater conditions in this unit. In addition to the monitoring wells, a groundwater seep (WNGSEEP), the french drain outfall (WNSP008), and a drainage point (WNDMPNE) from the former construction and demolition debris landfill (CDDL) are also sampled

regularly as additional characterization control points for the surficial sand and gravel unit. Well NB-1S, which is located at the southwestern margin of the sand and gravel in the WVDP parking lot next to Rock Springs Road, is the most upgradient well in the surficial sand and gravel.

- Gross Alpha (Fig. 4-87)

Gross alpha activity was below the lower limit of detection during all 1991 sampling rounds in twenty-four of the forty-four monitoring locations within the surficial sand and gravel unit. Gross alpha activity exceeded the lower limit of detection in only one sampling round during 1991 in ten of the forty-four monitoring locations and was above the LLD for two rounds at nine other stations. Well 86-5, with gross alpha activity above the LLD during five sampling events in 1991, was the only well in the sand and gravel unit with more than two positive gross alpha sampling events.

Gross alpha activity above the LLD appears to be localized in three areas within the surficial sand and gravel: lagoon 1, north of lagoons 4 and 5, and north of the high-level waste tank farm. The greatest activity appears to be in the area of former lagoon 1, where well B-86-05 and 111 had five and two detections, respectively, above the LLD during 1991. Lagoon 1, which was closed in 1984, was an unlined surface impoundment excavated into the sand and gravel. Lagoon 1 received untreated process wastewater from 1966 to 1971, when the low-level waste treatment facility was completed and went on-line. The 1977 NFS groundwater investigation program indicated that lagoon 1 was releasing tritium to the sand and gravel aquifer. It is likely that alpha-emitting radionuclides were also released from lagoon 1 to the sand and gravel aquifer during this time.

The rectangular area north of lagoons 4 and 5, defined by wells B-86-3, 802, B-86-12, and 106, is the second area that shows gross alpha activity above the LLD. Lagoons 4 and 5 were originally installed with a silty clay liner in the alluvial sand and gravel in 1971. Elevated tritium levels detected in groundwater near lagoons 4 and 5 in 1974 were attributed to releases of

wastewater from these lagoons, which prompted NFS to install synthetic membrane liners in these lagoons to prevent further releases to the alluvial sand and gravel. The gross alpha activity in the above-mentioned wells may be a vestige of the early 1970s releases from lagoons 4 and 5.

The third area where gross alpha activity was detected above the LLD was north of the high-level waste tank farm. The origin of gross alpha is more problematical, but it may be related to activities associated with the former hardstand, which had been used by NFS to store radioactively contaminated machinery and equipment that was too large to be placed in disposal containers. The old hardstand was exposed to precipitation, which transferred radiological contamination to the asphalt pad and the surrounding soil and vegetation. Radiological characterization of the soil and vegetation in the area of the old hardstand in 1983 indicated some alpha activity in the vicinity of the hardstand. Contaminated soil, vegetation, and asphalt was removed from the hardstand in 1984 and was used to fill in lagoon 1, which was being taken out of service.

- Gross Beta (Fig. 4-88)

Gross beta activity was detected at all of the monitoring locations in the surficial sand and gravel unit during 1991. The 1991 yearly average ranged from a minimum of 2.24 E-09 μCi/mL in well B-86-12 to a maximum of 1.50 E-04 μCi/mL in well 408. A mean activity of 3.43 E-09 μCi/mL was detected in background well NB-1S.

Two areas of high gross beta activity have been identified in the surficial sand and gravel unit. The first is centered around well 408 and extends northeastward towards well 106, with gross beta activity progressively decreasing from well 408 to well 106. Wells 408 and 501 are hydraulically downgradient of the process building. Gross beta activity upgradient of the process building is near background levels, ranging from 3.43 E-09 μCi/mL to 6.63 E-09 μCi/mL, five orders of magnitude less than the activity observed in well 408. The process building may be the source of the elevated gross beta activity that appears in downgradient wells.

A second area of elevated gross beta activity, ranging from 4.95 E-06 μCi/mL to 2.40 E-04 μCi/mL, is located around well B-86-05 in the vicinity of the closed lagoon 1. The area around lagoon 1 does not appear to be as extensive as that associated with well 408. A third region of elevated gross beta activity is located near the lag storage buildings, which are near the former old hardstand.

- Tritium (Fig. 4-89)

Tritium was consistently detected above the lower limit of detection (1.00 E-07 μCi/mL) in twenty-five of the forty-four groundwater monitoring locations is the sand and gravel unit. Tritium was not detected above the LLD (1.0 E-07 μCi/mL) during any 1991 sampling event in fifteen of the forty-four wells monitoring the sand and gravel. Of these twenty-five wells, the 1991 average concentration of tritium in groundwater from the surficial sand and gravel ranged from a minimum of 4.25 E-07 μCi/mL in well 804 to a maximum of 1.65 E-05 μCi/mL in well 408. A tritium plume extends from the process building northeastward across the north plateau towards well B-86-12. Three of the four wells with the highest tritium activities, wells 408, 501, and 602, are located immediately downgradient of the process building. These also have the highest gross beta activity. During 1991 tritium was not detected above the LLD in wells upgradient or crossgradient to the process building. The process building may be the source of the elevated tritium activity that appears to be emanating from the plant area.

A second area of elevated tritium concentration is located near closed lagoon 1. Tritium activities were below the LLD in background well NB-1S for six of the seven sampling rounds during 1991. Only one sampling round, with an activity of 1.19 E-07 μCi/mL, exceeded the LLD during 1991.

Weathered Lavery Till (Fig 4-90)

The WVDP currently samples sixteen monitoring wells screened across the weathered and unweathered Lavery till transition in order to monitor the groundwater quality in the weathered Lavery till. These wells are all located in and around the drum cell, the NDA, and the SDA in the south plateau of the WVDP. Well 1008C, which is located near Rock Springs Road at the southwestern corner of the site, is upgradient of the major disposal areas and is considered to be the most representative of background groundwater quality conditions.

- Gross Alpha (Fig. 4-91)

  Gross alpha activity was not detected above the LLD during any of the 1991 sampling episodes in seven of the wells monitoring the weathered Lavery till, including background well 1008C. The largest number of positive gross alpha detections were recorded east of the NDA in wells 1106A and 1109A, which had three and four detections above the LLD. Well 907 at the northwestern corner of the NDA had two positive gross alpha detections. Wells at the SDA did not show significant gross alpha activity, with the exception of 1101A at the southwest corner of the SDA.

- Gross Beta (Fig. 4-92)

  Mean gross beta activity in 1991 ranged from background levels of 3.0 E-09 μCi/mL in background well 1008C to a maximum of 1.49 E-08 μCi/mL in well 908 at the southeast corner of the NDA. Above-background gross beta activity is present in the area immediately north of the drum cell in wells 908, 1006, 1007, and 1108A, ranging from 7.70 E-09 μCi/mL to 1.49 E-08 μCi/mL. A second area of elevated gross beta is present in wells 1107A and 1110A in the north end of the SDA.

- Tritium (Fig. 4-93)

Tritium activity was not detected above the LLD (1.0 E-07 μCi/mL) during any of the 1991 sampling events in nine of the sixteen wells monitoring the weathered Lavery till, including upgradient monitoring well 1008C. Eight of these wells were located upgradient of the disposal areas and the ninth was next to the SDA's eastern fenceline. Tritium was detected during all sampling events in four of the sixteen wells; three were located in the north end of the SDA (1103A, 1106A, and 1107A) and the fourth (1109A) was in the eastern end of the NDA. The 1991 yearly average tritium activity in these wells ranged from a minimum of 3.25 E-07 μCi/mL in well 1109A to a maximum of 2.59 E-05 μCi/mL in well 1107A, which is located on the northwestern margin of the SDA. The tritium in well 1107A may originate from one of the trenches in the northern end of the SDA. Burial drainage sampling station 076, located between Erdman Brook and 1107A, has historically shown tritium activity ranging between 1.0 E-06 μCi/mL to 1.0 E-04 μCi/mL.

Unweathered Lavery Till (Fig. 4-94)

The WVDP currently samples twenty-four monitoring wells screened in the upper 1.5-11.6 meters (5-38 ft) of the unweathered Lavery till. These wells were installed to monitor three waste management areas at the site: the chemical process cell hardstand (seven wells), the wastewater treatment lagoons (six wells), and the NDA-SDA (ten wells). Monitoring well 1008C, which is located near Rock Springs Road at the southwestern corner of the site, is upgradient of all waste management operations and is designated as a background monitoring well for the unweathered Lavery till.

- Gross Alpha (Fig. 4-95)

Elevated gross alpha activity, as measured by the number of detections above the LLD in 1991, was present near lagoons 2 and 3, the SDA, and the chemical process cell hardstand. Well 114 at the northern corner of lagoon 3 had the highest number of detections above the LLD, followed by well 110 and wells along the perimeter of the SDA, which had three detections above the

LLD. The large number of detections above the LLD in each of these areas is most likely the result of wastewater storage or low-level radioactive waste disposal activities. Gross alpha activity was not detected above the LLD in background well 1008C during 1991.

- Gross Beta (Fig. 4-96)

Gross beta activity was detected above the LLD during all 1991 sampling events in only fourteen of the twenty-four wells monitoring the unweathered Lavery till. The mean gross beta activity in these wells ranged from a minimum of 3.57 E-09 μCi/mL in well 110 to a maximum of 2.13 E-08 μCi/mL in well 704 and averaged 7.28 E-09 μCi/mL across the unweathered Lavery till. The lowest activity was recorded at background well 1008C, which had the fewest detections (two) above the LLD of all wells monitoring the unweathered Lavery till during 1991.

- Tritium (Fig. 4-97)

In general, the presence of tritium is not very extensive in the unweathered Lavery till, as tritium was not detected above the LLD (1.0 E-07 μCi/mL) during 1991 in twelve of the twenty-four wells and was detected above the LLD only once in six other wells. Tritium was not detected above the LLD in background well 1008C during 1991.

Tritium was detected above the LLD during all of the 1991 sampling events in four of the twenty-four wells monitoring the unweathered Lavery till: wells 107, 109, 110, and 115. The average yearly tritium activity in these wells ranged from a minimum of 3.94 E-07 μCi/mL in well 115 to a maximum of 1.12 E-06 μCi/mL in well 107.

The highest tritium levels in the unweathered Lavery till are found in the north plateau in five wells located near lagoons 2, 3, and 5. The tritium in these wells may have originated from downward flow from the overlying sand and gravel unit or from releases from lagoons 2 and 3,

which were built into the Lavery till. The bottom elevations of lagoons 2 and 3 are at 415 meters (1360 ft) and 412 meters (1353 ft), respectively, while the bottom elevations of wells 107, 109, 110, and 114 range from 410-413 meters (1346 - 1354 ft).

The tritium in well 115 may be a vestige of the releases of tritium from lagoons 4 and 5 in the early 1970s or the result of downward flow from the overlying sand and gravel unit. Well 116, which is screened in the surficial sand and gravel, has a tritium activity of 14.2 E-07 μCi/mL as compared to 3.94 E-07 μCi/mL for well 115.

Tritium was consistently detected in only one well in the south plateau, well 1109B, which is located at the northeast corner of the NDA. Tritium was usually not detected above the LLD during 1991 in wells monitoring the unweathered Lavery till in the SDA, with the exception of 1105B (once) and 1111A (twice).

Till-Sand Unit (Fig 4-98)

Nine wells currently monitor groundwater conditions in the till-sand. Seven of the wells are located in the southern portion of the north plateau near the warehouses and the demineralizer sludge ponds. Based on its location upgradient of all plant operations, well 404 is considered representative of background conditions.

- Gross Alpha (Fig. 4-99)

Gross alpha activity was not detected above the LLD during any of the 1991 sampling events in six of the nine wells monitoring the till-sand. Gross alpha activity was detected above the LLD in well 202 twice, ranging from 5.08 E-09 μCi/mL to 9.88 E-09 μCi/mL, and once in wells 208 and 701 during 1991.

- Gross Beta (Fig. 4-100)

  Gross beta activity was not consistently detected in seven of the nine wells monitoring the till-sand during 1991. However, gross beta activity was detected above the LLD during all 1991 sampling events in well 202, with a mean activity of 3.53 E-08 μCi/mL, and in six of seven events in well 905, with a mean activity of 7.42 E-09 μCi/mL.

- Tritium (Fig. 4-101)

  Tritium was not detected in four of the wells monitoring the till-sand in 1991 and was detected above the LLD only once in wells 204, 206, 402, and 701. Above-background levels of tritium, ranging from 1.9 E-07 μCi/mL to 4.02 E-07 μCi/mL, were recorded in five of seven sampling events in well 905 in 1991.

Kent Recessional Unit (KR)

Thirteen wells currently monitor groundwater conditions in the Kent recessional unit. Eleven of these wells were installed in 1990 for the expanded monitoring program, and the remaining two wells are B-86-series wells installed in 1986. All of these wells are located in the south plateau of the WVDP and were installed to monitor the NDA and the drum cell. Wells 1103C and 1104C were monitored for radiological parameters only. Well 1008B is considered the most representative of background groundwater conditions because it is upgradient of all KR wells and facility operations.

- Gross Alpha (Fig. 4-103)

  Gross alpha activity was not detected above the LLD, ranging from <7.07 E-10 μCi/mL to <9.66 E-09 μCi/mL, in eight of the thirteen wells monitoring the KR, including background well 1008B. Gross alpha activity was detected above the LLD no more than twice in 1991 in the

remaining five wells monitoring the KR. The highest gross alpha activity was measured in well 1104C, located at the northern end of the SDA, which had an activity of 1.03 E-08 μCi/mL on two occasions during 1991.

- Gross Beta (Fig. 4-104)

Gross beta activity was detected above the LLD in every 1991 sampling event in five of the thirteen wells monitoring the KR. These wells were 901, 1001, 1001C, 1003C, and 1104C. Gross beta activity was detected above the LLD in more than 50% of the sampling events in the remaining monitoring wells. The highest gross beta activities, ranging from 1.09 E-08 μCi/mL to 8.81 E-08 μCi/mL, were recorded along the southwestern corner and northeastern margin of the SDA in wells 1101C, 1103C, and 1104C. Gross beta activity was detected above the LLD in five of seven sampling events in background well 1008B, which had a mean activity of 4.35 E-09 μCi/mL.

- Tritium (Fig. 4-105)

Tritium was not detected above the LLD (<1.0 E-07 μCi/mL) in nine of the thirteen wells monitoring the KR in 1991. Tritium was detected above the LLD only once during 1991 in wells 901, 903, 1103C, and 1104C, at values ranging from 2.27 E-07 μCi/mL in well 903 to 3.63 E-07 μCi/mL in well 1104C.

4.2.2.2 Nonradiological Groundwater Monitoring

Surficial Sand and Gravel Unit

- pH (Fig. 4-106)

The mean pH of groundwater in the surficial sand and gravel unit in 1991 ranged from a minimum of 6.17 in well 86-13B to a maximum of 12.01 in well 103 and averaged 6.94 across

the sand and gravel unit. The elevated pH at well 103 is most likely caused by several thousand gallons of sodium hydroxide that leaked from a transfer line between the sodium hydroxide storage tank and the day tank at the low-level waste treatment facility on July 20, 1984. If well 103 is excluded from the data set, the pH of the sand and gravel ranges from 6.17 to 8.30 and averages 6.83.

A distinct zonation of acidic and alkaline groundwater is present in the sand and gravel aquifer. Groundwater with a pH greater than 7.00 occurs in a northeast-trending elliptical zone extending from the process building and well 103 towards well B-86-12 at the northeastern margin of the site. Groundwater in the sand and gravel outside this elliptical zone is slightly acidic, with a mean annual pH ranging from 6.17 to 6.94.

- Specific Conductance (Fig. 4-107)

The 1991 mean specific conductance in the sand and gravel ranged from a minimum of 448 μmhos/cm @ 25° C in well 802 to a maximum of 12,763 μmhos/cm @ 25° C in well 103. The average specific conductance across the sand and gravel was 1169 μmhos/cm during 1991. The high conductance at 103 is most likely the result of the July 20, 1984 sodium hydroxide leak. If 103 is excluded from the data set the mean specific conductance for 1991 ranges from a minimum of 448 μmhos/cm @ 25° C in well 802 to a maximum of 2653 μmhos/cm @ 25° C in well 205, with an average specific conductance of 905 μmhos/cm across the sand and gravel.

Two areas of higher than average specific conductance occur in the north plateau. The highest specific conductances are located in the area south of the process plant to the demineralizer sludge ponds and the equalization basin. Sediment sampling in the sludge ponds in 1988 indicated that metal concentrations were two to seven times greater than in background sampling areas and that chloride and sulfate were also above background concentrations (Table 4-3). The most likely source of the metals are the regeneration solutions that were flushed through the plant's cation

exchange systems and discharged to the sludge ponds. The source of the chloride and sulfate in the DSP was most likely the sulfuric acid and brine solutions used to regenerate the plant's demineralizer and water softener.

A second area of elevated conductance, ranging from 875 to 1144 μmhos/cm @ 25° C, is located near lagoons 4 and 5 in a triangular area defined by wells 408, 106, and 801.

The lowest specific conductances are located along the margins of the north plateau. No significant plant processes or maintenance operations, which may increase the dissolved ionic concentrations in groundwater, are present at the margins of the sand and gravel.

- Total Organic Carbon (Fig. 4-108)

Mean total organic carbon (TOC) concentrations in 1991 ranged from a minimum of 1.68 mg/L in well 301 to a maximum of 475 mg/L in well 103 and averaged 16.9 mg/L. If well 103 is excluded from the data set, TOC ranges from 1.68 mg/L in well 301 to 26.25 mg/L in well 207 and averages 6.51 mg/L. The mean TOC content of background well NB-1S was 7.17 mg/L in 1991. Above-background concentrations of TOC are present near the equalization pond and north of the high-level waste tank farm.

- Total Organic Halogens (Fig. 4-109)

The 1991 mean total organic halogens (TOX) concentration in the sand and gravel unit ranged from a minimum of 0.006 mg/L in well 603 to a maximum of 0.14 mg/L in well B-86-06. A zone of elevated TOX appears downgradient of the process building in wells 408, 501, and 502.

- Volatile Organic Analysis (Fig. 4-110)

The WVDP began sampling groundwater near the high-level waste tank farm (HLW) for volatile organic chemicals (VOCs) in June 1989. Sampling for VOCs was expanded to all on-site wells

in 1990. As of 1992 only two VOCs, 1,1,1-trichloroethane (TCA) and 1,1-dichloroethane (1,1-DCA), have been consistently detected in only three sampling locations in the sand and gravel: wells B-86-09 and B-86-12 and the groundwater seep monitoring location WNGSEEP.

In June 1989 groundwater from four monitoring wells near the HLW were sampled and analyzed for VOCs. Only 1,1-DCA, at a concentration of 13 μg/L, was detected above the LLD in well B-86-09. No other VOCs were detected in any of the three other wells sampled at that time. 1,1-DCA has been detected in B-86-09 since then at concentrations ranging from 11 to 19 μg/L. TCA has been detected in B-86-09 on several occasions at concentrations below LLD (5 μg/L) since June 1989.

In October 1989 1,1-DCA was detected at concentrations of 6.7 μg/L in monitoring well B-86-12 during characterization work on the construction and demolition debris landfill (CDDL). 1,1-DCA has been consistently detected at B-86-12 since then at concentrations ranging from 6.5 to 7.5 μg/L. TCA was detected only once at well B-86-12 on October 18, 1990, at a concentration below the LLD of 5 μg/L.

Additional monitoring wells and the groundwater seep monitoring location WNGSEEP were added to the VOC monitoring network surrounding the CDDL in late October 1989 to find the source of the 1,1-DCA detected in well B-86-12. TCA was first detected below the LLD at WNGSEEP on February 21, 1990. Measurable quantities of TCA were first detected at WNGSEEP on April 24, 1990. The concentration of TCA reached a maximum of 41 μg/L on June 6, 1990 and has decreased since then to levels of approximately 5 to 7 μg/L (5 to 7 ppb) during the last two sampling rounds on October 9, 1991 and November 21, 1991.

- Chloride (Fig. 4-111)

The mean 1991 chloride concentration in the sand and gravel ranged from a minimum of 7.7 mg/L in well 706 to a maximum of 1090 mg/L in well 205 and averaged 164 mg/L. The background well NB-1S had a mean concentration of 75 mg/L.

Two areas with elevated chloride are present in the sand and gravel unit. The highest chloride concentrations, ranging from 145 mg/L to 1090 mg/L, are located at the demineralizer sludge ponds and extend westward to wells 305 and 307. The sludge ponds received recharge solutions backflushed from the plant's process water demineralizer and water softener, which were anion and cation exchange systems regenerated with 0.4M sulfuric acid and a brine solution, respectively. Soil sampling in the sludge ponds in 1988 indicated chloride in concentrations ranging from nondetectable to 395 ppm. (See Table 4-3). The probable source of the elevated chloride in wells near the sludge ponds are the brine solutions that were used to regenerate the water softener. The utility room, which is next to wells 305 and 307, used sodium chloride in the water softener system. The sodium chloride used in the water softener was originally stored in bags in the old warehouse, located just west of the demineralizer sludge ponds. The extensive use of sodium chloride in this area of the plant is the most likely source of the elevated chloride in the groundwater in this area.

A second area of elevated chloride, ranging from 61 mg/L to 349 mg/L, extends northeastward from well 408 to B-86-12. Roadway salt, which was reportedly stored outside near the present day melter disassembly building near well 502, may be a partial source of chloride for this zone.

Relatively low chloride concentrations ranging from 7.7 mg/L to 29 mg/L are found in the northern portion of the north plateau in the area of the lag storage buildings and the chemical process cell building (CPC). Several wells situated along roads or parking areas, most notably 301, 401, 403, R86-13A,B,C, and NB-1S, show high levels of chloride relative to those wells located along the northern portion of the sand and gravel. Road salting may be the source of the chloride in these wells.

- Sulfate (Fig. 4-112)

The 1991 mean sulfate concentration ranged from a minimum of 18 mg/L in well 301 to a maximum of 230 mg/L in well 86-13B, and averaged 80 mg/L across the sand and gravel unit. Background well NB-1S had a mean concentration of 24 mg/L.

Two areas of elevated sulfate are present in the sand and gravel: the area immediately north of the tank farm, which ranges from 103 mg/L to 200 mg/L, and the area northeast of the sludge ponds, ranges from 95 mg/L to 160 mg/L.

The source of the sulfate north of the tank farms is not presently understood. Precipitation may be the source, with sulfate produced by the reaction of sulfur dioxide (SO_2) in the atmosphere with either rain or snow. Another source of sulfate may be the mineral gypsum, which would dissociate into calcium and sulfate ions. The source of the elevated sulfate north of the demineralizer sludge ponds may be the dilute sulfuric acid solutions that were used to regenerate the process water demineralizer. Soil sampling around the demineralizer sludge ponds in February 1988 detected elevated sulfate in concentrations ranging from 35.6 to 536.5 ppm. (See Table 4-3.)

- Nitrate (Fig. 4-113)

The 1991 mean nitrate concentration ranged from 0.03 mg/L in well 207 to 10.5 mg/L in well 403. Background well NB-1S had a 7.0 mg/L concentration. In general, the monitoring stations on the perimeter of the sand and gravel unit had nitrate concentrations of less than 1.0 mg/L. Areas immediately downgradient of the process plant and neighboring buildings show higher nitrate concentrations.

- Ammonia (Fig. 4-114)

Ammonia concentrations were generally less than 0.05 mg/L across the sand and gravel unit, as twenty-nine of the forty-four monitoring points had values less than the LLD during 1991. The highest ammonia concentration of 24.3 mg/L was recorded in well 103. No other well exceeded 1.46 mg/L.

- Bicarbonate Alkalinity (Fig. 4-115)

Bicarbonate is the most abundant anion in groundwater from the surficial sand and gravel unit, ranging from non-detectable at well 103 to a maximum of 505 mg/L at well 207. The average concentration of bicarbonate in groundwater from the surficial sand and gravel during 1991 was 192 mg/L. Background well NB-1S had a mean bicarbonate concentration of 132 mg/L during 1991. Bicarbonate is not present at well 103, as bicarbonate is converted to carbonate at high pHs.

- Phenol (Fig. 4-116)

Mean phenol concentrations in 1991 ranged from 0.002 mg/L in wells 501 and B-86-5 to a maximum of 0.019 mg/L in well 201. Wells 104 and B-86-09 also showed high phenol concentrations of 0.014 mg/L and 0.016 mg/L, respectively. In general, phenol concentrations at the majority of the monitoring points were near or at the LLD.

- Calcium (Fig. 4-117)

The 1991 mean concentration of calcium ranged from a minimum of 26 mg/L in well 103 to a maximum of 220 mg/L in well 203 and averaged 108 mg/L across the sand and gravel. Background well NB-1S had a mean concentration of 70 mg/L.

- Magnesium (Fig. 4-118)

The 1991 mean concentration of magnesium ranged from 0.8 mg/L in well 103 to a maximum of 38 mg/L in well 205 and averaged 21 mg/L across the sand and gravel. Background well NB-1S had a mean concentration of 8.35 mg/L during 1991.

- Sodium (Fig. 4-119)

Sodium concentrations in the sand and gravel ranged from a minimum of 4 mg/L at well 706 to a maximum of 5080 mg/L at well 103. The average mean concentration across the sand and gravel was 170 mg/L. The concentration of sodium at 103 is two to three orders of magnitude greater than the other wells monitoring the sand and gravel and is most likely the result of the July 20, 1984 sodium hydroxide spill. If well 103 is removed from consideration, sodium ranges from 6 mg/L to 555 mg/L at well 205 and averages 58 mg/L. Background well NB-1S had a mean concentration of 38 mg/L.

The highest sodium concentrations, other than well 103, ranged from 154 mg/L to 555 mg/L and occur in the area defined by the utility building, the demineralizer sludge ponds, and the old warehouse. The source of the sodium in these wells appears to be the sodium chloride used to recharge the water softener at the utility building and the spent brine solutions that were discharged to the sludge ponds when the water softener had been recharged.

A second area of elevated sodium extends downgradient from well 103 and the process building into the lagoon 4 and 5 area. The sodium hydroxide spill and the process building may be probable sources of the sodium in this area.

Sodium concentrations are lowest on the margins of the north plateau. These areas are typically removed from routine plant operations and site maintenance such as road salting, and as such do not show elevated sodium levels.

- Potassium (Fig. 4-120)

The 1991 mean concentration of potassium ranged from 0.90 mg/L in B-86-12 to 10 mg/L in wells B-86-5 and 205 and averaged 3.64 mg/L across the sand and gravel unit. Background well NB-1S had an average of 2.85 mg/L of potassium. The highest potassium concentrations are

found near the demineralizer sludge ponds and the new warehouse in wells R86-13 A, B, and C. Potassium levels are lowest in the northeastern margin of the sand and gravel unit.

- Iron (Fig. 4-121)

Mean total iron concentrations ranged from <0.005 mg/L in well B-86-3 to 155 mg/L in well 205 and averaged 16.17 mg/L across the sand and gravel unit. Dissolved iron concentrations are one to two orders of magnitude lower, ranging from <0.03 mg/L to 5.6 mg/L. Samples collected for total iron are unfiltered, and the sediment contained in the water sample when analyzed results in a high total iron concentration.

- Manganese (Fig. 4-122)

The 1991 mean concentration of manganese ranged from <0.01 mg/L at WNGSEEP to 19.5 mg/L at well 604 and averaged 2.15 mg/L across the sand and gravel unit. High manganese concentrations occur immediately north of the demineralizer sludge ponds and immediately downgradient of the high-level radioactive waste storage tanks.

Weathered Lavery Till

- pH (Fig. 4-123)

The 1991 mean pH of groundwater in the weathered Lavery till ranged from 6.49 in well 1107A to 7.43 in the background well 1008C. In general, groundwater in the weathered Lavery till was neutral to slightly alkaline with a mean pH of 7.04 during 1991. Upgradient wells 1008C and 1005 are the most alkaline, while wells 908, 1006, and 1007, which are cross- and downgradient of the drum cell, are slightly acidic.

- Specific Conductance (Fig. 4-124)

The 1991 mean specific conductance ranged from a minimum of 513 μmhos/cm @ 25°C in background well 1008C to a maximum of 2715 μmhos/cm @ 25°C in well 908. The mean specific conductance of the weathered Lavery till during 1991 was 1142 μmhos/cm @ 25°C. Wells 908, 1006, 1007, and 1108A, which are crossgradient and downgradient from the drum cell, show the highest specific conductance in the weathered Lavery till. This probably can be attributed to the high concentrations of sulfate, calcium, and magnesium in these wells as described below.

- Total Organic Carbon (Fig. 4-125)

The mean total organic carbon (TOC) concentration for 1991 ranged from a minimum of 1.83 mg/L in well 1106A to a maximum of 19.3 mg/L in well 1107A. The background well 1008C had a TOC concentration of 6.08 mg/L.

- Total Organic Halogens (Fig. 4-126)

The mean 1991 total organic halogens (TOX) concentration ranged from <0.005 mg/L in well 1006 to 0.068 mg/L in well 1107A. TOX concentrations were near the LLD of 0.005 mg/L in most of the wells during 1991, although higher concentrations were observed in wells 906 and 1007.

- Chloride (Fig. 4-127)

The 1991 mean chloride concentration in the weathered Lavery till ranged from a minimum of 1.7 mg/L in well 1109A to a maximum of 31 mg/L in background well 1008C. The mean average chloride concentration across the weathered Lavery till was 5.92 mg/L during 1991. The elevated chloride in background well 1008C is difficult to explain, given its distance from any

roadways. The chloride in well 1008C may originate from road salt spread on Rock Springs Road by the Town of Ashford Highway Department during the winter months that migrated downgradient to the well.

- Sulfate (Fig. 4-128)

Sulfate concentrations in the weathered Lavery till ranged from a minimum of 9 mg/L in background well 1008C to a maximum of 1000 mg/L in well 908. The mean average sulfate concentration was 305 mg/L during 1991. Sulfate concentrations increase abruptly by one to two orders of magnitude downgradient of 1008C. The highest sulfate concentrations occur in an east-west zone immediately north of the drum cell, in wells 908, 1006, 1007, and 1108A. Sulfate concentrations are lower downgradient of the drum cell, ranging from 37 mg/L to 420 mg/L in the NDA and SDA. The source of the sulfate is presently unknown but may be the result of naturally occurring gypsum or pyrite in the Lavery till.

- Nitrate (Fig. 4-129)

Mean nitrate concentrations ranged from less than 0.10 mg/L in six wells to a maximum of 1.0 mg/L in well 906 in 1991. In general, mean nitrate concentrations were less than 0.20 mg/L in thirteen of the sixteen wells monitoring the weathered Lavery till.

- Ammonia (Fig. 4-130)

Mean ammonia concentrations ranged from less than 0.05 mg/L in eight of the sixteen wells to a maximum of 0.35 mg/L in well 1107A.

- Bicarbonate Alkalinity (Fig. 4-131)

The 1991 mean bicarbonate alkalinity concentration ranged from a minimum of 205 mg/L in well 1109A to a maximum of 520 mg/L in well 1107A. The mean concentration in background well 1008C was 220 mg/L. The 1991 mean average bicarbonate alkalinity in the weathered Lavery till was 318 mg/L.

- Phenol (Fig. 4-132)

The 1991 mean phenol concentration ranged from less than 0.005 mg/L in wells 1008C, 1005, and 1110A to a maximum of 0.030 mg/L in 1108A.

- Calcium (Fig. 4-133)

The 1991 mean calcium concentration ranged from a minimum of 74 mg/L in the background well 1008C to a maximum of 440 mg/L in well 908. The average mean concentration across the weathered Lavery till was 150 mg/L. Calcium concentrations increase downgradient of well 1008C. The highest calcium concentrations are found in an east-west zone immediately north of the drum cell in wells 908, 1006, 1007, and 1108A, ranging from 170 mg/L to 440 mg/L.

- Magnesium (Fig. 4-134)

The 1991 mean concentration of magnesium ranged from a minimum of 9.4 mg/L in the background well 1008C to a maximum of 150 mg/L in well 908. The average mean concentration across the weathered Lavery till was 55 mg/L. The highest magnesium concentrations, ranging from 62 mg/L to 150 mg/L, were observed in wells 908, 1006, 1007, and 1108A, immediately north of the drum cell. Naturally occurring dolomite and chlorite may be the source of magnesium in groundwater in the weathered Lavery till.

- Sodium (Fig. 4-135)

The 1991 mean sodium concentration ranged from a minimum of 8.9 mg/L in well 907 to a maximum of 28 mg/L in well 1110A. Background well 1008C had a mean concentration of 13 mg/L in 1991.

- Potassium (Fig. 4-136)

The 1991 mean concentration of potassium ranged from an minimum of 1.3 mg/L in background well 1008C to a maximum of 8.7 mg/L in well 1007. The highest concentrations were found in wells 908, 1006, 1007, and 1108A, immediately north of the drum cell.

- Iron (Fig. 4-137)

The 1991 mean total iron concentration ranged from 0.05 mg/L in well 1101A to 12.20 mg/L in well 1007. The average mean for total iron across the weathered Lavery till was 1.98 mg/L in 1991. Total iron concentrations in the weathered Lavery till were generally one order of magnitude higher than dissolved iron concentrations.

- Manganese (Fig. 4-138)

The 1991 mean manganese concentration ranged from 0.02 mg/L in well 907 to 7.40 mg/L in well 1107A at the northern end of the NDA.

Unweathered Lavery Till

- pH (Fig. 4-139)

The mean pH of groundwater in the unweathered Lavery till ranged from a minimum of 6.34 in well 704 to a maximum of 7.79 in well 409 during 1991. The pH of the upgradient well 1008C

averaged 7.43 in 1991. Overall, the groundwater in the unweathered Lavery till is slightly alkaline, with an average pH of 7.24.

- Specific Conductance (Fig. 4-140)

The 1991 mean specific conductance ranged from a minimum of 381 μmhos/cm @ 25°C in well 409 to a maximum of 1036 μmhos/cm @ 25°C in well 702 and averaged 732 μmhos/cm @ 25°C across the unweathered Lavery till. The specific conductance at background well 1008C was 513 μmhos/cm @ 25°C.

- Total Organic Carbon (Fig. 4-141)

The 1991 mean concentration of TOC ranged from a minimum of 1.19 mg/L in well 1111A to a maximum of 40.03 mg/L in well 704 and averaged 7.32 mg/L across the unweathered Lavery till. The mean TOC concentration in well 1008C was 6.08 mg/L during 1991. The TOC does not vary significantly from the background concentration established at well 1008C. Two wells near the chemical process cell hardstand (CPC), wells 704 and 705, show elevated TOC concentrations of 40.03 mg/L and 10.89 mg/L, respectively.

- Total Organic Halogen (Fig. 4-142)

The 1991 mean concentrations of TOX ranged from less than 0.005 mg/L in four wells to a maximum of 0.123 mg/L in well 703. Background well 1008C had a mean concentration of 0.007 mg/L. The highest TOX concentrations were recorded in wells surrounding the chemical process cell hardstand in the northwestern portion of the north plateau.

- Chloride (Fig. 4-143)

The 1991 mean concentration of chloride ranged from nondetectable in well 1102B to a maximum of 31 mg/L in background well 1008C and averaged 6.0 mg/L across the unweathered Lavery

till. Chloride concentrations in the unweathered Lavery till in the north plateau of the WVDP are much lower than those observed in the overlying sand and gravel unit, suggesting that plant operations have not adversely affected this unit.

- Sulfate (Fig. 4-144)

The concentration of sulfate ranges from 8.5 mg/L in background well 1008C to a maximum of 360 mg/L in well 702 and averages 172 mg/L across the unweathered Lavery till. Sulfate concentrations are considerably higher downgradient of well 1008C, as high levels of sulfate are present near the chemical process cell hardstand, lagoon 3, and the SDA. The source of the sulfate in these wells is presently unknown, but could be naturally occurring gypsum ($CaSO_4$ $2H_2O$), which undergoes dissociation reactions forming calcium and sulfate ions, or perhaps pyrite (FeS_2).

- Nitrate (Fig. 4-145)

The 1991 mean concentration of nitrate ranged from nondetectable in wells 1008C, 1106B, and 703 to 2.20 mg/L in well 405. In general, nitrate concentrations were below 0.50 mg/L in the majority of wells monitoring the unweathered Lavery till.

The highest nitrate concentrations occurred in wells surrounding the chemical process cell hardstand in the northwestern portion of the north plateau.

- Ammonia (Fig. 4-146)

Mean ammonia concentrations in the unweathered Lavery till ranged from less than 0.05 mg/L to a maximum of 0.34 mg/L in well 704 during 1991. Only wells 704, 1106B, and 1109B had mean ammonia concentrations greater than 0.10 mg/L during 1991.

- Bicarbonate Alkalinity (Fig. 4-147)

  Bicarbonate alkalinity ranged from 125 mg/L in well 409 to a maximum of 405 mg/L in well 1111A and averaged 238 mg/L across the unweathered Lavery till. Background well 1008C had a concentration of 220 mg/L.

- Phenol (Fig. 4-148)

  Mean phenol concentrations ranged from less than 0.005 mg/L in six wells to a maximum of 0.022 mg/L in well 1103B.

- Calcium (Fig. 4-149)

  The 1991 mean concentration of calcium ranges from 45 mg/L at well 409 to a maximum of 165 mg/L at well 704 and averages 98 mg/L across the unweathered Lavery till. The 1991 mean concentration in background well 1008C was 74 mg/L.

- Magnesium (Fig. 4-150)

  The 1991 mean concentration of magnesium ranged from 9.0 mg/L in background well 1008C to a maximum of 60 mg/L in well 1111A and averaged 26.6 mg/L across the unweathered Lavery till. The source of the magnesium is most likely dolomite and chlorite in the unweathered Lavery till.

- Sodium (Fig. 4-151)

  The 1991 mean concentration of sodium ranged from 3.0 mg/L in well 705 to a maximum of 42.0 mg/L in well 405 and averaged 20 mg/L across the unweathered Lavery till. The background concentration of sodium in well 1008C was 13.0 mg/L during 1991.

- Potassium (Fig. 4-152)

  Mean potassium concentrations ranged from 1.30 mg/L in background well 1008C to 6.30 mg/L in well 707. The highest potassium concentrations were measured in the area of the chemical process cell hardstand in the northwestern portion of the north plateau.

- Iron (Fig. 4-153)

  The 1991 mean total iron concentration ranged from less than 0.03 mg/L in wells 1105A and 1104B to a maximum of 55.0 mg/L in well 115. Background well 1008C had a concentration of 0.45 mg/L. Total iron concentrations were generally one to two orders of magnitude higher than dissolved iron concentrations due to the unfiltered sediment present in the total iron samples.

- Manganese (Fig. 4-154)

  Mean manganese concentrations ranged from 0.03 mg/L in well 1103B to 7.60 mg/L in well 704. Background well 1008C had a concentration of 0.19 mg/L. The highest manganese concentrations were detected in wells associated with the chemical process cell hardstand in the northwestern portion of the north plateau.

Till-Sand Unit

- pH (Fig. 4-155)

  The 1991 mean pH in the till-sand ranged from 6.69 in well 905 to a maximum of 12.01 in well 202. The average mean pH across the till-sand was 8.12. Background well 701 had a pH of 7.41. Well 202 had a consistently high pH of 11 to 12 throughout 1991. The source of the elevated pH at 202 is presently unknown. The July 20, 1984 sodium hydroxide spill is being ruled out at this time because it is crossgradient to well 202 and well 204, which has a low pH and is between the spill and well 202.

- Specific Conductance (Fig. 4-156)

The 1991 mean specific conductance ranged from a minimum of 249 μmhos/cm @ 25°C in well 404 to a maximum of 1786 μmhos/cm @ 25°C in well 202 and averaged 938 μmhos/cm @ 25°C across the till-sand. Background well 701 had a specific conductance of 905 μmhos/cm @ 25°C.

- Total Organic Carbon (Fig. 4-157)

Mean TOC concentrations ranged from 1.75 mg/L in well 208 to 34.88 mg/L in well 905 and averaged 7.13 mg/L across the till-sand in 1991.

- Total Organic Halogen (Fig. 4-158)

The 1991 mean TOX concentrations in the till-sand ranged from 0.006 mg/L in well 208 to 0.017 in well 206 and averaged 0.012 mg/L in 1991.

- Chloride (Fig. 4-159)

The 1991 mean concentration of chloride ranged from 1.5 mg/L in well 208 to a maximum of 325 mg/L in well 302 and averaged 96 mg/L across the till-sand. Background well 701 had a chloride concentration of 2.2 mg/L. Chloride concentrations increase downgradient of well 701, with the highest chloride concentrations, ranging from 220 to 325 mg/L, in wells 402 and 302 immediately west of the plant. Wells 204 and 206 at the demineralizer sludge ponds also show high chloride concentrations that may originate from the spent brine solutions in the demineralizer sludge ponds.

- Sulfate (Fig. 4-160)

Mean sulfate concentrations ranged from 14 mg/L in well 208 to a maximum of 365 mg/L in well 905 and averaged 83 mg/L across the till-sand. Background well 701 had a sulfate concentration of 200 mg/L.

- Nitrate (Fig. 4-161)

Mean 1991 nitrate concentrations in the till-sand ranged from less than 0.05 mg/L in five wells to a maximum of 1.20 mg/L in well 302 and averaged 0.21 mg/L across the till-sand.

- Ammonia (Fig. 4-162)

Mean 1991 ammonia concentrations ranged from less than 0.05 mg/L in three till-sand wells to a maximum of 0.85 mg/L in well 202.

- Bicarbonate Alkalinity (Fig. 4-163)

Bicarbonate alkalinity in the till-sand ranged from less than 1 mg/L in well 202 to a maximum of 420 mg/L in well 905 and averaged 194 mg/L. Bicarbonate alkalinity in background well 701 was 305 mg/L. Bicarbonate alkalinity in well 202 is less than 1.0 mg/L, similar to that observed in sand and gravel well 103, which also had a mean pH of 12.0. The nondetectable levels of bicarbonate in well 202 result from bicarbonate being converted to carbonate at high pHs.

- Phenol (Fig. 4-164)

Mean phenol concentrations ranged from less than 0.005 mg/L in three till-sand wells to a maximum of 0.009 mg/L in well 404.

- Calcium (Fig. 4-165)

  The 1991 mean calcium concentration ranged from 34 mg/L in well 404 to a maximum of 223 mg/L in well 905 and averaged 108 mg/L across the till-sand. Background well 701 had 140 mg/L of calcium.

- Magnesium (Fig. 4-166)

  The 1991 mean concentration of magnesium in the till-sand ranged from 0.4 mg/L in well 202 to a maximum of 78 mg/L in well 905 and averaged 22 mg/L. Background well 701 had a mean concentration of 25 mg/L.

- Sodium (Fig. 4-167)

  The 1991 mean concentration of sodium in the till-sand ranged from 8.2 mg/L in well 404 to a maximum of 87 mg/L in well 302 and averaged 26 mg/L across the till-sand.

- Potassium (Fig. 4-168)

  The 1991 mean concentration of potassium ranged from 1.1 mg/L in well 208 to a maximum of 35 mg/L in well 202 and averaged 5.83 mg/L across the till-sand.

- Iron (Fig. 4-169)

  The 1991 mean concentration of total iron ranged from 0.24 mg/L in well 202 to a maximum of 4.60 mg/L in background well 701.

- Manganese (Fig. 4-170)

The 1991 mean concentration of manganese ranged from less than 0.01 mg/L in well 202 to a maximum of 0.68 mg/L in well 905. The background well 701 had a mean manganese concentration of 0.43 mg/L.

Kent Recessional Unit

- pH (Fig. 4-171)

The 1991 mean pH of groundwater from the Kent recessional unit ranged from 7.19 in well 1002 to a maximum of 8.38 in wells 902 and 903 and averaged 7.74 across the unit in the south plateau. The 1991 mean pH for the background well 1008B was 7.51.

- Specific Conductance (Fig. 4-172)

The 1991 mean specific conductance ranged from 338 μmhos/cm @ 25°C at the designated background well 1008B to a maximum of 906 μmhos/cm @ 25°C at B-86-11 and averaged 545 μmhos/cm @ 25°C across the Kent recessional unit. The specific conductance of the unit increases downgradient of background well 1008B.

- Total Organic Carbon (Fig. 4-173)

The 1991 mean TOC concentration ranged from 2.22 mg/L in well 1101C to a maximum of 13.88 mg/L in well 903 and averaged 4.96 mg/L across the Kent recessional. The TOC concentration in background well 1008B was 3.05 mg/L.

- Total Organic Halogen (Fig. 4-174)

Mean 1991 TOX concentrations ranged from 0.006 mg/L in well 1004 to a maximum of 0.021 mg/L in well 903. Background well 1008B had an annual mean concentration of 0.010 mg/L.

- Chloride (Fig. 4-175)

The mean 1991 concentration of chloride ranged from 1.0 mg/L in well 1002 to a maximum of 43 mg/L in background well 1008B and averaged 12.2 mg/L across the unit. The highest chloride concentrations, ranging from 12 to 43 mg/L, occurred upgradient of the NDA, SDA, and the drum cell. Chloride concentrations ranged from 1.0 to 13 mg/L in wells downgradient of the NDA and drum cell.

- Sulfate (Fig. 4-176)

The mean annual concentration of sulfate ranged from nondetectable in well 902 to a maximum of 240 mg/L in well B-86-11 and averaged 71 mg/L across the Kent recessional unit. The sulfate concentration in the background well 1008B was 3 mg/L during 1991. Sulfate concentrations were greatest immediately downgradient of the NDA, ranging from 115 to 240 mg/L, and were lowest immediately upgradient of the waste management areas, ranging from nondetectable to 5 mg/L.

- Nitrate (Fig. 4-177)

Mean 1991 nitrate concentrations ranged from less than 0.05 mg/L in B-86-10 to a maximum of 1.68 mg/L in well 903. Nitrate concentrations were less than the LLD in eight of the eleven wells sampled for chemical parameters.

- Ammonia (Fig. 4-178)

The 1991 mean concentration of ammonia ranged from nondetectable in well B-86-11 to a maximum of 0.71 mg/L in well 1002 and averaged 0.42 mg/L across the unit.

- Bicarbonate Alkalinity (Fig. 4-179)

The 1991 mean bicarbonate alkalinity ranged from 114 mg/L in background well 1008B to a maximum of 355 mg/L in well 1002 and averaged 216 mg/L across the Kent recessional. Bicarbonate concentrations were lower, ranging from 114 mg/L to 190 mg/L immediately upgradient of the waste management areas.

- Phenol (Fig. 4-180)

Mean 1991 phenol concentrations ranged from less than 0.005 mg/L in three wells monitoring the Kent recessional to a maximum of 0.009 mg/L in wells 901 and 1003.

- Calcium (Fig. 4-181)

The mean concentration of calcium ranged from 31 mg/L in well 1001 to a maximum of 143 mg/L in well 903 and averaged 62 mg/L across the KR. The 1991 mean calcium concentration in the background well 1008B was 36 mg/L. The concentration of calcium in the Kent recessional unit groundwater increased downgradient of the background monitoring well 1008B.

- Magnesium (Fig. 4-182)

The 1991 mean concentration of magnesium ranged from 8.2 mg/L in background well 1008B to a maximum of 70 mg/L in well 903 and averaged 24 mg/L across the unit. The concentration of magnesium increased downgradient of the background monitoring well in a north-northeasterly direction, towards well 903 and Erdman Brook.

- Sodium (Fig. 4-183)

The mean concentration of sodium in 1991 ranged from 26 mg/L in well 1101C to a maximum of 66 mg/L in well B-86-10 and averaged 38 mg/L across the Kent recessional. The mean concentration of sodium in background well 1008B was 34 mg/L in 1991. The highest sodium concentrations, of 65 mg/L and 66 mg/L, occur in wells B-86-10 and B-86-11 at the northeast margin of the NDA.

- Potassium (Fig. 4-184)

The 1991 mean concentration of potassium ranged from 2.5 mg/L in well 1002 to a maximum of 14 mg/L in well 903 and averaged 5.4 mg/L across the unit. Background well 1008B had a concentration of 4.70 mg/L.

- Iron (Fig. 4-185)

Mean 1991 total iron concentrations ranged from 1.40 mg/L in background well 1008B to a maximum of 134 mg/L in well 903. Total iron concentrations were one to two orders of magnitude higher than dissolved iron concentrations, as total iron samples are unfiltered.

- Manganese (Fig. 4-186)

Mean 1991 manganese concentrations ranged from 0.09 mg/L in well B-86-11 to a maximum of 2.13 mg/L in well 903. Background well 1008B had a concentration of 0.26 mg/L.

5.0 Water Quality Determinations Based on Monitoring to Date

5.1 Surface Waters

Pre-operational and operational sampling indicates that NFS nuclear fuel processing operations increased levels of manmade radionuclides in surface waters downstream of the NFS site shortly after fuel processing operations began in April 1966.

NFS and NYSDOH sampled surface waters in 1963 and 1965, respectively, to establish pre-operational baseline concentrations of various radiological parameters. The NFS pre-operational sampling for gross alpha, gross beta, and Sr-90 was limited to upstream and downstream locations on Cattaraugus Creek and Erdman Brook. NFS determined pre-operational concentrations of 8.0 E-09 μCi/mL for gross alpha, 1.0 E-08 μCi/mL for gross beta, and 6.0 E-10 μCi/mL for Sr-90. (See Table 3-8.) NYSDOH sampled only for Sr-90 in 1965, but sampled Buttermilk Creek upstream and downstream of the plant and Cattaraugus Creek upstream of its confluence of Buttermilk Creek and downstream to Irving Bridge, where Cattaraugus Creek empties into Lake Erie. NYSDOH determined a Sr-90 background concentration of less than 3.0 E-09 μCi/mL at all of the NYSDOH sampling sites.

Although NYSDOH did not sample for gross beta, tritium, or Cs-137 before start-up of operations, background values for these parameters can be obtained from the upstream sampling location at Fox Valley Road on Buttermilk Creek and Bigelow Bridge on Cattaraugus Creek. (See Table 3-2.) NYSDOH determined background gross beta concentrations of 2.0 to 6.0 E-09 μCi/mL from the upstream sampling locations and background tritium concentrations ranging from 1.57 E-06 μCi/mL to 2.28 E-06 μCi/mL. Background Cs-137 concentrations were less than 2.0 E-08 μCi/mL.

Beta-emitting radionuclides released from lagoon 3 from 1967 through 1971 were detected downstream of NFS. Gross beta concentrations increased by two orders of magnitude between 1966 and 1967 at the Thomas Corners Bridge sampling location. Ten- to fiftyfold increases in gross beta activity were observed along Cattaraugus Creek downstream of the Buttermilk Creek confluence all the way to Irving Bridge near Lake Erie. Gross beta activity was two orders of magnitude above background at Irving

Bridge by 1969. The majority of the gross beta activity is attributable to Sr-90 and Cs-137, which showed similar increases during this time. Gross beta concentrations reached a maximum in 1971 at nearly all of the sampling locations. Gross beta concentrations generally began to decline in 1971 and 1972. The decline is attributed to the operation of the low-level wastewater treatment facility, which removed Sr-90 and Cs-137 from the waste stream, and to the termination of nuclear fuel reprocessing operations. (The LLWTF, which went into operation in 1971, was constructed to remove Sr-90 and Cs-137 from the wastewater generated by the NFS plant processes. The LLWTF consisted of the lagoon system, a flocculator-clarifier, an anthracite bed, and a anion-cation exchange system. Wastewater was pumped from lagoon 2 to the LLWTF to the flocculator-clarifier, which used ferrous sulfate and clay to remove suspended material. The clarified water was then passed through a 2-foot deep bed of anthracite coal to remove particulates remaining from the clarifier. The waste stream was then passed to an anion-cation exchange system where any remaining radioactive material was exchanged.)

Average tritium concentrations at Thomas Corners Bridge were two orders of magnitude higher than background levels by 1967. Increased tritium was also observed along Cattaraugus Creek downstream of the Buttermilk Creek confluence at Springville Dam, Gowanda, and Irving Bridge. Tritium concentrations at Thomas Corners Bridge were approximately ten times higher than at Springville Dam. Tritium concentrations at all downstream sampling locations dropped by several orders of magnitude in 1972 as nuclear fuel reprocessing operations by NFS ceased in March 1972. Tritium levels between Thomas Corners Bridge and Irving Bridge at Lake Erie did not differ significantly, indicating that tritium was transported quite readily.

Tritium levels increased sharply in 1975 and reached another high (although less than levels observed in 1971) at all sampling locations in 1976. This increase is attributed to the SDA burial trench pump-out operations that were conducted in 1975 and 1976. (Water had been observed seeping from SDA burial trenches 4 and 5 in March 1975. Approximately 2,137,300 gallons of trench water containing 6,254 curies of tritium was pumped to the SDA waste burial lagoon and later transferred to the low-level wastewater treatment facility (LLWTF) for treatment and release to Erdman Brook via lagoon 3

[Smokowski 1977]. A total of 3,584 curies of tritium was released from lagoon 3 to Erdman Brook after the trench water was treated. The remaining 2,670 curies of tritium may have been transferred to the surficial sand and gravel unit via leakage from lagoons 1,2, and 3.)

Tritium concentrations increased up to two orders of magnitude at all of the sampling stations from 1980 to 1981. This increase is attributed to a second SDA trench pump-out campaign that was conducted between November 5, 1980 and April 4, 1981. Approximately 800,000 gallons of trench water were pumped to the LLWTF during this pumping campaign. Average radionuclide concentrations in this water were: tritium—1.14 μCi/mL; gross beta—1.82 E-03 μCi/mL; gross alpha—3.53 E-06 μCi/mL; and Sr-90—1.38 E-04 μCi/mL (Wiedemann 1981).

Similar increases in gross beta, Sr-90, and Cs-137 were not observed since the burial trench waters were processed through the low-level waste treatment facility (LLWTF), which removed the majority of these before release from lagoon 3 to Erdman Brook. Gross beta and tritium activity along Buttermilk Creek and Cattaraugus Creek reached background levels by 1986 and have remained at background levels to the present. Above-background levels of gross beta generally in the range of (E-08 μCi/mL) are still being observed along Frank's Creek where it leaves the WVDP.

5.2 Groundwater

NFS and WVDP operations have affected on-site groundwater quality in both the north and south plateau areas of the WVDP. Groundwater in the surficial sand and gravel unit in the north plateau and the weathered and unweathered Lavery till in the south plateau have been most affected by plant processes and waste disposal operations that were conducted in each of these areas.

Surficial Sand and Gravel Unit

The surficial sand and gravel unit has been most affected by releases of beta-emitting radionuclides and tritium. Gross beta and tritium contamination was documented in the sand and gravel unit as early as 1974 when NFS observed above-background concentrations of tritium in the french drain outfall. Gross

beta activity of 3.0 E-06 μCi/mL and tritium activity upwards of 1.0 E-04 μCi/mL were detected near lagoons 4 and 5 in 1974. Lagoons 4 and 5 were considered to be the source of the gross beta and tritium, and NFS relined lagoons 4 and 5 with impermeable synthetic membrane liners to stop further releases of radiological material from these units. Above-background levels of gross beta and tritium continued to be detected through 1982 in the lagoon area and french drain outfall. Lagoon 1, which was excavated into the sand and gravel, was ultimately determined to be the source of radionuclides in groundwater in this area. Lagoon 1 was closed, its sludge removed, and it was filled with material from the old hardstand in 1984.

Mean annual gross beta activity in the sand and gravel during 1991 ranged from background concentrations of 3.43 E-09 μCi/mL to a maximum of 1.5 E-04 μCi/mL. Mean annual tritium activity in 1991 ranged from < 1.0 E-07 μCi/mL to a maximum of 1.65 E-05 μCi/mL. Above-background levels of both gross beta and tritium activity are present near former lagoon 1, in a larger zone that extends northeastward from the plant to a point north of lagoons 4 and 5, and in the french drain outfall. Above-background levels of gross beta, 1.34 E-07 μCi/mL to 1.48 E-07 μCi/mL, are present north of the lag storage buildings.

The gross beta and tritium activity in the former lagoon 1 area is probably the result of radionuclides remaining from the closing of lagoon 1 or from the old hardstand material that was used to fill lagoon 1. Gross beta and tritium activity in the northeast-trending zone are highest near the process building in well 408 and progressively decrease to the northwest away from the process building. Groundwater in wells upgradient of the plant have background levels of gross beta and tritium. The process building may be the source of the gross beta and tritium in this zone. Groundwater in the area of lagoon 1 and portions of the northeast-trending zone near lagoons 4 and 5 most likely contribute to the gross beta and tritium activity at the french drain outfall.

Groundwater in the surficial sand and gravel is either moderately acidic or alkaline depending on location. Groundwater with a pH greater than 7.00 occurs in a northeast-trending elliptical zone extending from the process building towards well 105 north of lagoon 5. The maximum width of this alkaline zone is approximately 170 meters, constrained by the distance between wells 103 and 406. Groundwater in this

zone at wells 86-3 and 86-4 has been alkaline since 1986. Groundwater outside this alkaline elliptical zone is slightly acidic, with pH ranging from 6.17 to 6.94. Wells 80-5, 80-6, 86-5, 86-6, 86-7, and 86-8, located outside the alkaline zone, have been slightly acidic since 1986.

The average yearly pH of precipitation around the WVDP has ranged from 3.85 to 4.75 since 1986 (Table 5-1). The WVDP has measured the pH of precipitation collected in open precipitation fallout collectors on a monthly basis since February 1986. The acidity is attributed to dissolved CO_2 and SO_2, forming dilute carbonic acid (H_2CO_3) and sulfuric acid (H_2SO_4). The CO_2 is both naturally occurring in the atmosphere and artificially produced by hydrocarbon combustion. The SO_2 originates from the combustion of hydrocarbons at coal- or petroleum-fired power plants. (A large coal-burning power plant is located in Dunkirk, New York, approximately 58 kilometers [36 mi] west of the WVDP. Although the predominant wind direction at the WVDP is from the southwest, westerly winds are common and these westerly winds may carry SO_2 emissions from the Dunkirk power plant to the WVDP.)

Acidic precipitation at the WVDP is buffered to a more alkaline condition as it migrates through the sand and gravel unit, most likely by the dissolution of calcite in this unit, which may explain the moderately acidic pH along the margin of the sand and gravel. The northeast-trending alkaline zone, and in particular the consistent pH of 12 at well 103, are most likely the result of the release of several thousand gallons of sodium hydroxide from a transfer line near the maintenance shop and low-level waste treatment facility on July 20, 1984. The process building may be an additional source of alkaline water that is contributing to the northeast-trending zone of alkaline water in the surficial sand and gravel unit.

Routine plant operations that use sodium chloride and calcium chloride have caused chloride concentrations in the sand and gravel unit to increase since 1986. Chloride concentrations range from 145 mg/L to 1090 mg/L in the triangular area defined by wells 305, 86-6, and 201, which are next to the plant's utility room, the demineralizer sludge ponds, and the main warehouse next to the railroad tracks, respectively. Plant operations associated with each of the above units may be responsible for the elevated chloride in this area. NFS and WVDP both used sodium chloride in the utility room as a water

conditioner for the water softener system. The salt used in the water softener was formerly stored in bags in the warehouse. The demineralizer sludge ponds received spent sulfuric acid and brine solutions used to regenerate the water treatment plants cation and anion exchange systems.

Elevated chloride also occurs in a northeast-trending zone extending from well 0408 near the plant towards well 86-3. The source of the chloride in this area may be the main plant, as NFS used sodium chloride (tradename Met-L-hex) in its spent-fuel processing operations. Road salting activities may also have contributed to the chloride in this area. The WVDP uses a "highway mix," which is a sand and sodium chloride or calcium chloride mixture, for its road-salting activities. Highway mix containing calcium chloride and sodium chloride was at one time stored outside, approximately 46 meters (150 ft) northeast of the maintenance shop, under the northwest corner of the present day melter disassembly building.

Elevated sulfate occurs near the demineralizer sludge ponds and the area immediately north of the tank farm. The 0.4M sulfuric acid used to regenerate the cation exchange system is the most likely source of the sulfate in the sludge pond area.

Weathered Lavery Till

Plant operations have affected overall groundwater quality in the weathered Lavery till, but not to the extent observed in the surficial sand and gravel unit. Gross beta activity is generally near background levels of 3.0 E-09 μCi/mL to 7.0 E-09 μCi/mL in the majority of the weathered Lavery till. However, a zone of elevated gross beta activity, ranging from 7.7 E-09 μCi/mL to 1.49 E-08 μCi/mL, is present north of the drum cell in wells 908, 1006, 1007, and 1108A.

Tritium activity is generally near background levels: nine of the sixteen wells monitoring the weathered Lavery till showed a mean tritium below the LLD. Well 1107A, which is located at the northwestern end of the SDA, had a consistently high tritium activity of approximately 2.5 E-05 μCi/mL throughout 1991. The source of the elevated tritium in 1107A may be the nearby burial trenches in the SDA. Well

1107A is located near SDA burial trenches 4 and 5, which have flooded on several occasions since 1975. Tritium levels of E-05 μCi/mL were measured during these trench floods at the NYSDOH burial drainage sampling location (076), which is located approximately 20 meters northwest of 1107A.

The pH of the weathered Lavery till was on average more alkaline than the surficial sand and gravel unit. Wells 908, 1008, 1007, and 1108A, which are situated in a west-east trending array immediately north of the drum cell, have a specific conductance that is two to four times greater than that observed in other wells screened in the unweathered Lavery till. The high specific conductance observed in wells 908, 1008, 1007, and 1108A is directly attributable to the high concentrations of dissolved sulfate, calcium, and magnesium in these wells.

Chloride concentrations in the weathered Lavery till are generally low, ranging from 1.7 mg/L to 31 mg/L, which are much lower than those observed in the surficial sand and gravel unit, where chloride concentrations ranged from 7.7 mg/L to 1090 mg/L. Iron concentrations in the weathered Lavery till ranged from 0.05 mg/L to 12.2 mg/L. The high iron content may result from the weathering of the mineral chlorite, an iron- and magnesium-rich clay mineral. Chlorite makes up an estimated 0% to 1% by weight of the weathered Lavery till, whereas chlorite in the unweathered Lavery till ranges from 3% to 12%. Weathering of chlorite may account for both the dissolved iron and magnesium in groundwater from the weathered Lavery till.

Unweathered Lavery Till

The groundwater quality of the unweathered Lavery till has not been as extensively affected by plant operations as has the surficial sand and gravel unit. Gross beta activity is generally near background levels across the unweathered Lavery till, ranging from 3.0 E-09 μCi/mL to 7.0 E-09 μCi/mL. The highest mean gross beta activity of 2.13 E-08 μCi/mL was measured in well 704 near the chemical process cell hardstand. Wells 1101B and 1104B near the SDA also showed higher gross beta activity of 9.19 E-09 μCi/mL.

Tritium activity in the unweathered Lavery till is generally at background levels, as most of the wells monitoring this unit show activity levels below or near the lower limit of detection for tritium (1.0 E-07 μCi/mL). Above-background levels of tritium are present in the area of the lagoons, ranging from 3.32 E-07 μCi/mL in well 114 to 1.12 E-06 μCi/mL in well 107. Releases of tritium from lagoons 2 and 3, which are excavated into the unweathered Lavery till, are the most likely source of the tritium in these wells.

Till-Sand

Groundwater quality in portions of the till-sand unit have been affected by plant processes, especially around wells 202, 302, and 905. Well 202 has above-background levels of gross beta, pH, and sodium. Gross beta activity is one order of magnitude higher than background levels in well 202, averaging 3.53 E-08 μCi/mL in 1991. The pH of groundwater in the till-sand is typically moderately alkaline, with the average pH ranging from 6.69 to 8.76, yet well 202 was very alkaline, averaging 12.01 during 1991. Adjacent well 201, which monitors the overlying surficial sand and gravel unit, has a pH of 6.33.

Tritium was consistently detected above the LLD in only one well, 905, in 1991. Elevated chloride occurs in wells 402 (220 mg/L) and 302 (325 mg/L). Chloride in the sludge pond area, ranging from 57 mg/L in well 206 to 98 mg/L in well 204, is not as high as in the sand and gravel unit. Brine solutions discharged to the sludge ponds may be the source of chloride. Low sulfate concentrations are present near the sludge ponds, ranging from 27 mg/L in 204 to 31 mg/L in 206. Elevated sulfate occurs in well 701 (200 mg/L) and 905 (365 mg/L). Calcium is elevated in wells 701 and 905 (140 and 223 mg/L). Magnesium is high in well 905 (78 mg/L). Sodium is high in well 302 and 202. Potassium concentrations are typically 1.1 to 4.1 mg/L, but 0202 has a concentration of 35 mg/L. Gross beta was consistently detected above background levels in well 202 at an activity of 3.53 E-08 μCi/mL and in well 905 at 7.42 E-09 μCi/mL. Tritium has been detected above LLD more than once in well 905.

Kent Recessional Unit

Groundwater quality in the Kent recessional unit is expected to be the least affected of all the water-bearing units on-site by plant operations because of its stratigraphic position.

Tritium was not detected during any 1991 sampling event in nine of the thirteen wells monitoring the Kent recessional and was detected above the LLD only once in the four remaining wells. Mean tritium concentrations in these four wells ranged from 1.18 E-07 μCi/mL to 1.44 E-07 μCi/mL.

Mean gross beta activity is near background levels in the majority of Kent recessional wells. However, gross beta activity in wells 1101C, 1104C, and 1103C at the SDA are well above background levels, ranging from 1.09 E-08 μCi/mL in 1101C to 8.81 E-08 μCi/mL in 1103C. It is unlikely that the gross beta activity represents releases from the beta-emitting radionuclides from the disposal areas, as tritium has not been detected in the Kent recessional unit and the groundwater velocity of 0.06 m/yr (Prudic 1986) through the overlying Lavery till would require travel times on the order of 500 years to reach the unit. The gross beta activity in 1001C, 1104C, and 1103C may be the result of abnormally high concentrations of K-40 or Rb-87 contained in the mineral orthoclase in this portion of the Kent recessional unit. Orthoclase may constitute upwards of 3% by weight of the Kent recessional. (See Table 2-1.)

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TABLE 2-1

MINERAL COMPOSITION OF SELECTED CORE SAMPLES FROM THE WESTERN NEW YORK NUCLEAR SERVICE CENTER[1]
[All values are in weight percent; from LaFleur (1979]

Test-hole identification symbol: depth interval;[2] and material

Minerals	F 22.4 - 22.9 Till	I3 7.5 - 7.9 Oxidized Till	J 52.7 - 53.2 Till	N 24.5 - 24.9 Till	C2 9.5 - 10.0 Oxidized Till	C2 42.5 - 43.0 Till	D 14.0 - 14.5 Till	D 29.8 - 30.3 Lacustrine	G 36.2 - 36.7 Laustrine	L 15.3 - 15.8 Lacustrine
quartz	24	24	24	22	26	22	27	32	23	33
potassium feldspar	1	<1	<1	1	2	1	1	3	0	3
plagio-clase feldspar	7	7	5	4	7	5	5	9	6	10
calcite	11	7	7	8	9	7	9	11	7	9
dolomite	5	3	5	5	7	5	5	9	5	11
chlorite	3	0	4	4	1	12	5	4	6	4
kaolinite	9	9	10	9	7	0	9	6	8	5
illite	24	27	27	21	28	26	30	16	19	15
montmor-illonite	0	<1	0	0	0	0	0	0	0	0
mixed-layer clay minerals	4	9	4	6	4	1	<1	4	7	5
Totals	88	86	86	80	91	79	91	94	81	95

[1] Totals between 90 and 105 percent are considered normal for this semiquantitative method. Low totals in some samples probably indicate a higher iron content; the fluorescent radiation produced by iron causes loss of peak intensity and therefore generally lower percentages (B. J. Anderson, written commun., 1978).

[2] Depths are in feet below land surface.

TABLE 3-1

NEW YORK STATE DEPARTMENT OF HEALTH (NYSDOH) 1963 ENVIRONMENTAL SAMPLING PROGRAM IN THE VICINITY OF THE WESTERN NEW YORK NUCLEAR SERVICE CENTER

PHASE I[1] (Pre-operational)		PHASE II[2] (Operational)	
SAMPLE	ANALYSES	SAMPLE	ANALYSES
Stream	Gross Alpha Gross Beta Gamma Scan** Tritium (one Station)	Stream	Gross Beta Gross Alpha Gamma Scan** Tritium
Fish	Gross Beta Gross Scan	Milk	Sr^{89}, Sr^{90} Gamma Scan (Incl. I-131) Tritium
Stream Bottom	Gross Beta Gamma Scan**	Air	Gross Beta Gamma Scan
Milk	Sr^{89}, Sr^{90} Gamma Scan**	Fish	Gross Beta Gamma Scan*
Air	Gross Beta Gamma Scan	Drinking Water	Gross Alpha Gross Beta Gamma Scan*
Drinking Water	Gross Beta Gross Alpha Gamma Scan**	Vegetation	Gross Alpha Gamma Scan
Vegetation	Gross Beta Gamma Scan**	Soil	Gamma Scan*
Soil	Gamma Scan**	Herbivores	Gamma Scan*
Fallout	Gross Beta Tritium (one Station)	Stream Bottom	Gross Beta Gamma Scan*
Groundwater	Gross Beta Gross Alpha Gamma Scan** Tritium	Fallout	Gross Beta Tritium
		Animal Thyroid Sample	I-131

[1] 400 samples - 1,000 analyses (Phase I)
[2] 1000 Samples - 2,500 analyses (Phase II)
** Quantitative and qualitative reporting on principal gamma emitters

TABLE 3-2

RADIOACTIVITY IN SURFACE WATER SAMPLES 1965 - 1967
(NYS DEPARTMENT OF HEALTH GENERAL SURVEILLANCE PROGRAM 1965 - 1967)

Concentration (pCi/L)

	1965		1966		1967			
Location	Sr-90	Gross Beta	Sr-90	Gross Beta	Sr-90	Cs-137	Gross Beta	Tritium
Buttermilk Creek, Upstream (004)								
Average	<3		<3	2	<3	<20	6	1,570
Maximum	<3		<3	3	<3	<20	13	2,900
Cattaraugus Creek, Upstream (007)								
Average	<3		<3	2.5	<3	<20	5	1,860
Maximum	<3		<3	3	8	50	10	4,500
Buttermilk Creek, Thomas Corners Bridge (035)								
Average	<3		<3[a]	5.8[a]	335	112	970	320,430
Maximum	<3		<3	15	1,305	506	4,668	1,452,000

TABLE 3-2
(continued)

Location	1965		1966		1967			
	Sr-90	Gross Beta	Sr-90	Gross Beta	Sr-90	Cs-137	Gross Beta	Tritium
Cattaraugus Creek, Springville Dam (042)								
Average	<3		62	116	24	<20	95	30,730
Maximum	<3		265	1,387	53	77	315	183,170
Cattaraugus Creek, Gowanda (060)								
Average	<3						52	21,510
Maximum							157	100,950
Cattaraugus Creek, Irving Bridge (065)								
Average	<3						51	24,710
Maximum	<3						112	82,670
Statewide								
Average	<3	11.7	<3	5.3	<3	<20	6	2,280
Maximum	9	30	5.6	34	<3	<20	103	7,200

(a) Samples not taken during period of discharge from Nuclear Fuel Services for latter half of 1966.

TABLE 3-3

PLUTONIUM AND URANIUM ISOTOPES IN SURFACE WATER 1966 - 1967
(NYS DEPARTMENT OF HEALTH GENERAL SURVEILLANCE PROGRAM 1965 - 1967)

Concentration in Water (pCi/L)

	1966					1967				
Location	Pu-238	Pu-239	U-234	U-235	U-238	Pu-238	Pu-239	U-234	U-235	U-238
Cattaraugus Creek, Upstream (Bigelow Bridge) (007)										
Average	<0.03	<0.02	0.19	<0.04	0.05					
Maximum	0.06	<0.03	<0.33	<0.15	0.12					
Cattaraugus Creek, Downstream Springville Dam (042)										
Average	0.03	<0.02	0.28	<0.05	0.20	<0.5	<0.4	0.15	0.07	0.12
Maximum	0.063	<0.02	0.44	<0.12	0.41	1.16	0.7	0.15	0.11	0.15

TABLE 3-4

RADIOACTIVITY IN SURFACE WATERS
(NEW YORK STATE AQUATIC ECOSYSTEM SURVEY 1965 - 1967)

Concentration in Water (pCi/L)

	1966				1967			
Location	Ru-Rh 106	Cs-137	Cs-134	Co-60	Ru-Rh 106	Cs-137	Cs-134	Co-60
Buttermilk Creek, Upstream (004)	0	5	2	0	40	3	0	1
Buttermilk Creek, Thomas Corners Bridge (035)	0	1	6	0	1000	100	10	10
Cattaraugus Creek, Springville Dam (042)	0	1	0	0	100	10	0	4

TABLE 3-5

RADIONUCLIDE CONCENTRATIONS IN CATTARAUGUS AND BUTTERMILK CREEKS, JUNE 1969
(U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE 1969)

Concentration in Water (pCi/L)

Location	Tritium	Gross α	Gross β	Ru-106	Cs-137	Cs-134	Sr-90	Sb-125	Co-60
Buttermilk Creek, Upstream (004)	1,000	<1	110	110	<1	<0.5	<1	<2	<0.3
Cattaraugus Creek, Upstream (007)	1,000	<1	200	160	<1	<0.5	<1	<2	<0.3
Confluence Frank's and Buttermilk Creeks	280,000	3	5,900	4,000	54	18	420	35	4.3
Buttermilk Creek at Bond Road Bridge	400,000	4	7,400	5,400	30	13	480	41	5.3
Buttermilk Creek at Thomas Corners Bridge (035)	370,000	4	6,800	4,700	16	5.2	480	41	4.9
Confluence of Buttermilk and Cattaraugus Creek	340,000	4	6,200	4,300	16	4.7	440	40	4.4
Cattaraugus Creek at Felton Bridge (032)	30,000	<1	560	430	1.3	<0.5	41	3.6	0.4
Cattaraugus Creek at Springville Dam (042)	30,000	<1	530	410	1.2	<0.5	38	3.4	0.3

TABLE 3-6

RADIONUCLIDE CONCENTRATIONS IN CATTARAUGUS AND BUTTERMILK CREEKS, NOVEMBER 1969 (U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE 1969)

Concentration in Water (pCi/L)

Location	Tritium	Gross α	Gross β	Ru-106	Cs-137	Cs-134	Sr-90	Sb-125	Co-60
Buttermilk Creek, Thomas Corners Bridge (035)	43,000	1.4	1,400	380	17	<10	360	49	<10
Cattaraugus Creek, Felton Bridge (032)	3,400	<1	270	75	<10	<10	69	<40	<10

TABLE 3-7

URANIUM AND PLUTONIUM CONCENTRATIONS IN BUTTERMILK CREEK
(U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE 1969)

Concentration in Water (pCi/L)

Date	Location	U-232	U-234	U-238	Pu-238	Pu-239
6/17/69	Buttermilk Creek at Thomas Corners Bridge (035)	3.4	1.4	0.22	0.02	0.02
11/4/69	Buttermilk Creek at Thomas Corners Bridge (035)	0.6	0.3	0.12	0.01	0.01
Concentrations Suspended Solids (pCi/ℓ)						
6/17/69	Buttermilk Creek at Thomas Corners Bridge (035)	0.01	0.02	0.02	0.01	0.01
11/4/69	Buttermilk Creek at Thomas Corners Bridge (035)				0.015	0.018

TABLE 3-8

NFS 1963 PREOPERATIONAL AND 1967 OPERATIONAL RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER

	Gross Alpha		Gross Beta		Sr-90	
Location	7/1963 Preoperational Activity (μCi/mL)	1/1967 - 9/1967 Average Level (μCi/mL)	7/1963 Preoperational Activity (μCi/mL)	1/1967 - 9/1967 Average Level (μCi/mL)	7/1963 Preoperational Activity (μCi/mL)	1/1967 - 9/1967 Average Level (μCi/mL)
Cattaraugus Creek Upstream	8.0E-09	7.6E-10	1.0E-08	4.1E-08	-------	———
Cattaraugus Creek Downstream	8.0E-09	5.8E-09	1.0E-08	2.10E-07	6.0E-10	3.1E-08
Erdman Brook (upstream of burial area)	8.0E-09	9.0E-10	1.0E-08	1.7E-07	6.0E-10	2.1E-08
Erdman Brook (downstream of burial area)	8.0E-09	1.4E-09	1.0E-08	1.1E-06	6.0E-10	1.6E-07

From NFS 1967 Environmental Report

TABLE 3-9

NFS AND WESTERN NEW YORK NUCLEAR RESEARCH CENTER (WNYNRC) 1967 WATER SAMPLING (μCi/mL)

Sample Location	Analyst	Gross Beta	Gross Alpha	Sr-90	Tritium
Cattaraugus Creek, Downstream (Felton Bridge) (032)	NFS WNYNRC	9.8E-08 2.1E-07	2.0E-09 5.8E-09	--- 3.1E-08	6.1E-05 ---
Cattaraugus Creek, Upstream (Bigelow Bridge) (007)	NFS	4.1E-08	7.6E-10		3.4E-05
Erdman Brook, Downstream	NFS WNYNRC	9.7E-08 1.1E-06	1.4E-09 ---	--- 1.6E-07	2.9E-05 ---
Erdman Brook, Upstream	NFS WNYNRC	5.0E-08 ---	9.0E-10 ---	--- 2.1E-08	2.5E-05 ---
Frank's Creek	NFS	1.5E-05	5.1E-08	---	1.3E-03
Springville Dam (042)	WNYNRC	2.0E-07	1.7E-08	1.4E-07	2.1E-05

From NFS 1967 Environmental Report

TABLE 3-10

GROSS BETA AND TRITIUM ACTIVITY IN GROUND WATER
FROM TEST HOLES 15 - 19, 21,22 AND 24

GROSS BETA (uCi/ml)*10-7

	HOLE 15	HOLE 16	HOLE 17	HOLE 18	HOLE 19	HOLE 21	HOLE 22	HOLE 24
06/04/74	1.82	15.10	10.6	14.3	6.49			
06/14/74	12.70	9.31	12.4	11.3	6.56			
06/27/74						< 0.3	4.74	
07/12/74	1.86	11.10		12.7	5.29	< 0.3		
08/01/74	2.30	9.01			4.40			
08/21/74							13.70	
08/27/74								< 0.4
10/16/74	1.50		1.9					
11/14/74	0.84	4.20	2.4	2.9	4.20	9.0	0.40	
12/30/74	0.88	1.50	1.5	0.5	3.10	0.5		0.7
01/31/75	0.38		1.5	0.5	3.60			

TRITIUM (uCi/ml)*10-6

	HOLE 15	HOLE 16	HOLE 17	HOLE 18	HOLE 19	HOLE 21	HOLE 22	HOLE 24
06/04/74	368.00	394.00	232.0	284.0	161.00			
06/14/74	444.00	372.00	165.0	268.0	131.00			
06/27/74						141.0	44.50	
07/12/74	52.20	309.00		341.0	117.00	165.0		
08/01/74	57.40	311.00			123.00			
08/21/74							80.00	
08/27/74								< 2.0
10/16/74	2.02		< 2.0					
11/14/74	3.70	120.00	60.8	74.3	170.00	620.0	63.00	
12/30/74	< 1.70	< 1.70	< 1.6	< 1.7	86.00	14.0		< 1.7
01/31/75	< 1.50		< 1.5	< 1.5	182.00			

BLANK ENTRY INDICATES HOLE NOT SAMPLED DURING SAMPLING EVENT

TABLE 3-11

TRITIUM ACTIVITY IN NFS WELLS 1 - 5
FROM LAGOON AREA

	1	2	3	4	5
5/75	1.20E-04	1.10E-04	2.40E-03	1.90E-04	
6/75	5.10E-05	8.80E-05	1.50E-03	1.70E-04	
7/75	7.80E-05	9.50E-03	1.00E-03	1.30E-04	
8/75	4.60E-05	7.80E-05	7.00E-04	1.20E-04	
9/75	9.00E-05	8.00E-05	5.90E-04	1.10E-04	
10/75	1.00E-04	9.20E-05	7.10E-04	1.40E-04	5.70E-03
11/75	8.00E-05	1.10E-04	7.00E-04	1.60E-04	5.50E-03
12/75	5.00E-05	1.00E-04	2.50E-04	1.50E-04	3.50E-03
1/76	6.20E-05	8.50E-05	1.30E-04	1.50E-04	3.50E-03
2/76	4.10E-05	7.80E-05	2.20E-04	6.50E-05	3.50E-03
3/76	2.10E-05	7.80E-05	1.70E-04	6.80E-05	2.50E-03
4/76	4.00E-05	9.30E-05	1.90E-04	9.80E-05	1.90E-03
5/76	3.00E-05	7.10E-05	1.70E-04	1.10E-04	1.40E-03
6/76	1.00E-04	7.00E-05	1.60E-04	1.20E-04	1.20E-03
7/76					
8/76	1.80E-05	9.40E-05	1.50E-04	1.10E-04	8.30E-04
9/76	2.40E-05	8.90E-05	1.40E-04	1.30E-04	9.30E-04
10/76	3.20E-05	9.50E-05	2.60E-04	1.00E-04	5.80E-03
11/76	6.00E-05	1.80E-04	6.40E-04	1.30E-04	3.30E-02
12/76					
1/77					
2/77	5.80E-05	1.20E-04	1.30E-03	1.10E-04	3.20E-02
3/77	7.70E-05	5.70E-05	1.20E-03	1.10E-04	2.80E-02
4/77	1.60E-05	4.30E-05	9.00E-04	4.80E-05	1.10E-02
5/77	1.90E-05	6.00E-05	6.40E-04	6.40E-05	1.10E-02
6/77	2.50E-05	4.30E-05	6.90E-04	8.90E-05	1.60E-02

BLANK ENTRY INDICATES WELL NOT ANALYZED

TABLE 3-12

TRITIUM ACTIVITY IN NFS WELLS IN THE NORTH PLATEAU (1979 - 1982)

WELL	04/26/79	08/13/79	09/13/80	06/16/81	10-11/82
A	1.59E-05	DRY	1.25E-05	3.29E-06	5.06E-06
B	2.13E-05	1.12E-04	1.42E-05	5.35E-05	2.86E-05
C	4.86E-05	1.01E-04	5.78E-05	4.57E-05	1.37E-05
D	2.28E-04	3.12E-04	8.39E-05	1.75E-04	3.28E-05
E	5.75E-05	7.89E-05	7.60E-06	1.94E-05	9.70E-07
F	1.09E-05	1.17E-05	4.75E-06	2.35E-05	1.24E-06
G	4.42E-04		6.07E-04	3.70E-02	1.14E-03
H	5.48E-06		2.35E-06	2.67E-05	2.83E-07
J-1	1.35E-06	2.12E-06	1.85E-06	1.65E-06	6.91E-07
J-2	1.55E-06	2.88E-06	1.52E-06	2.22E-06	4.03E-07
J-3	1.87E-06	3.27E-06	2.85E-06	2.49E-06	1.01E-06
J-4	1.40E-06	2.94E-06	1.61E-06	3.44E-06	1.07E-06
J-5	3.21E-06	3.39E-06	2.39E-06	3.75E-06	8.36E-07
J-6	1.56E-06	2.40E-06	1.85E-06	6.66E-06	7.03E-07
J-7	2.84E-06	9.34E-06	4.22E-06	7.62E-06	6.58E-07
J-8	8.05E-05	6.42E-05	4.66E-05	4.03E-05	2.90E-05
J-9	7.59E-06	1.01E-05	5.45E-06	7.48E-06	2.52E-06
K	7.39E-06	1.81E-05	2.51E-06	6.46E-05	1.44E-06
L-1	5.20E-05	7.15E-05	4.36E-06	5.97E-05	8.96E-06
L-2	8.02E-06	8.69E-06	2.77E-06	4.75E-05	1.77E-06
L-3	3.64E-06	3.42E-06	2.24E-06	1.56E-05	4.06E-07
L-4	1.31E-05	4.44E-06	3.28E-06	7.37E-06	1.43E-06
L-5	2.22E-06	2.69E-06	1.50E-06	6.44E-06	7.91E-07
M-1	5.83E-06	5.00E-06	2.90E-06	8.00E-06	4.97E-07
M-2	3.99E-06	1.37E-05	2.96E-06	4.51E-06	7.82E-07
M-3	2.22E-06	2.55E-06	2.07E-06	3.70E-06	6.12E-07
M-4	2.53E-06	3.33E-06	2.52E-06	2.69E-06	2.71E-07
M-5	8.48E-06	2.63E-05	7.48E-06	6.04E-06	6.13E-06
N-1	2.46E-05	2.68E-05	2.42E-05	3.39E-06	1.21E-05
N-2	9.77E-06	5.98E-06	3.39E-06	1.14E-05	6.52E-06
N-3	1.69E-06	2.64E-06	1.80E-06	1.98E-06	2.82E-07
P	1.63E-05	1.36E-05	6.97E-06	5.52E-06	2.64E-06
Q	2.91E-05	2.96E-05	1.53E-05	3.51E-05	
R	2.61E-06	5.98E-06	2.81E-06	4.33E-05	5.24E-06
FRENCH DRAIN	6.15E-05	6.20E-05	4.00E-05	8.79E-05	
NE SWAMP	7.22E-06	1.48E-05			
WTF SUMP					6.32E-06
WTF S. E. WELL					1.13E-05
SWAMP K-3-6					9.05E-07
SWAMP L-3-4					3.34E-06
SWAMP M-3-5					2.77E-06

BLANK ENTRY INDICATES WELL NOT ANALYZED

TABLE 4-1

Schedule of Groundwater Sampling and Analysis

Category	Parameter	Frequency	Comment
I. EPA Interim Drinking Water Standards	Arsenic Barium Cadmium Fluoride Lead Mercury Nitrate (as N) Selenium Silver Radium Gross Alpha Gross Beta	Quarterly for 1st year	Annually after 1st year except coliform and pesticides
	Coliform Bacteria Endrin Lindane Methoxychlor Toxaphene 2,4-D 2,4,4-TP Silvex		These were omitted because site history does not indicate past usage or potential for contamination
II. Groundwater Quality Indicators	Chloride Iron Manganese Phenols Sodium Sulfate	Quarterly for 1st year, annually thereafter	
III. Groundwater Contamination Indicators	Nitrate pH Conductivity Total Organic Carbon Total Organic Halogens Specific Metals Tritium Gross Alpha Gross Beta Specific Gamma-Emitters	Quarterly for 1st year, semiannually thereafter	All parameters are measured in 4 replicates of each sample. Parameters selected by WVNS as indicators of waste treatment/disposal at WVDP.
IV. Groundwater Elevations		Once before collecting each well sample	

TABLE 4-2

RADIOLOGICAL ACTIVITY IN OFFSITE WELLS

GROSS ALPHA
(µCi/mL)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
1	<2.00E-10		<4.50E-10		<1.10E-09	<1.39E-09	<7.00E-10	<1.38E-09
2	<1.67E-10	<8.50E-10		<6.90E-10		<7.33E-10	1.25E-09	<1.29E-09
3	<1.67E-10		<8.50E-10		<1.10E-09	<3.48E-09	<3.08E-09	<2.40E-09
4	<2.00E-10		<1.80E-09		<1.40E-09	<1.64E-08	<1.66E-08	<8.00E-09
5	<1.23E-10	<5.70E-10		<5.60E-10		<1.01E-09	<7.99E-10	<1.20E-09
6	<1.23E-10	<7.00E-10	<5.90E-10	<4.90E-10	<5.40E-10	<5.55E-10	<5.62E-10	<1.59E-09
7	<2.00E-10		<1.00E-09		<9.30E-10	<1.11E-09	<8.14E-10	<1.11E-09
8	<2.30E-10	<1.40E-09		<7.10E-10		<1.96E-09	1.93E-09	<1.71E-09
9	<1.67E-10	<1.20E-09		<1.10E-09		<2.09E-09	<1.50E-09	<2.60E-09
10	<1.67E-10	<9.00E-10		<1.50E-09	<9.50E-10	<1.14E-09	<9.96E-10	<1.29E-09

GROSS BETA
(µCi/mL)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
1	1.76E-09		3.53E-09		1.35E-09	3.41E-09	2.22E-09	4.16E-09
2	1.59E-09	<8.7E-10		1.40E-09		1.64E-09	5.90E-09	3.41E-09
3	2.19E-09		3.71E-09		2.76E-09	4.43E-09	2.24E-09	5.11E-09
4	2.10E-09		3.07E-09		2.09E-09	2.22E-09	<2.34E-09	3.33E-09
5	2.29E-09	2.58E-09		3.10E-09		3.51E-09	2.58E-09	4.50E-09
6	1.48E-09	1.39E-09	3.40E-09	<9.2E-10	<8.00E-10	1.63E-09	<1.45E-09	2.92E-09
7	<7.25E-10		2.86E-09		<8.80E-10	1.89E-09	2.51E-09	<2.17E-09
8	4.61E-09	<1.10E-09		1.91E-09		2.21E-09	2.97E-09	5.32E-09
9	2.39E-09	2.46E-09		1.31E-09		2.88E-09	2.66E-09	2.76E-09
10	9.67E-10	<9.40E-10		1.46E-09	<9.30E-10	2.09E-09	<1.56E-09	2.37E-09

BLANK ENTRY INDICATES WELL NOT ANALYZED DURING THE YEAR

TABLE 4-2 (CONT.)

TRITIUM
(µCi/mL)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
1	<1.55E-07		<1.00E-07		<1.00E-07	<1.00E-07	<1.14E-07	<1.00E-07
2	1.23E-07	<1.00E-07		4.00E-07		<1.00E-07	<1.00E-07	<1.00E-07
3	<1.39E-07		<1.00E-07		<1.00E-07	<1.00E-07	<1.00E-07	<7.37E-08
4	<1.51E-07		<1.00E-07		<1.00E-07	<1.00E-07	<7.85E-08	<1.00E-07
5	<1.64E-07	<1.00E-07		<1.00E-07		<1.00E-07	<1.00E-07	<1.00E-07
6	<1.38E-07	1.22E-07	2.59E-07	<1.00E-07	<1.00E-07	<1.00E-07	<1.00E-07	<6.08E-08
7	<1.53E-07		<1.00E-07		<1.00E-07	<1.00E-07	<1.00E-07	<1.00E-07
8	<1.58E-07	<1.00E-07		<1.00E-07		<1.00E-07	<1.11E-07	<1.00E-07
9	<1.31E-07	1.90E-07		<1.00E-07		<1.00E-07	<1.05E-07	<1.00E-07
10	<1.48E-07	1.79E-07		<1.00E-07	<1.00E-07	<1.00E-07	<1.00E-07	<7.72E-08

CS-137
(µCi/mL)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
1			<2.10E-08		<3.70E-08	<3.70E-08	<3.70E-08	<3.40E-08
2		<2.10E-08		<2.10E-08		<3.70E-08	<3.70E-08	<3.40E-08
3			<2.10E-08		<3.70E-08	<3.70E-08	<3.70E-08	<3.40E-08
4			<2.10E-08		<3.70E-08	<3.70E-08	<3.70E-08	<3.40E-08
5		<2.10E-08		<2.10E-08		<3.70E-08	<3.70E-08	<3.40E-08
6		<2.10E-08	<2.10E-08	<2.10E-08	<3.70E-08	<3.70E-08	<3.70E-08	<2.31E-08
7			<2.10E-08		<3.70E-08	<3.70E-08	<3.70E-08	<2.31E-08
8		<2.10E-08		<2.10E-08		<3.70E-08	<3.70E-08	<2.31E-08
9		<2.10E-08		<2.10E-08		<3.70E-08	<3.70E-08	<2.31E-08
10		<2.10E-08		<2.10E-08	<3.70E-08	<3.70E-08	<3.70E-08	<2.31E-08

BLANK ENTRY INDICATES WELL NOT ANALYZED DURING THE YEAR

Table 4-3

1988 Demineralizer Sludge Pond Sludge/Sediment Analytical Results

Metals Concentrations from the North (N) and South (S) Demineralizer Sludge Ponds Analysis

Concentration in ppm

Sample ID	As	Cr	Cu	Pb	Ni	Zn	Cd
N-55B-12-24	51.7	79.4	52.5	17.3	29.0	103.1	4.8
N-55C-12-24	26	86.2	55.5	17.1	28.3	110.5	4.9
S-29-12-24	22.9	77.9	71.6	19.6	33.5	211.4	4.8
S-37-0-12	27.6	103.9	45.7	14.2	23.0	94.2	4.3
Background Surface	10.5	31.4	10.4	13.9	22.4	71.6	1.2
Background 1 6" depth	9.8	22.5	9.7	14.2	34.4	77.6	1.4
Background 2 6" depth	11.1	18.7	7.2	12.7	10.0	53.5	0.7

Metals Concentration from the North (N) and South (S) Demineralizer Sludge Ponds Analysis by IT Corporation

Concentration in ppm

Sample ID	An	As	Be	Cd	Cr	Cu	Pb	Ni	Se	Ag	Th	Zn	Hg
N-16	<1.5	20.2	0.798	7.61	95.3	58.7	17.2	34.3	0.20	<0.3	<5.7	123	<0.1
S-27	<1.5	26.8	0.662	9.68	128	65.1	39.0	25.4	0.60	4.52	<2.8	128	<0.1

Table 4-3 (continued)

EP-Toxicity Metals and Major Anion Concentrations from the North Demineralizer Sludge Pond

		EPTOX Sample Extracts (mg/L)									Major Anions PPM (WET WT)					
SAMPLE ID	SAMPLE DATE	As	Ba	Cd	Cr	Pb	Hg	Se	Ag	pH	F	Cl	NO2	NO3	PO4	SO4
S-25-0-12	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.74	<2.0	<10	<10	<10	<10	80.1
S-25-12-24	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.72	<2.0	22	<10	<10	<10	84.8
S-29-0-12	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.67	<2.0	193	<10	12	<10	46.0
S-29-12-24	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	7.05	<2.0	88.9	<10	<10	<10	252.7
S-37-0-12	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.84	<2.0	<10	<10	<10	<10	137.4
S-37-12-24	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.88	<2.0	<10	<10	<10	<10	225.2
S-44-0-12	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.42	<2.0	240	<10	<10	<10	200.1
S-52-0-12	10JUN88	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	7.01	<2.0	42	<10	<10	<10	52.8
S-AVG-0-12	CALCULATED	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.73	<2.0	99	<10	<10	<10	103
S-AVG-12-24	CALCULATED	<0.5	<10	<0.1	<0.5	<0.5	<0.02	<0.1	<0.5	6.88	<2.0	40	<10	<10	<10	188

NOTES: 10ppm NO3 = 2.26 NO3-N; 10ppm NO2 = 3.04 NO2-N

TABLE 4-4

1991 SCHEDULE OF GROUNDWATER SAMPLING AND ANALYSIS

Contamination Indicator Parameters (Scheduled eight times per year)	*pH**
	Total Organic Carbon
	Gross Alpha
	Gamma Scan
	*Conductivity**
	Total Organic Halogens
	Gross Beta
	Tritium
	Volatile Organic Analysis
Groundwater Quality Parameters (Scheduled two times per year)	*Chloride*
	Iron
	Sodium
	Manganese
	Phenols
	Sulfate
	Magnesium
	Nitrate + Nitrite-N
	Calcium
	Potassium
	Ammonia
	Bicarbonate/Carbonate
EPA Interim Primary Drinking Water Standards (Scheduled four times per year, one year only)	*Arsenic*
	Barium
	Cadmium
	Chromium
	Lead
	Mercury
	Selenium
	Silver
	Fluoride
	Endrin
	Methoxychlor
	2,4 D
	Radium
	Nitrate + Nitrite-N
	Lindane
	Toxaphene
	2,4,5-TP Silvex
	*Turbidity**

** Field measurement*

TABLE 5-1

AVERAGE YEARLY pH OF PRECIPITATION COLLECTED IN FALLOUT POTS 1986 - 1991

Year	Dutch Hill (AFDHFOP)	Fox Valley Road (AFFXFOP)	Route 240 (AF24FOP)	Thomas Cnrs. Rd (AFTCFOP)
1986	4.29	4.56	4.61	4.40
1987	4.28	4.56	4.74	4.56
1988	4.31	4.75	4.57	4.56
1989	4.49	4.66	4.58	4.44
1990	4.68	4.34	4.22	3.99
1991	3.85	4.17	4.55	3.95

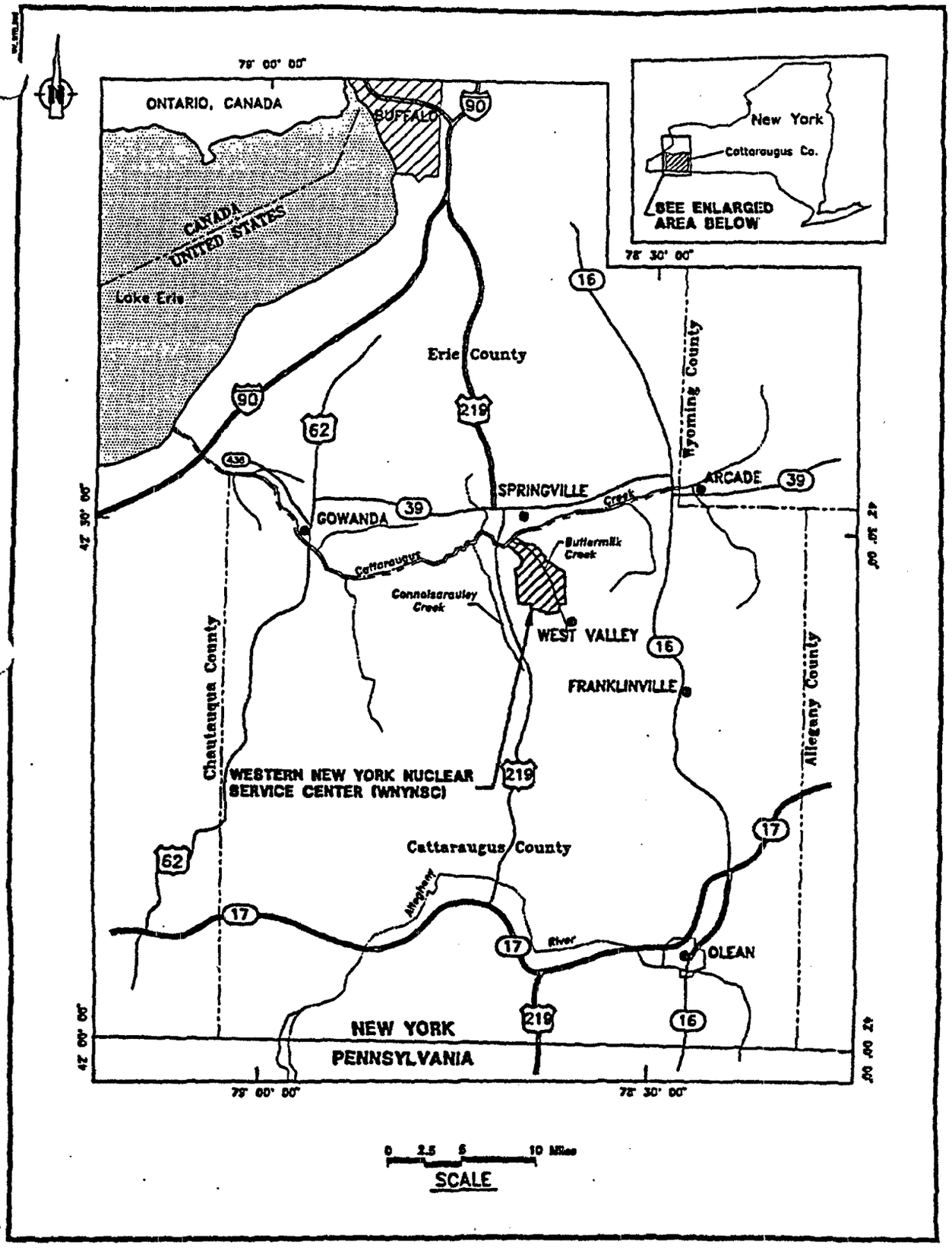


Figure 2-1 Location of the Western New York Nuclear Service Center.

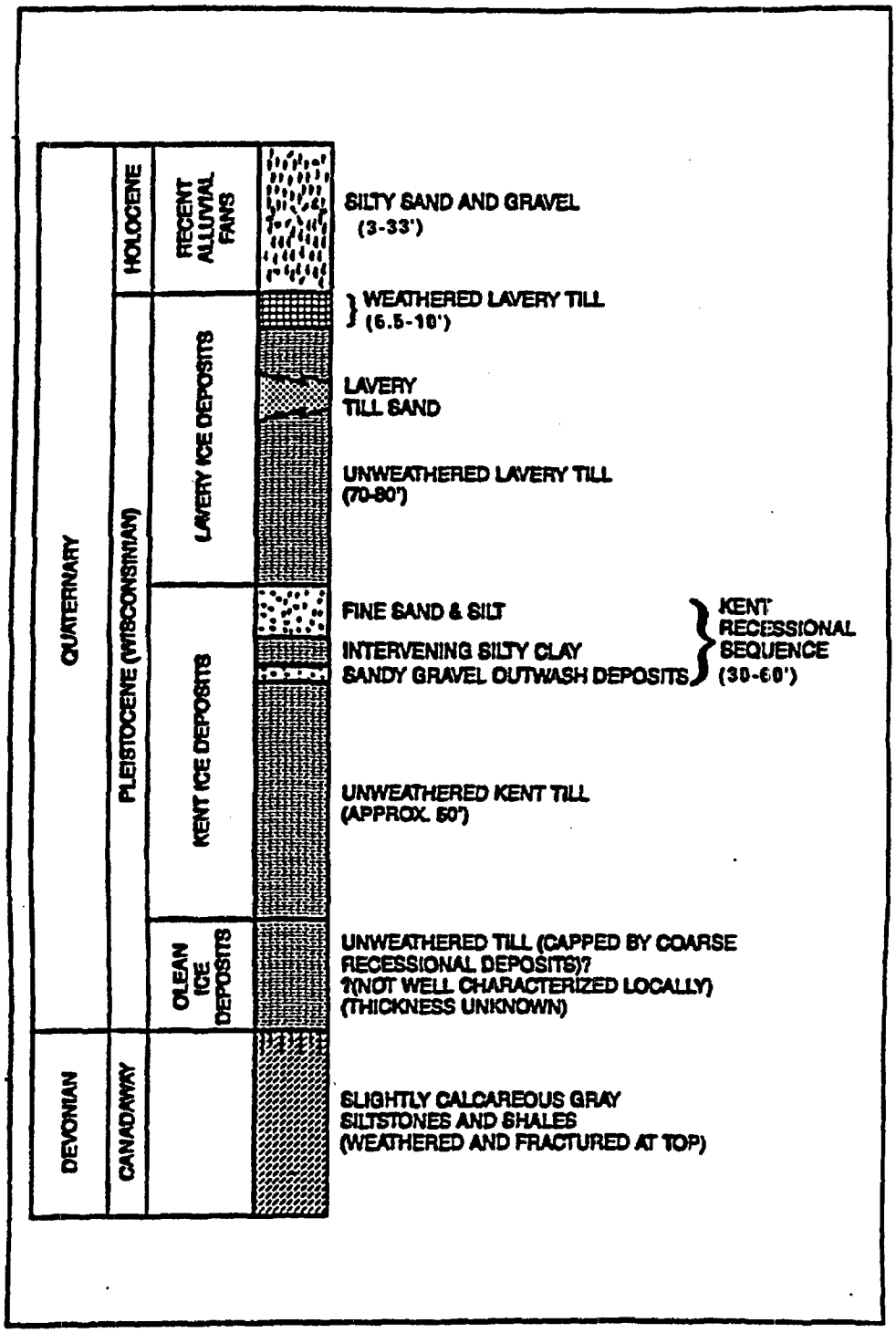


Figure 2-2 Bedrock and glacial stratigraphy at the WVDP

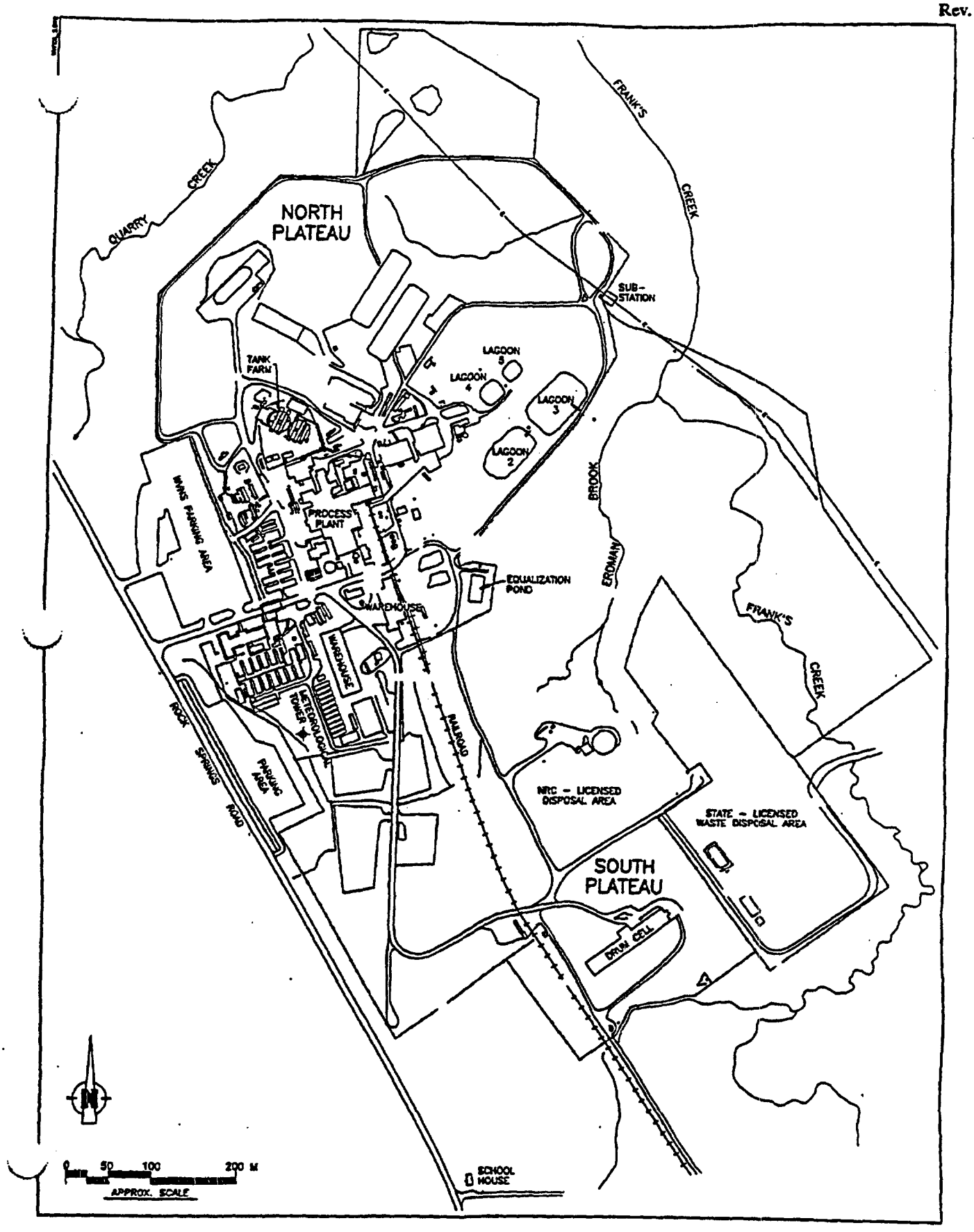


Figure 2-3 Map of The West Valley Demonstration Project (WVDP).

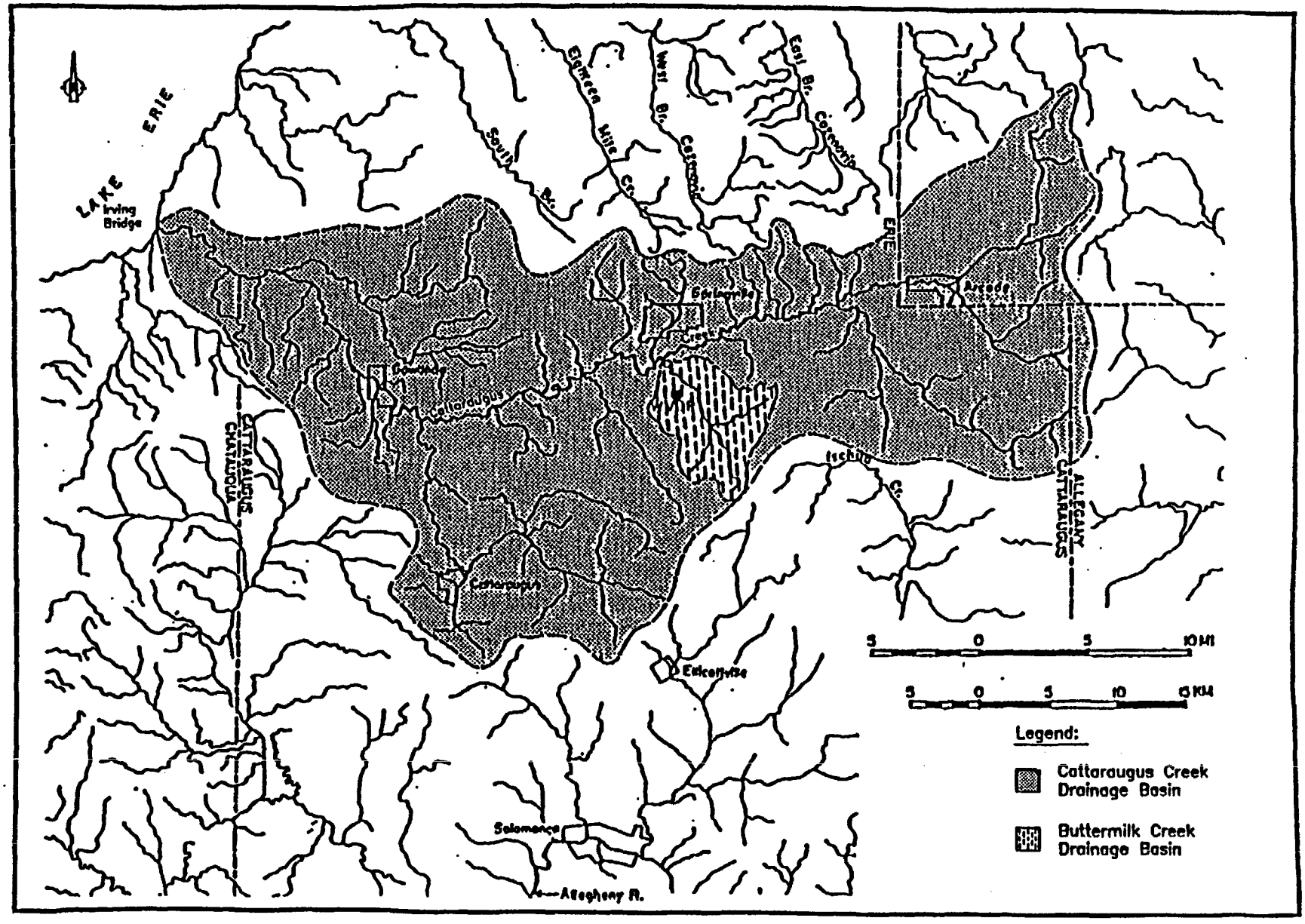


Figure 2-4 Cattaraugus Creek Drainage Basin

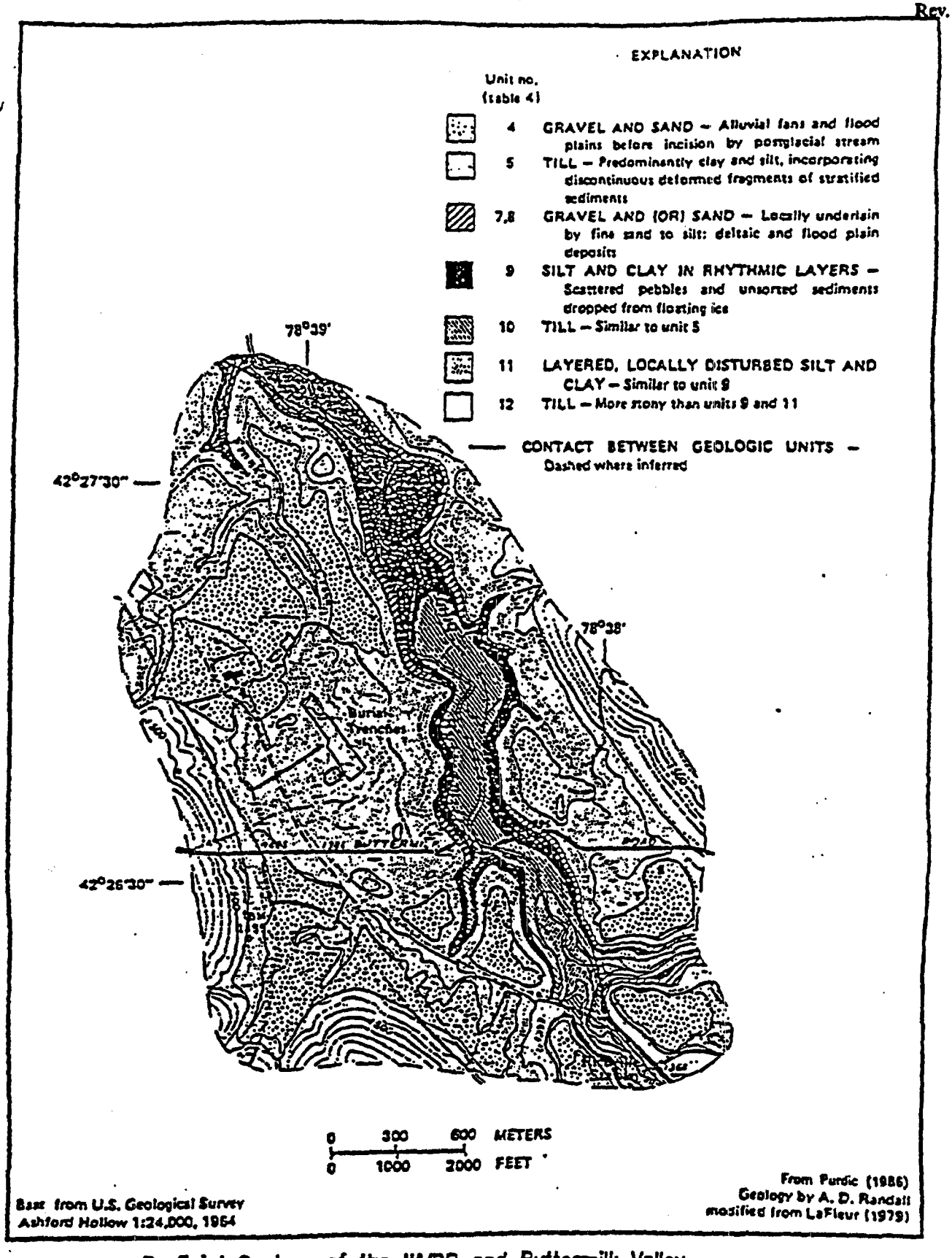


Figure 2-5 Surficial Geology of the WVDP and Buttermilk Valley

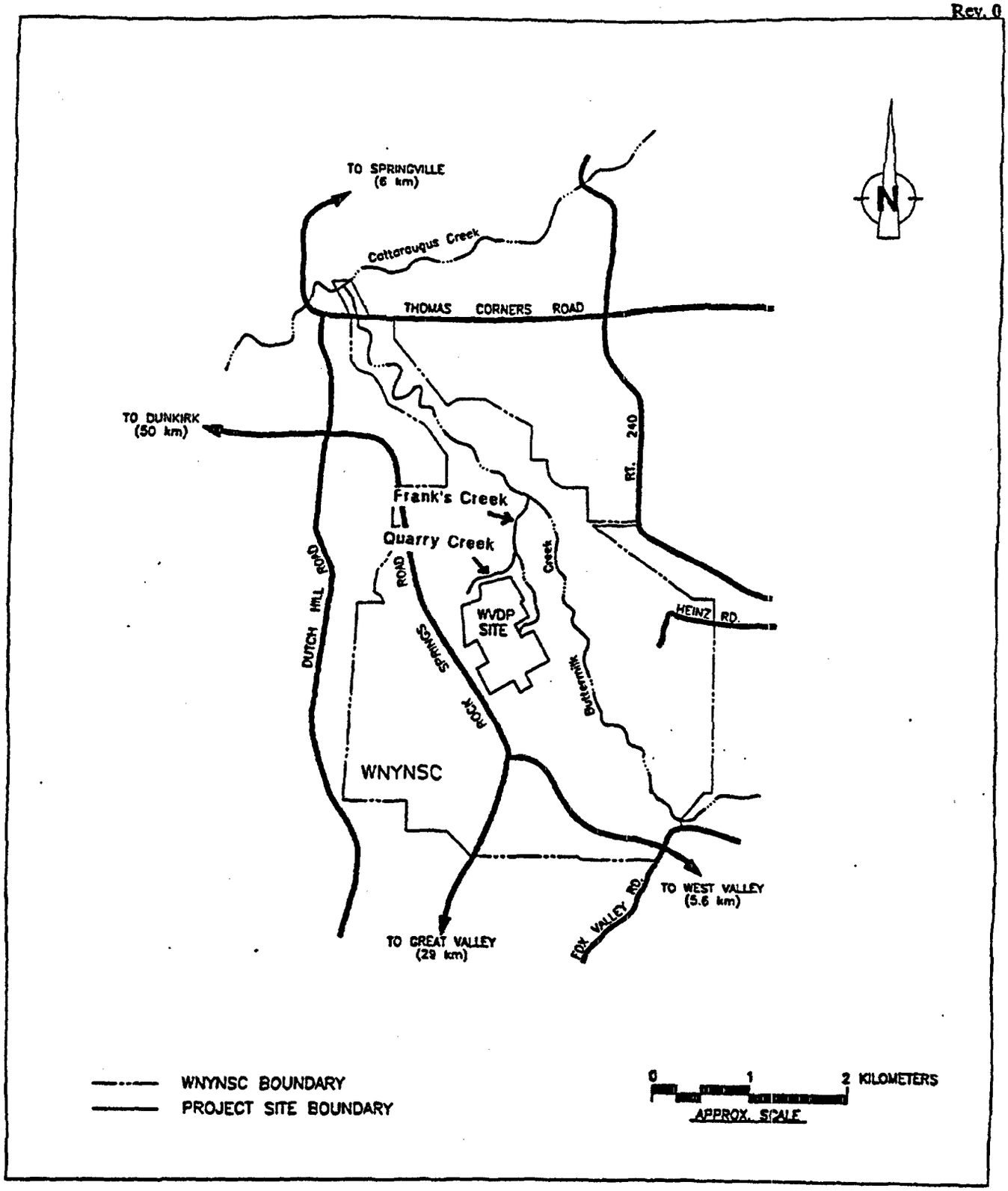


Figure 2-6 Major streams draining the WVDP and WNYNSC

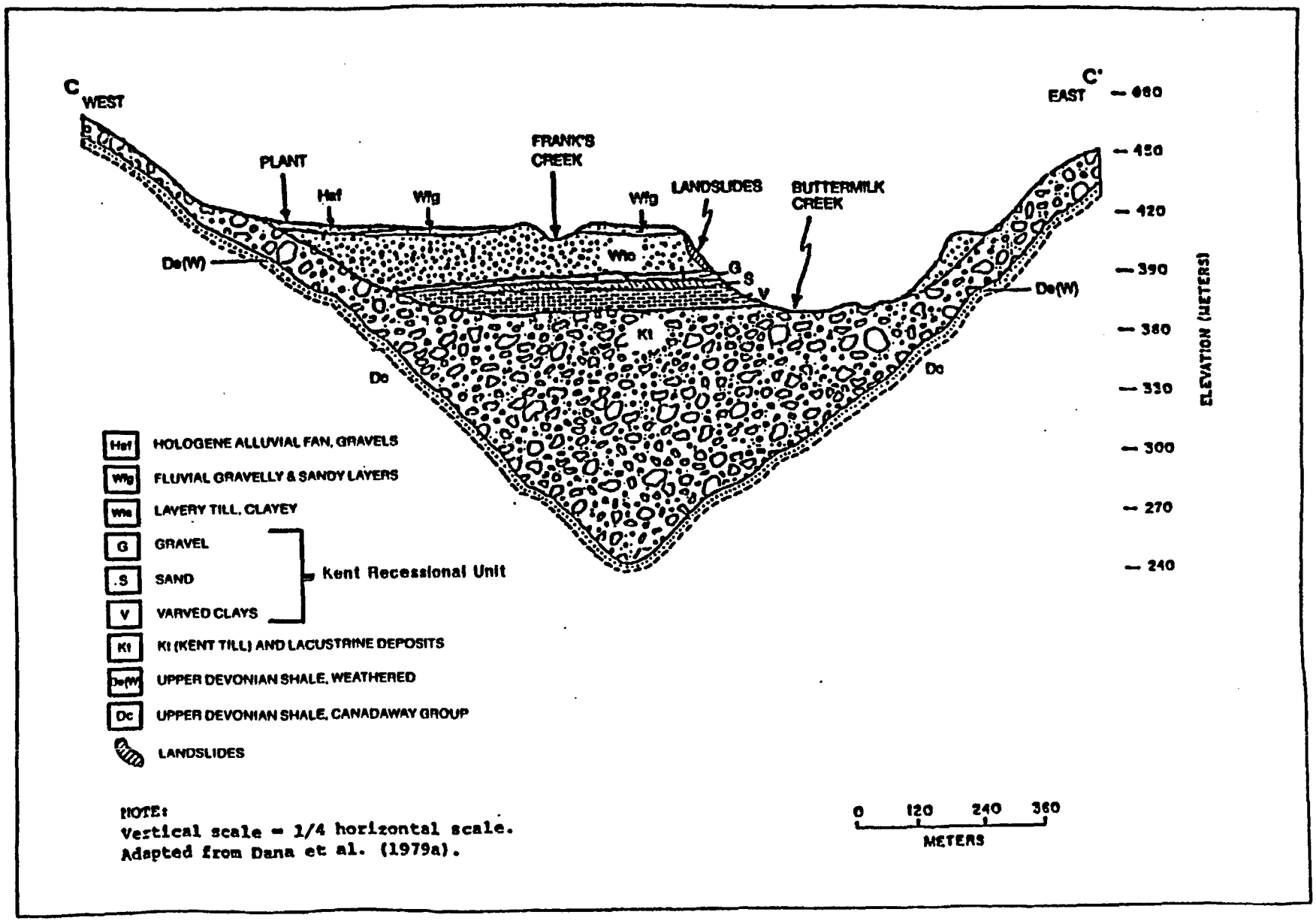


Figure 2-7 Geological Cross Section Through the North Plateau.

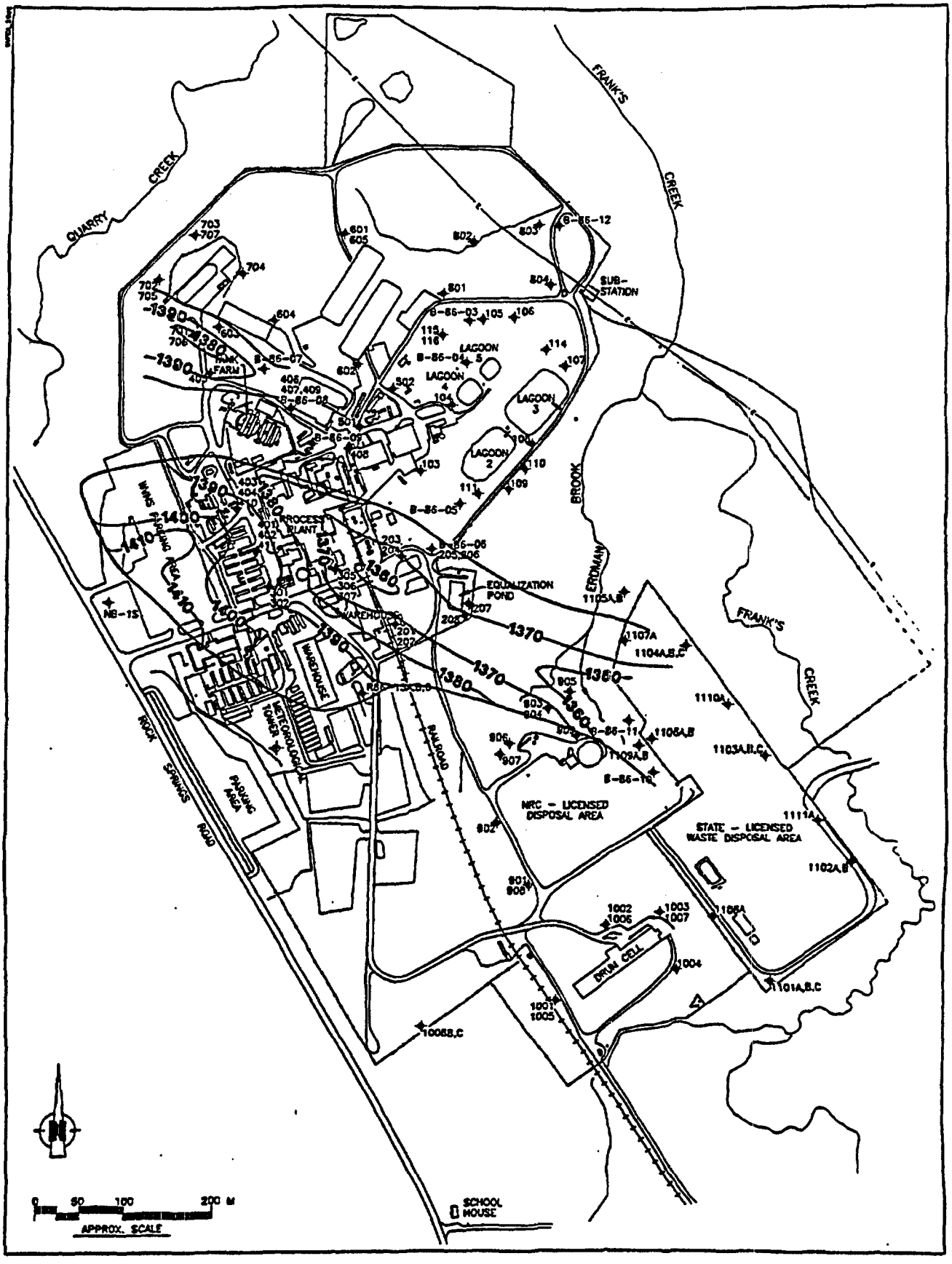


Figure 2-8 Structure Contour Map of The Till Sand Unit.

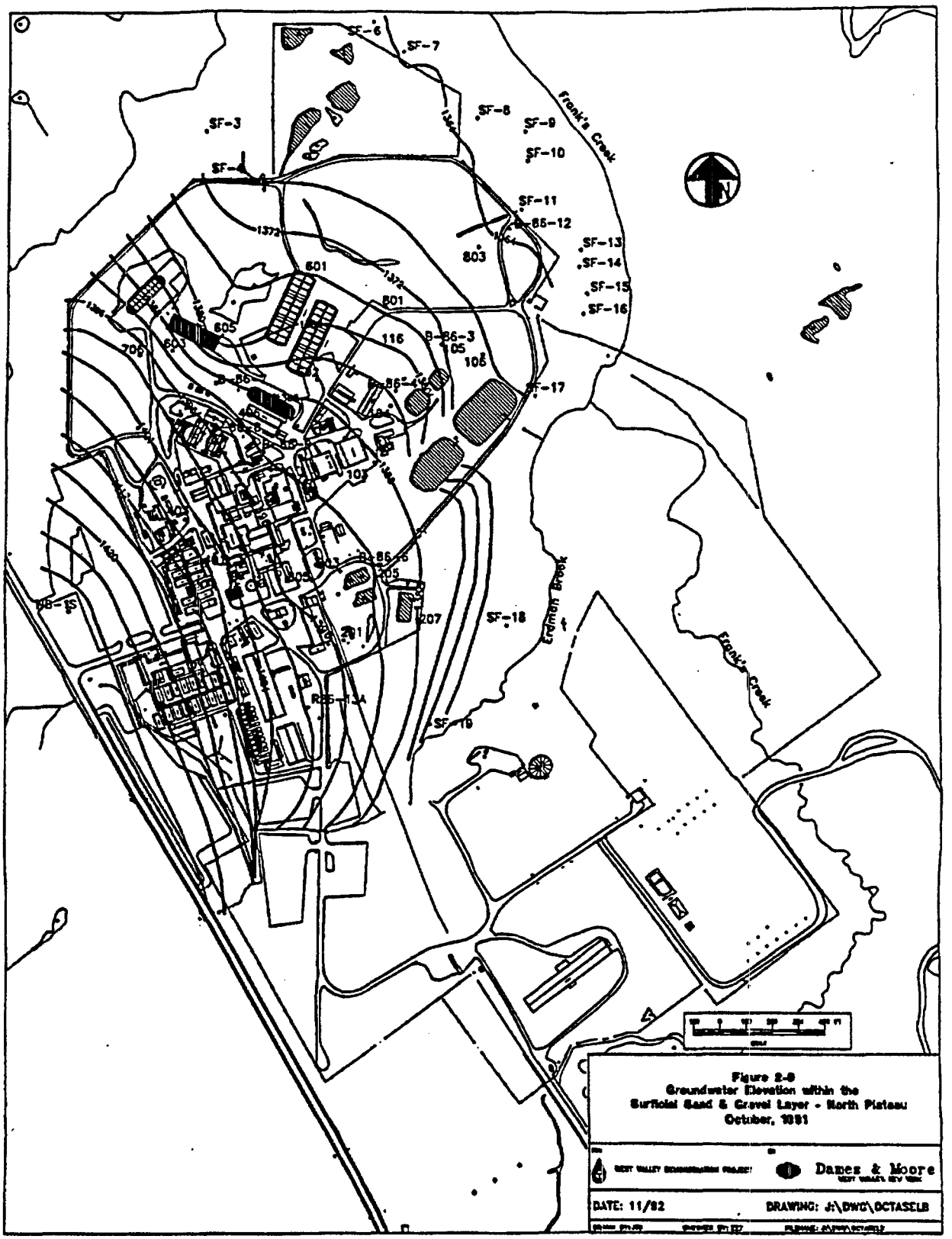


Figure 2-8
Groundwater Elevation within the
Surficial Sand & Gravel Layer - North Plateau
October, 1991

WEST VALLEY DEMONSTRATION PROJECT

Dames & Moore

DATE: 11/92

DRAWING: J:\DWG\OCTASELB

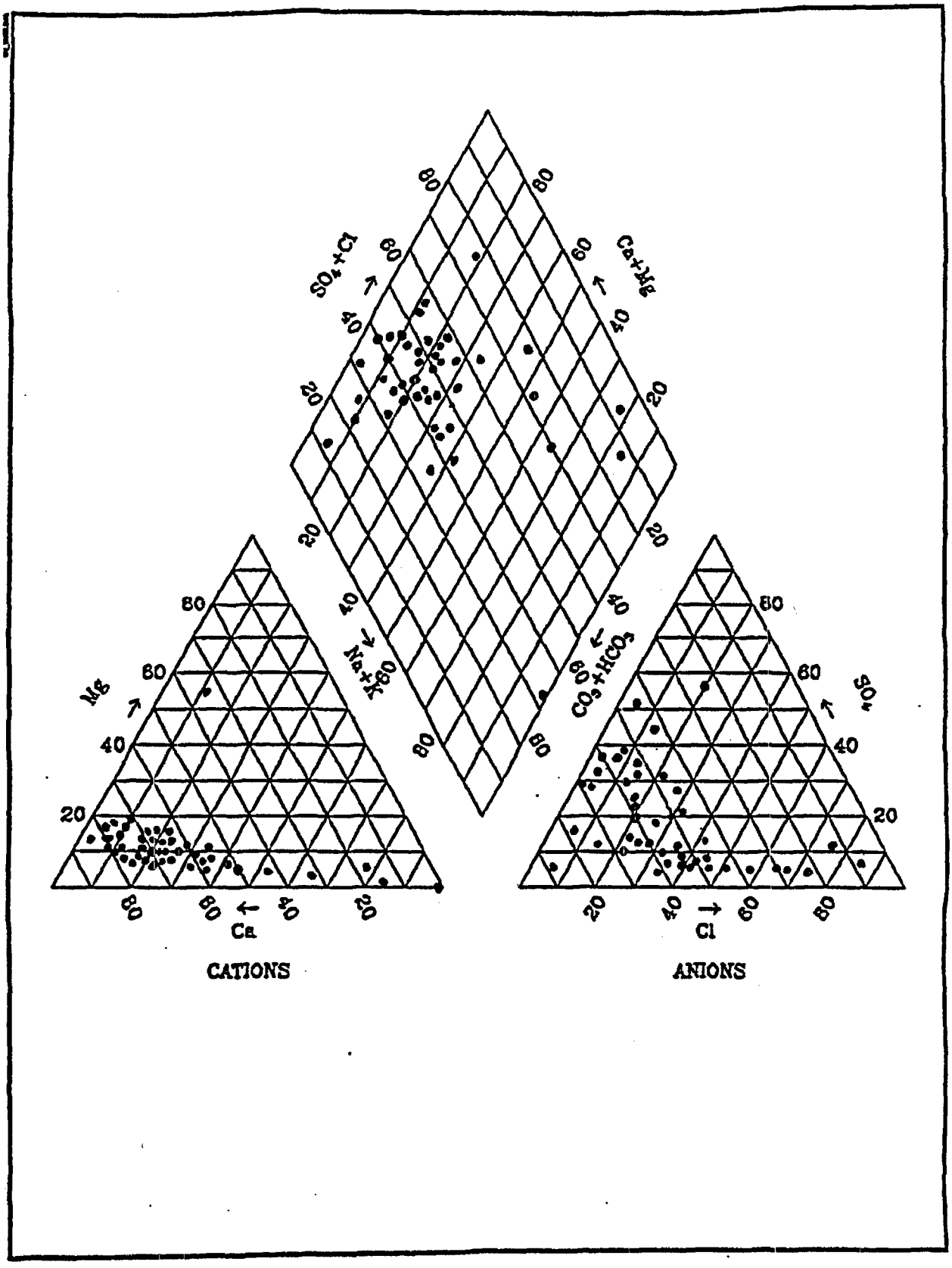


Figure 2-10 Trilinear Diagram For The Surficial Sand and Gravel Unit (n = No. of Wells = 44).

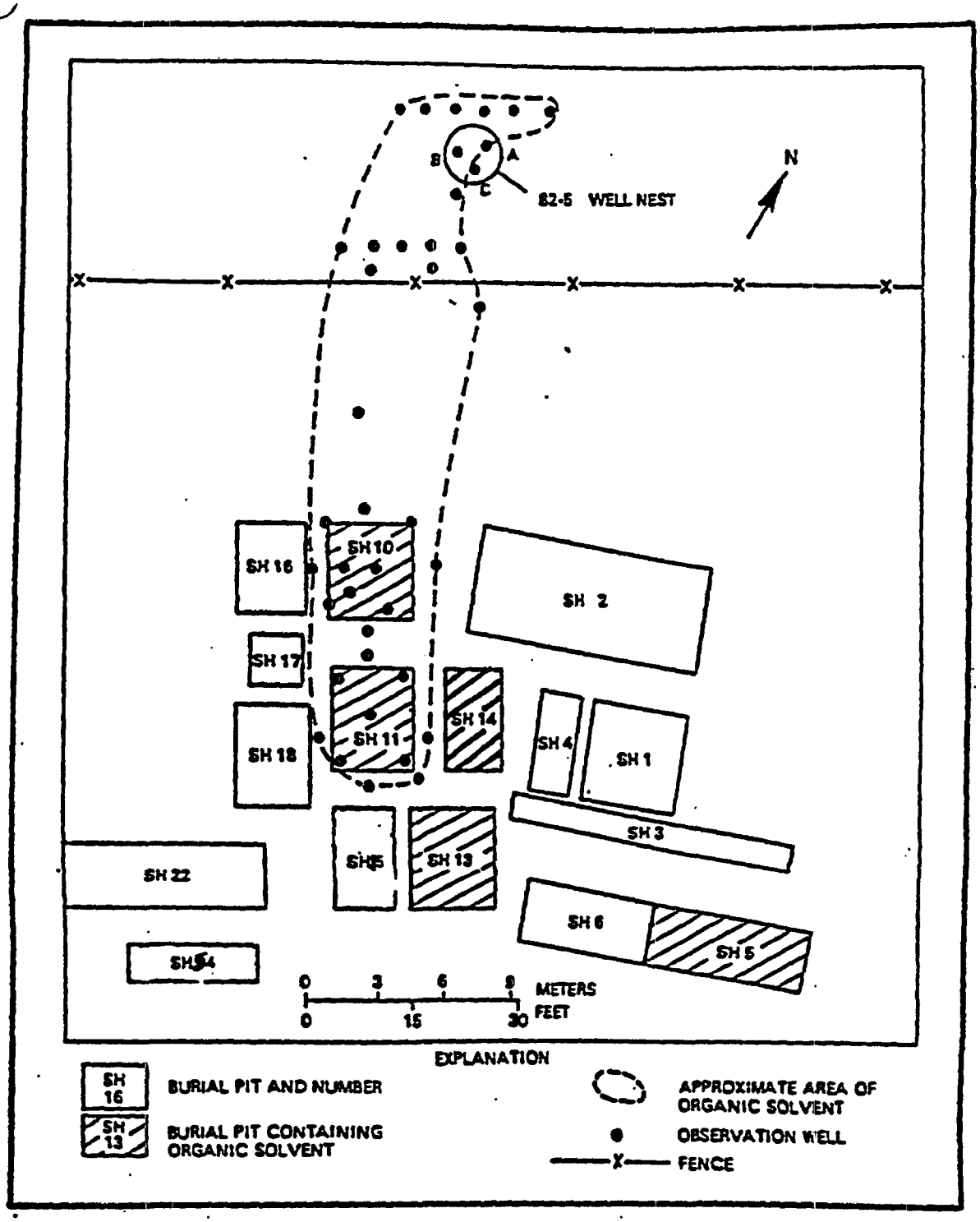


Figure 2-11 Extent of solvent migration in weathered Lavery Till from the NDA to piezometer cluster 82-5

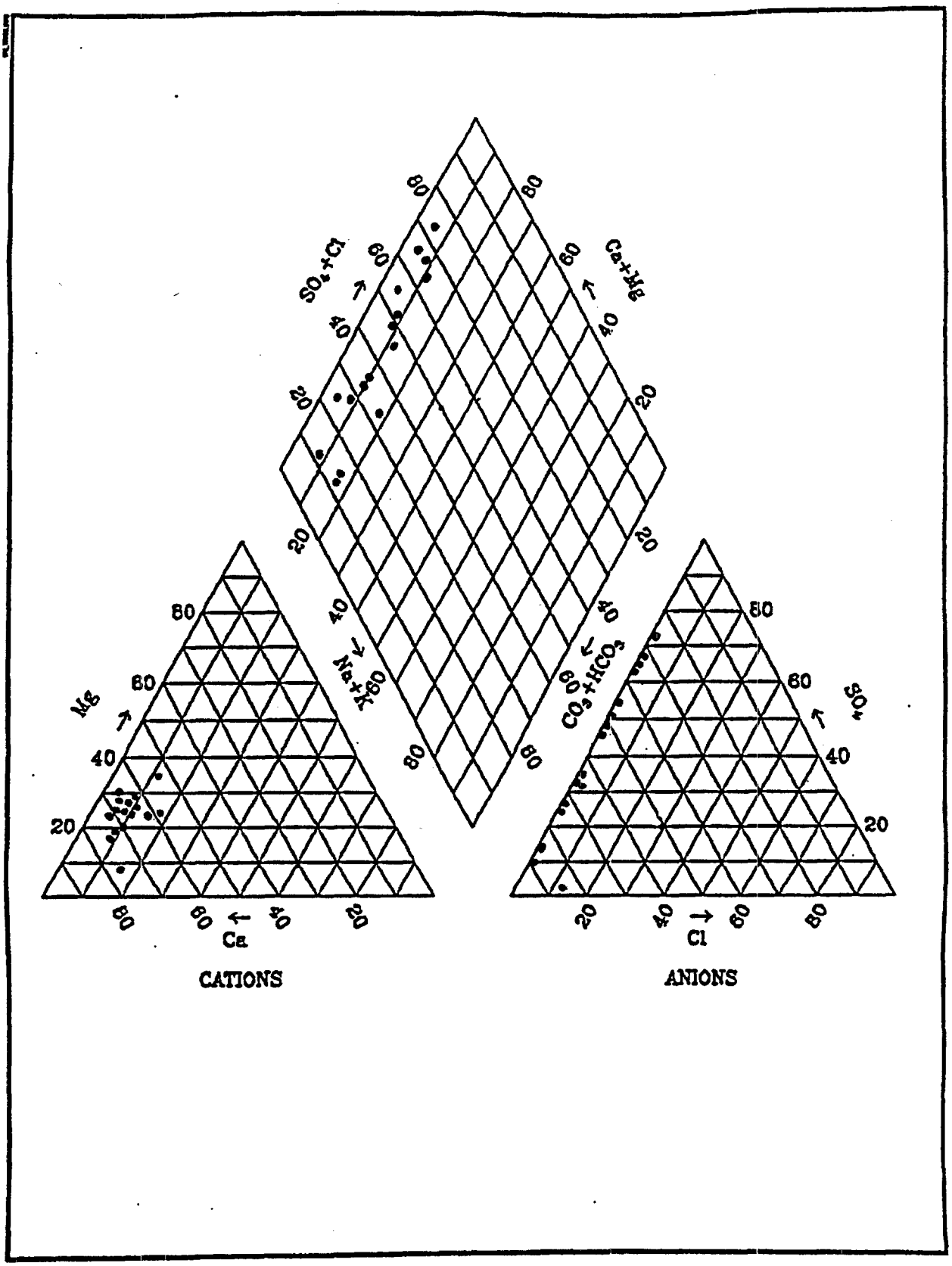


Figure 2-12 Trilinear Diagram For The Weathered Lavery Till Unit (n = No. of Wells = 16).

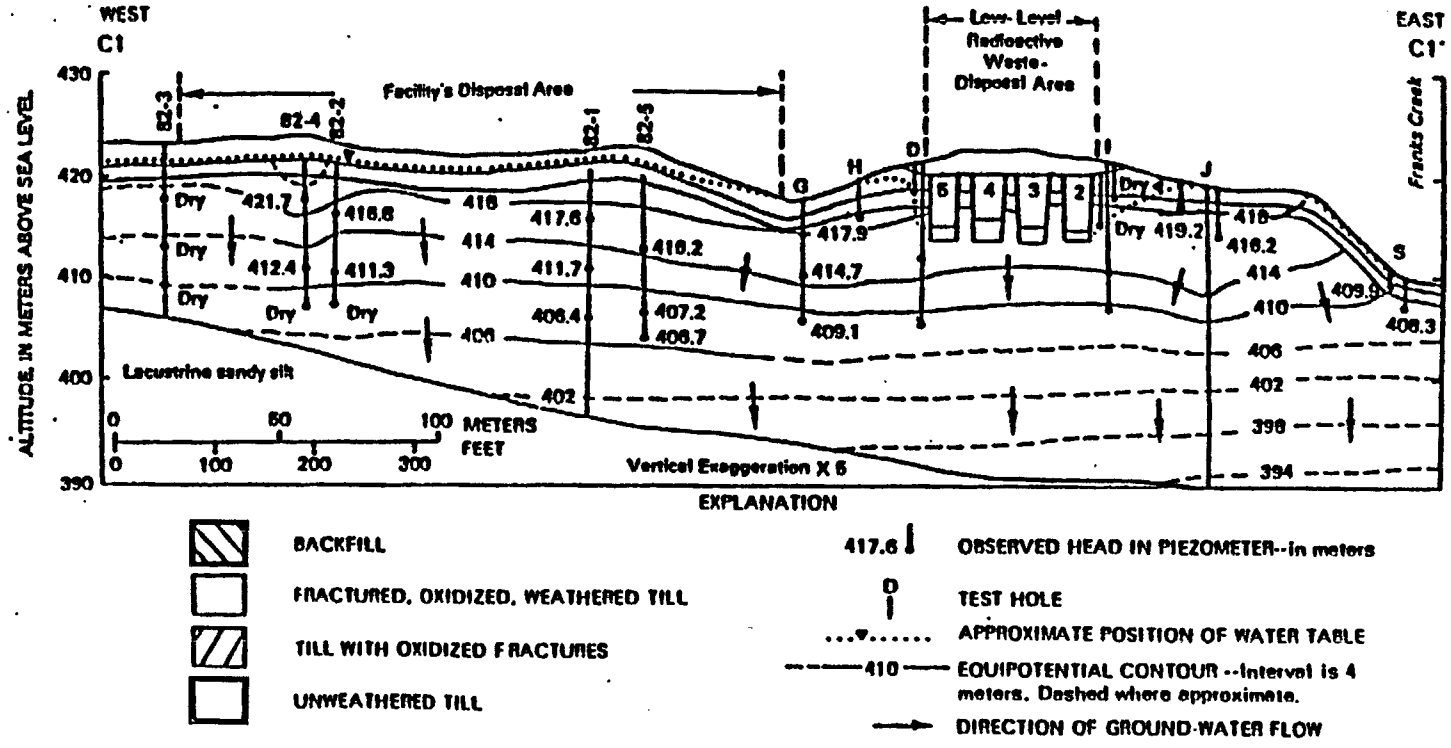


Figure 2-13 West-east cross-section showing distribution of head and groundwater flow directions in the unweathered Lavery Till (from Bergeron et. al. 1987)

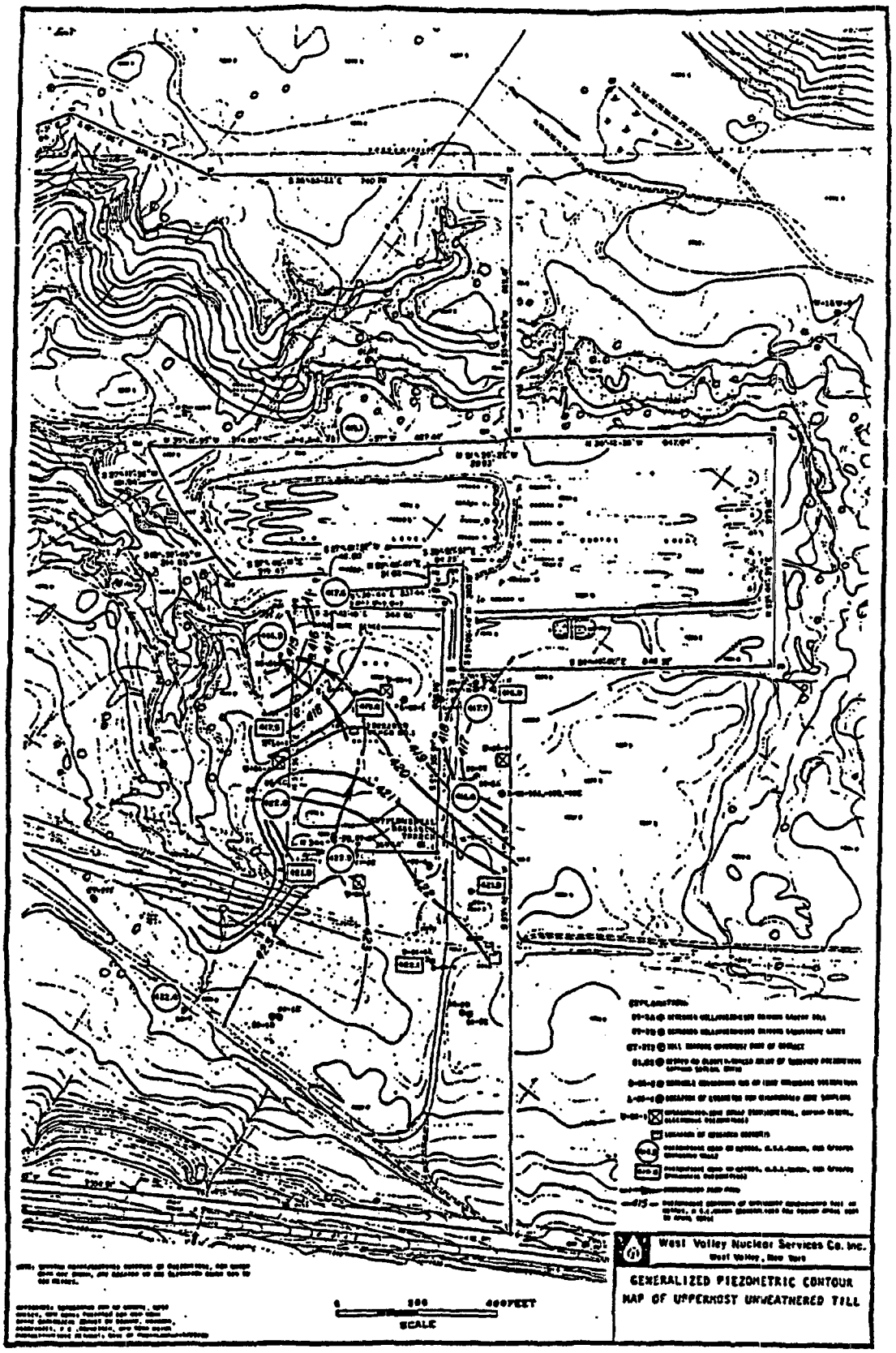


Figure 2-14 April 1985 water table of the unweathered Lavery Till

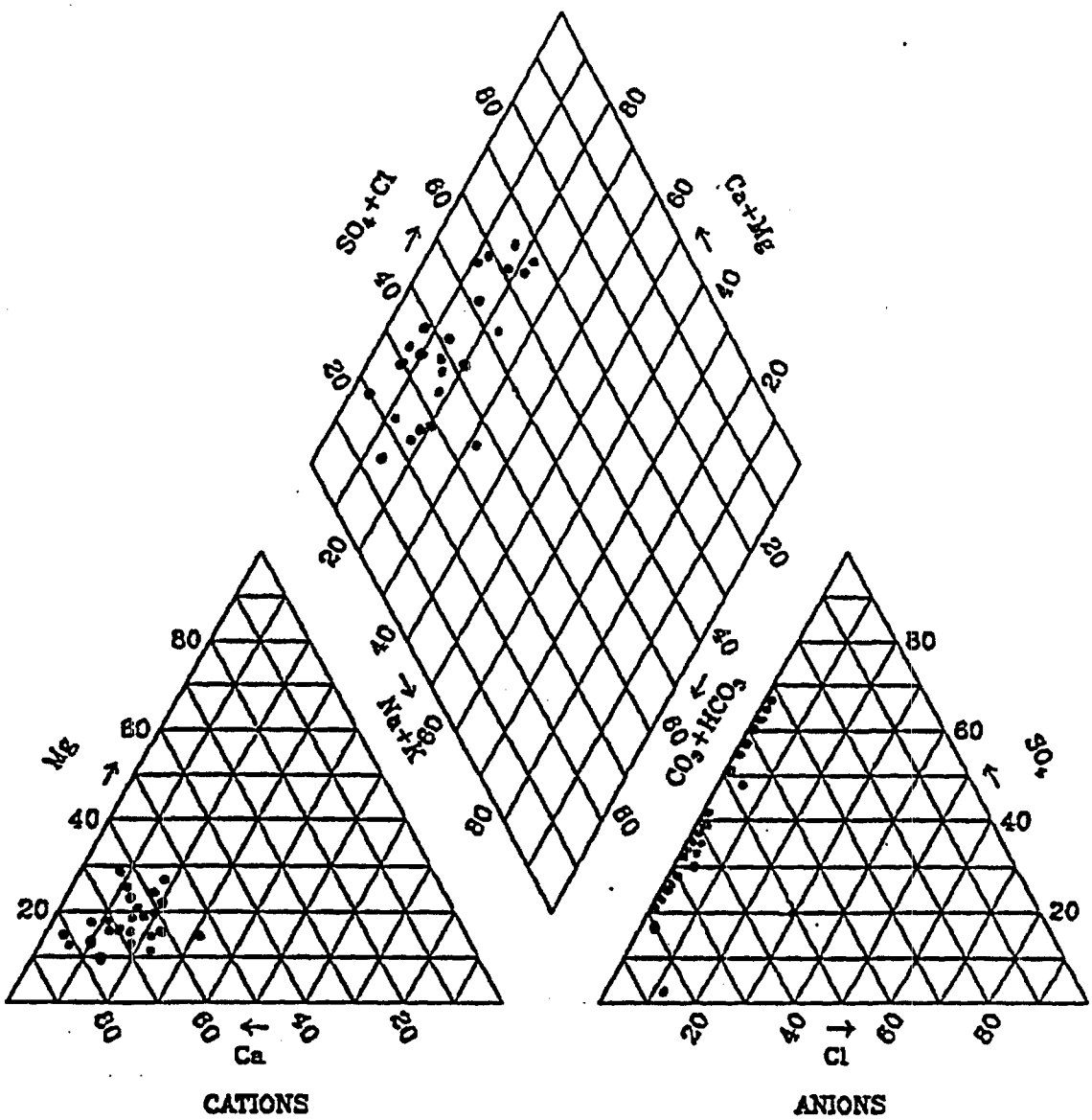


Figure 2-15 Trilinear Diagram For The Unweathered Lovery Till Unit (n = No. of Wells = 24).

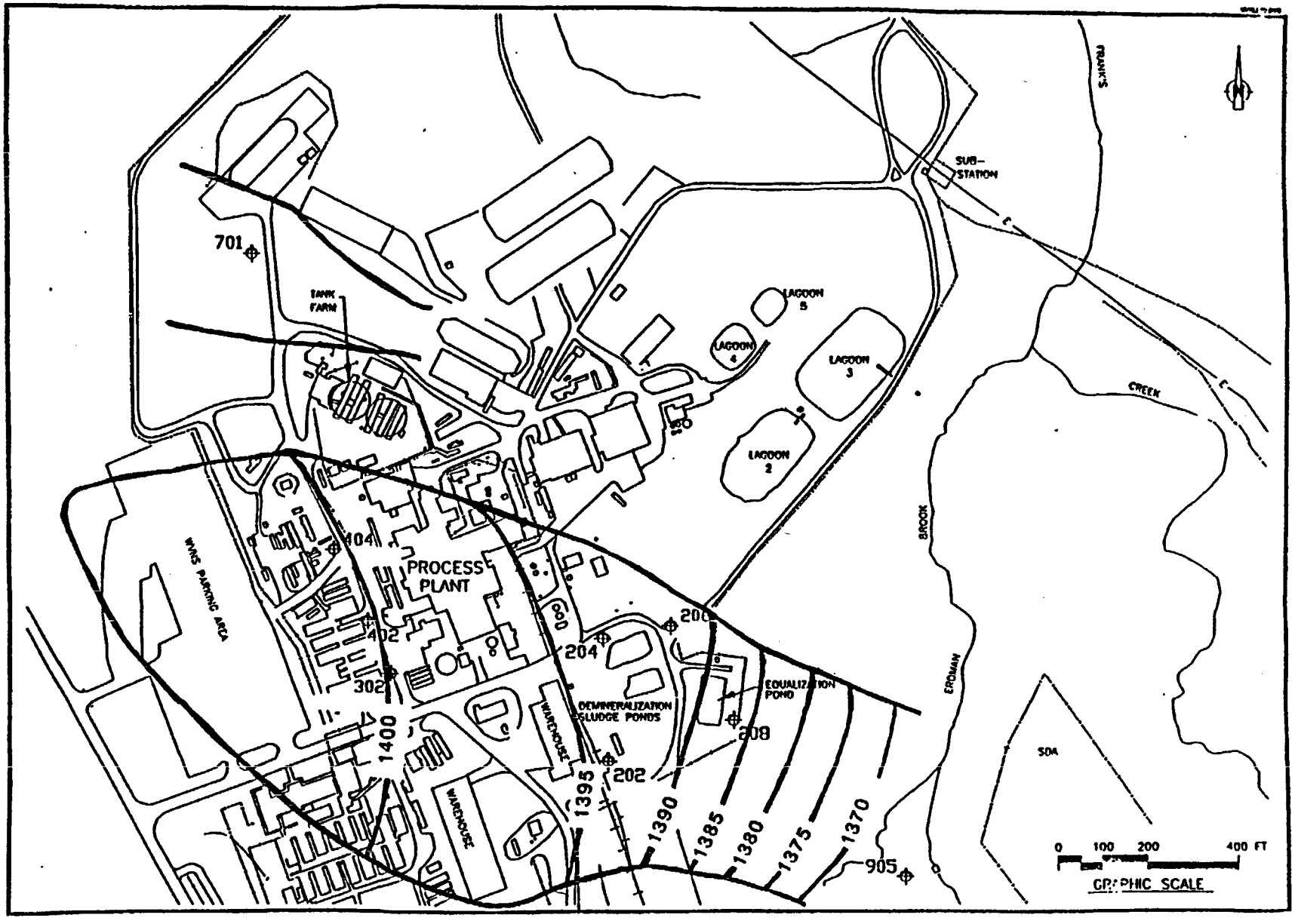


Figure 2-16 October 1991 water table map of the Till Sand Unit

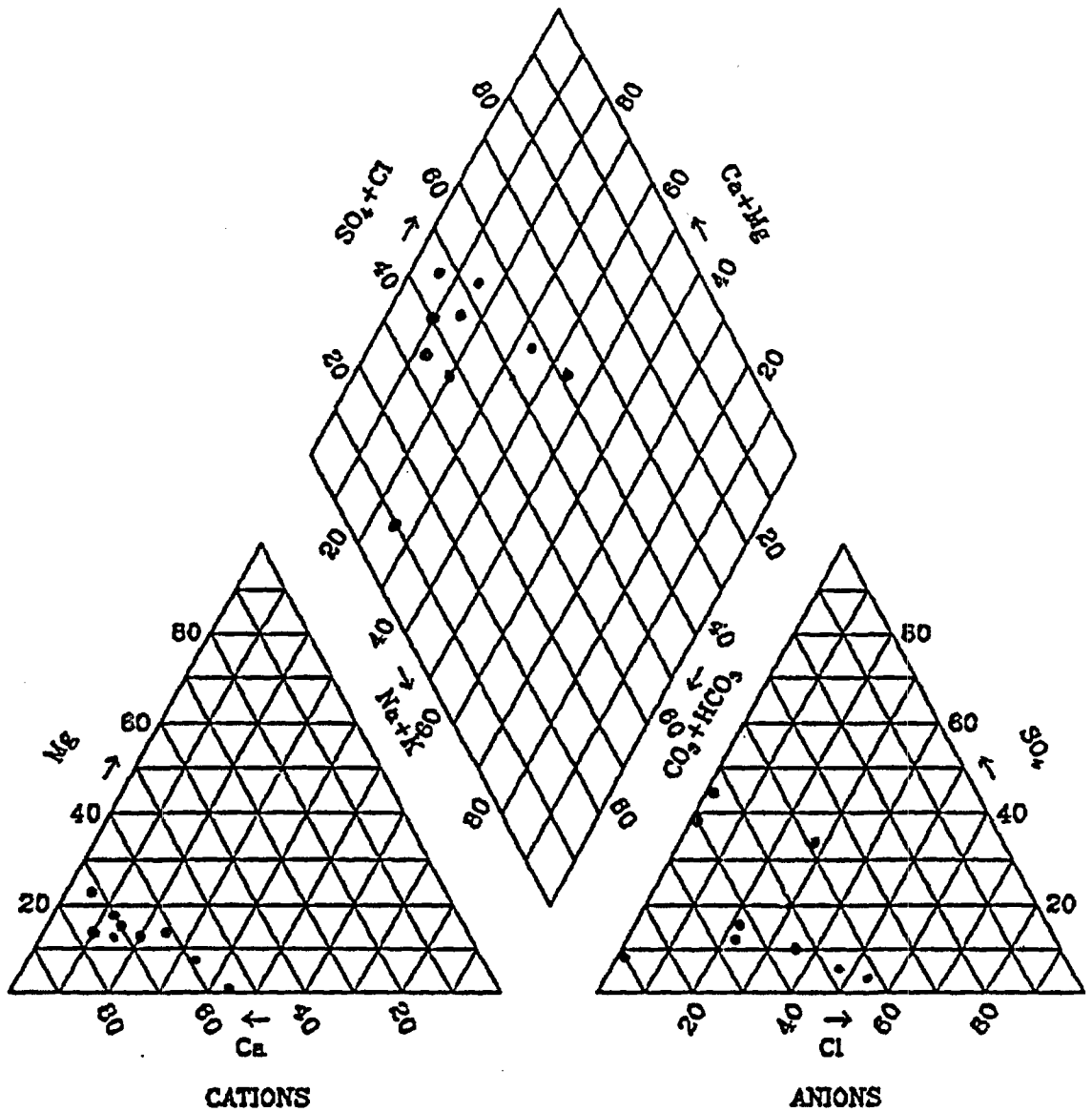


Figure 2-17 Trilinear Diagram For The Till Sand Unit (n = No. of Wells = 9).

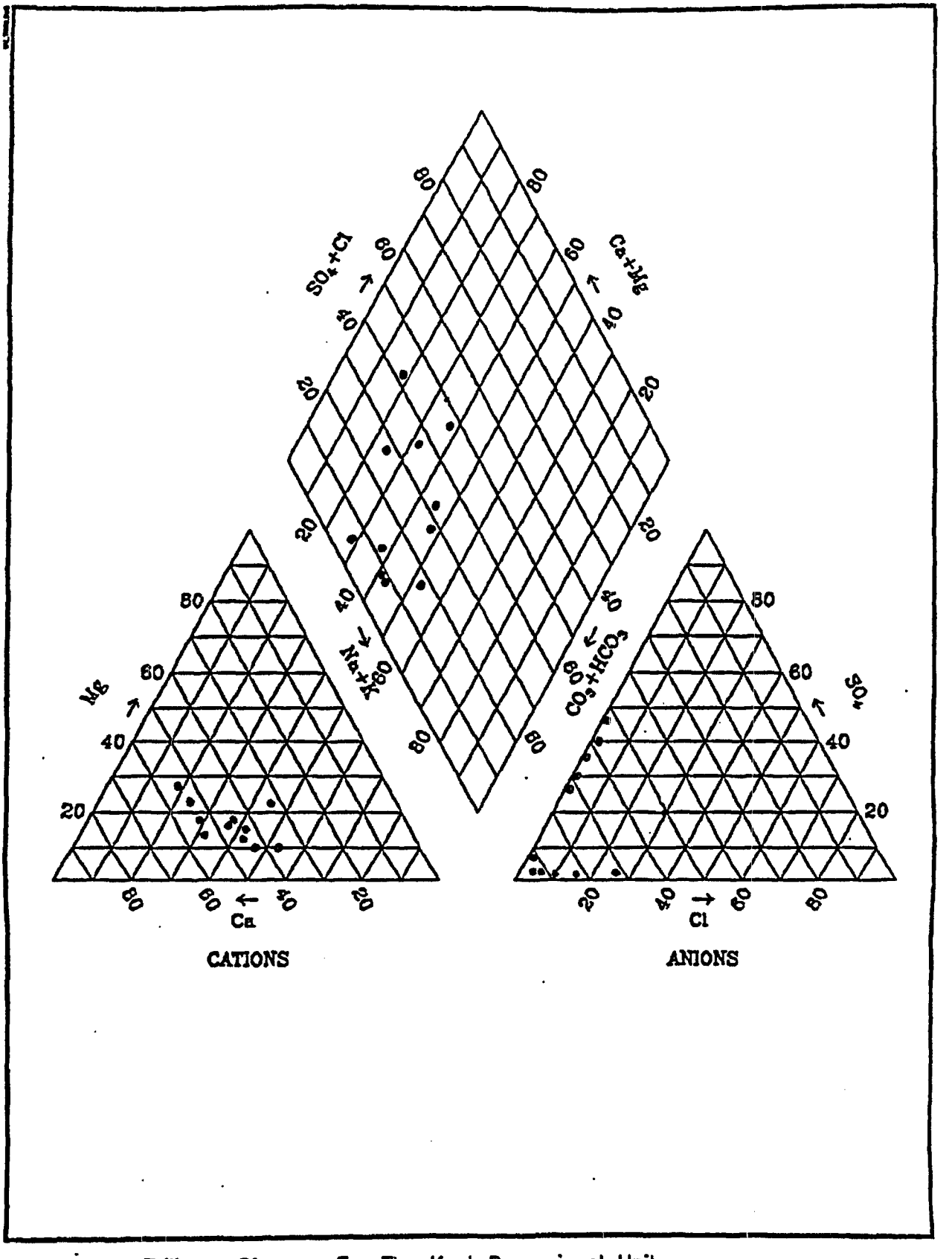
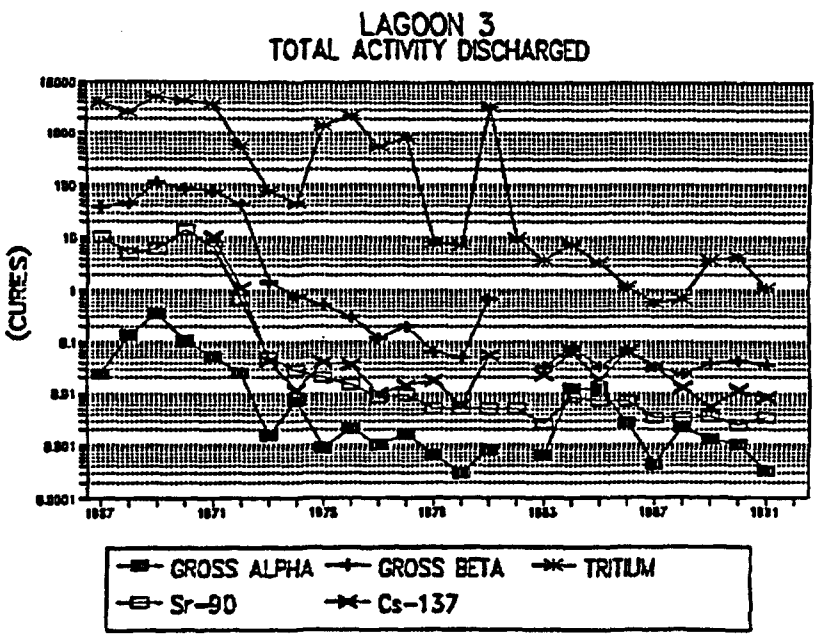


Figure 2-18 Trilinear Diagram For The Kent Recessional Unit (n = No. of Wells = 11).

FIGURE 3.1

LAGOON 3 TOTAL ACTIVITY DISCHARGED (CURIES)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs-137
1967	2.40E-02	3.80E+01	4.20E+03	9.86E+00	
1968	1.39E-01	4.64E+01	2.60E+03	5.03E+00	
1969	3.67E-01	1.08E+02	5.29E+03	6.50E+00	
1970	1.03E-01	8.70E+01	4.52E+03	1.42E+01	
1971	5.50E-02	7.71E+01	3.85E+03	6.59E+00	1.00E+01
1972	2.60E-02	4.29E+01	5.93E+02	6.69E-01	1.09E+00
1973	1.52E-03	1.38E+00	7.52E+01	5.19E-02	4.30E-02
1974	7.00E-03	7.50E-01	4.32E+01	2.90E-02	1.14E-02
1975	9.10E-04	5.30E-01	1.40E+03	2.00E-02	4.10E-02
1976	2.20E-03	3.20E-01	2.20E+03	1.50E-02	3.70E-02
1977	9.80E-04	1.16E-01	5.38E+02	8.20E-03	9.50E-03
1978	1.67E-03	1.93E-01	7.74E+02	9.40E-03	1.40E-02
1979	6.40E-04	6.60E-02	8.10E+00	5.30E-03	1.80E-02
1980	3.10E-04	5.00E-02	7.46E+00	5.40E-03	6.14E-03
1981	8.20E-04	6.90E-01	3.50E+03	5.30E-03	5.60E-02
1982			9.51E+00	5.17E-03	
1983	6.70E-04	3.40E-02	3.90E+00	2.60E-03	2.30E-02
1984	1.20E-02	8.10E-02	7.30E+00	8.50E-03	6.30E-02
1985	1.20E-02	3.30E-02	3.40E+00	7.00E-03	1.90E-02
1986	2.72E-03	7.18E-02	1.15E+00	7.02E-03	6.63E-02
1987	4.30E-04	3.30E-02	5.96E-01	3.35E-03	3.31E-02
1988	2.25E-03	2.45E-02	6.78E-01	3.41E-03	1.26E-02
1989	1.29E-03	3.92E-02	3.88E+00	3.58E-03	5.51E-03
1990	9.90E-04	4.40E-02	4.40E+00	2.50E-03	1.19E-02
1991	3.27E-04	3.83E-02	1.09E+00	3.47E-03	8.42E-03



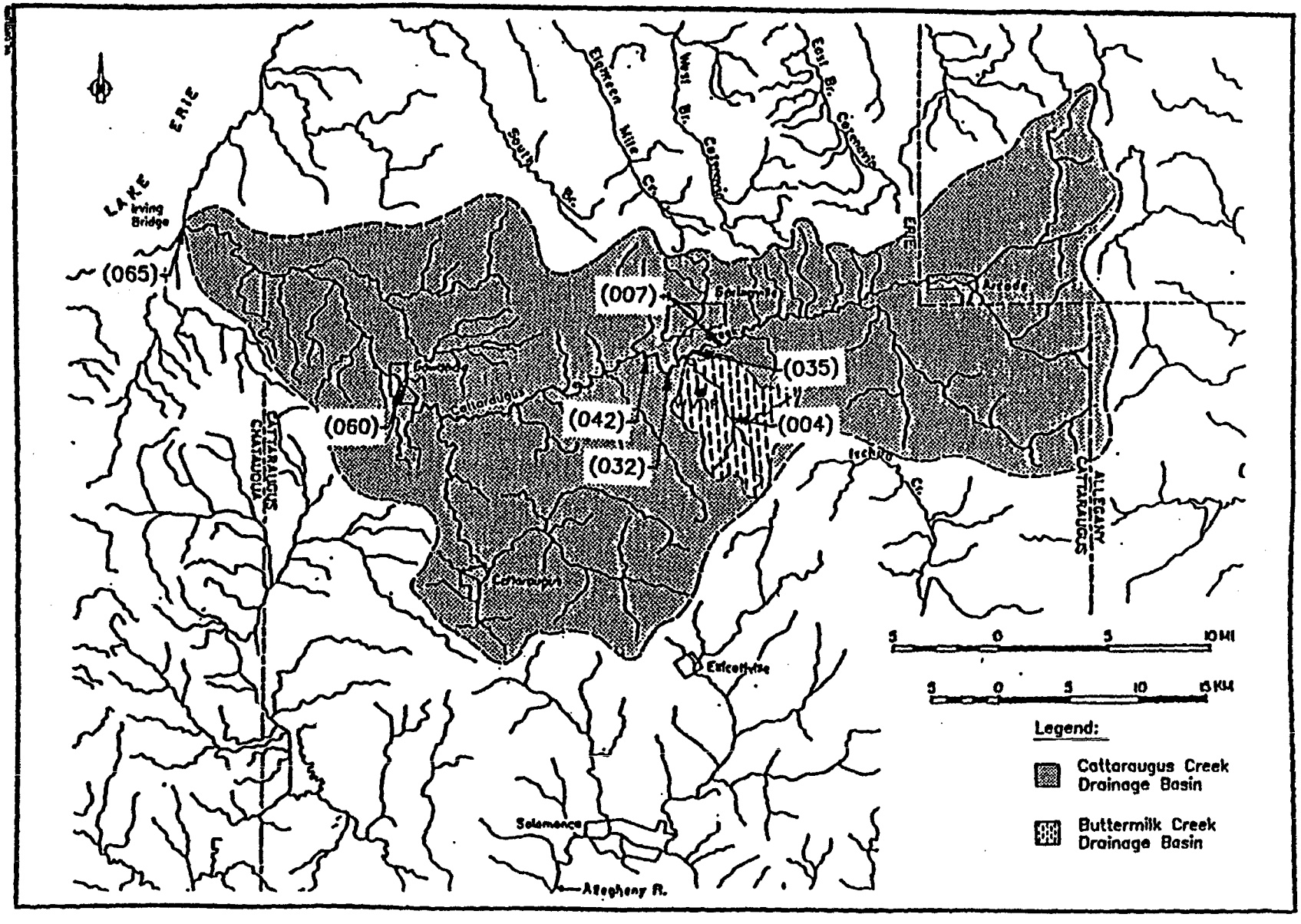


Figure 3-2 Cattaraugus Creek Drainage Basin With Sampling Locations.

FIGURE 3-3

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN BUTTERMILK CREEK, UPSTREAM
AT FOX VALLEY ROAD, SAMPLING LOCATION 004
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965	< 3.0E-09				
1966	< 3.0E-09	2.0E-09			
1967	< 3.0E-09	6.0E-09	< 2.0E-08	1.6E-06	
1968	< 3.0E-09	7.0E-09	< 3.0E-08	1.0E-06	
1969	< 3.0E-09	5.0E-09	< 3.0E-08	< 1.0E-06	
1970	< 3.0E-09	6.0E-09	< 3.0E-08	< 1.0E-06	
1971	< 1.0E-09	4.0E-09	< 3.0E-08	5.0E-07	< 1.0E-09
1972		4.0E-09		< 5.0E-07	< 1.0E-09
1973		3.0E-09		5.0E-07	1.0E-09
1974		6.0E-09		2.8E-07	< 3.0E-09
1975		8.0E-09		2.9E-07	5.0E-09
1976		5.0E-09		4.2E-07	2.0E-09
1977		6.0E-09		3.5E-07	< 3.0E-09
1978		5.0E-09		2.1E-07	4.0E-09
1979		7.5E-09		< 2.1E-07	< 2.4E-09
1980		4.5E-09		1.9E-07	< 2.5E-09
1981		< 3.8E-09		1.7E-07	< 5.0E-09

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

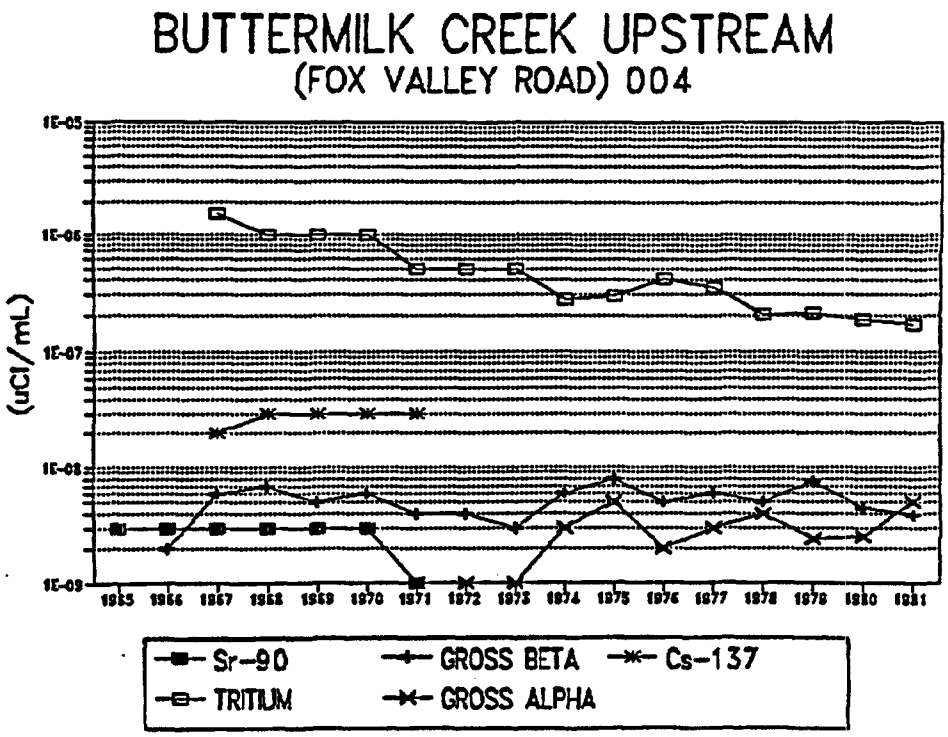


FIGURE 3-4

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN CATTARAUGUS CREEK, UPSTREAM
AT BIGELOW BRIDGE, SAMPLING LOCATION 007
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965	< 3.0E-09				
1966	< 3.0E-09	2.5E-09			
1967	< 3.0E-09	5.0E-09	< 2.0E-08	1.9E-06	
1968	< 3.0E-09	6.0E-09	< 3.0E-08	1.0E-06	
1969	< 3.0E-09	4.0E-09	< 3.0E-08	1.0E-06	
1970	< 3.0E-09	5.0E-09	< 3.0E-08	1.0E-06	
1971	< 3.0E-09	4.0E-09	< 3.0E-08	5.0E-07	< 1.0E-09
1972	3.0E-09	1.1E-08		< 1.0E-06	< 1.0E-09
1973	< 3.0E-09	6.0E-09		< 5.0E-07	1.0E-09
1974	< 1.0E-09	5.0E-09		3.7E-07	< 3.0E-09
1975	7.0E-10	4.0E-09		2.9E-07	< 3.0E-09
1976	< 7.0E-10	4.0E-09		4.5E-07	3.0E-09
1977		5.0E-09		3.0E-06	< 4.0E-09
1978		1.2E-08	< 7.0E-09	4.1E-07	< 5.8E-09
1979		9.3E-09		2.4E-07	6.2E-09
1980		5.4E-09		1.8E-07	< 1.5E-09
1981					

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
STATION NOT SAMPLED IN 1981

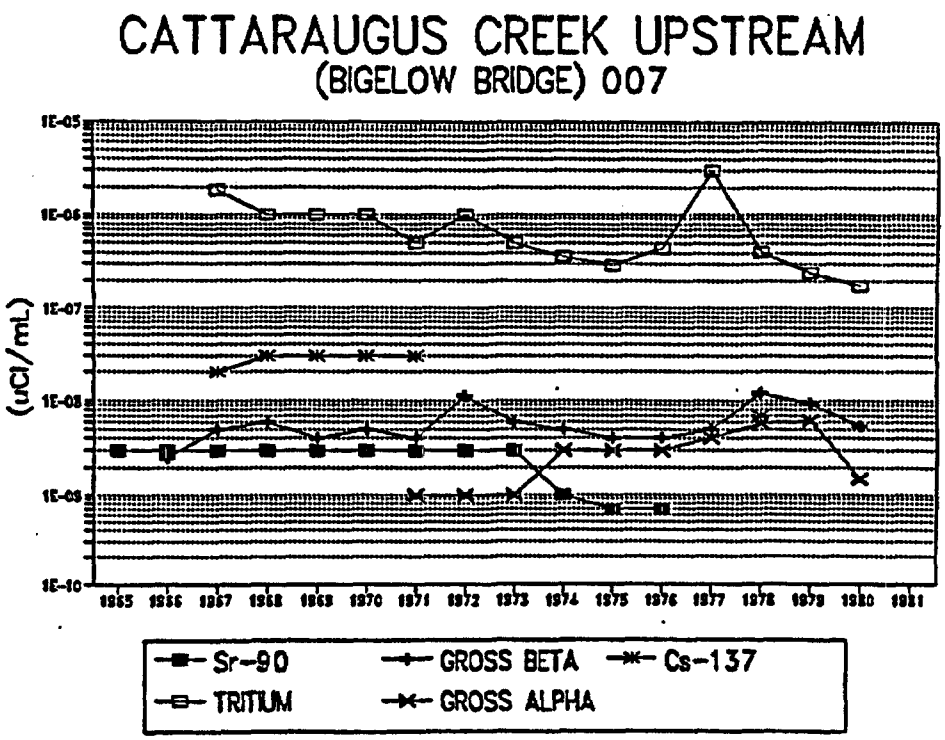


FIGURE 3-5

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN BUTTERMILK CREEK, DOWNSTREAM
AT THOMAS CORNERS BRIDGE, SAMPLING LOCATION 035
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965	< 3.0E-09				
1966	< 3.0E-09	5.8E-09			
1967	3.4E-07	9.7E-07	1.1E-07	3.2E-04	
1968	3.2E-07	1.3E-06	1.2E-07	2.7E-04	
1969	4.1E-07	1.8E-06	1.5E-07	1.2E-04	
1970	6.6E-07	1.7E-06	1.8E-07	2.0E-04	
1971	4.7E-07	2.7E-06	7.4E-08	4.1E-04	< 1.0E-09
1972	9.5E-08	1.9E-06	3.0E-08	2.3E-05	1.0E-09
1973	3.1E-08	1.1E-07	3.0E-08	2.1E-06	1.0E-09
1974	2.1E-08	5.0E-09	7.0E-09	2.9E-06	7.1E-08
1975	1.6E-08	5.5E-08	1.5E-07	4.6E-05	5.0E-09
1976	8.0E-09	3.8E-08	9.0E-09	8.3E-05	6.0E-09
1977		2.5E-08	1.3E-08	1.5E-05	< 6.0E-09
1978		2.2E-08	1.1E-08	3.7E-05	6.0E-09
1979		1.8E-08		7.4E-07	5.1E-09
1980		2.5E-08	1.6E-08	6.6E-07	9.2E-09
1981		1.5E-08		7.7E-05	< 6.0E-09

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

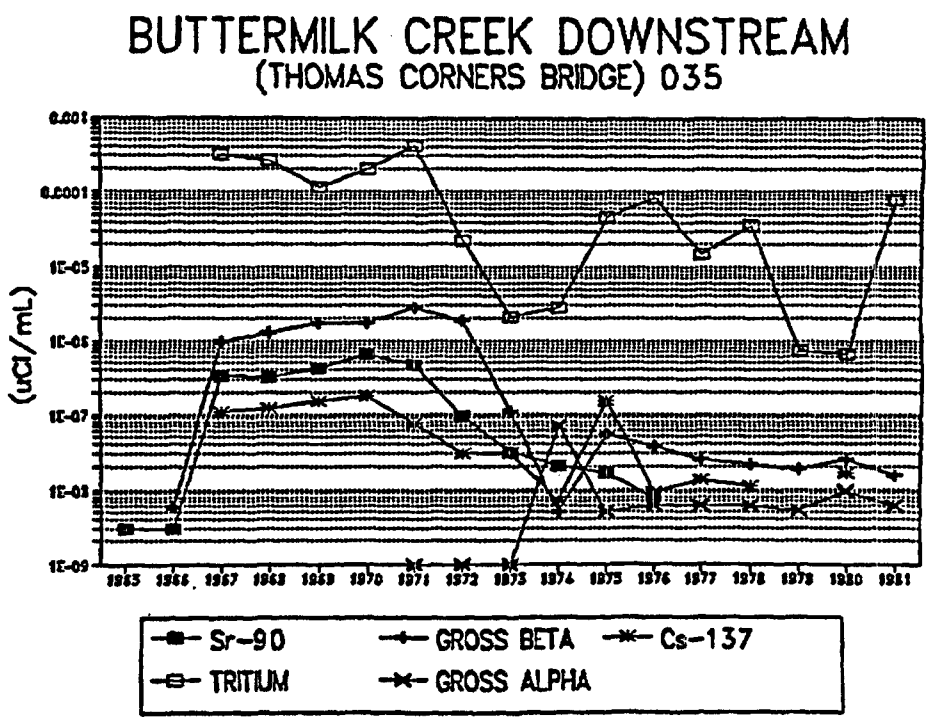


FIGURE 3-6

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN CATTARAUGUS CREEK, DOWNSTREAM
FELTON BRIDGE, SAMPLING LOCATION 032
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965					
1966					
1967					
1968	2.31E-07	2.82E-07	3.58E-07	7.49E-05	
1969	1.27E-07	3.27E-07	< 3.00E-08	8.78E-06	
1970		1.76E-07	8.60E-08		
1971					
1972					
1973					
1974					
1975					
1976					
1977		1.30E-08	7.00E-09	4.50E-07	
1978		3.70E-09	< 2.07E-09	1.06E-05	< 5.00E-09
1979		1.20E-08		4.40E-07	< 3.00E-09
1980	9.00E-10	2.50E-09	< 9.00E-09	2.13E-07	< 1.90E-09
1981	8.00E-10	5.00E-09	< 7.00E-09	3.96E-06	< 5.00E-09

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
STATION NOT SAMPLED 1965 - 1967 AND 1971 - 1976

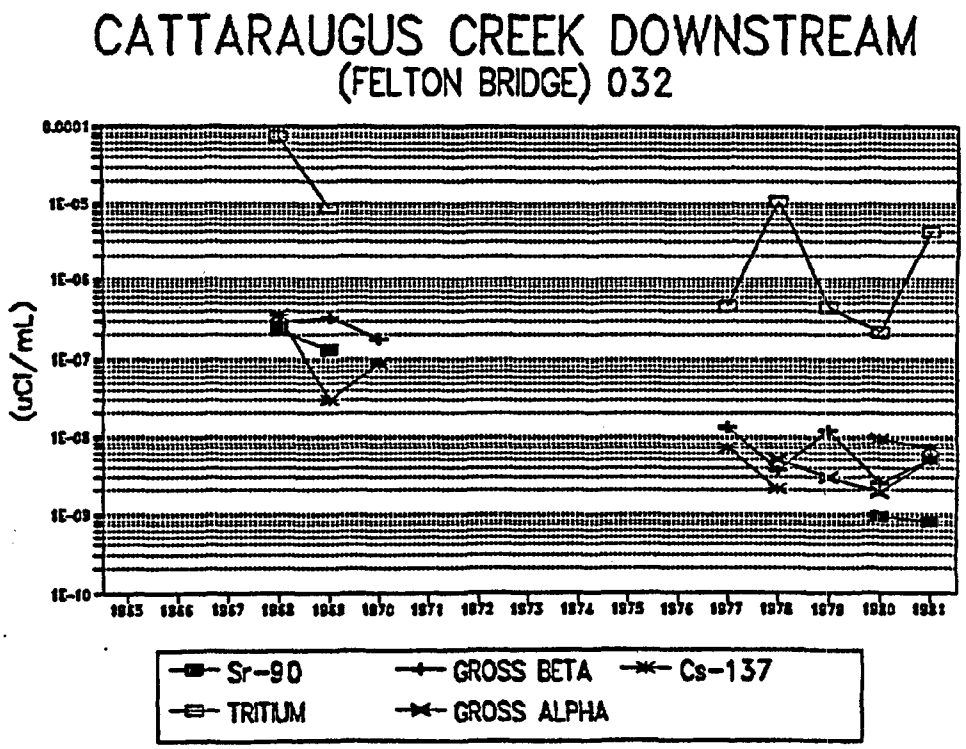


FIGURE 3-7

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN CATTARAUGUS CREEK, DOWNSTREAM
AT SPRINGVILLE DAM, SAMPLING LOCATION 042
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965	< 3.00E-09				
1966	6.20E-08	1.16E-07			
1967	2.40E-08	9.50E-08	< 2.00E-08	3.07E-05	
1968	2.50E-08	1.23E-07	2.00E-08	2.17E-05	
1969	7.20E-08	2.25E-07	8.60E-08	1.80E-05	
1970	1.48E-07	2.34E-07	1.97E-07	1.99E-05	
1971	9.50E-08	2.03E-07	2.90E-08	3.32E-05	
1972	1.30E-08	1.67E-07	3.00E-08	2.24E-06	2.00E-09
1973	4.00E-09	1.90E-08		5.00E-07	1.00E-09
1974	3.00E-09	1.50E-08	< 5.00E-09	7.64E-07	4.00E-09
1975	3.00E-09	1.10E-08	8.00E-08	6.22E-06	4.00E-09
1976	2.00E-09	1.00E-08		8.40E-06	5.00E-09
1977	1.20E-09	9.00E-09		1.79E-06	< 6.00E-09
1978	2.30E-09	7.20E-09	< 5.00E-09	2.72E-06	3.90E-09
1979	1.20E-09	5.00E-09	< 7.00E-09	3.47E-07	< 2.50E-09
1980	1.20E-09	5.00E-09		2.18E-07	4.60E-09
1981	1.60E-09	9.50E-09	< 1.00E-08	9.61E-06	8.40E-09

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

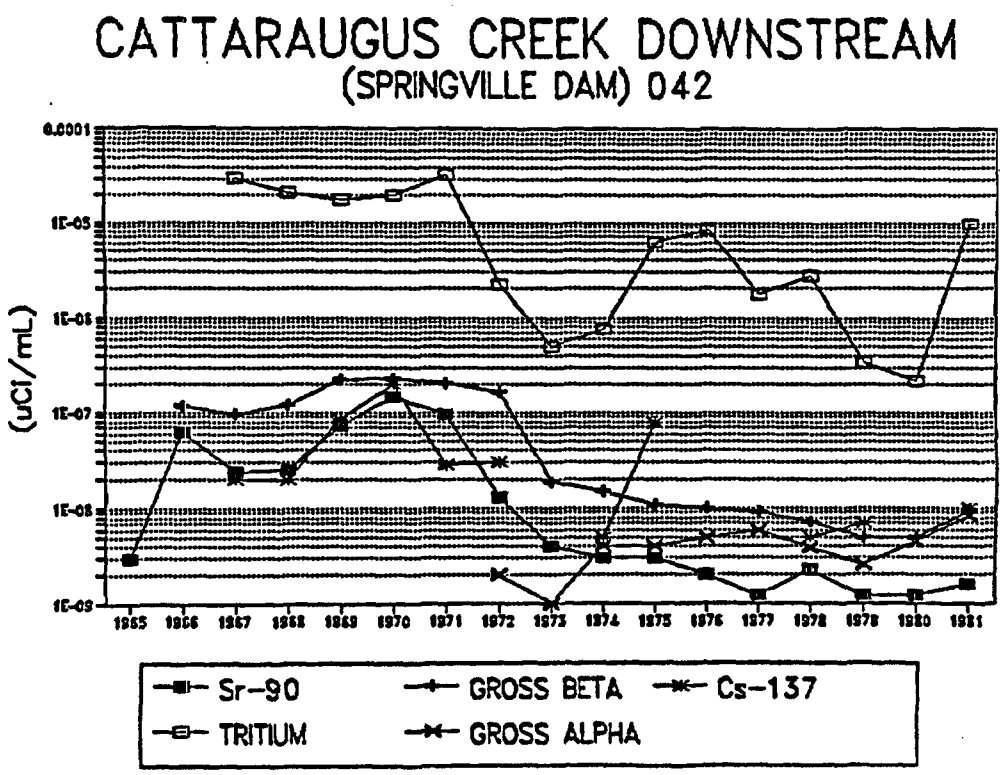


FIGURE 3-8

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN CATTARAUGUS CREEK, DOWNSTREAM
AT GOWANDA, SAMPLING LOCATION 060
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM
1965	< 3.00E-09			
1966				
1967		5.20E-08		2.15E-05
1968		6.50E-08	3.60E-08	1.46E-06
1969	2.30E-08	1.34E-07	< 3.00E-08	1.14E-05
1970	3.60E-08	1.25E-07	2.00E-08	1.04E-05
1971	2.30E-08	7.40E-08	3.00E-08	1.08E-05
1972				
1973				
1974				
1975				
1976				
1977				
1978				
1979				
1980				
1981				

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
STATION NOT SAMPLED IN 1972 - 1981

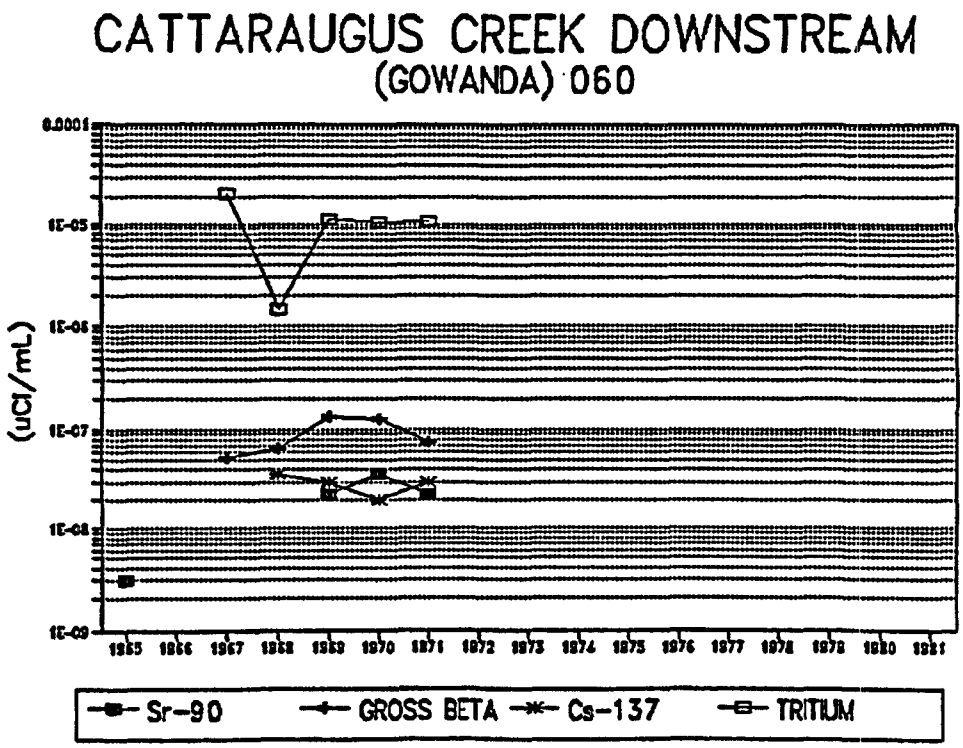


FIGURE 3-9

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN CATTARAUGUS CREEK, DOWNSTREAM
AT IRVING BRIDGE, SAMPLING LOCATION 065
(NYSDOH NYSDEC SAMPLING 1965 - 1981)

	Sr-90	GROSS BETA	Cs-137	TRITIUM	GROSS ALPHA
1965	< 3.00E-09				
1966					
1967		5.10E-08		2.47E-05	
1968		4.70E-08	2.80E-08	1.19E-05	
1969	2.20E-08	1.12E-07	< 3.00E-08	8.53E-06	
1970	3.00E-08	1.06E-07	< 3.00E-08	9.15E-06	
1971	1.70E-08	8.60E-08	3.00E-08	2.01E-05	< 1.00E-09
1972		8.50E-08		9.94E-07	< 1.00E-09
1973		1.20E-08		5.00E-07	
1974		7.00E-09		3.09E-07	< 1.00E-09
1975		6.00E-09		2.53E-06	
1976		6.00E-09		5.65E-06	< 6.00E-09
1977		1.20E-08		7.00E-07	
1978		4.20E-09		1.02E-06	< 2.90E-09
1979		5.40E-09		3.70E-07	< 2.90E-09
1980		4.00E-09		1.85E-07	< 3.00E-09
1981					

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
STATION NOT SAMPLED IN 1966 -1981

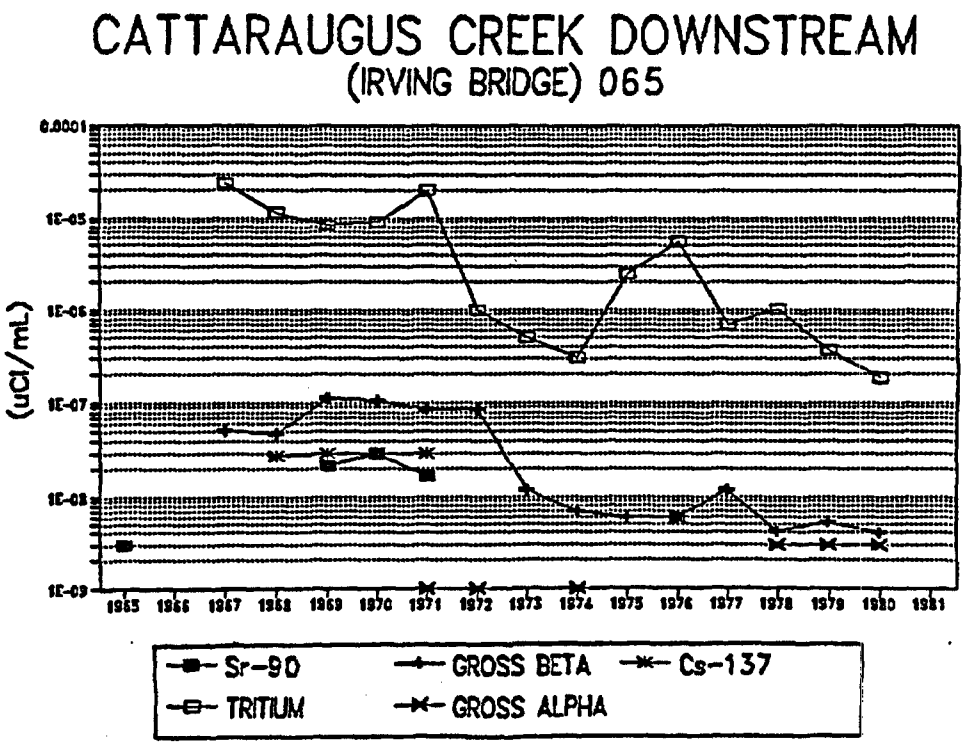


FIGURE 3-10

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
BUTTERMILK CREEK, THOMAS CORNERS BRIDGE SAMPLING LOCATION 035
(NFS SAMPLING 1971 - 1981)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1971	< 7.6E-08	3.0E-06	2.0E-03
1972	< 5.4E-08	1.1E-06 (3)	3.6E-03 (3)
1973	1.8E-09 (1)	5.9E-08	< 2.2E-06
1974	1.3E-09 (3)	2.0E-06	3.6E-06 (1)
1975	6.7E-10 (1)	3.8E-08	1.3E-04
1976	7.0E-10 (1)	4.7E-08	1.9E-04
1977	< 1.1E-09	1.4E-08	6.5E-05
1978	< 8.4E-10	2.1E-08	1.5E-05
1979	< 7.5E-10	1.7E-08	2.9E-06
1980	< 8.3E-10	1.7E-08	4.8E-06
1981	< 7.3E-10	2.1E-08	1.1E-04

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

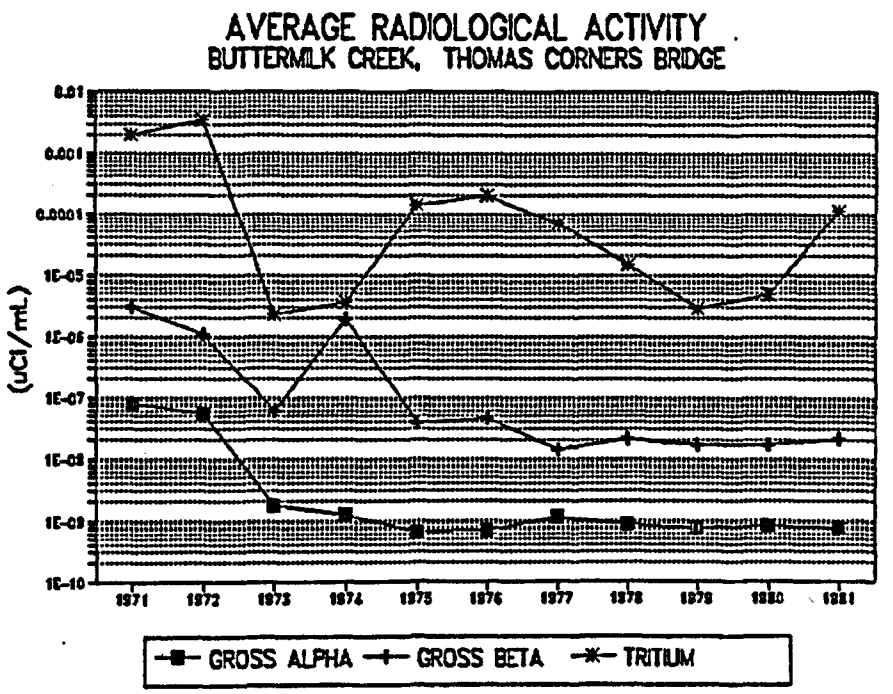


FIGURE 3-11

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
CATTARAUGUS CREEK UPSTREAM, BIGELOW BRIDGE, SAMPLING LOCATION 007
(NFS SAMPLING 1971 - 1981)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1971	7.9E-10 (2)	< 3.4E-08	6.8E-06 (3)
1972	< 1.9E-08	< 1.4E-08	6.9E-06 (2)
1973	1.7E-09 (3)	1.6E-08 (3)	1.9E-06 (1)
1974	5.2E-10 (1)	3.8E-09 (8)	1.8E-06 (1)
1975	6.6E-10 (3)	3.6E-09 (6)	< 1.5E-06
1976	< 6.4E-10	3.3E-09 (5)	3.7E-07 (2)
1977	7.8E-10 (3)	6.4E-09	< 4.8E-07
1978	< 9.1E-10	5.4E-09	9.3E-07
1979	< 7.7E-10	7.9E-09 (10)	9.9E-07
1980	< 7.4E-10	8.9E-09	1.0E-06
1981	4.1E-10 (1)	7.7E-09 (9)	1.2E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

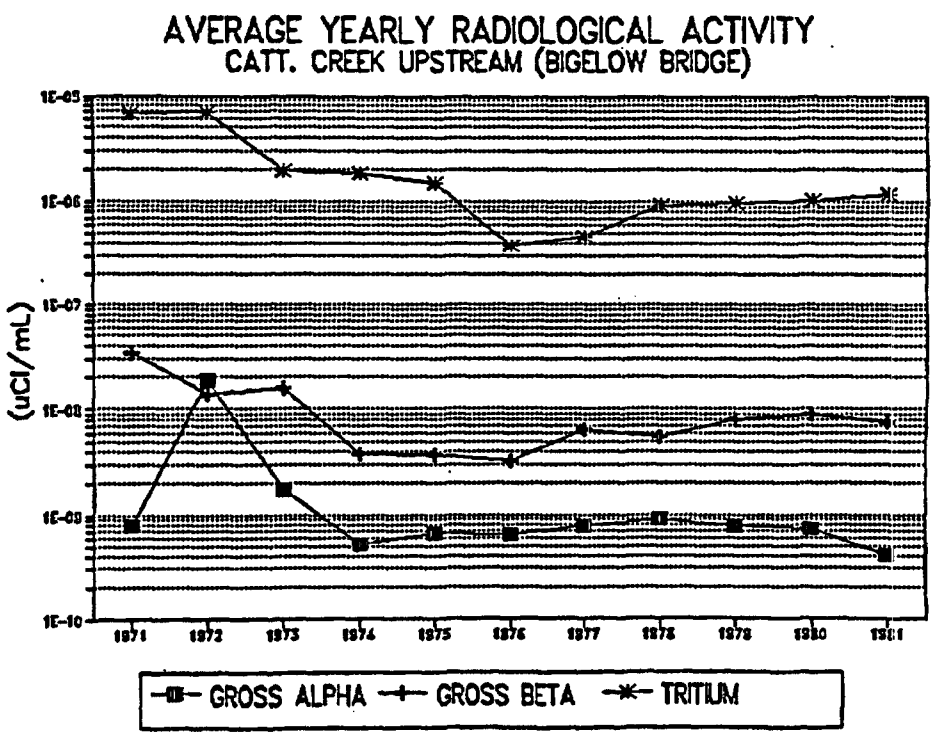
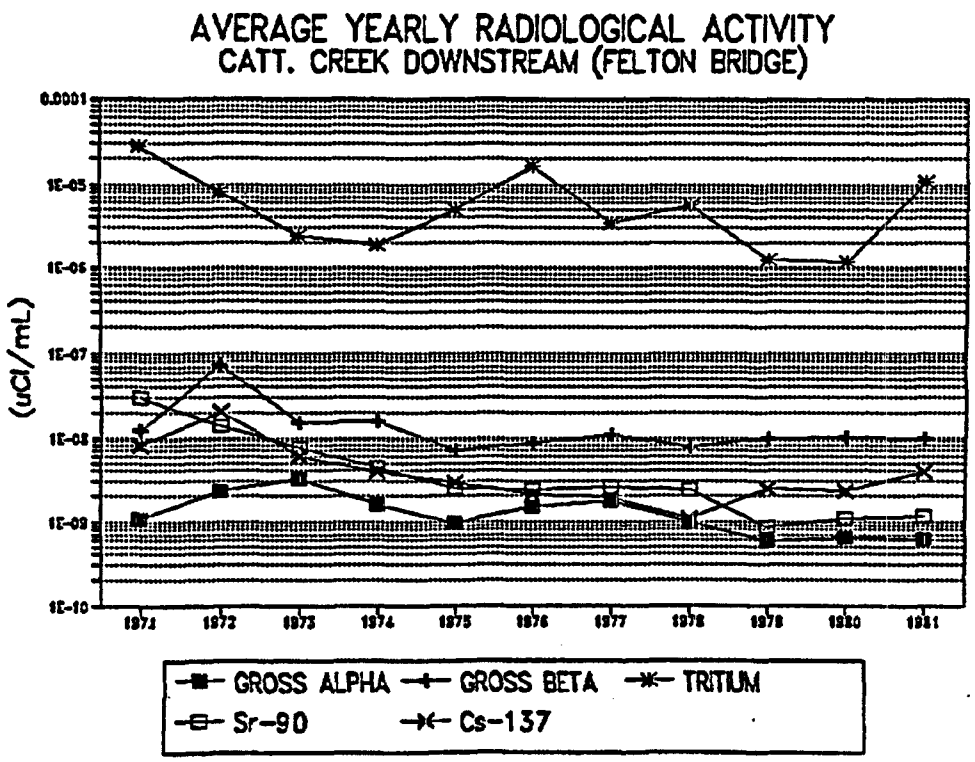


FIGURE 3-12

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
CATTARAUGUS CREEK DOWNSTREAM, FELTON BRIDGE, SAMPLING LOCATION 032
(NFS SAMPLING 1971 - 1981)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs-137
1971	1.11E-09 (2)	1.22E-08	2.78E-05	3.00E-08	8.09E-09
1972	2.26E-09 (1)	7.46E-08	8.17E-06 (2)	1.39E-08	2.08E-08
1973	< 3.21E-09	1.52E-08 (5)	2.42E-06 (2)	7.49E-09	5.79E-09
1974	1.63E-09 (2)	1.55E-08	1.87E-06 (1)	4.42E-09	3.89E-09
1975	< 9.53E-10	6.96E-09 (11)	4.94E-06 (6)	2.51E-09	2.96E-09
1976	1.52E-09 (7)	8.43E-09 (11)	1.64E-05 (10)	2.41E-09	2.09E-09
1977	1.74E-09 (6)	1.09E-08	3.45E-06 (10)	2.58E-09 (11)	1.99E-09
1978	< 9.94E-10	7.67E-09	5.69E-06	2.43E-09	1.06E-09 (1)
1979	5.91E-10 (1)	9.46E-09 (10)	1.20E-06	8.66E-10 (10)	2.46E-09 (3)
1980	6.35E-10 (2)	1.02E-08	1.14E-06	1.08E-09	< 2.27E-09
1981	< 6.30E-10	9.75E-09	1.09E-05	1.18E-09 (10)	< 3.98E-09

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION



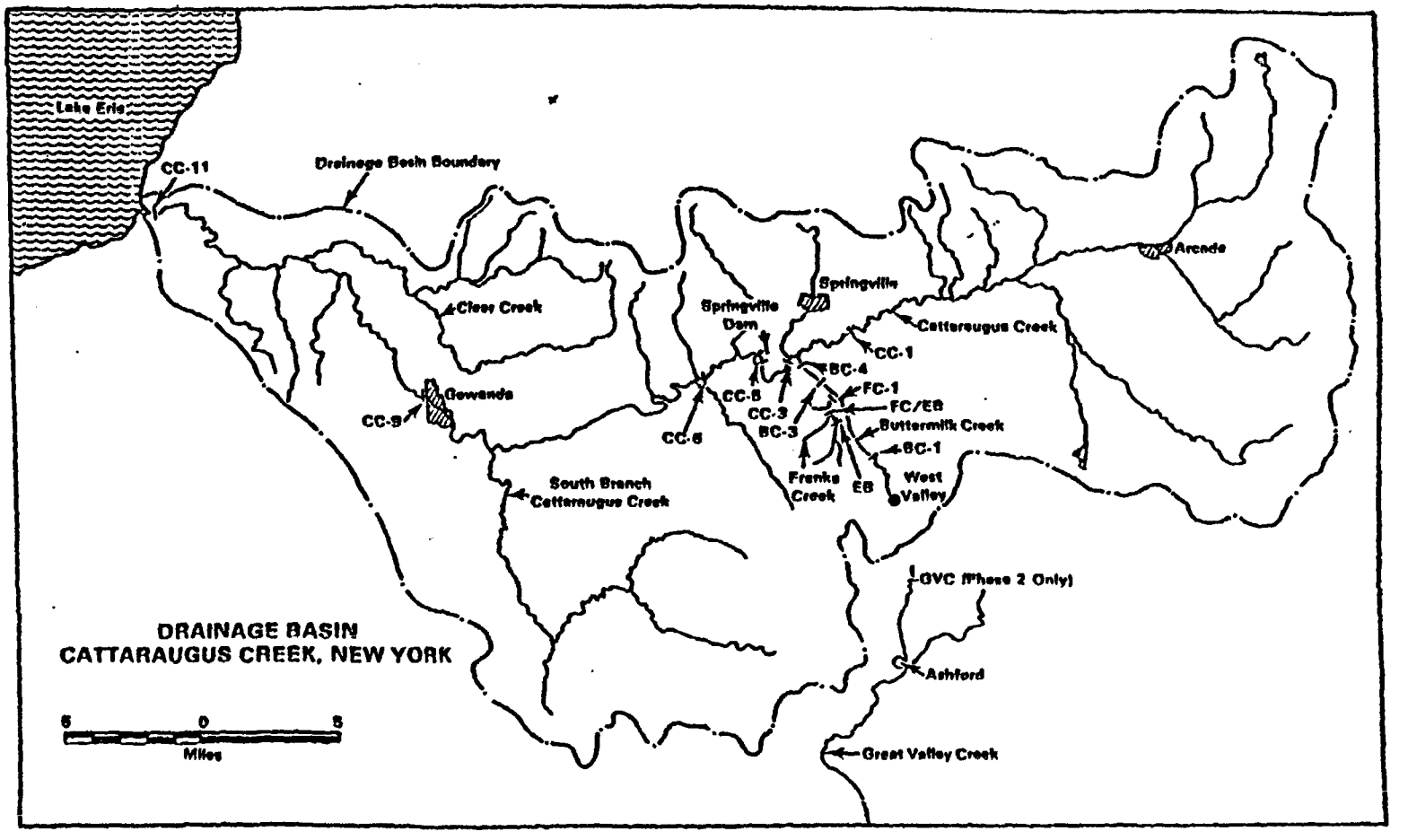
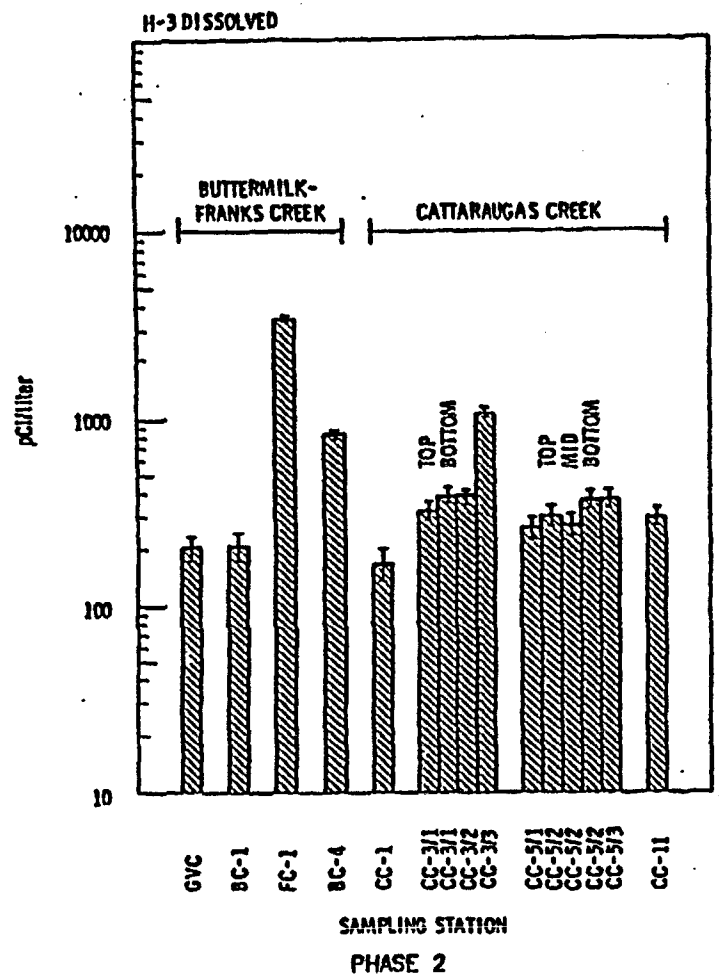


Figure 3-13 Pacific Northwest Laboratory (PNL) Surface Water Sampling Locations (1977–1979).



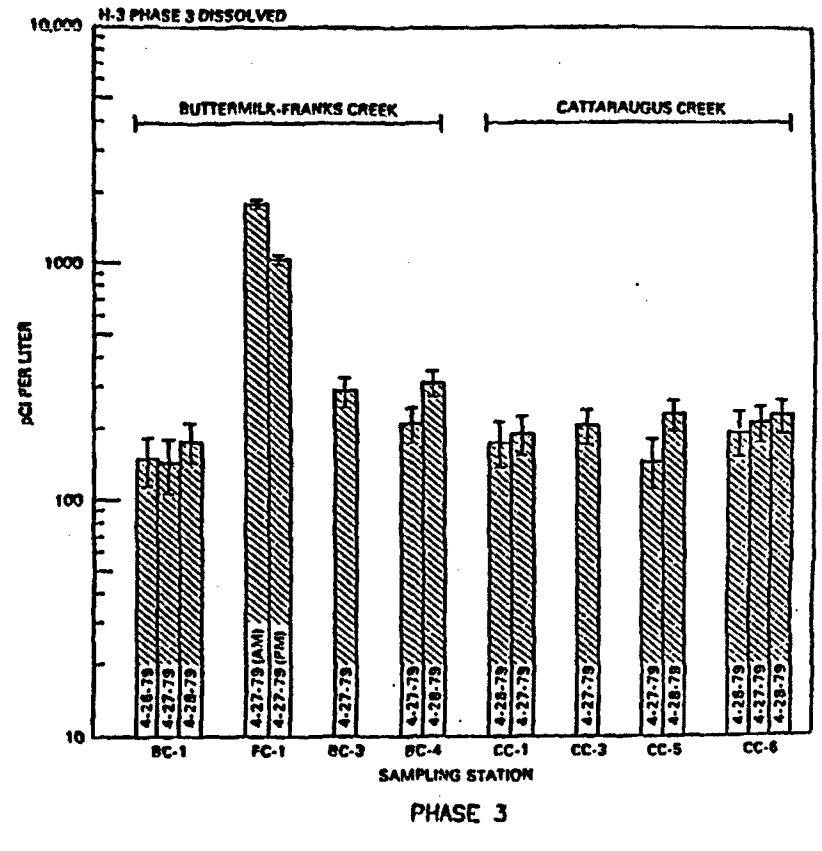


Figure 3-14 PNL Phase 2 and Phase 3 Tritium Concentrations in Water.

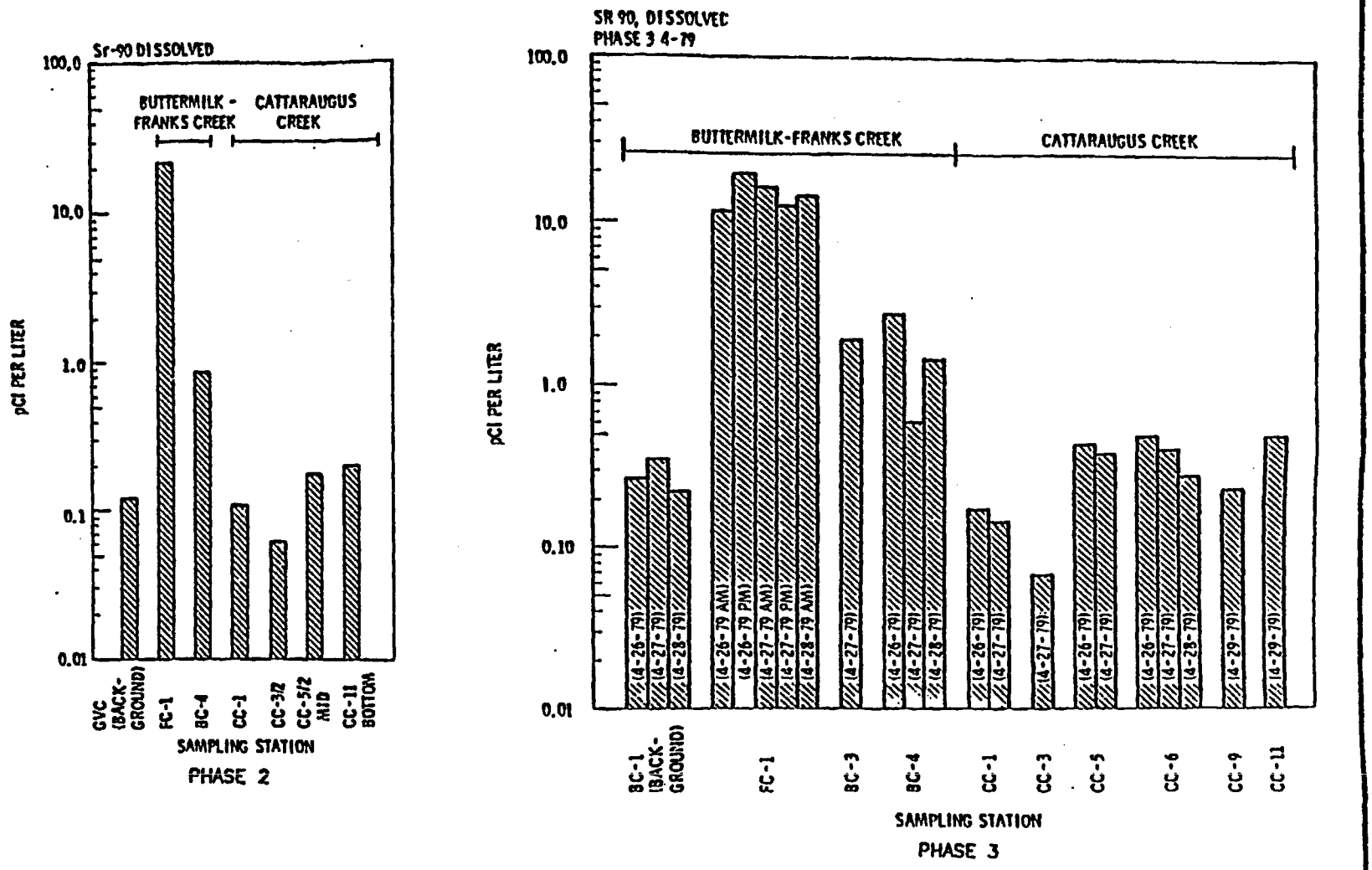


Figure 3-15 PNL Phase 2 and Phase 3 Sr-90 Concentrations in Water.

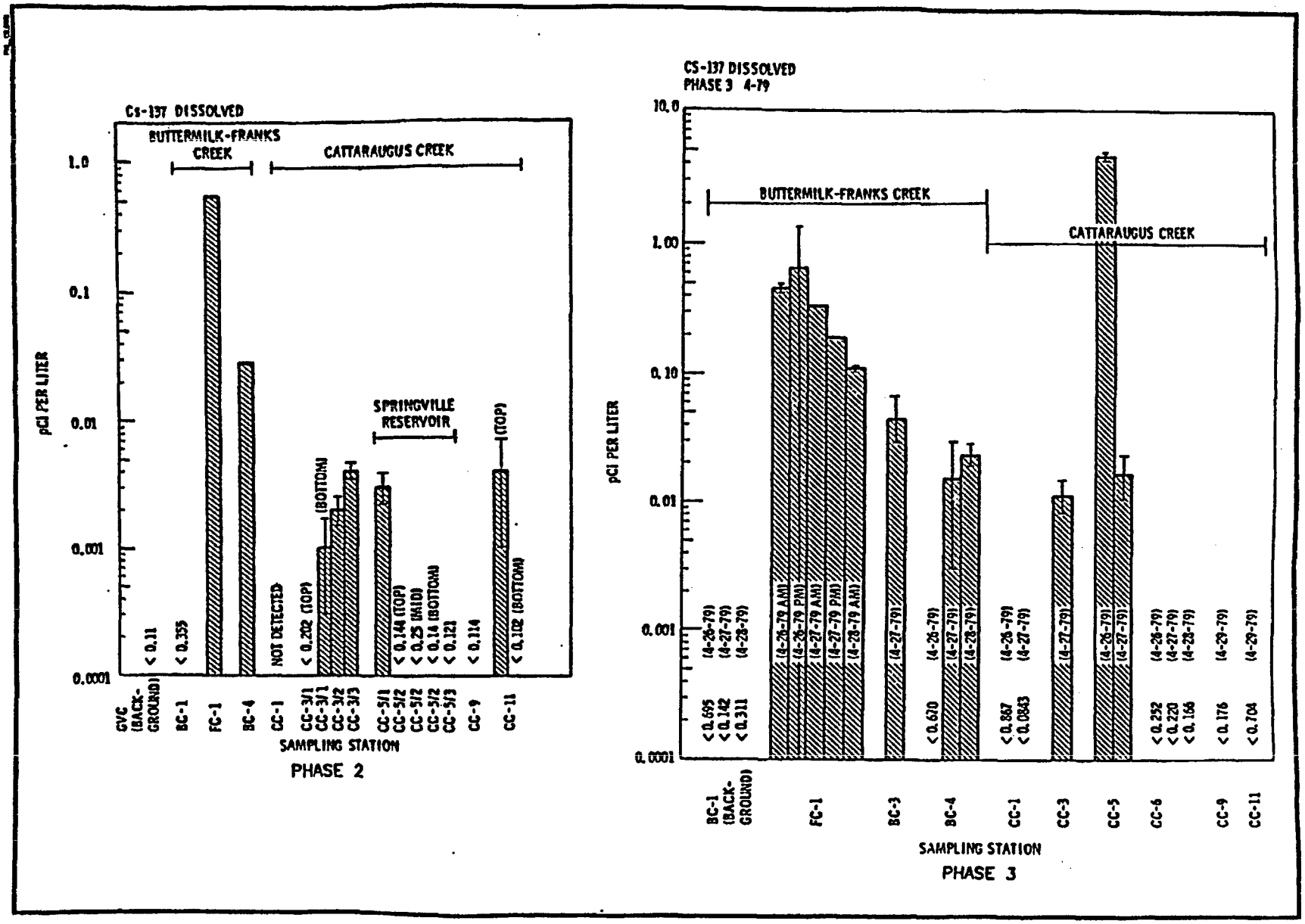


Figure 3-16 PNL Phase 2 and Phase 3 Cs–137 Concentrations in Water.

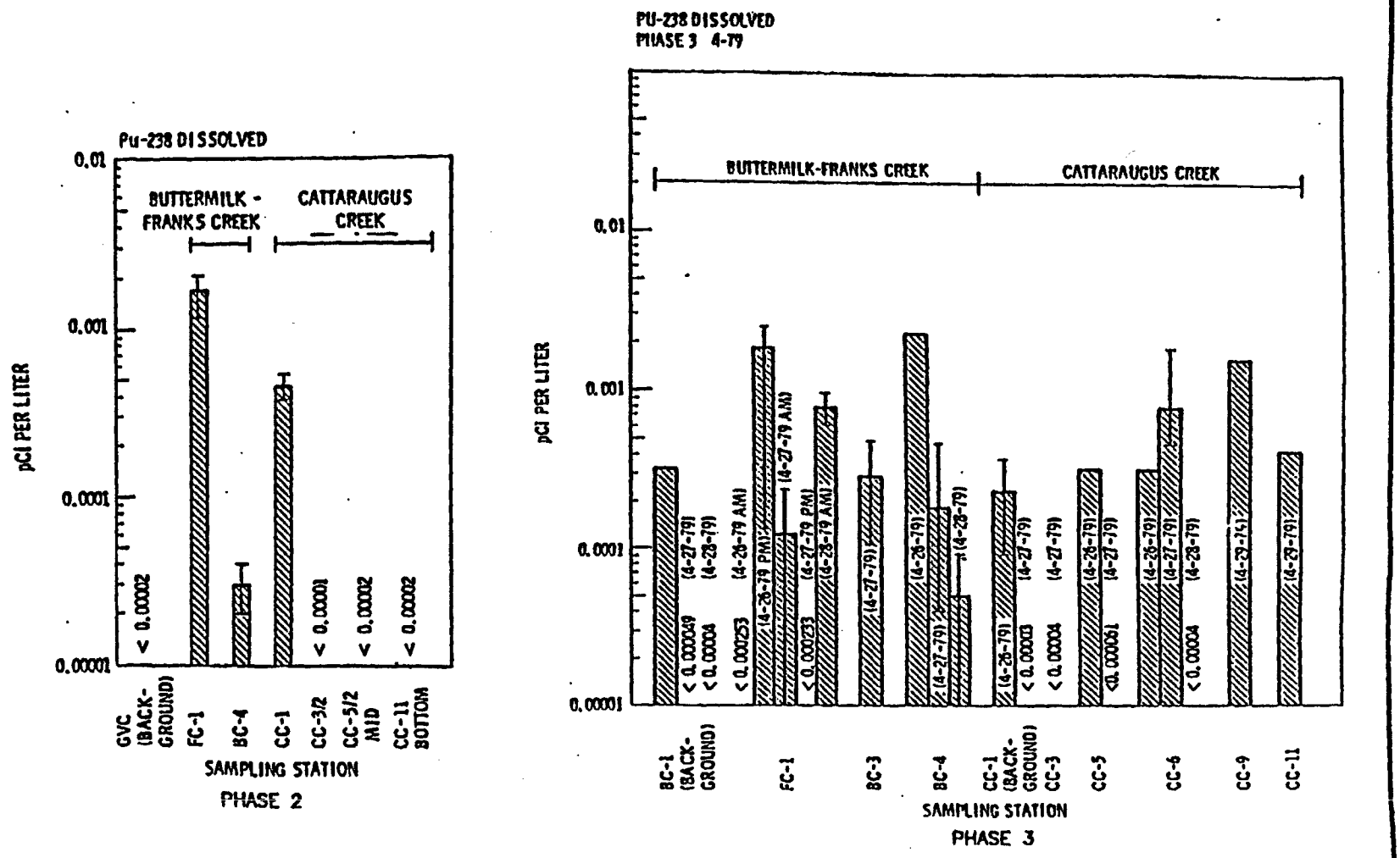


Figure 3-17 PNL Phase 2 and Phase 3 Pu-238 Concentrations in Water.

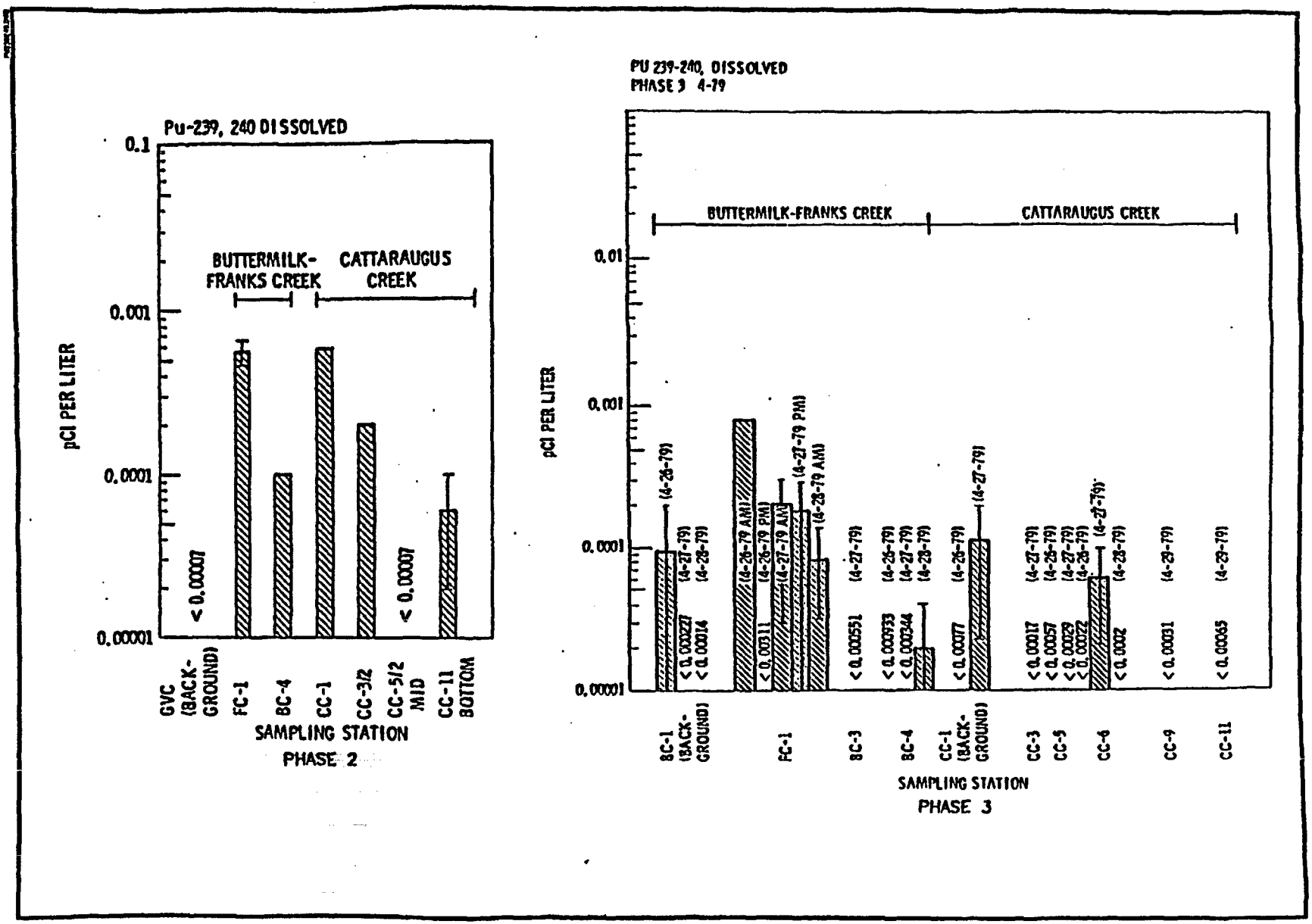


Figure 3-18 PNL Phase 2 and Phase 3 Pu-239,240 Concentrations in Water.

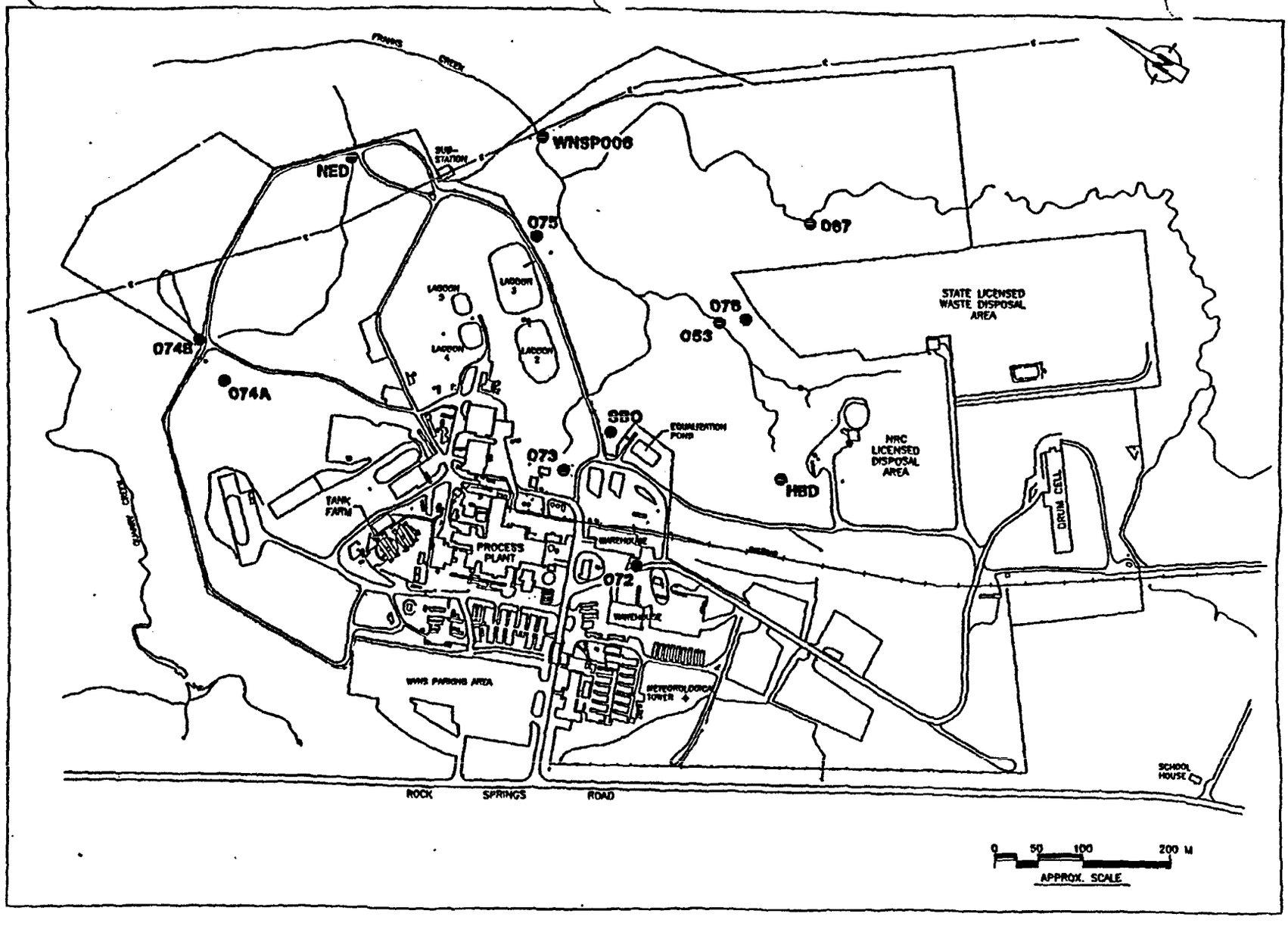


Figure 3-19 NYSDEC and NFS On-Site Water Sampling Locations (1967–1981).

FIGURE 3-20

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE SEWAGE OUTFALL, SAMPLING LOCATION 072
(NYSDEC SAMPLING 1972 - 1980)

	Cs-137	Sr-90	GROSS BETA		GROSS ALPHA	TRITIUM
1972	4.46E-06	2.82E-06	3.99E-05		1.39E-08	2.68E-06
1973	2.27E-07	2.73E-06	7.03E-06		9.00E-09	5.77E-06
1974	1.22E-07	1.20E-06	2.65E-06	<	4.00E-09	1.44E-06
1975	1.58E-07	1.08E-07	5.18E-07	<	8.00E-09	6.58E-07
1976	4.30E-08	2.20E-08	1.19E-07	<	4.00E-09	3.03E-06
1977	5.60E-08	1.70E-08	9.70E-08	<	5.00E-09	3.92E-07
1978	4.96E-08	1.14E-08	7.38E-08		4.30E-09	3.73E-07
1979	3.83E-08	1.05E-08	6.00E-08	<	3.00E-09	2.20E-07
1980	2.90E-08	6.30E-09	3.20E-08	<	3.00E-09	1.90E-07

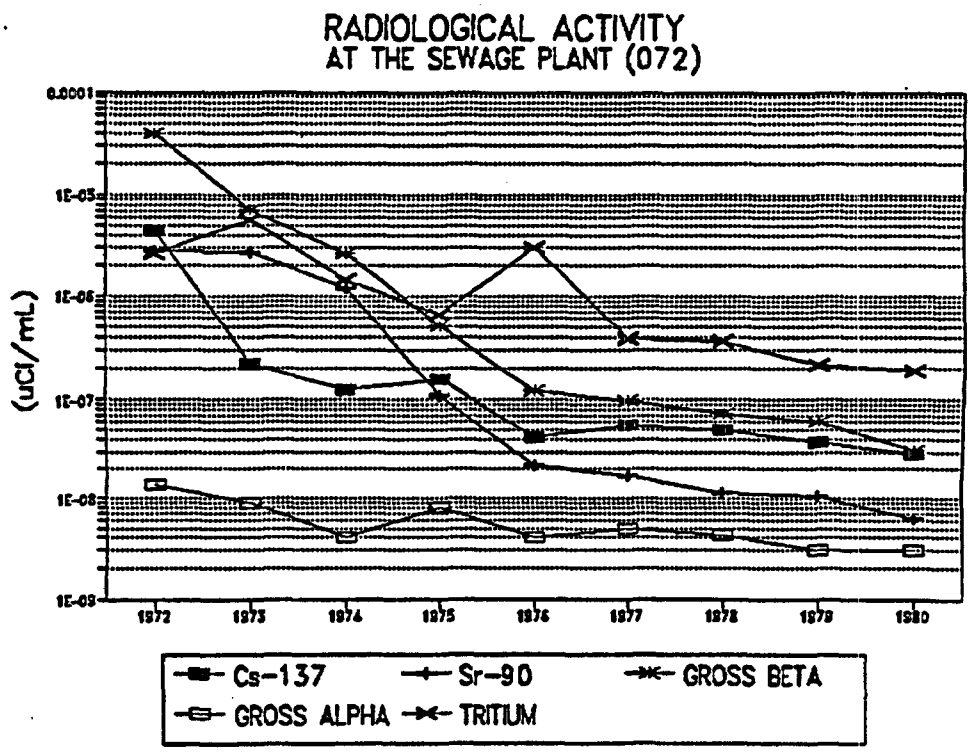


FIGURE 3-21

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE HOT & COLD DITCH, SAMPLING LOCATION 073
(NYSDEC SAMPLING 1972 - 1980)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1972	1.51E-07	2.2E-07	2.8E-06	1.67E-09	
1973		1.6E-09	4.9E-09		
1974		< 5.1E-09	< 1.1E-08	< 2.00E-09	3.39E-07
1975		4.0E-09	1.3E-08	< 4.00E-09	3.83E-07
1976		4.0E-09	1.9E-08	4.00E-09	2.63E-05
1977	6.00E-09	8.0E-09	3.1E-08	< 1.20E-08	1.63E-06
1978		7.1E-09	2.3E-08	5.50E-09	2.50E-06
1979		6.1E-09	1.8E-08	< 4.00E-09	3.75E-07
1980		5.2E-09	1.5E-08	< 4.00E-09	2.05E-07

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

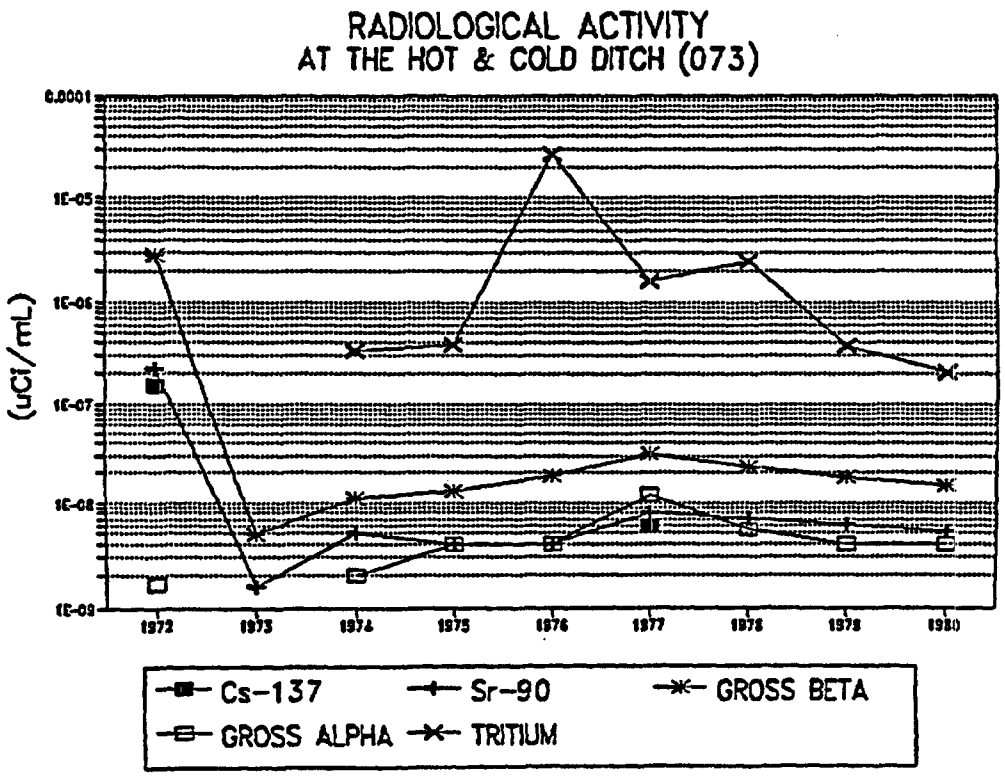


FIGURE 3-22

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE BURIAL DRAINAGE, SAMPLING LOCATION 076
(NYSDEC SAMPLING 1972 - 1979)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1972		3.2E-08	2.3E-07		9.97E-06
1973		5.0E-08	9.0E-07		2.75E-06
1974		1.3E-08	6.0E-08		1.99E-06
1975	< 1.3E-08	1.4E-05	1.9E-05	1.20E-08	3.29E-04
1976	6.0E-09	3.8E-07	7.4E-07	2.20E-08	4.21E-05
1977	5.0E-09	2.5E-07	5.6E-07		1.00E-05
1978	5.1E-09	3.0E-07	3.9E-07	1.89E-08	4.39E-06
1979	< 5.0E-09	1.2E-07	3.7E-07	< 1.70E-08	5.87E-07

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

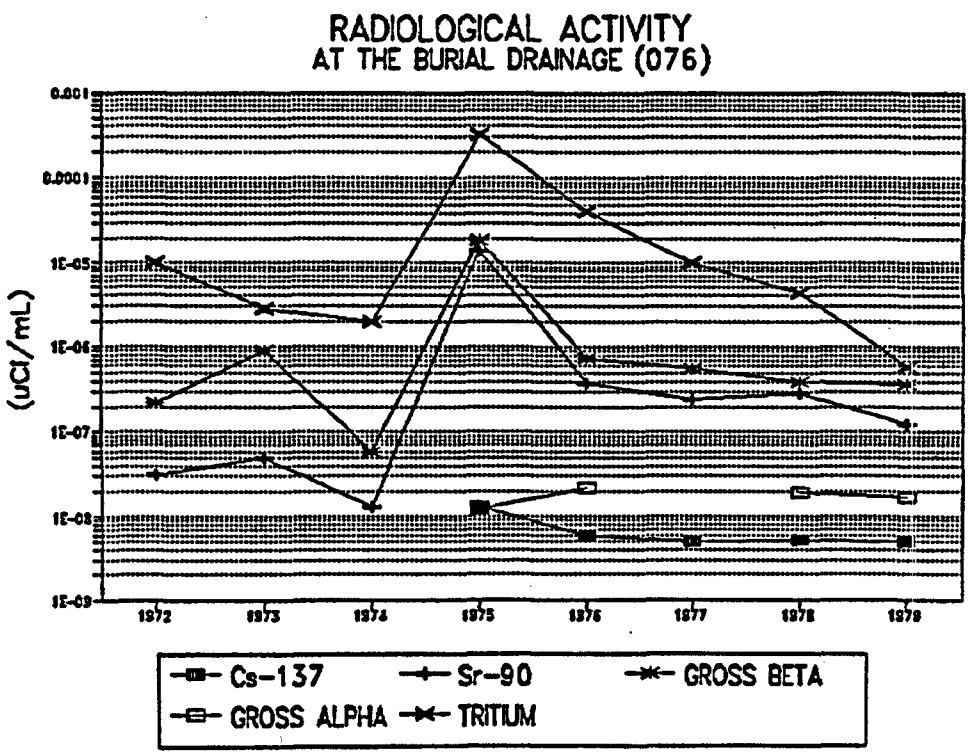


FIGURE 3-23

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT ERDMAN BROOK, SAMPLING LOCATION 053
(NYSDEC SAMPLING 1969 - 1981)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1969		3.6E-07	6.2E-07		5.73E-05
1970		3.2E-07	6.2E-07		6.29E-05
1971		9.1E-07	1.9E-06	3.00E-09	6.11E-05
1972	3.1E-08	6.0E-07	1.5E-06	1.00E-08	7.96E-05
1973		1.8E-07	3.2E-07	1.00E-09	2.91E-06
1974	< 1.2E-08	1.6E-07	2.9E-07	< 5.00E-09	2.39E-06
1975	< 1.1E-08	9.3E-08	1.8E-07	< 4.00E-09	1.38E-04
1976	6.0E-09	3.4E-08	8.8E-08	4.00E-09	8.99E-06
1977	9.0E-09	2.8E-08	6.5E-08	< 6.00E-09	4.99E-06
1978	4.5E-09	4.7E-08	8.8E-08	4.60E-09	7.15E-06
1979	< 5.0E-09	4.9E-08	7.4E-08	3.10E-09	2.05E-06
1980	7.0E-09	2.8E-08	5.3E-08	< 5.40E-09	2.41E-06
1981	1.0E-08	2.4E-08	5.5E-08	7.00E-09	2.03E-06

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

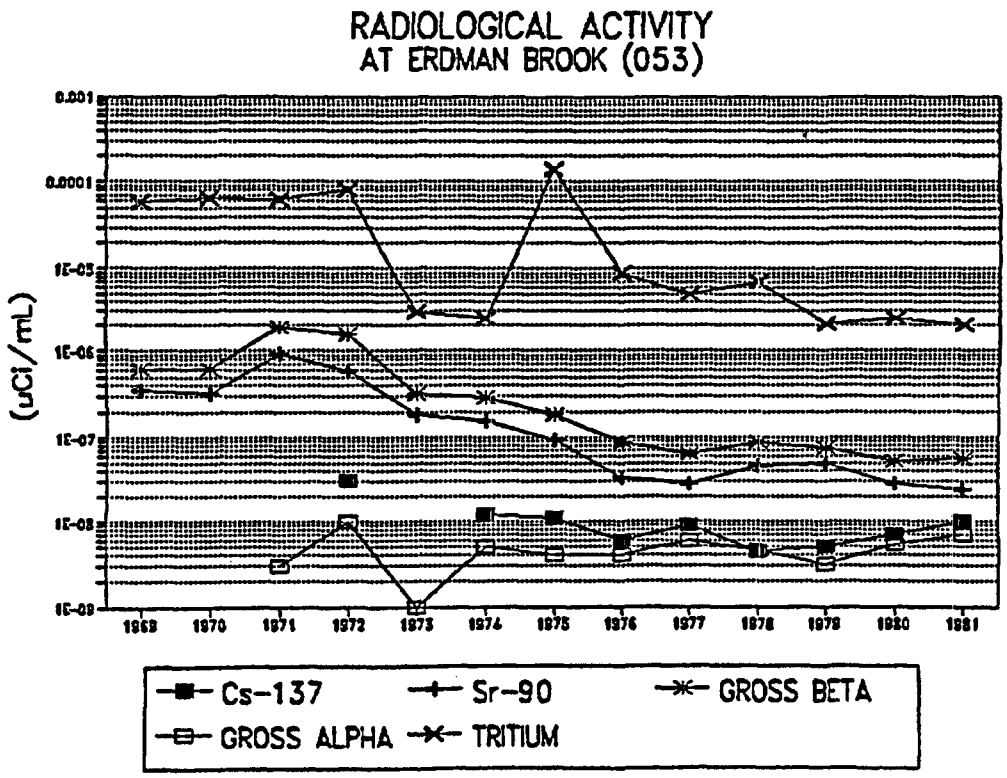


FIGURE 3-24

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE FRENCH DRAIN, SAMPLING LOCATION 075
(NYSDEC SAMPLING 1972 - 1980)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1972		2.0E-08	5.6E-06	1.80E-09	6.61E-04
1973	1.80E-08	2.0E-09	3.5E-06		3.77E-04
1974	< 1.40E-08	< 3.2E-09	1.1E-06	< 6.00E-09	2.93E-04
1975	< 9.00E-09	3.0E-09	3.6E-07	< 6.00E-09	1.97E-04
1976	< 5.00E-09	8.0E-09	1.4E-07	< 5.00E-09	3.35E-04
1977	< 4.00E-09	1.0E-08	8.6E-08	< 8.00E-09	2.69E-04
1978	< 6.40E-08	1.5E-08	5.7E-08	< 6.40E-09	9.91E-05
1979	< 6.00E-09	1.2E-08	3.7E-08	< 6.00E-09	5.23E-05
1980		2.7E-08	5.4E-08	< 5.00E-09	4.10E-05

· BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

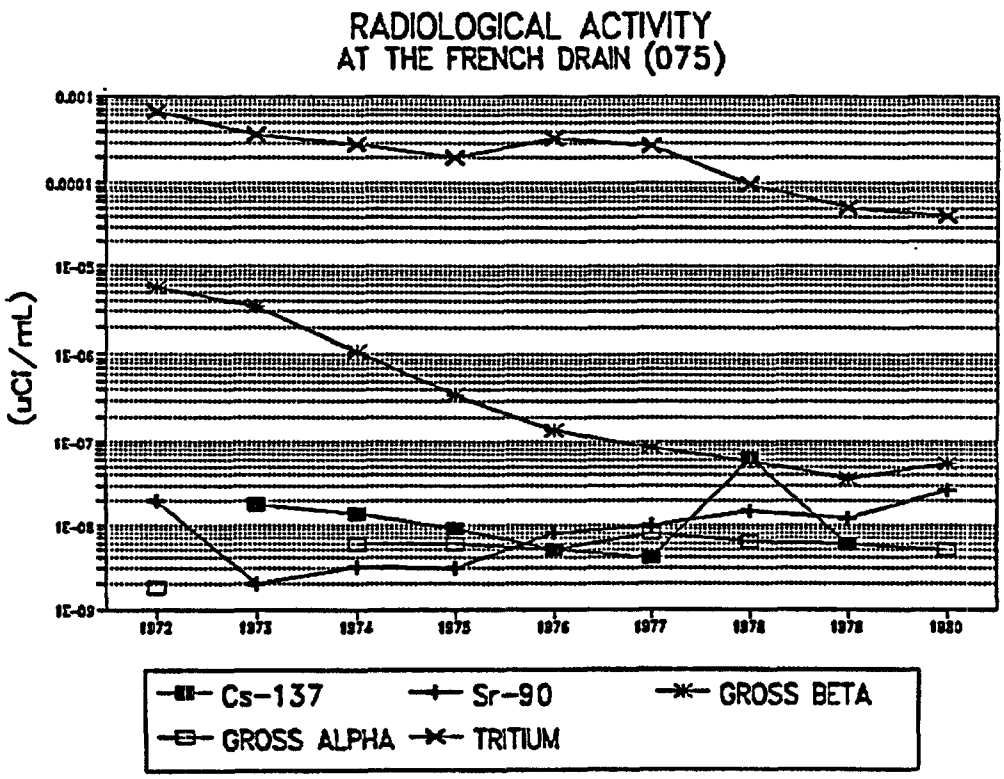


FIGURE 3-25

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE ACID RECOVERY TANKS, SAMPLING LOCATION 074A
(NYSDEC SAMPLING 1975 - 1981)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1975	7.0E-09	1.4E-08	3.4E-08	< 3.00E-09	3.02E-06
1976		7.0E-09	1.9E-08	4.00E-09	8.75E-07
1977	< 5.0E-09		5.6E-08	< 4.00E-09	1.39E-06
1978		7.0E-09	1.8E-08	< 3.70E-09	1.04E-06
1979		8.0E-09	1.6E-08	< 4.00E-09	3.33E-07
1980	< 7.0E-09	4.9E-09	2.9E-08	< 5.00E-09	4.60E-07
1981	< 1.7E-08	6.3E-09	5.3E-08	2.50E-08	2.82E-06

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

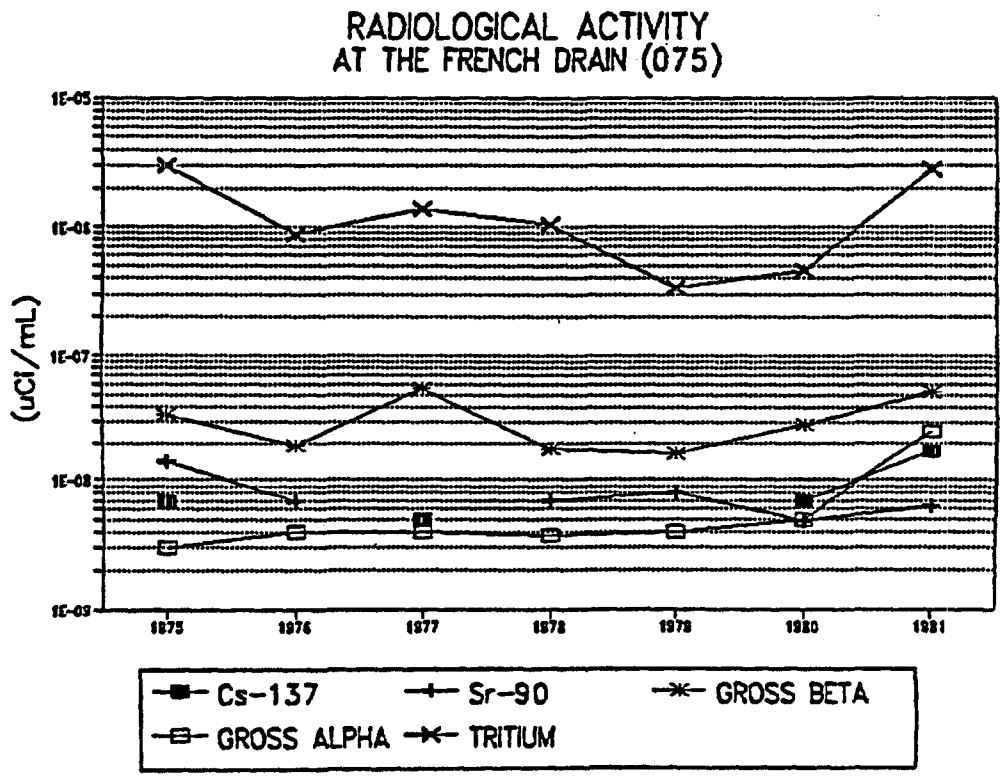


FIGURE 3-26

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE SPRING FED SWAMP, SAMPLING LOCATION 074B
(NYSDEC SAMPLING 1975 - 1981)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1975	< 7.0E-09	1.5E-07	3.3E-07	< 3.00E-09	2.36E-05
1976	4.0E-09	1.1E-07	2.0E-07	3.00E-09	2.65E-05
1977	7.0E-09	1.7E-07	3.8E-07	8.00E-09	6.29E-06
1978	1.0E-08	8.1E-08	1.8E-07	< 8.20E-09	9.65E-06
1979	< 5.0E-09	7.6E-08	1.4E-07	< 4.30E-09	7.49E-06
1980	< 5.0E-09	8.8E-08	1.7E-07	< 4.00E-09	5.61E-06
1981	8.0E-09	7.7E-08	1.6E-07	< 7.00E-09	8.01E-06

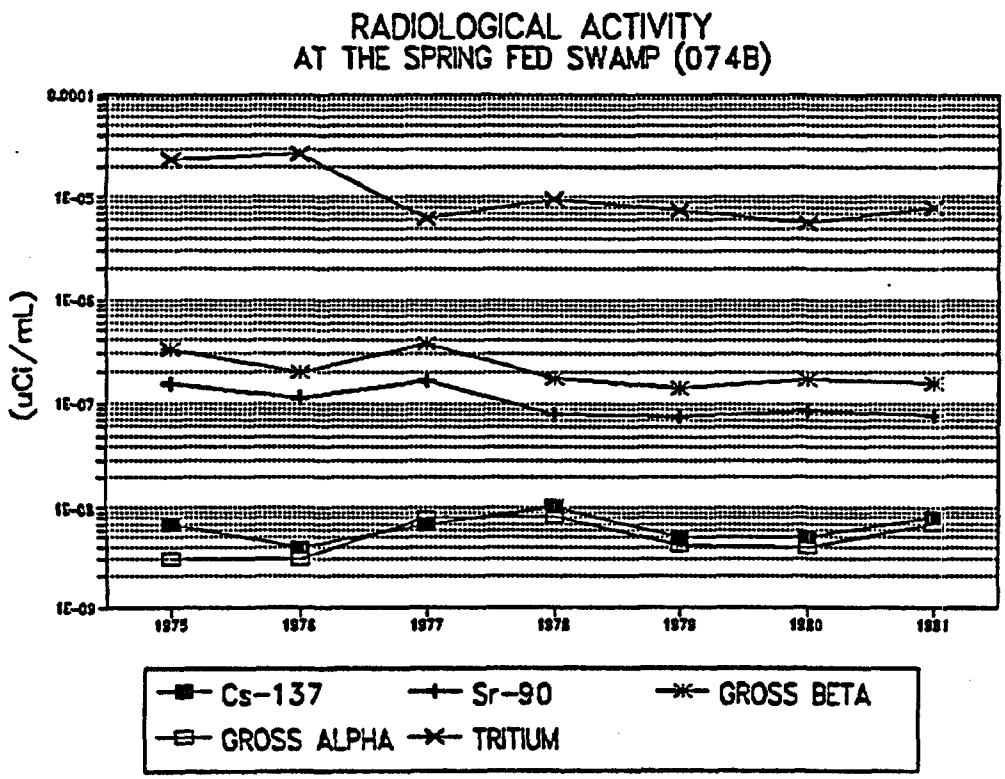


FIGURE 3-27

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE NORTHEAST BROOK, SAMPLING LOCATION 067
(NYSDEC SAMPLING 1969 - 1981)

	Cs-137	Sr-90	GROSS BETA	GROSS ALPHA	TRITIUM
1969		1.0E-09	8.0E-09		1.75E-06
1970			1.7E-08		4.77E-06
1971		3.0E-09	4.7E-08		8.38E-06
1972			2.8E-08		5.07E-06
1973			1.8E-08		8.55E-07
1974	< 7.0E-09		3.8E-08	< 5.00E-09	7.00E-07
1975	< 1.0E-08		2.1E-08	< 2.00E-09	7.36E-07
1976			1.0E-08	< 2.00E-09	1.58E-06
1977			1.0E-08	< 3.00E-09	7.44E-07
1978	< 6.0E-09		1.5E-08	3.90E-09	5.85E-07
1979			7.9E-09	< 1.80E-09	3.37E-07
1980			9.0E-09	< 2.40E-09	4.67E-07
1981			1.0E-08	< 3.90E-09	8.70E-07

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

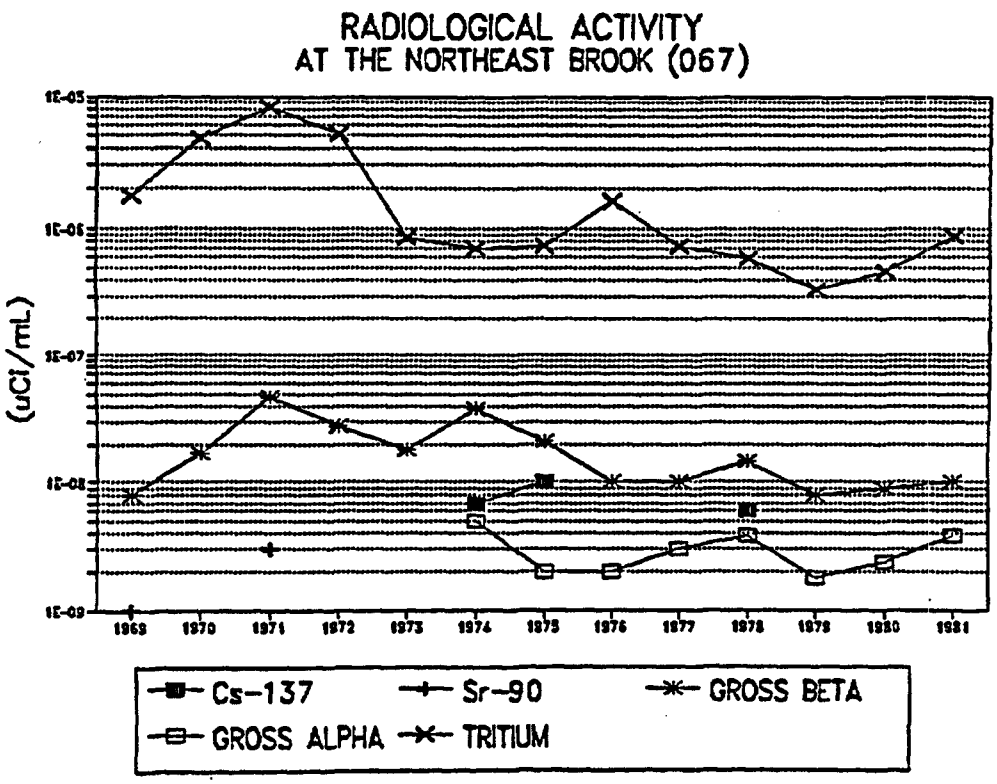


FIGURE 3-28

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
OF THE SEWAGE OUTFALL, SAMPLING LOCATION 072
(NFS SAMPLING 1972 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90
1972	< 4.1E-08	1.0E-05	1.9E-03	1.2E-06
1973	8.6E-09 (7)	5.9E-06	4.1E-04	1.7E-06
1974	3.6E-09 (3)	2.1E-06	8.6E-06 (10)	1.3E-06
1975	6.3E-09 (5)	6.3E-07	1.2E-05 (4)	1.1E-07
1976	3.1E-09 (3)	1.4E-07	1.4E-06 (8)	2.6E-08
1977	3.6E-09 (4)	1.2E-07	< 3.0E-07	1.8E-08
1978	< 1.5E-09	1.1E-07	1.0E-06	1.1E-07
1979	< 1.4E-09	7.2E-08	1.2E-06 (11)	4.2E-08 (8)
1980	< 1.3E-09	6.9E-08	1.5E-06	1.3E-08 (7)
1981	< 1.3E-09	5.7E-08	1.5E-06	1.4E-08
1982	< 2.1E-09	6.5E-08	1.3E-06	1.1E-08 (8)
1983	< 2.1E-09	4.0E-08	4.3E-07 (8)	6.0E-09
1984	< 1.6E-09	5.1E-08	2.4E-07 (3)	2.2E-08

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

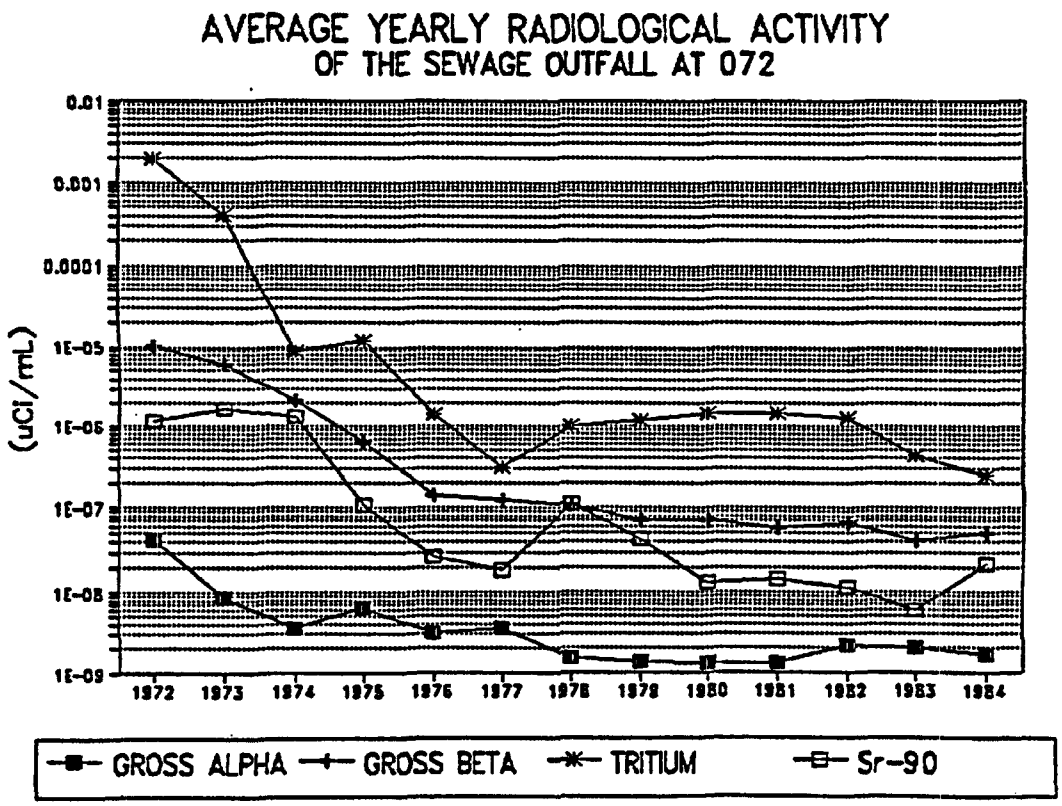


FIGURE 3-29

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE CONDENSATE & COOLING WATER DITCH, SAMPLING LOCATION 073
(NFS SAMPLING 1973 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1973		3.29E-08	
1974		6.55E-09	
1975		5.50E-09	(11)
1976		2.02E-08	
1977		1.24E-08	
1978		6.35E-09	(9)
1979		7.79E-09	(10)
1980		9.41E-09	(11)
1981		7.38E-09	(11)
1982		1.10E-08	
1983		4.77E-09	(11)
1984		8.31E-09	

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

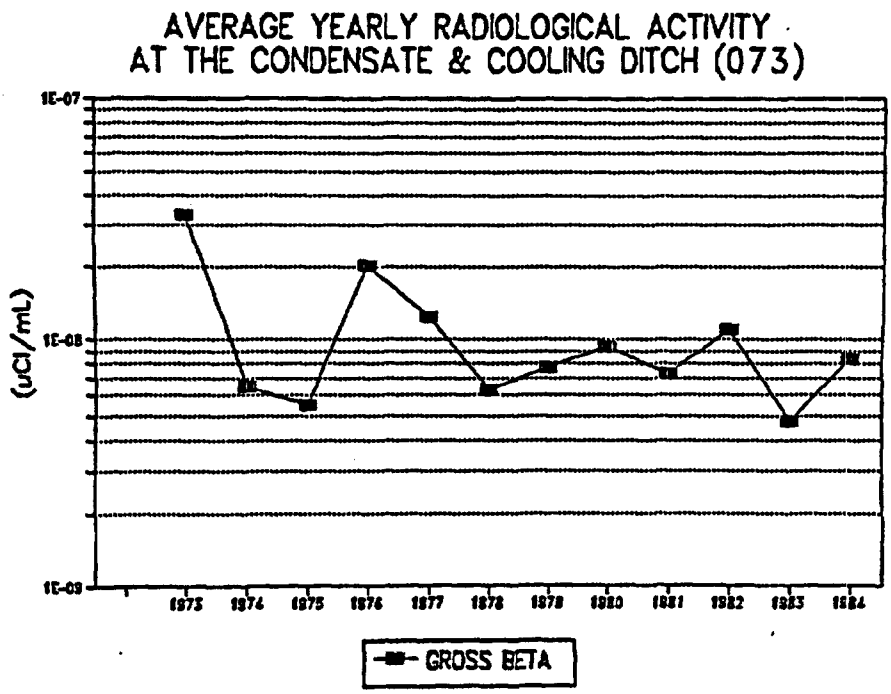


FIGURE 3-30

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE SETTLING BASIN OUTFALL, SAMPLING LOCATION SBO
(NFS SAMPLING 1974 - 1981)
(WVNS 1982 - 1984)

YEAR	GROSS ALPHA		GROSS BETA		TRITIUM	
1974	2.2E-09	(1)	3.52E-08	(10)	< 1.9E-06	
1975	< 3.4E-09		2.79E-08		3.1E-06	(5)
1976	8.0E-10	(1)	1.52E-08		1.2E-06	(10)
1977	7.0E-10	(2)	7.99E-09	(11)	5.3E-07	(3)
1978	9.1E-10	(1)	7.66E-09	(11)	1.1E-06	(11)
1979	9.1E-10	(1)	1.73E-08		1.1E-06	
1980	6.3E-10	(1)	1.38E-08		1.5E-06	
1981	4.3E-10	(1)	1.13E-08		2.8E-06	
1982	4.1E-10	(1)	1.06E-08		9.9E-07	(11)
1983	3.8E-10	(5)	6.84E-09		4.1E-07	(9)
1984	2.7E-10	(5)	7.12E-09		2.3E-07	(6)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

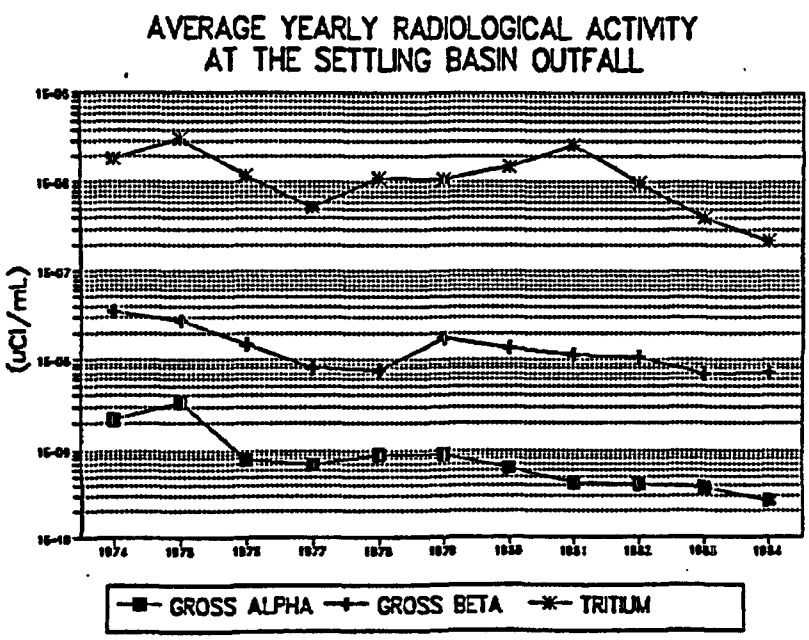


FIGURE 3-31

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE DITCH NORTH OF HULL BURIAL, SAMPLING LOCATION HBD
(NFS SAMPLING 1975 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1975		6.45E-07	2.82E-06 (3)
1976		4.55E-07	2.59E-06
1977		7.14E-07	2.96E-06
1978		6.12E-07	1.63E-06
1979		5.40E-07	1.62E-06
1980		4.18E-07	1.95E-06
1981		4.62E-07	2.18E-06
1982		3.65E-07	2.43E-06
1983		7.91E-07	6.87E-07
1984		1.61E-07	2.80E-06 (5)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
1975 VALUES BASED ON FIVE MONTHLY SAMPLES
1976 VALUES BASED ON TEN MONTHLY SAMPLES

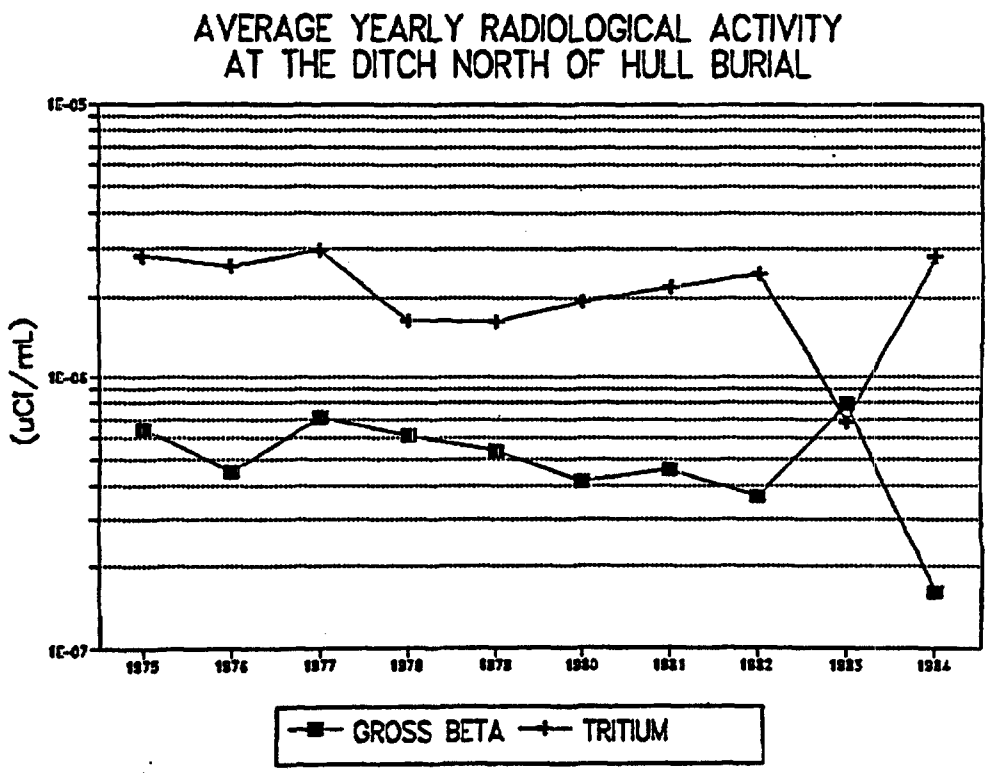


FIGURE 3-32

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN ERDMAN BROOK, SAMPLING LOCATION 053
(NFS SAMPLING 1971 - 1981)

YEAR		GROSS ALPHA	GROSS BETA	TRITIUM
1971		1.1E-09 (4)	2.4E-08 (4)	2.5E-05 (7)
1972		1.3E-09 (5)	2.0E-08 (3)	9.5E-06 (6)
1973		1.9E-09 (2)	1.7E-08 (8)	4.1E-06 (4)
1974				
1975				
1976				
1977		6.7E-10 (8)	5.8E-08	3.9E-06
1978	<	3.1E-10	4.8E-08	4.4E-06
1979	<	3.9E-10	4.4E-08	3.3E-06
1980	<	3.2E-10	4.8E-08	4.6E-06
1981	<	2.9E-10	2.9E-08	2.6E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
STATION NOT SAMPLED FROM 1974 - 1976

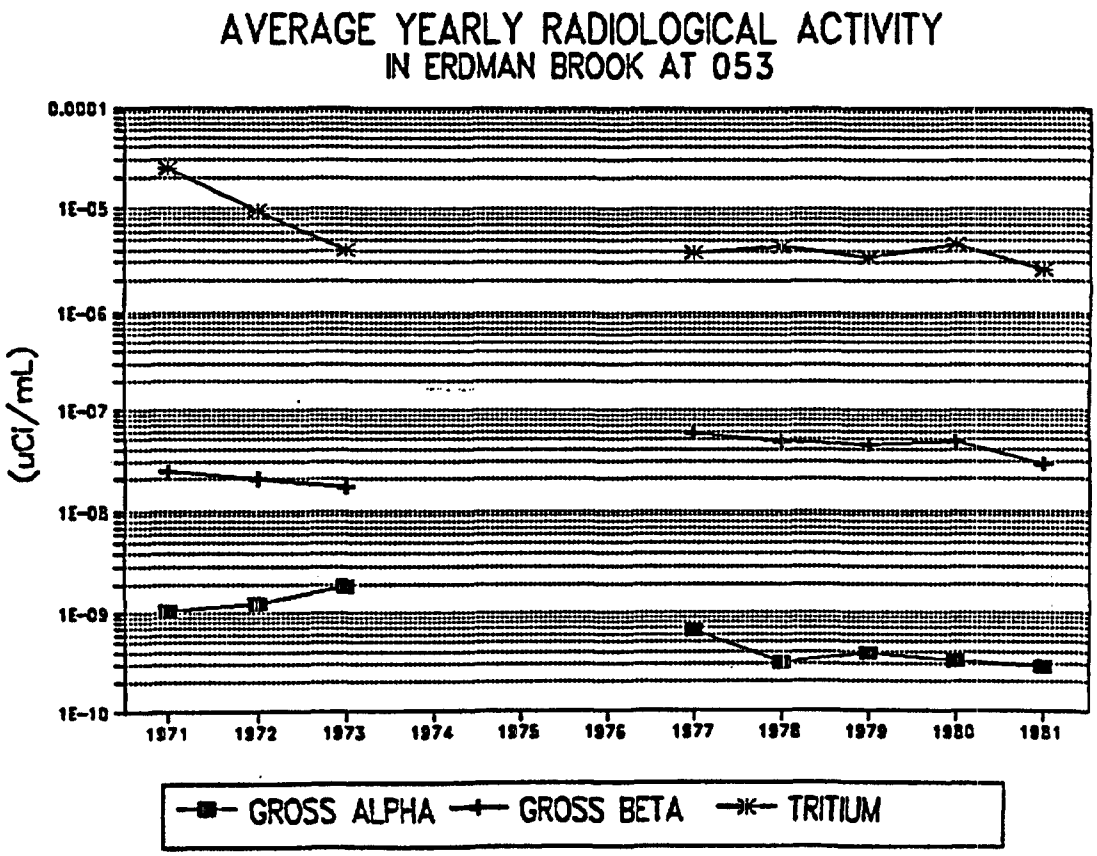


FIGURE 3-33

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE STREAM EAST OF THE WASTE BURIAL SITE, SAMPLING LOCATION 067
(NFS SAMPLING 1974 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1974	5.9E-10 (4)	1.22E-08	1.92E-06 (2)
1975	7.1E-10 (3)	7.92E-09 (11)	1.43E-06 (1)
1976	6.8E-10 (4)	7.76E-09	1.04E-06 (10)
1977	4.3E-10 (3)	1.18E-08	4.68E-07 (3)
1978	< 4.3E-10	1.34E-08	1.03E-06
1979	< 7.0E-10	1.06E-08	1.26E-06
1980	< 4.0E-10	1.20E-08	1.81E-06 (11)
1981	2.6E-10 (1)	1.00E-08	1.86E-06
1982	< 4.1E-10	9.01E-09	8.85E-07 (10)
1983	3.1E-10 (4)	1.06E-08	5.66E-07 (10)
1984	4.3E-10 (8)	6.38E-09	2.21E-07 (4)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

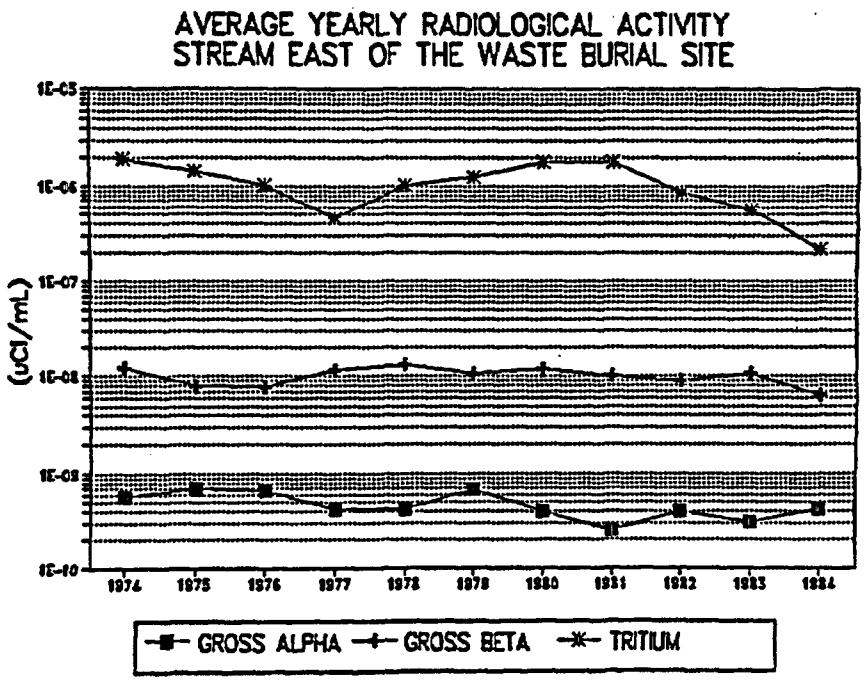


FIGURE 3-34

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN THE FRENCH DRAIN, SAMPLING LOCATION 075
(NFS SAMPLING 1972 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR		GROSS ALPHA		GROSS BETA	TRITIUM
1972		1.0E-07	(1)	6.9E-06	2.4E-03
1973		6.9E-09	(1)	2.4E-06	4.2E-04
1974		1.5E-09	(4)	8.8E-07	2.7E-04
1975	<	8.9E-10		2.4E-07	2.2E-04
1976		1.0E-09	(2)	1.1E-07	2.4E-04
1977		9.4E-10	(2)	5.9E-08	3.1E-04
1978		7.1E-10	(2)	4.4E-08	9.2E-05
1979	<	9.3E-10		4.5E-08	5.6E-05
1980	<	7.1E-10		3.8E-08	4.6E-05
1981		7.7E-10	(1)	3.6E-08	9.7E-05
1982	<	6.5E-10		3.7E-08	3.5E-05
1983	<	4.8E-10		1.8E-08	3.2E-05
1984		2.4E-10	(3)	1.2E-08	2.3E-05

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

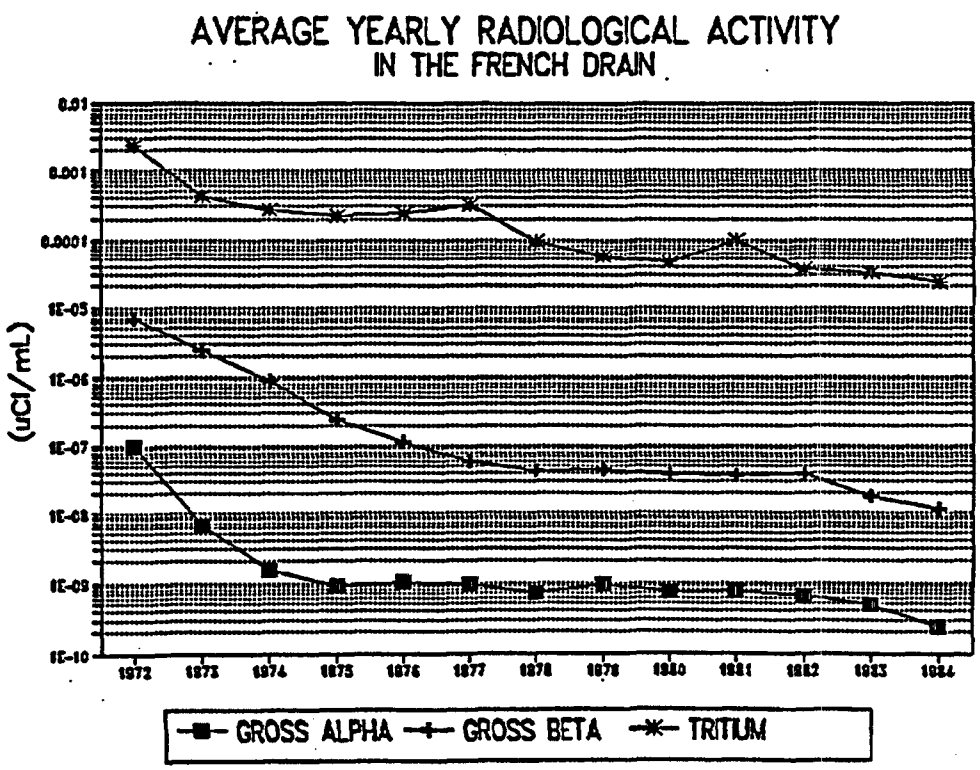
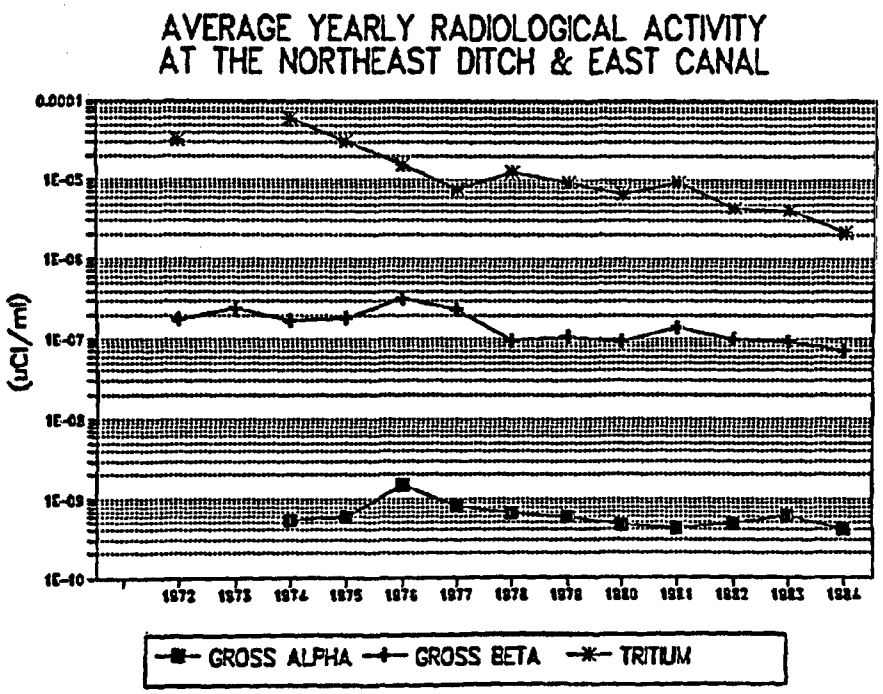


FIGURE 3-35

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT THE NORTHEAST DITCH (1972-1978) AND EAST CANAL (1979-1984)
IN THE NORTH PLATEAU
(NFS SAMPLING 1972 - 1981)
(WVNS SAMPLING 1982 - 1984)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1972		1.78E-07	3.31E-05
1973		2.50E-07	
1974	5.35E-10 (3)	1.71E-07	6.06E-05
1975	< 6.02E-10	1.85E-07	3.09E-05
1976	1.51E-09 (5)	3.14E-07	1.57E-05
1977	< 8.11E-10	2.32E-07	7.70E-06
1978	6.51E-10 (1)	9.71E-08	1.29E-05
1979	< 6.00E-10	1.08E-07	9.29E-06
1980	< 4.76E-10	9.42E-08	6.64E-06
1981	< 4.25E-10	1.44E-07	9.35E-06
1982	< 4.83E-10	9.99E-08	4.47E-06
1983	< 6.29E-10	9.29E-08	4.05E-06
1984	4.03E-10 (7)	7.07E-08	2.09E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR



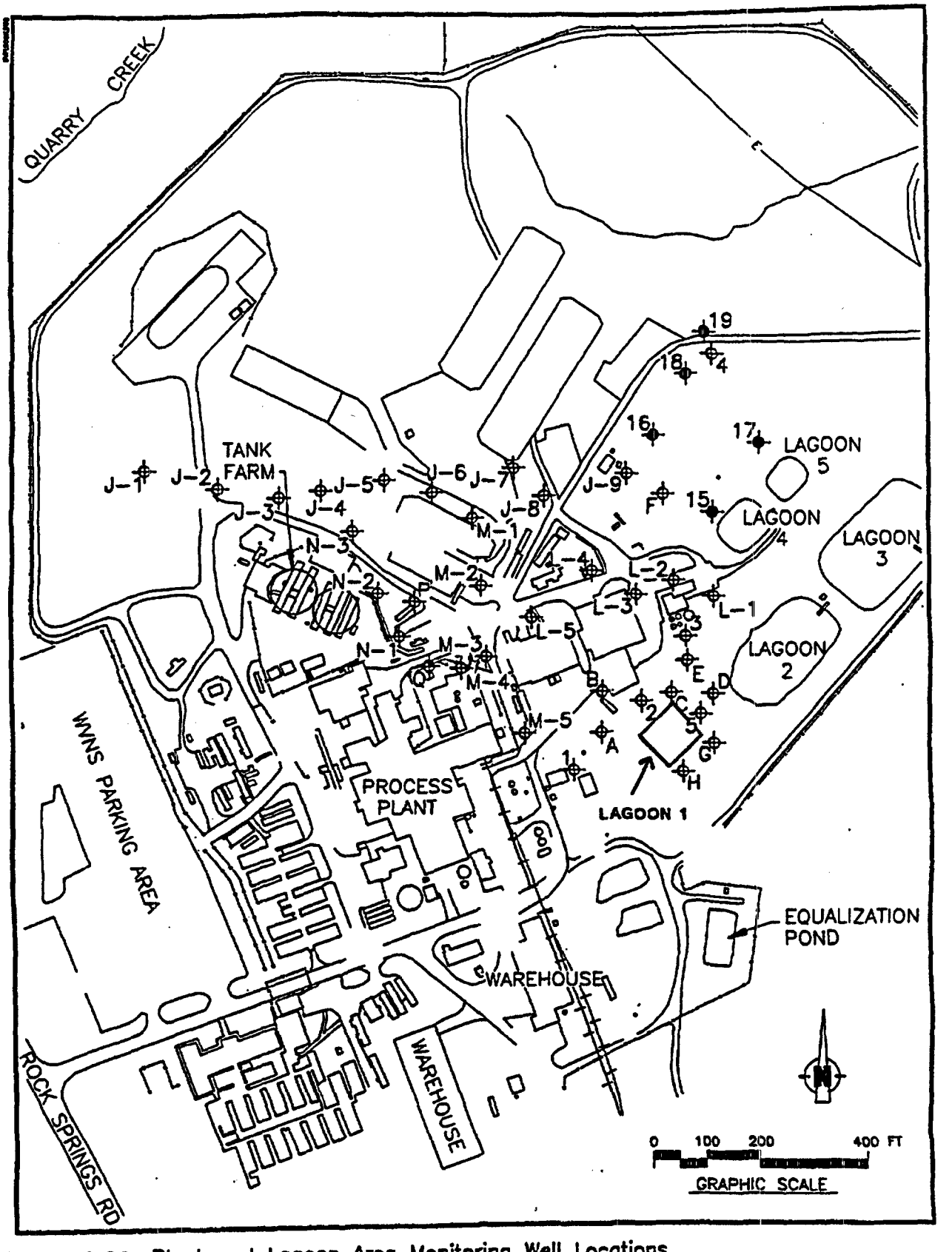


Figure 3-36 Plant and Lagoon Area Monitoring Well Locations.

FIGURE 3-37

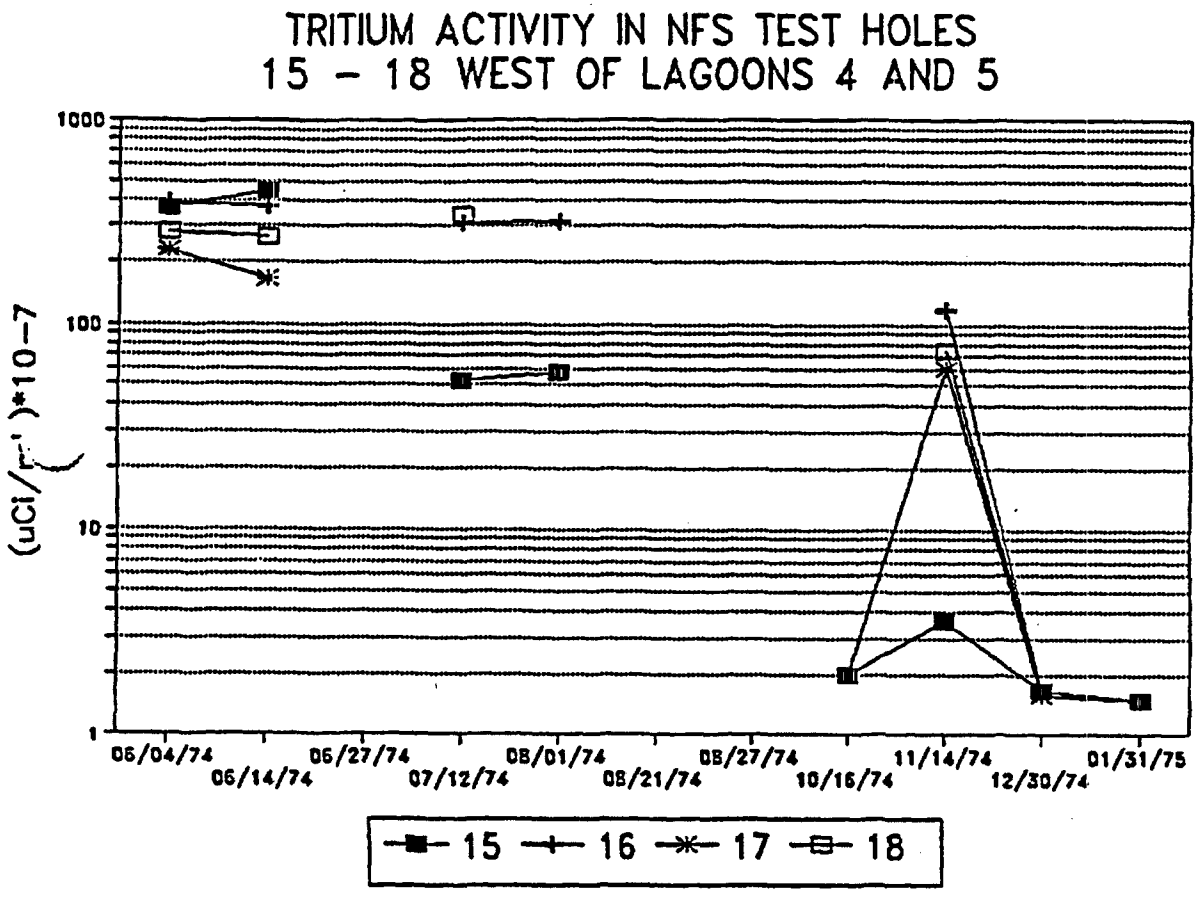

TRITIUM ACTIVITY IN NFS TEST HOLES
15 - 18 WEST OF LAGOONS 4 AND 5
1000
100
10
1
(uCi/ml)*10-7
06/04/74
06/14/74
06/27/74
07/12/74
08/01/74
08/21/74
08/27/74
10/16/74
11/14/74
12/30/74
01/31/75
15
16
17
18

FIGURE 3-38

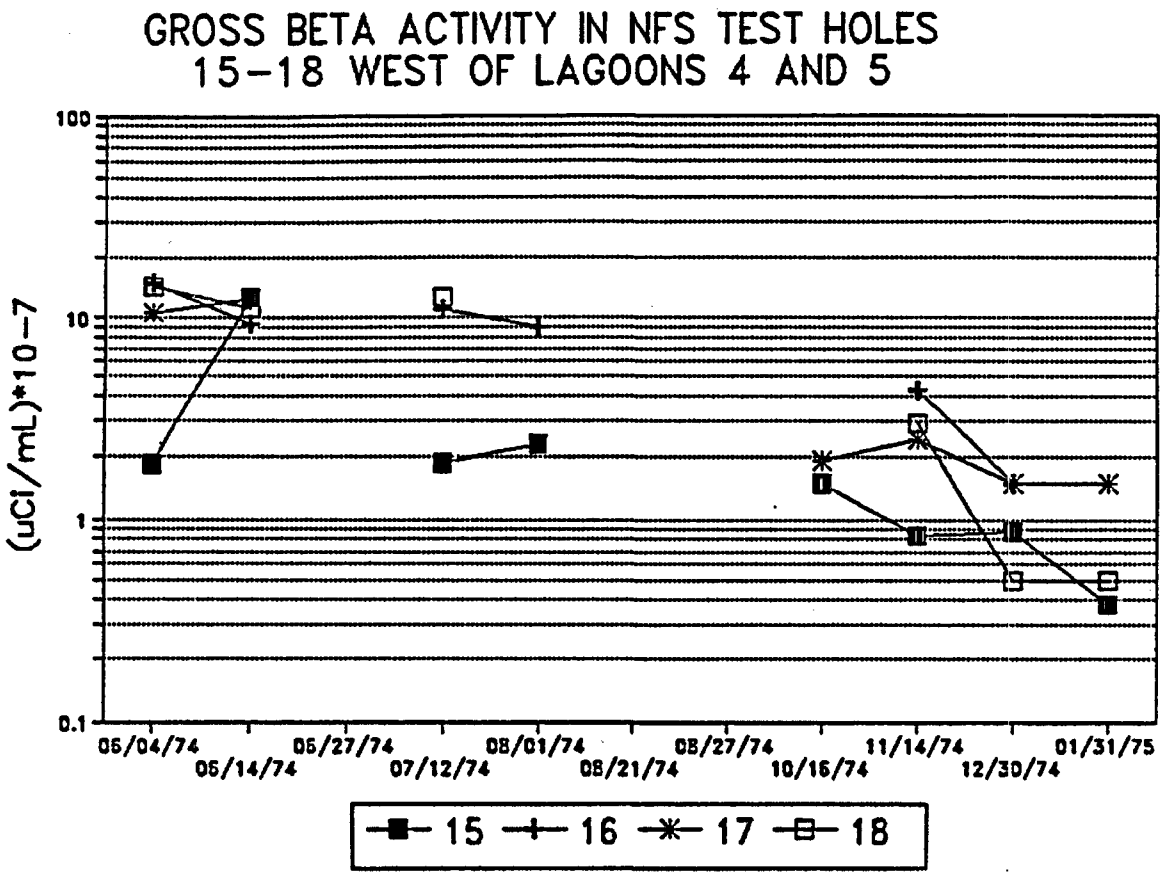

GROSS BETA ACTIVITY IN NFS TEST HOLES
15-18 WEST OF LAGOONS 4 AND 5
(uCi/mL)*10-7
100
10
1
0.1
05/04/74
05/14/74
05/27/74
07/12/74
08/01/74
08/21/74
08/27/74
10/16/74
11/14/74
12/30/74
01/31/75
15
16
17
18

FIGURE 3-39

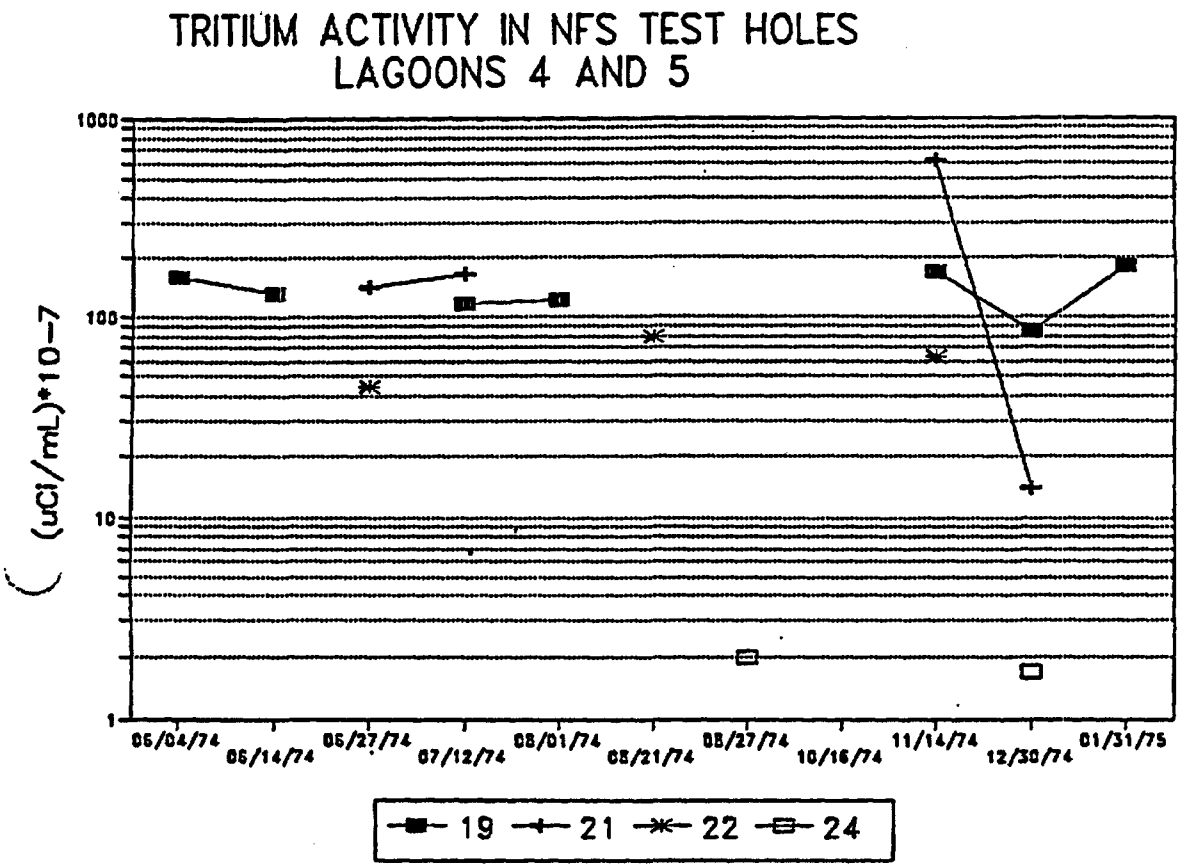

TRITIUM ACTIVITY IN NFS TEST HOLES
LAGOONS 4 AND 5
(uCi/mL)*10-7
1000
100
10
1
06/04/74
06/14/74
06/27/74
07/12/74
08/01/74
08/21/74
08/27/74
10/16/74
11/14/74
12/30/74
01/31/75
19
21
22
24

FIGURE 3-40

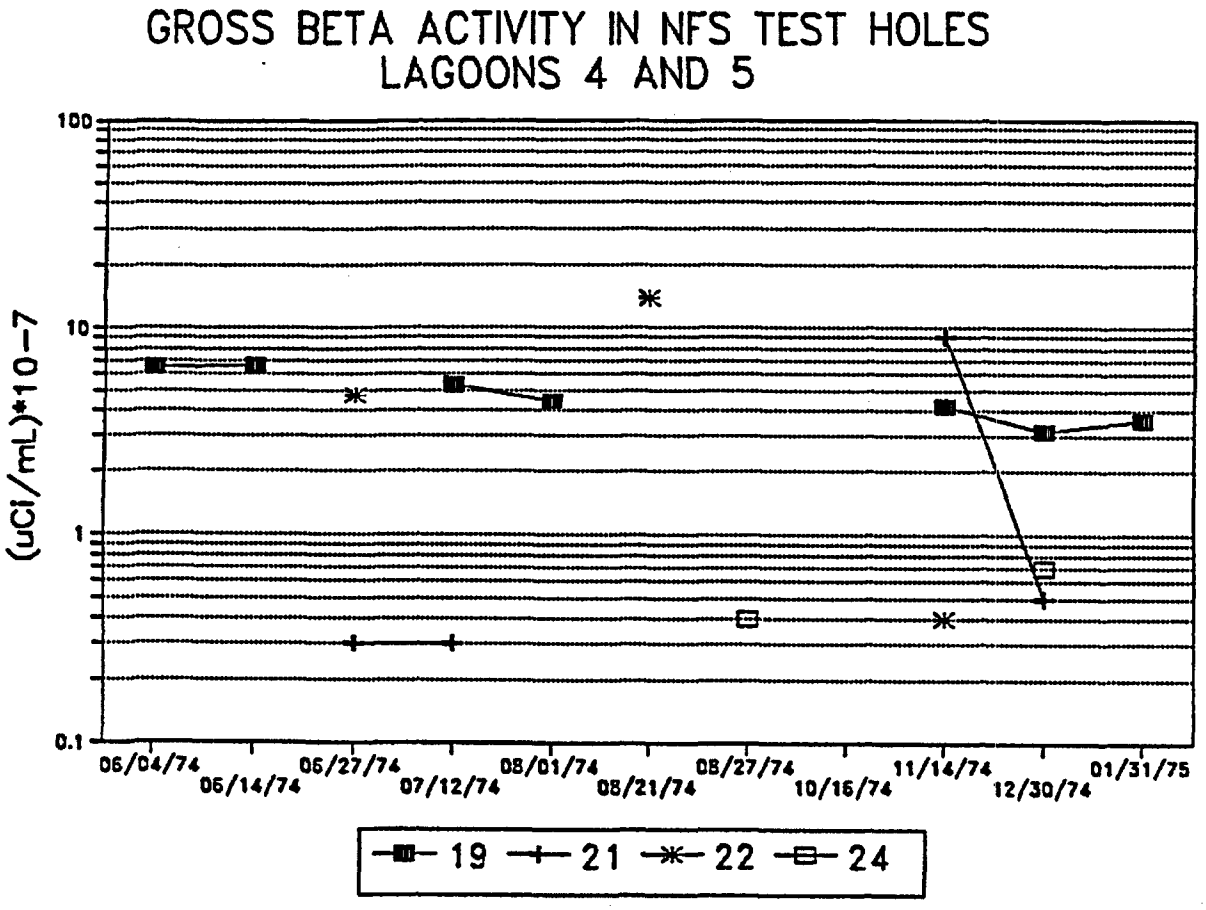
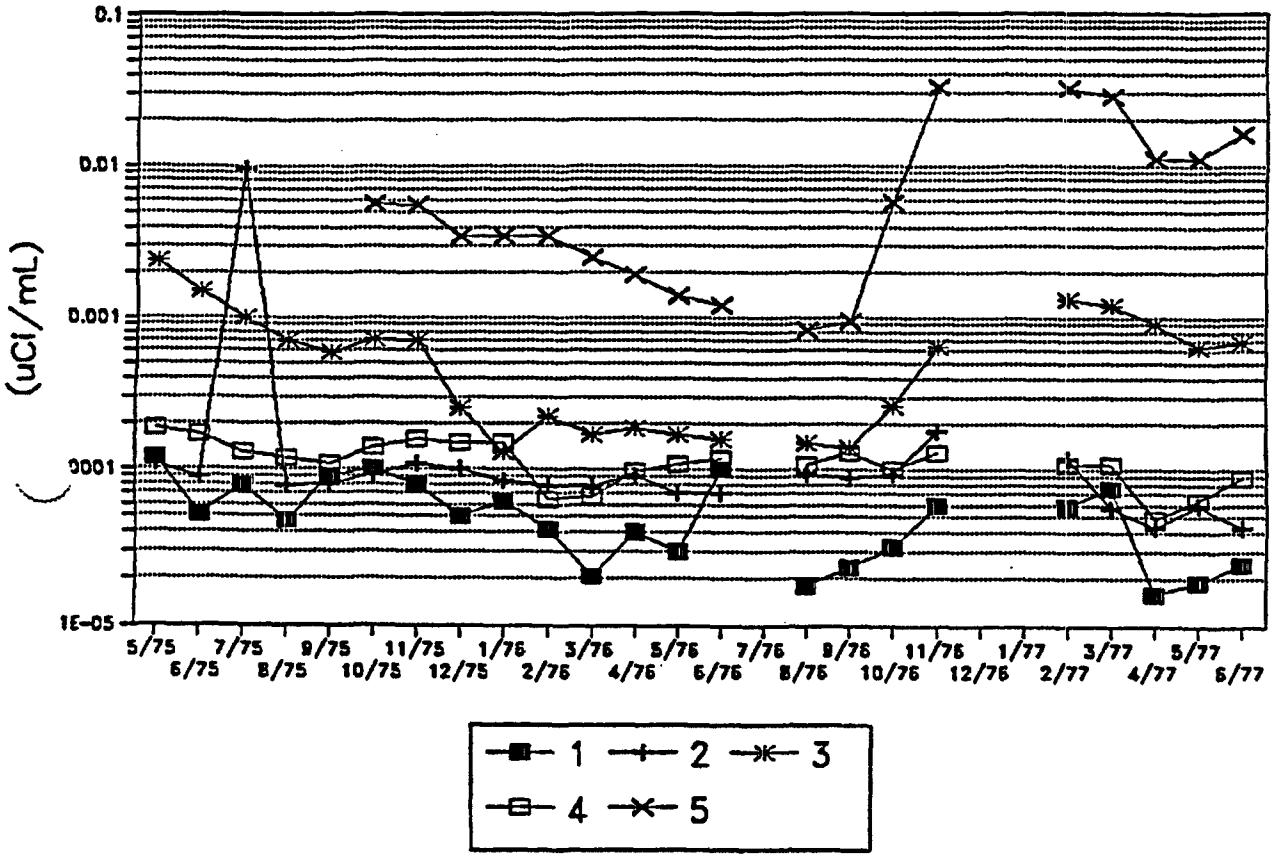

GROSS BETA ACTIVITY IN NFS TEST HOLES
LAGOONS 4 AND 5
(uCi/mL)*10-7
100
10
1
0.1
06/04/74
06/14/74
06/27/74
07/12/74
08/01/74
08/21/74
08/27/74
10/16/74
11/14/74
12/30/74
01/31/75
19
21
22
24

FIGURE 3-41

TRITIUM ACTIVITY IN NFS WELLS 1 - 5
LAGOON AREA



/ELLS 1 - 5 NOT SAMPLED 7/76, 12/76, AND 1/77

FIGURE 3-42

TRITIUM ACTIVITY (uCi/mL)
IN NFS WELLS NEAR LAGOON 1
(1979 - 1982)

	B	C	D	E	G	H
4/26/79	2.13E-05	4.86E-05	2.28E-04	5.75E-05	4.42E-04	5.48E-06
8/13/79	1.12E-04	1.01E-04	3.12E-04	7.89E-05		
9/13/80	1.42E-05	5.78E-05	8.39E-05	7.60E-06	6.07E-04	2.35E-06
6/16/81	5.35E-05	4.57E-05	1.75E-04	1.94E-05	3.70E-02	2.67E-05
10/11/82	2.86E-05	1.37E-05	3.28E-05	9.70E-07	1.14E-03	2.83E-07

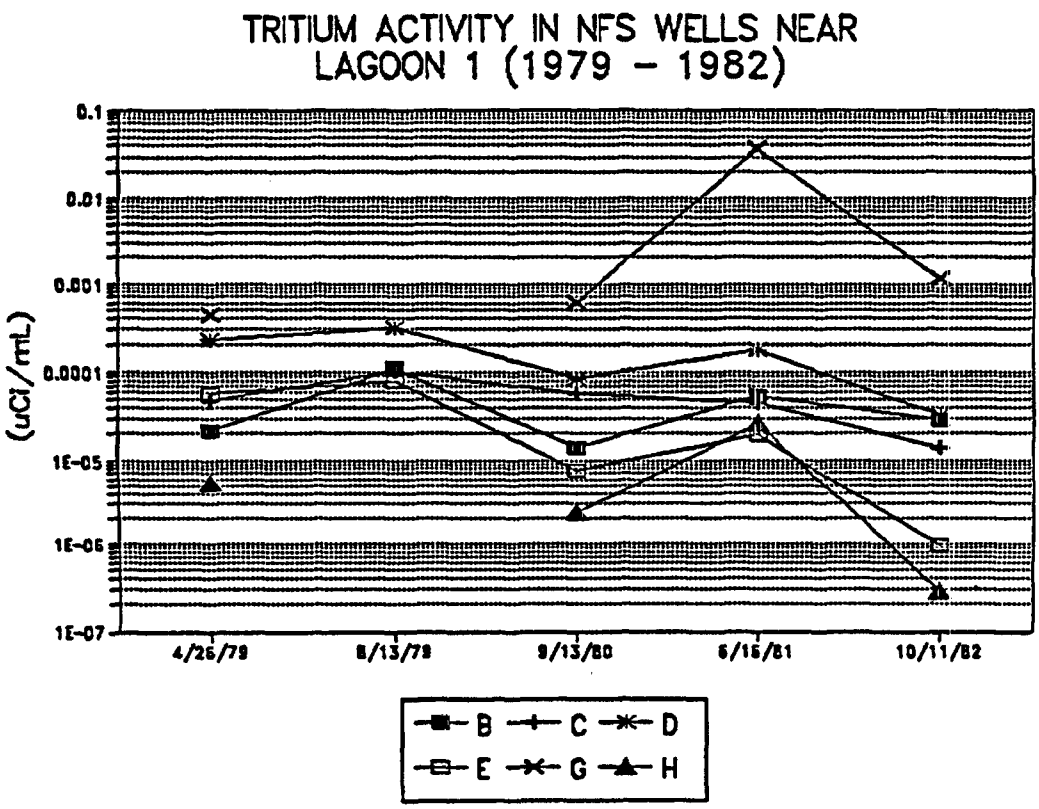


FIGURE 3-43

TRITIUM ACTIVITY (uCi/mL)
IN NFS WELLS DOWNGRADIENT OF THE PROCESS PLANT
(1979-1982)

	N-1	N-2	P	Q	M-5
4/26/79	2.46E-05	9.77E-06	1.63E-05	2.91E-05	8.48E-06
8/13/79	2.68E-05	5.98E-06	1.36E-05	2.96E-05	2.63E-05
9/13/80	2.42E-05	3.39E-06	6.97E-06	1.53E-05	7.48E-06
6/16/81	3.39E-06	1.14E-05	5.52E-06	3.51E-05	6.04E-06
10/11/82	1.21E-05	6.52E-06	2.64E-06		6.13E-06

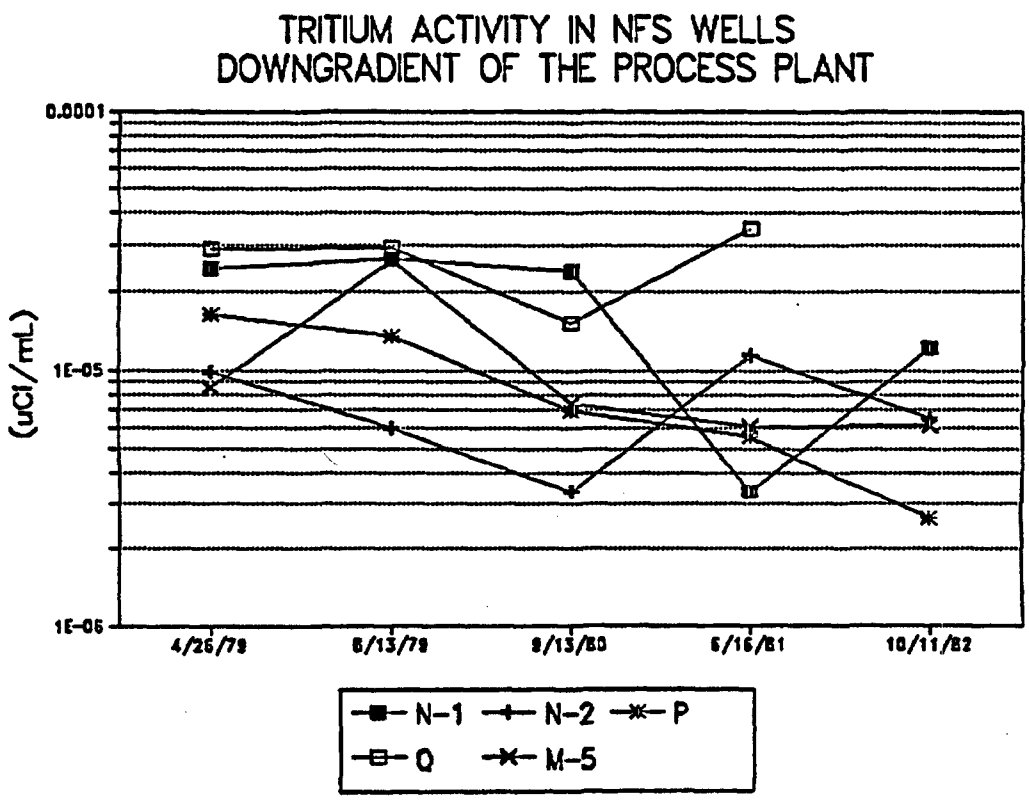


FIGURE 3-44

TRITIUM ACTIVITY (uCi/mL)
IN NFS WELLS M-1 THROUGH M-4
(1979 - 1982)

	M-1	M-2	M-3	M-4
4/26/79	5.83E-06	3.99E-06	2.22E-06	2.53E-06
8/13/79	5.00E-06	1.37E-05	2.55E-06	3.33E-06
9/13/80	2.90E-06	2.96E-06	2.07E-06	2.52E-06
6/16/81	8.00E-06	4.51E-06	3.70E-06	2.69E-06
10-11/82	4.97E-07	7.82E-07	6.12E-07	2.71E-07

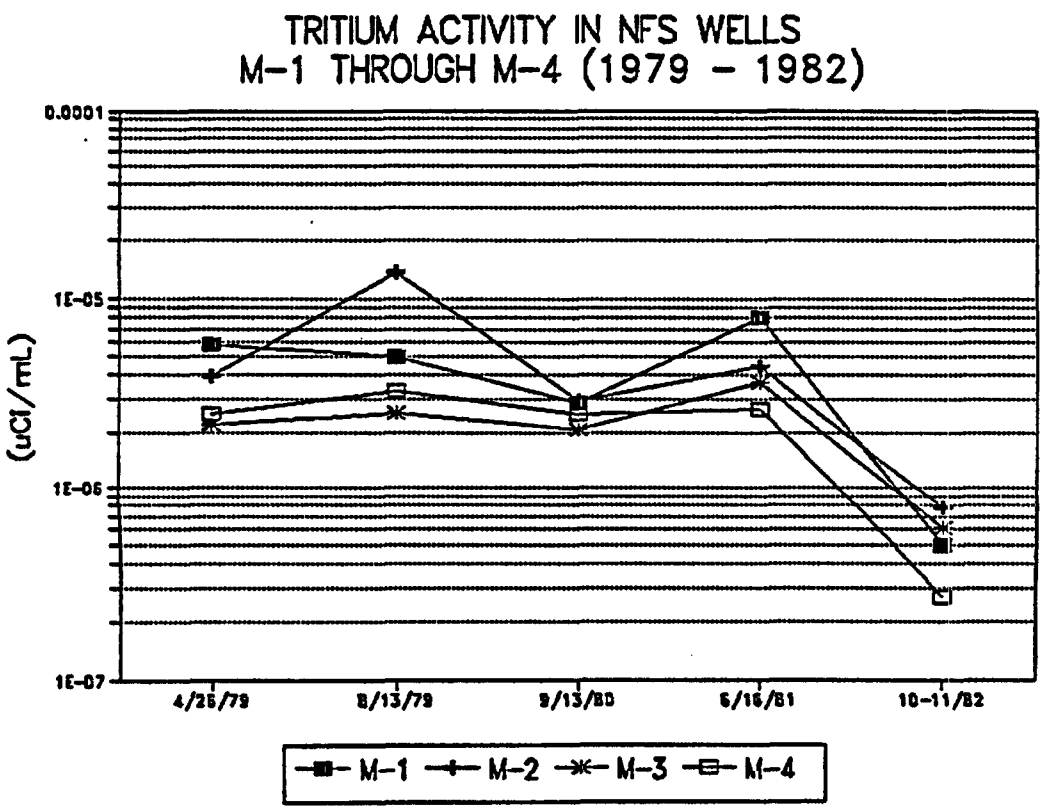


FIGURE 3-45

TRITIUM ACTIVITY (uCi/mL)
IN NFS WELLS J-1 THROUGH J-6
(1979 - 1982)

	J-1	J-2	J-3	J-4	J-5	J-6
4/26/79	1.35E-06	1.55E-06	1.87E-06	1.40E-06	3.21E-06	1.56E-06
8/13/79	2.12E-06	2.88E-06	3.27E-06	2.94E-06	3.39E-06	2.40E-06
9/13/80	1.85E-06	1.52E-06	2.85E-06	1.61E-06	2.39E-06	1.85E-06
6/16/81	1.65E-06	2.22E-06	2.49E-06	3.44E-06	3.75E-06	6.66E-06
10/11/82	6.91E-07	4.03E-07	1.01E-06	1.07E-06	8.36E-07	7.03E-07

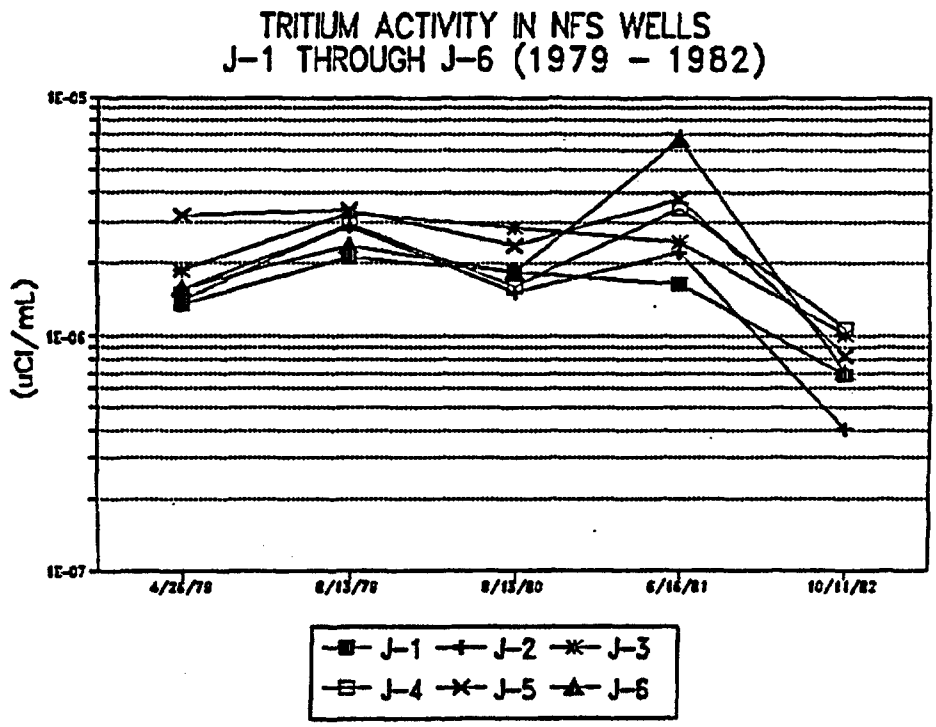
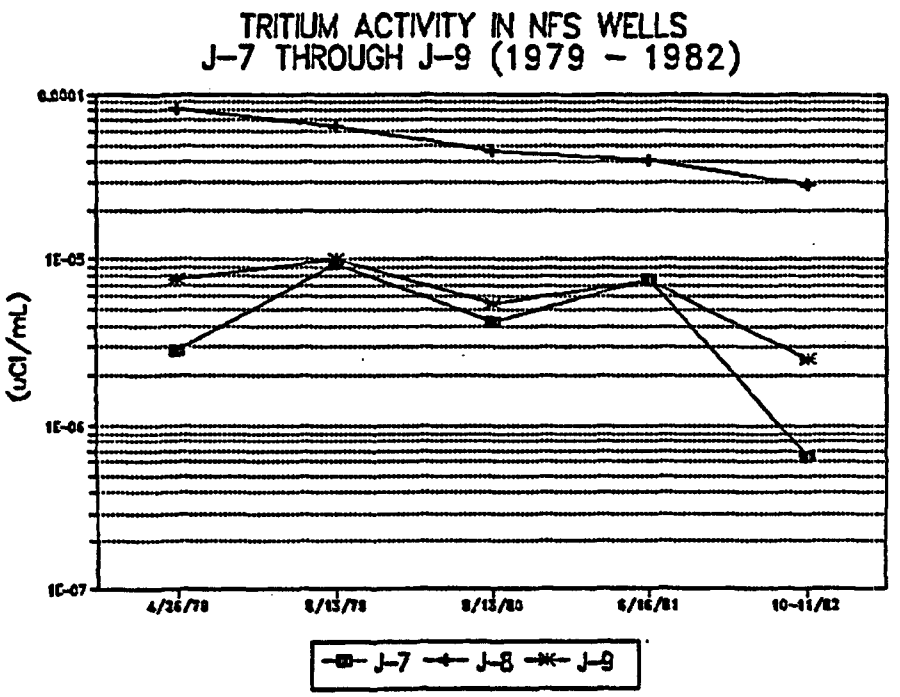


FIGURE 3-46

TRITIUM ACTIVITY (uCi/mL)
IN NFS WELLS J-7 THROUGH J-9
(1979 - 1982)

	J-7	J-8	J-9
4/26/79	2.84E-06	8.05E-05	7.59E-06
8/13/79	9.34E-06	6.42E-05	1.01E-05
9/13/80	4.22E-06	4.66E-05	5.45E-06
6/16/81	7.62E-06	4.03E-05	7.48E-06
10-11/82	6.58E-07	2.90E-05	2.52E-06



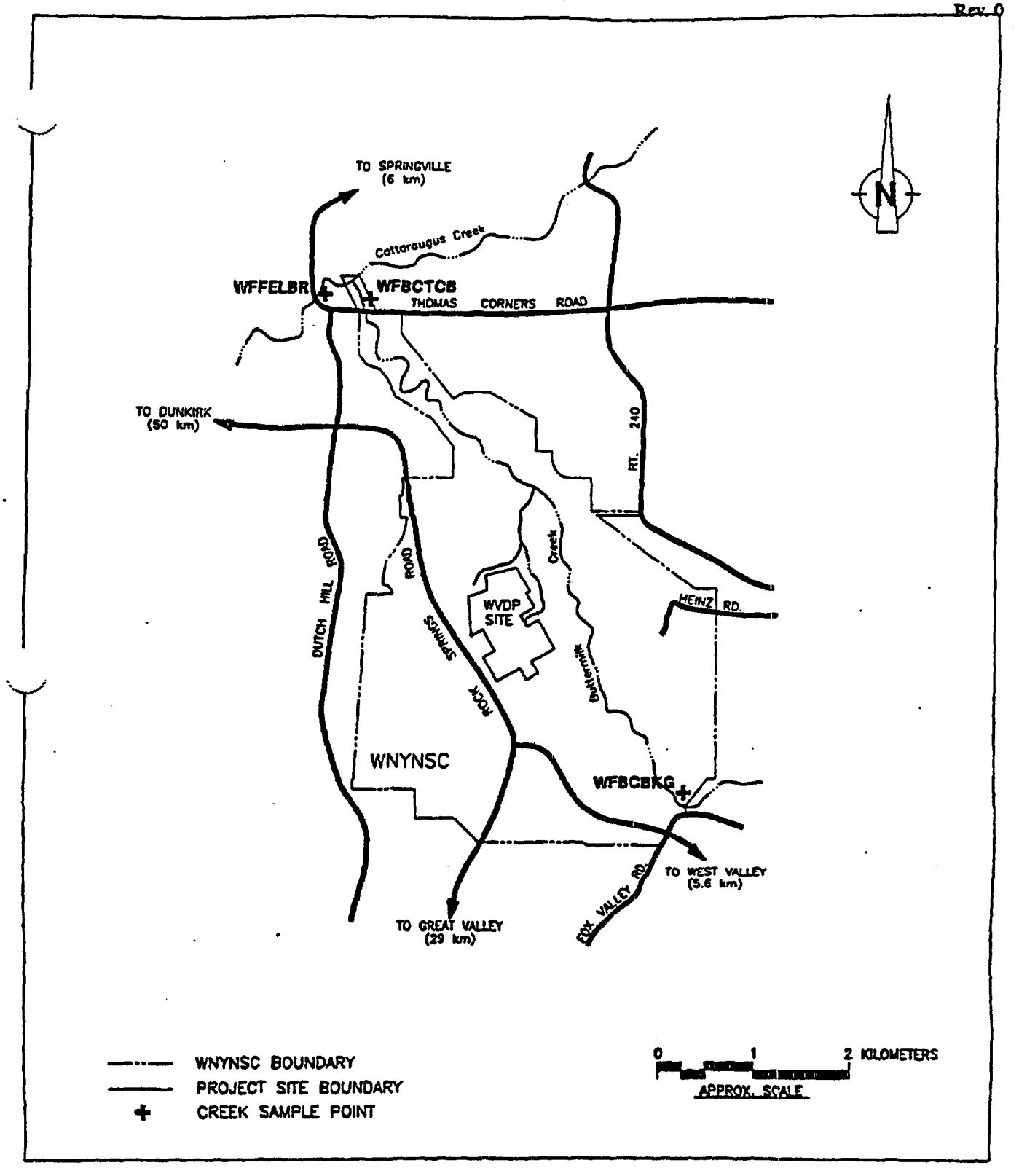


Figure 4-1 Location of Off-Site Surface Water Samplers.

FIGURE 4-2

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
BUTTERMILK CREEK, UPSTREAM
AT FOX VALLEY ROAD, SAMPLING LOCATION WFBCBKG
(WVDP 1983 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs-137
1983		3.82E-09	4.55E-07		
1984	3.56E-10 (6)	4.92E-09	1.88E-07	4.00E-09	< 7.00E-08
1985	5.27E-10 (2)	3.23E-09 (11)	1.29E-07 (4)	4.59E-09	< 7.00E-08
1986	1.02E-09 (2)	4.21E-09	1.12E-07 (1)	5.07E-09	< 2.10E-08
1987	7.52E-10 (1)	3.47E-09 (11)	1.25E-07 (4)	3.79E-09 (3)	2.96E-08 (1)
1988	1.00E-09 (2)	3.67E-09	< 1.00E-07	2.27E-09 (3)	< 2.10E-08
1989	1.07E-09 (2)	3.31E-09	< 1.00E-07	2.44E-09 (2)	< 2.10E-08
1990	1.27E-09 (2)	2.96E-09 (11)	< 1.00E-07	5.08E-09 (3)	< 1.10E-08
1991	1.53E-09 (2)	3.86E-09	1.06E-07 (1)	2.12E-09 (3)	< 3.40E-08

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
1983 - SIX SAMPLING EVENTS

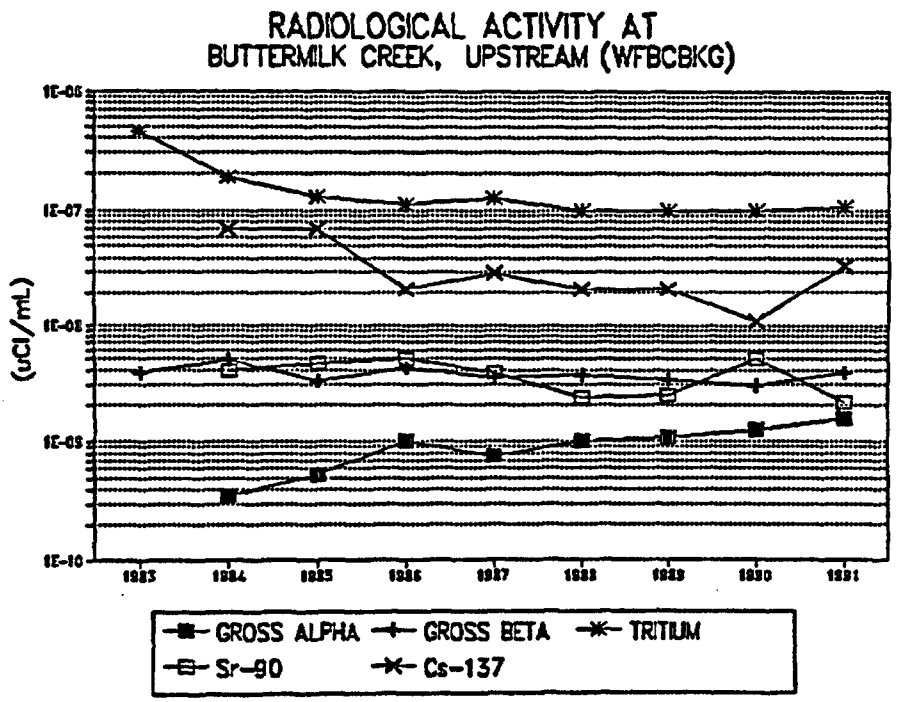


FIGURE 4-3

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
BUTTERMILK CREEK, DOWNSTREAM
AT THOMAS CORNERS BRIDGE, SAMPLING LOCATION WFBCTCB
(WVDP 1982 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs-137
1982	< 5.83E-10	1.78E-08	7.94E-06		
1983	5.97E-10	1.01E-08	5.98E-07		
1984	6.88E-10 (11)	1.18E-08	7.42E-07	1.54E-08	< 7.00E-08
1985	1.54E-09 (8)	1.02E-08	3.06E-07 (9)	4.44E-09	< 7.00E-08
1986	1.75E-09 (6)	7.82E-09	1.14E-07 (2)	3.99E-09	2.45E-08 (1)
1987	1.15E-09 (3)	5.78E-09	1.33E-07 (2)	5.28E-09	2.68E-08 (1)
1988	1.02E-09 (3)	5.94E-09	1.06E-07 (1)	2.93E-09 (3)	< 2.10E-08
1989	1.42E-09 (2)	6.26E-09	1.51E-07 (3)	2.47E-09	< 2.10E-08
1990	1.38E-09 (3)	5.29E-09	1.77E-07 (6)	3.58E-09	< 1.10E-08
1991	2.42E-09 (1)	1.03E-08	< 1.00E-07	1.22E-08	< 3.40E-08

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
1982 - FOUR SAMPLING EVENTS
1983 - SIX SAMPLING EVENTS

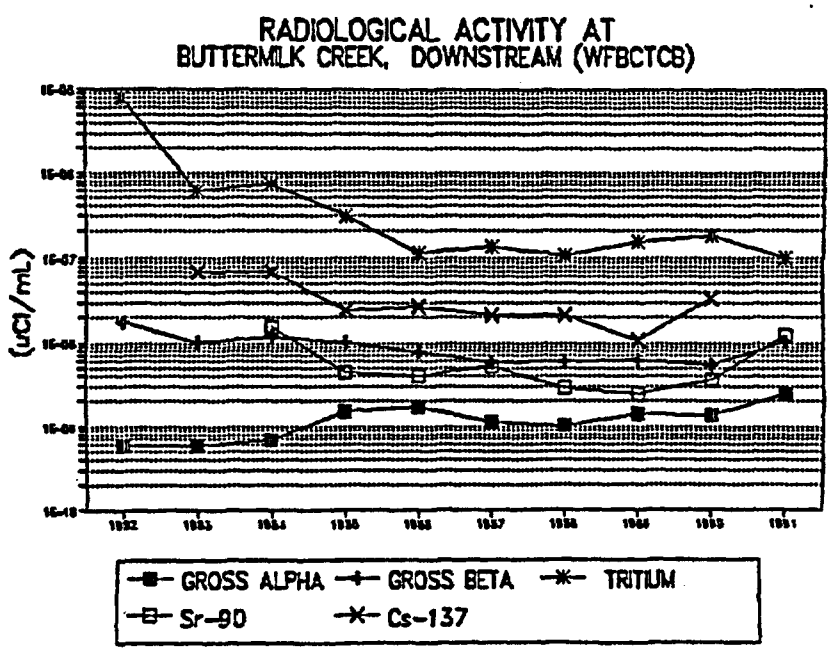


FIGURE 4-4

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
CATTARAUGUS CREEK, UPSTREAM
BIGELOW BRIDGE
(WVDP 1982 - 1985)

	GROSS ALPHA	GROSS BETA	TRITIUM
1982	< 4.0E-10	7.28E-09	9.58E-07
1983	2.9E-10 (1)	4.76E-09	3.43E-07 (7)
1984	4.4E-10 (8)	6.59E-09	1.97E-07 (2)
1985	6.6E-10 (3)	3.85E-09	1.70E-07 (6)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

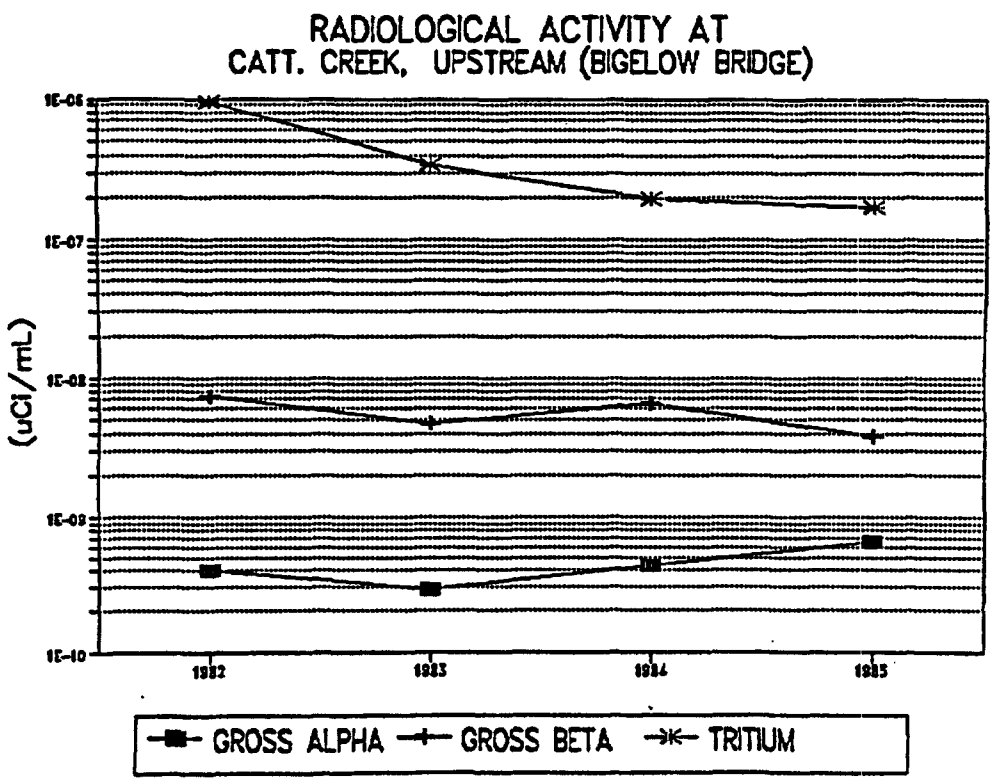
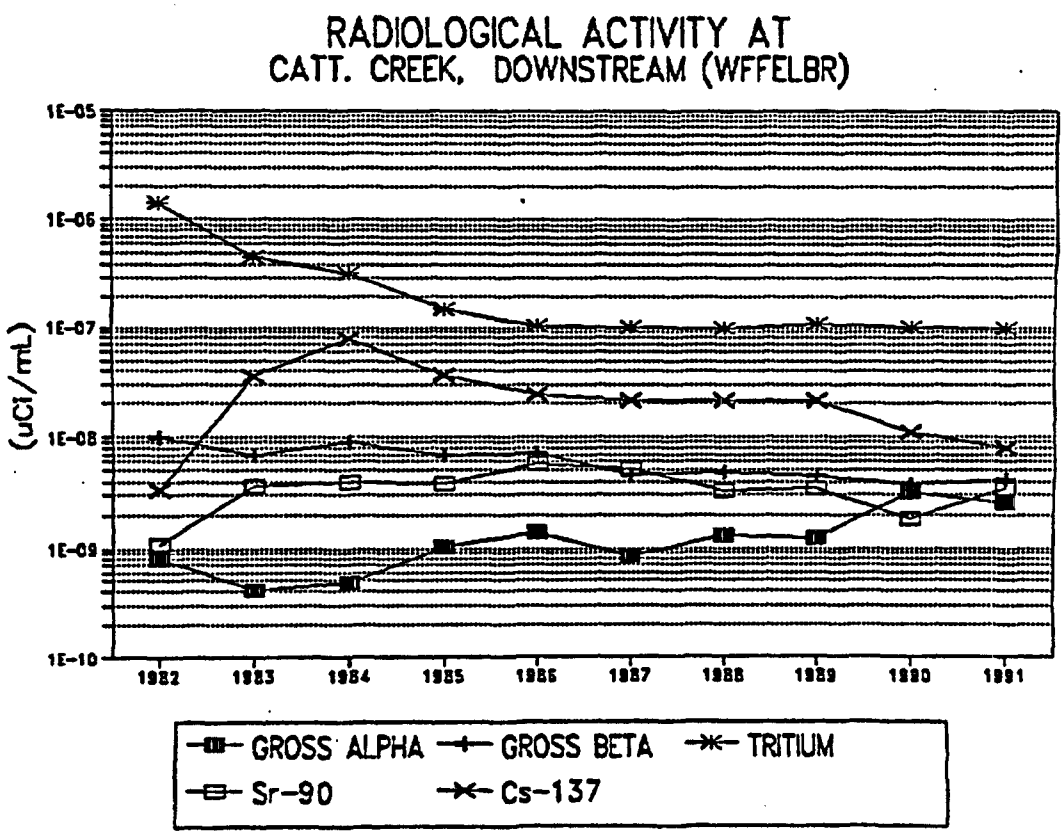


FIGURE 4-5

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
CATTARAUGUS CREEK, DOWNSTREAM
FELTON BRIDGE, SAMPLING STATION WFFELBR
(WVDP 1982 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs137
1982	< 8.0E-10	1.00E-08	1.4E-06	1.09E-09	< 3.4E-09
1983	4.1E-10 (3)	6.80E-09	4.6E-07	3.65E-09 (6)	3.6E-08
1984	4.8E-10 (7)	9.03E-09	3.4E-07 (6)	3.95E-09 (7)	< 7.8E-08
1985	1.0E-09 (5)	6.87E-09	1.5E-07 (4)	3.90E-09	3.6E-08 (1)
1986	1.4E-09 (5)	7.36E-09	1.1E-07 (2)	5.73E-09	2.4E-08 (2)
1987	8.3E-10 (1)	4.56E-09	1.0E-07 (1)	5.21E-09 (11	< 2.1E-08
1988	1.3E-09 (3)	4.80E-09	< 1.0E-07	3.24E-09 (10	< 2.1E-08
1989	1.2E-09 (4)	4.45E-09	1.1E-07 (2)	3.46E-09	< 2.1E-08
1990	3.2E-09 (2)	3.78E-09	1.0E-07 (1)	1.84E-09	< 1.1E-08
1991	2.6E-09 (1)	4.14E-09	< 1.0E-07	3.43E-09 (11)	8.1E-09 (1)

)=NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION



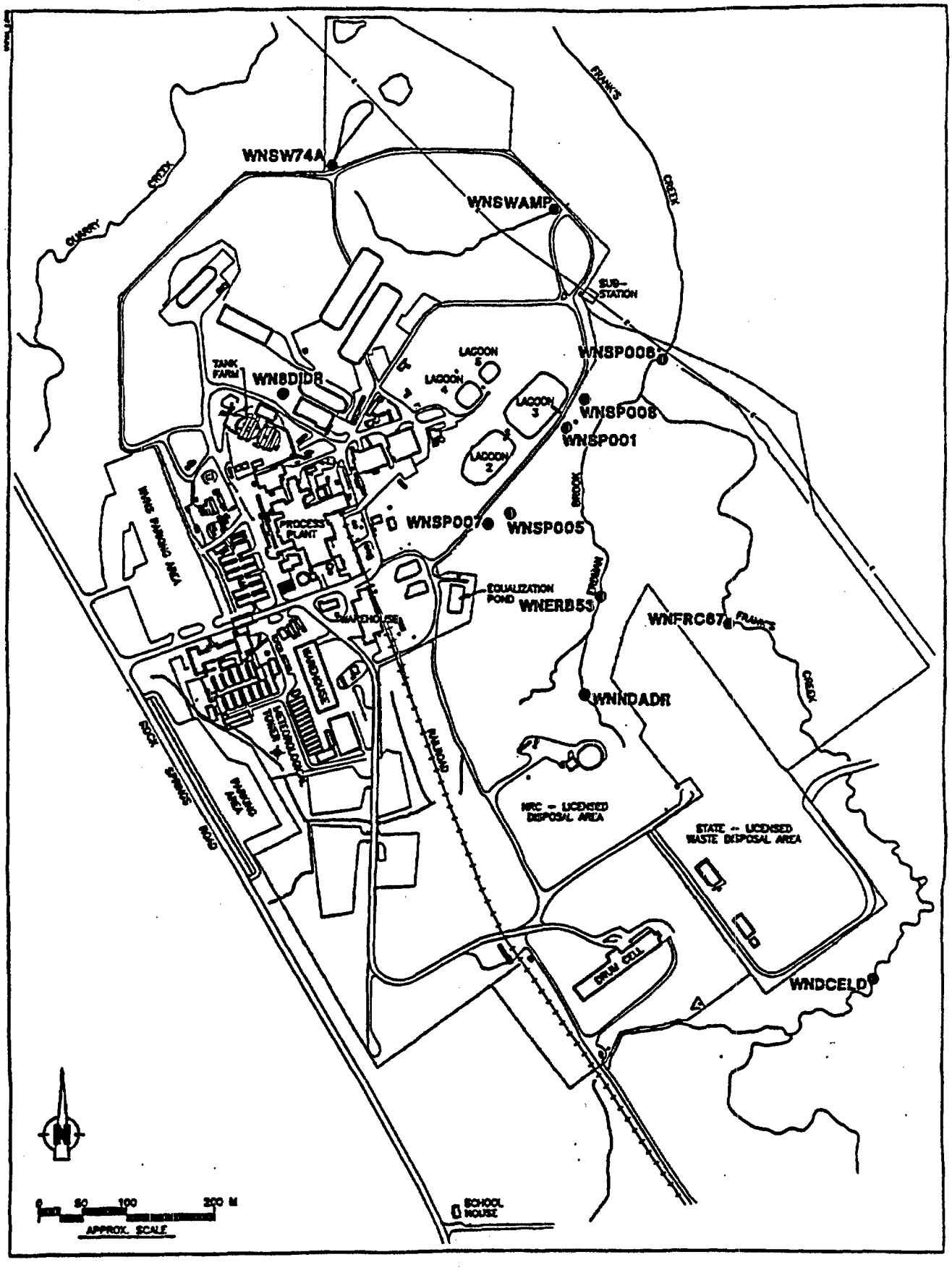


Figure 4-6 Sampling Locations for On-Site Surface Water.

FIGURE 4-7

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
FRANK'S CREEK, SAMPLING LOCATION WNSP006
(WVNS 1983 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM	Sr-90	Cs-137
1983	5.4E-10 (4)	5.42E-08	3.34E-06		
1984	2.0E-09 (9)	9.34E-08	9.20E-06	3.07E-08	1.4E-07
1985	5.2E-09 (10)	4.88E-08	4.31E-06	2.26E-08	< 7.0E-08
1986	3.2E-09 (9)	4.99E-08	1.07E-06 (11)	1.97E-08	1.8E-07
1987	2.2E-09 (2)	4.42E-08	1.20E-06 (9)	2.17E-08	1.9E-07 (3)
1988	2.0E-09 (3)	4.34E-08	6.53E-07 (11)		
1989	1.7E-09 (4)	4.57E-08	4.29E-06 (11)		
1990	2.5E-09 (4)	1.00E-07	4.69E-06 (10)		
1991	< 5.4E-09	9.25E-08	1.58E-06 (10)		

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

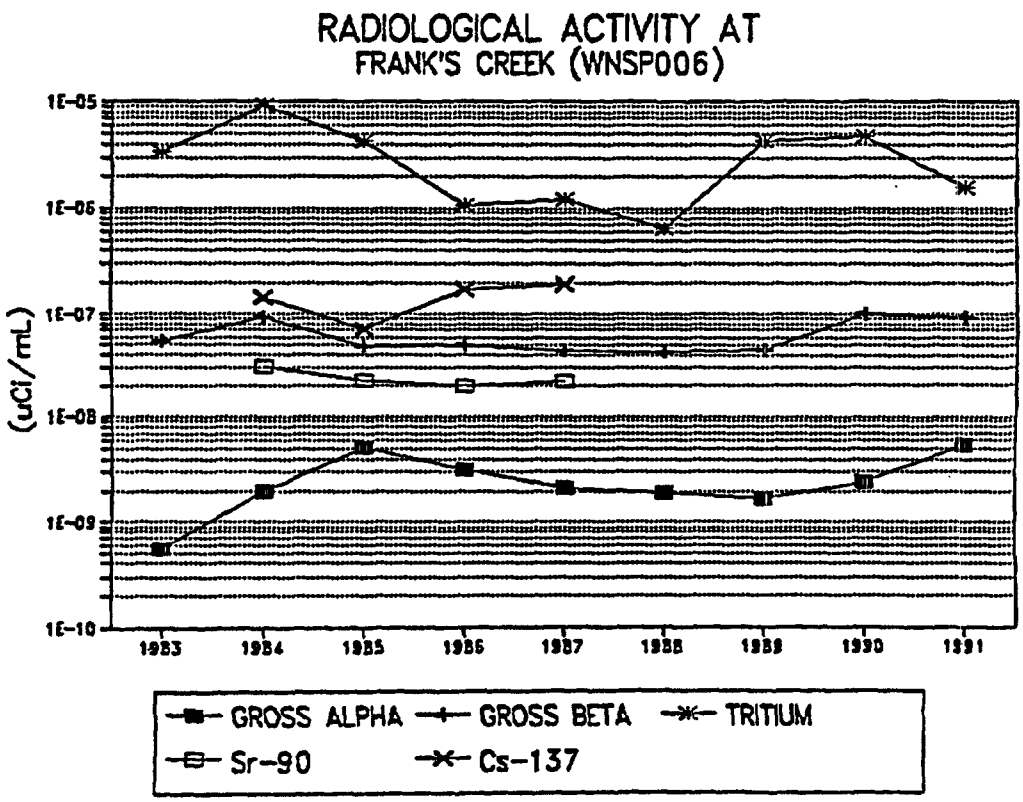


FIGURE 4-8

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN ERDMAN BROOK, SAMPLING LOCATION 053
WVNS SAMPLING (1982-1991)

YEAR	GROSS ALPHA	GROSS BETA	TRITIUM
1982	< 2.7E-10	2.46E-08	1.6E-06
1983	3.2E-10 (5)	2.99E-08	1.5E-06
1984	4.0E-10 (8)	2.29E-08	4.1E-07 (9)
1985	6.1E-10 (4)	2.69E-08	4.6E-07 (11)
1986	9.6E-10 (3)	3.20E-08	3.9E-07
1987	9.4E-10 (1)	2.32E-08	2.5E-07 (7)
1988	1.3E-09 (5)	3.52E-08	4.3E-07 (8)
1989	1.2E-09 (1)	2.76E-08	2.5E-07 (7)
1990	1.5E-09 (1)	2.33E-08	1.4E-07 (5)
1991	< 4.3E-09	2.18E-08	1.8E-07 (2)

( )=NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

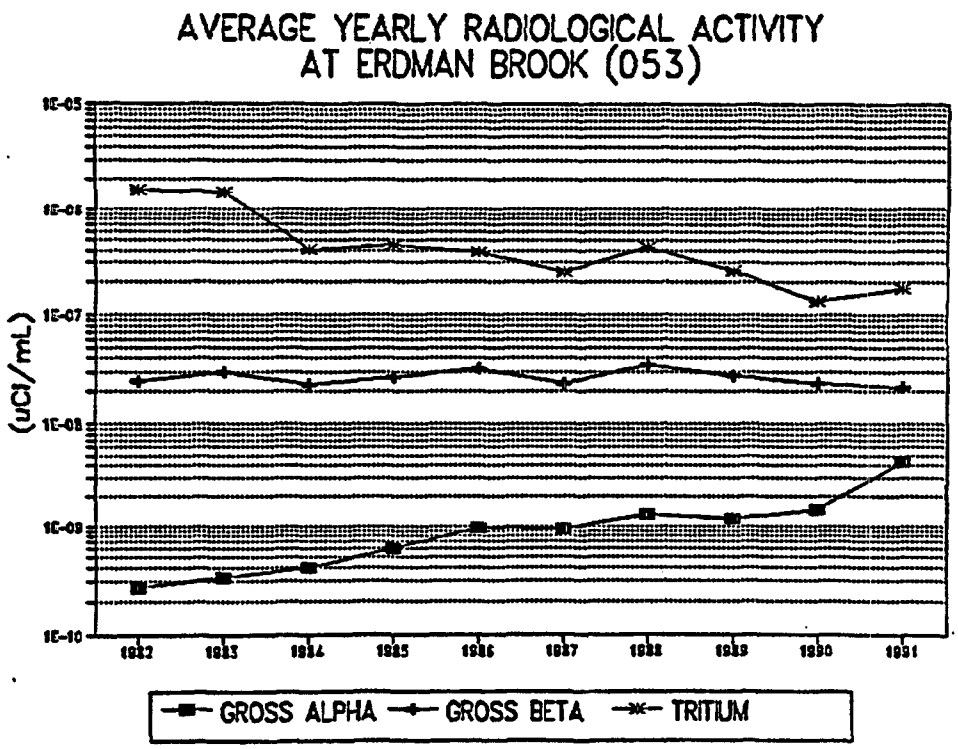


FIGURE 4-9

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
AT FRANK'S CREEK, SAMPLING LOCATION 067
(WVNS SAMPLING 1982-1991)

YEAR	GROSS ALPHA		GROSS BETA		TRITIUM	
1982	< 4.1E-10		9.01E-09		8.9E-07	(10)
1983	3.1E-10	(8)	1.06E-08	(11)	5.7E-07	(10)
1984	4.3E-10	(8)	6.38E-09		2.2E-07	(4)
1985	8.5E-10	(5)	6.02E-09		2.1E-07	(6)
1986	7.8E-10	(2)	4.94E-09		2.0E-07	(7)
1987	7.6E-10	(2)	5.69E-09		1.5E-07	(3)
1988	< 1.2E-09		5.11E-09		1.4E-07	(3)
1989	1.1E-09	(2)	6.38E-09		1.1E-07	(1)
1990	1.4E-09	(4)	5.41E-09		< 1.0E-07	
1991	< 5.5E-09		5.22E-09		< 1.0E-07	

( )=NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

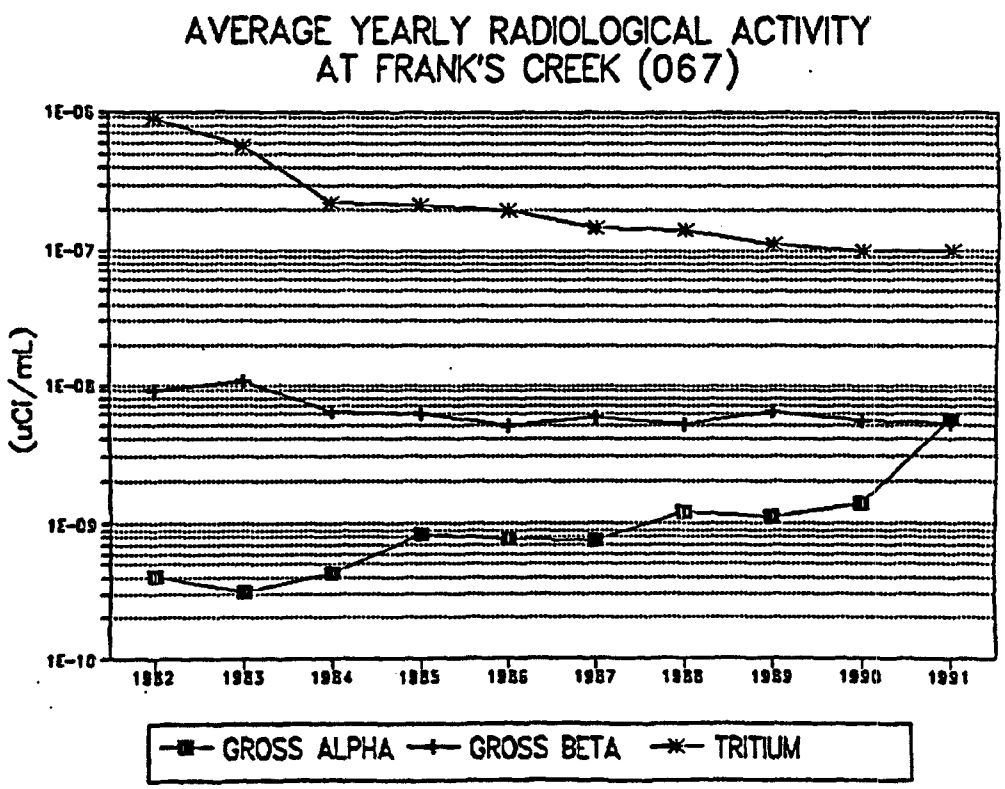


FIGURE 4-10

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN THE FRENCH DRAIN, SAMPLING LOCATION WNSP008
(WVNS SAMPLING 1982 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM
1982	< 6.45E-10	3.70E-08	3.52E-05
1983	< 4.83E-10	1.75E-08	3.19E-05
1984	2.39E-10 (3)	1.17E-08	2.33E-05
1985			1.74E-05
1986			4.44E-05
1987	1.92E-09 (1)	3.07E-08	7.73E-06
1988	1.53E-09 (1)	3.57E-08	7.30E-06
1989	3.89E-09 (1)	4.68E-08	6.11E-06
1990	< 8.74E-09	4.77E-08	5.00E-06
1991		4.05E-08	4.49E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

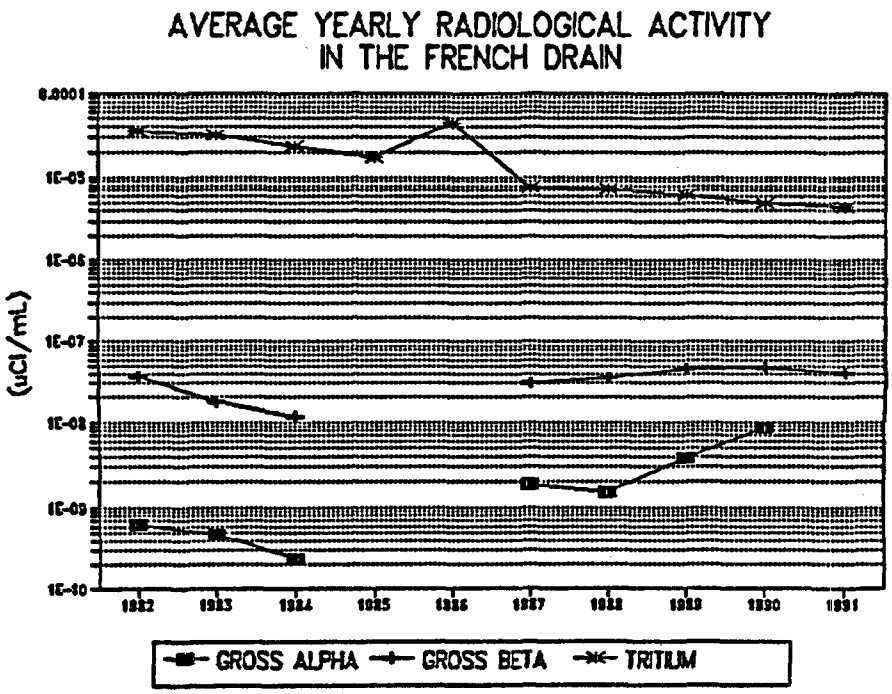


FIGURE 4-11

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN THE SEWAGE TREATMENT OUTFALL, SAMPLING LOCATION WNSP007
(WVNS SAMPLING 1983 - 1991)

		GROSS ALPHA		GROSS BETA		TRITIUM
1983		1.64E-09		3.93E-08		8.36E-07
1984		1.61E-09		5.08E-08		2.30E-07
1985	<	1.00E-09		3.00E-08		2.33E-07
1986	<	6.90E-10		5.75E-09	<	1.30E-07
1987	<	8.30E-10		8.18E-09	<	1.10E-07
1988	<	7.80E-10		6.26E-09	<	1.00E-07
1989	<	9.50E-10		6.45E-09	<	1.00E-07
1990	<	1.15E-09		1.58E-08	<	1.00E-07
1991	<	6.50E-09		5.68E-07		2.69E-08

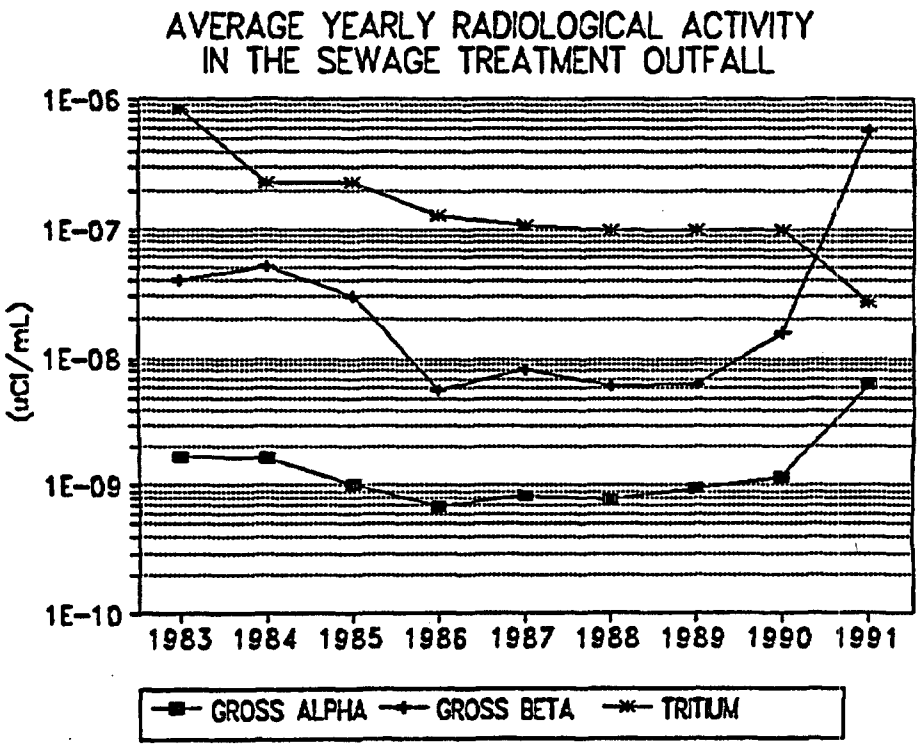


FIGURE 4-12

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN LAGOON 3, SAMPLING LOCATION WNSP001
(WVNS SAMPLING 1982 - 1991)

	GROSS ALPHA	GROSS BETA	TRITIUM	Cs-137	Sr-90
1982			3.17E-04	5.22E-07	1.50E-07
1983	2.31E-08	1.17E-06	1.34E-04	7.93E-07	8.97E-08
1984	2.27E-07	1.57E-06	1.41E-04	1.22E-06	1.64E-07
1985	3.47E-07	9.57E-07	9.88E-05	5.54E-07	2.01E-07
1986	5.44E-08	1.44E-06	2.30E-05	1.33E-05	1.40E-07
1987	1.20E-08	9.25E-07	1.67E-05	9.25E-07	9.36E-08
1988	7.41E-08	8.07E-07	2.23E-05	4.15E-07	1.12E-07
1989	3.30E-08	1.00E-06	9.95E-05	1.41E-07	9.17E-08
1990	2.36E-08	1.07E-06	1.06E-04	2.84E-07	5.97E-08
1991	9.78E-09	1.14E-06	3.25E-05	2.51E-07	1.03E-07

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

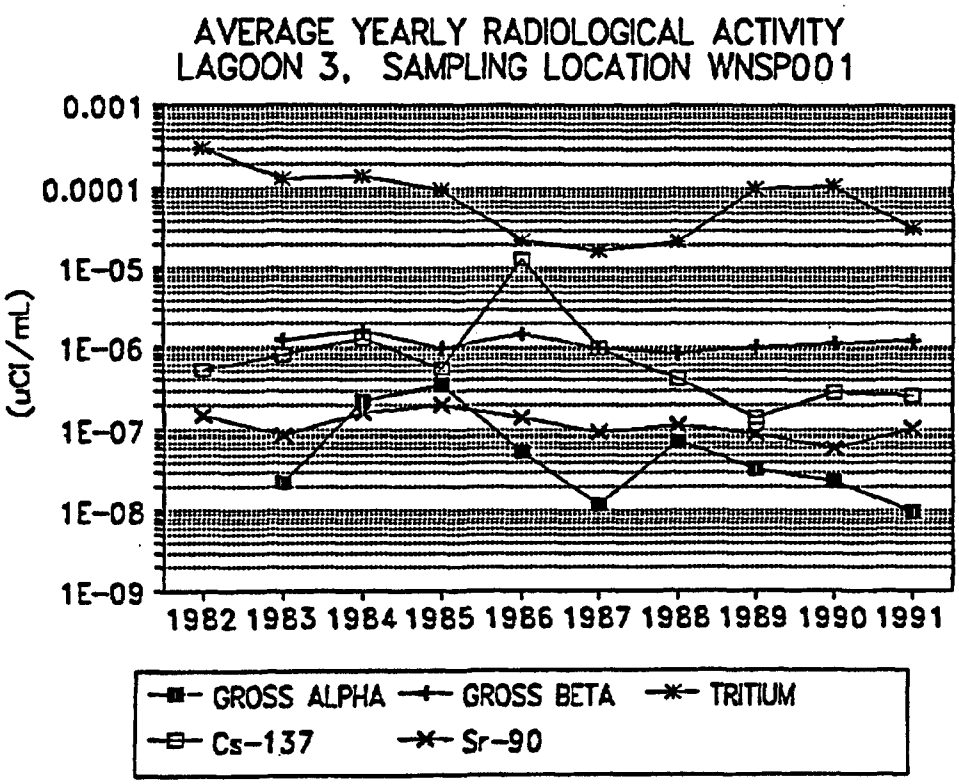
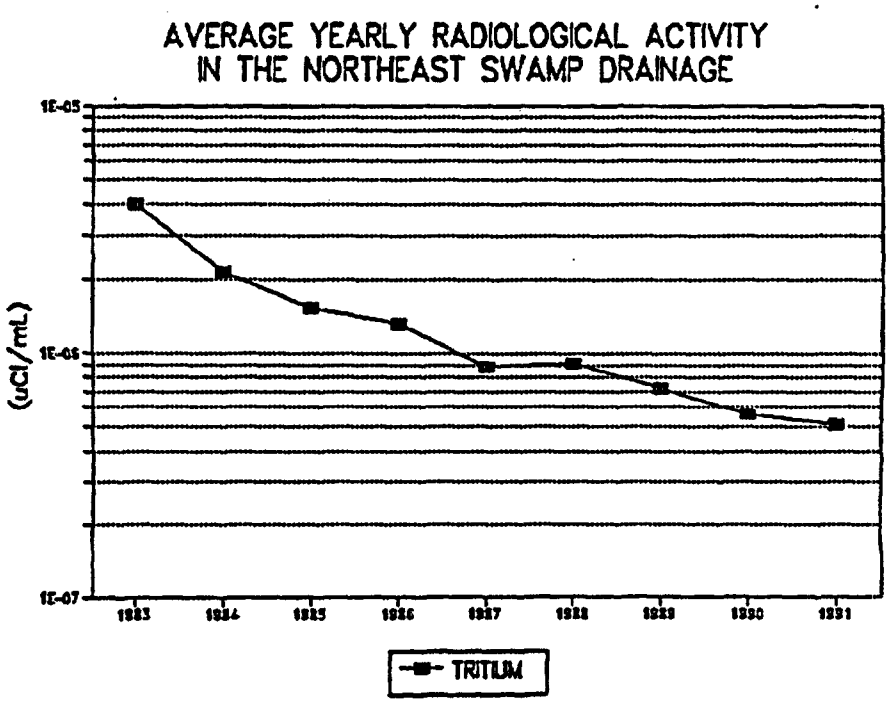


FIGURE 4-13

AVERAGE YEARLY RADIOLOGICAL ACTIVITY (uCi/mL)
IN THE NORTHEAST SWAMP DRAINAGE, SAMPLING LOCATION WNSWAMP
(WVNS SAMPLING 1983 - 1991)

	TRITIUM
1983	4.00E-06
1984	2.13E-06
1985	1.55E-06
1986	1.33E-06
1987	8.90E-07
1988	9.23E-07
1989	7.23E-07
1990	5.68E-07
1991	5.12E-07



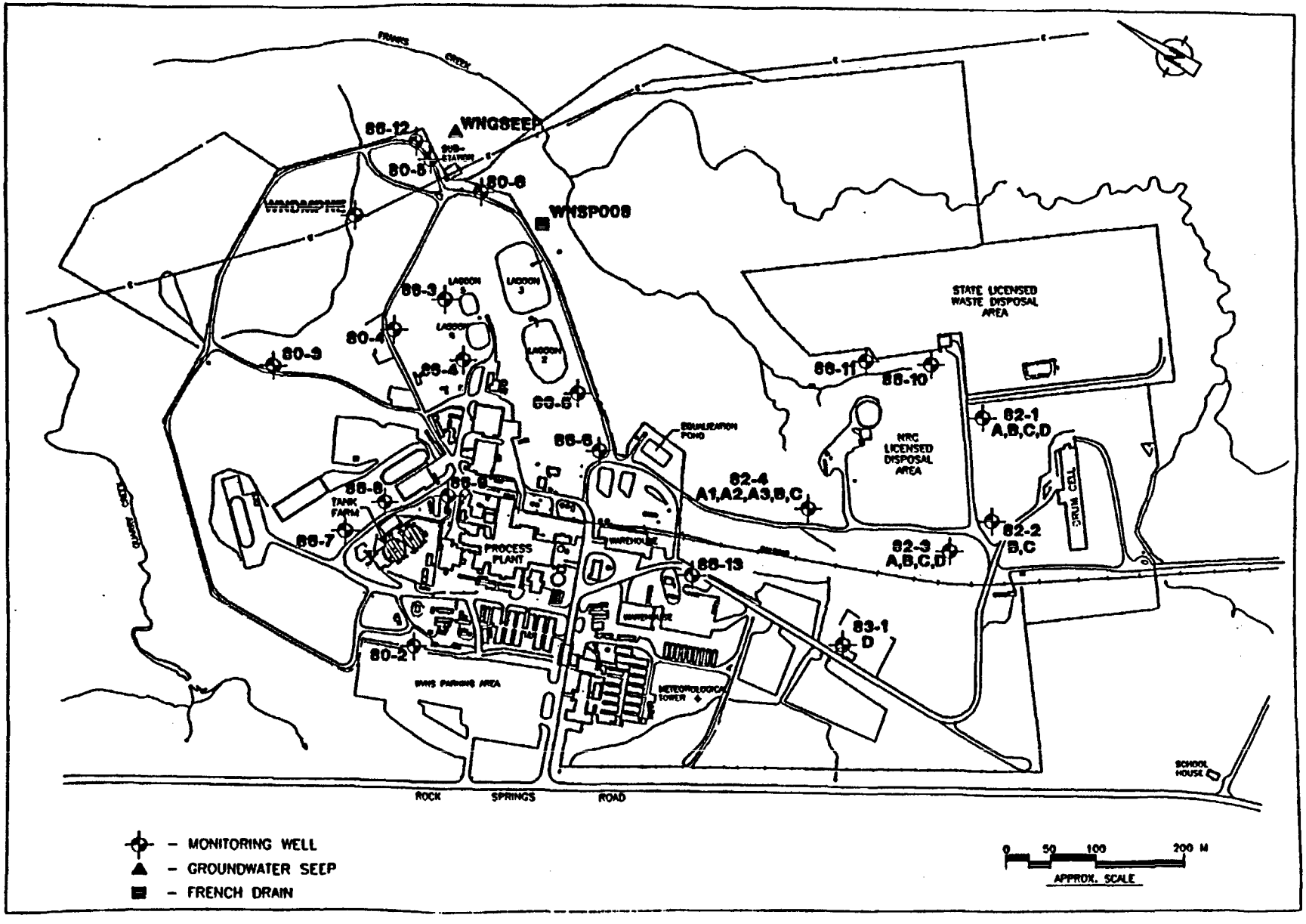


Figure 4-14 Groundwater Monitoring Points 1986-1990.

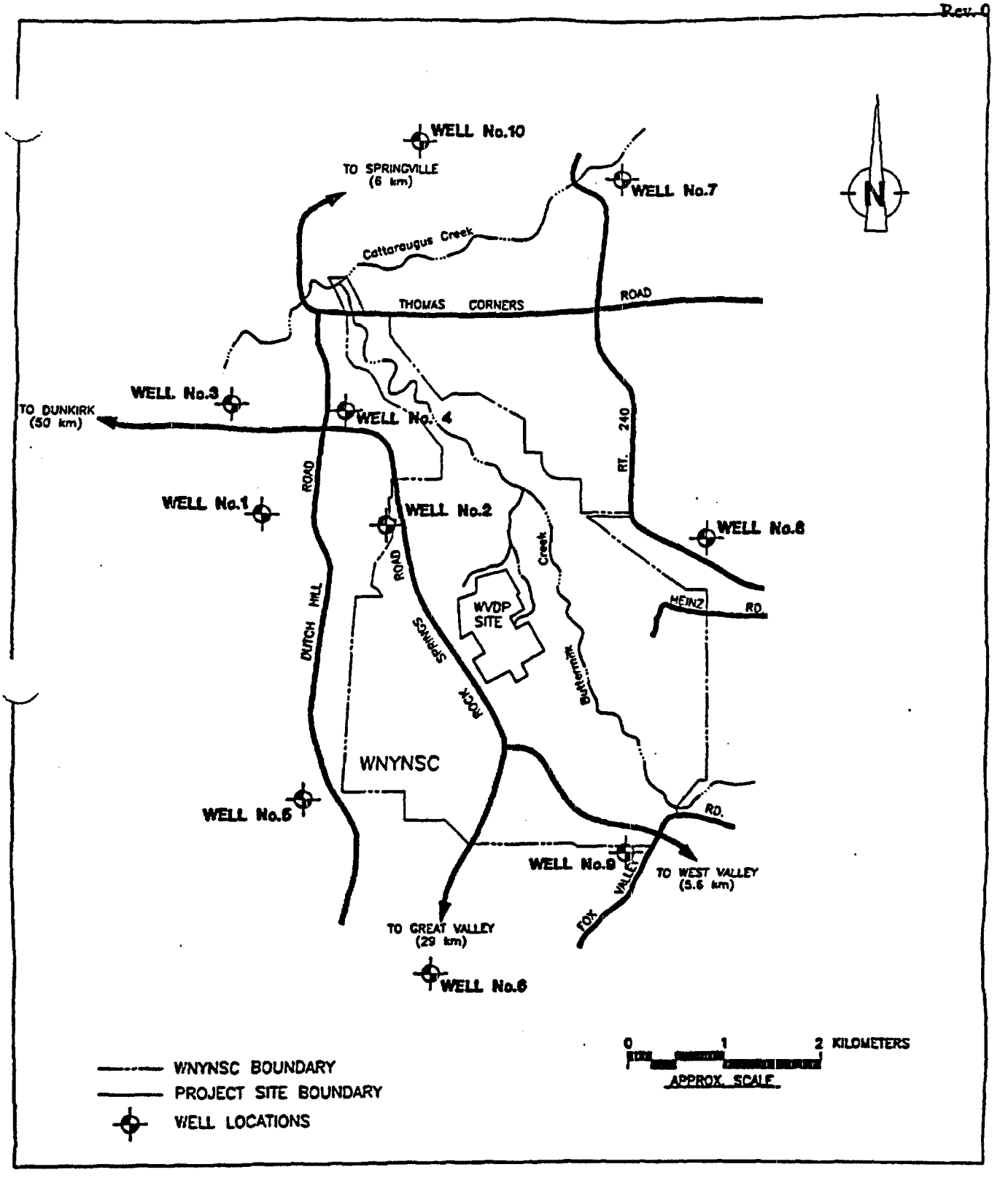


Figure 4-15 Off-Site Groundwater Monitoring Points.

FIGURE 4-16

AVERAGE YEARLY GROSS ALPHA ACTIVITY (uCi/mL)
IN WVDP WELLS-LAGOON AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	3.99E-10	<1.30E-09	<6.60E-10	1.26E-09	<8.70E-10	1.16E-09 (1)	<4.06E-09	
86-3			<9.70E-10	1.09E-09	<1.38E-09	<6.12E-09	<8.99E-09	8.74E-09 (2)
86-4			<1.70E-09	1.33E-09	<1.59E-09	<5.52E-09	<1.17E-08	<1.25E-08
86-5			3.47E-09	8.24E-09	1.59E-08	9.52E-09	8.32E-09 (3)	1.12E-08 (5)
86-6			<4.50E-09	<5.30E-09	<3.44E-09	7.26E-09 (1)	4.97E-09 (1)	<3.08E-08
WNSP008				1.12E-09	1.53E-09	3.89E-09 (1)	<8.74E-09	<7.23E-09

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

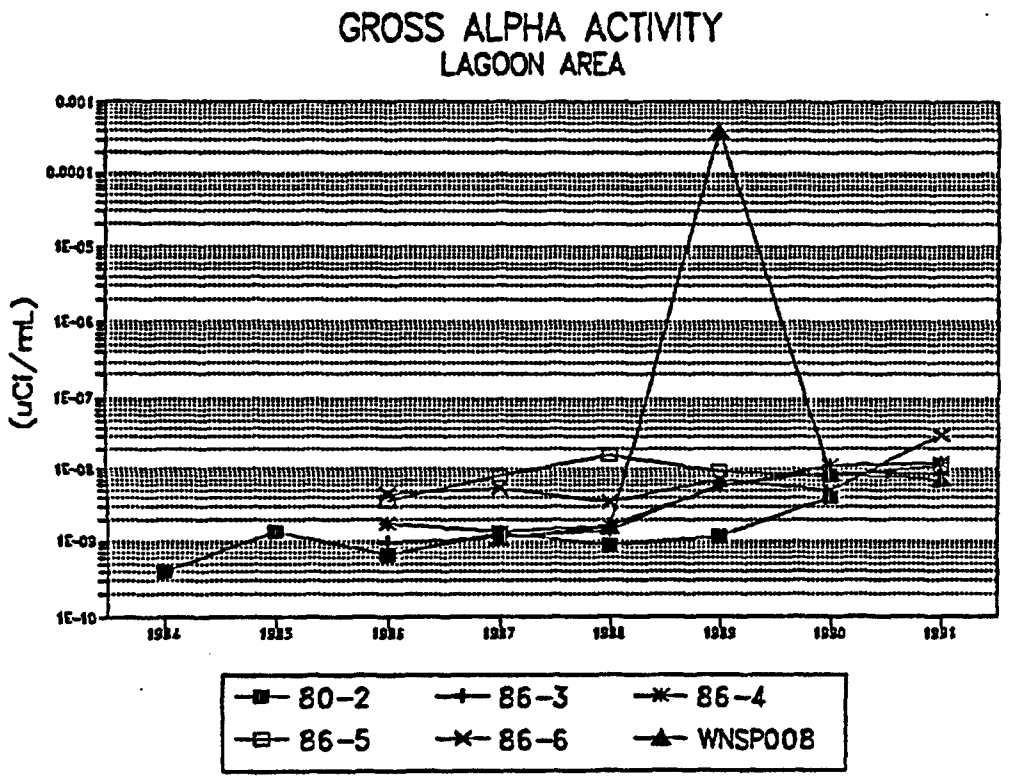


FIGURE 4-17

AVERAGE YEARLY GROSS ALPHA ACTIVITY (uCi/mL)
IN WVDP WELLS-TANK FARM AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	3.99E-10	<1.3E-09	<6.6E-10	1.26E-09	<8.70E-10	1.16E-09 (1)	<4.06E-09	
80-3	1.98E-09	1.03E-08	1.15E-09	<2.29E-09	<5.41E-09	<2.34E-09	<3.19E-09	
80-4	2.81E-10	<1.5E-09	<1.0E-09	<1.75E-09	<2.09E-09	<4.39E-09	<1.29E-09	
86-7			<2.1E-09	3.31E-09	1.86E-09	<7.49E-09	<5.53E-09	4.45E-09 (2)
86-8			<1.1E-09	3.53E-09	2.00E-09	<4.77E-09	2.53E-09 (1)	<3.70E-09
86-9			<1.1E-09	6.89E-09	4.38E-09	<4.21E-09	5.04E-09 (1)	<7.41E-09

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

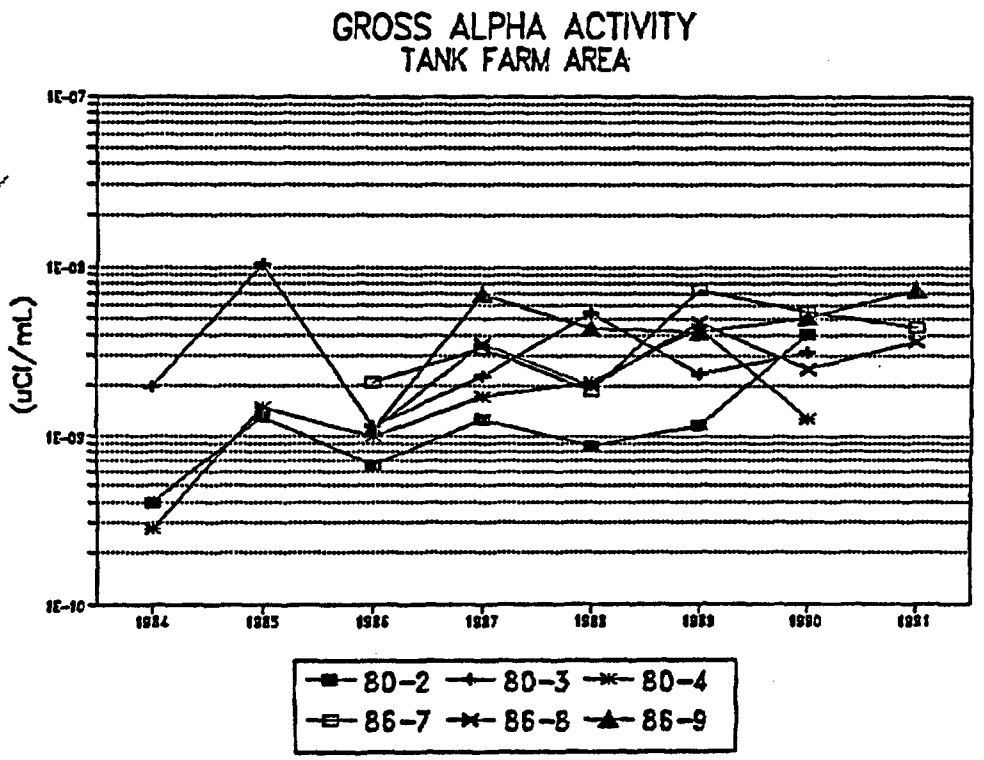


FIGURE 4-18

AVERAGE YEARLY GROSS ALPHA ACTIVITY (uCi/mL)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	3.99E-10	<1.30E-09	<6.60E-10	1.26E-09	<8.70E-10	1.16E-09 (1)	<4.06E-09	
80-5	6.41E-10	<1.10E-09	<1.10E-09	1.63E-09	<1.08E-09	<8.86E-09	<6.84E-09	
80-6	3.67E-10	<3.10E-09	<5.50E-09	2.64E-09	<1.41E-09	<7.66E-09	<9.67E-09	
86-12				<1.92E-09	1.02E-09	3.15E-09 (2)	5.75E-09 (1)	5.51E-09 (1)
WNGSEEP				<2.44E-09	3.91E-09	<2.72E-09	3.28E-09 (1)	<5.18E-09
WNDMPNE				2.21E-09	<9.22E-10	3.34E-09	3.82E-09 (1)	<6.53E-09

( )=NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

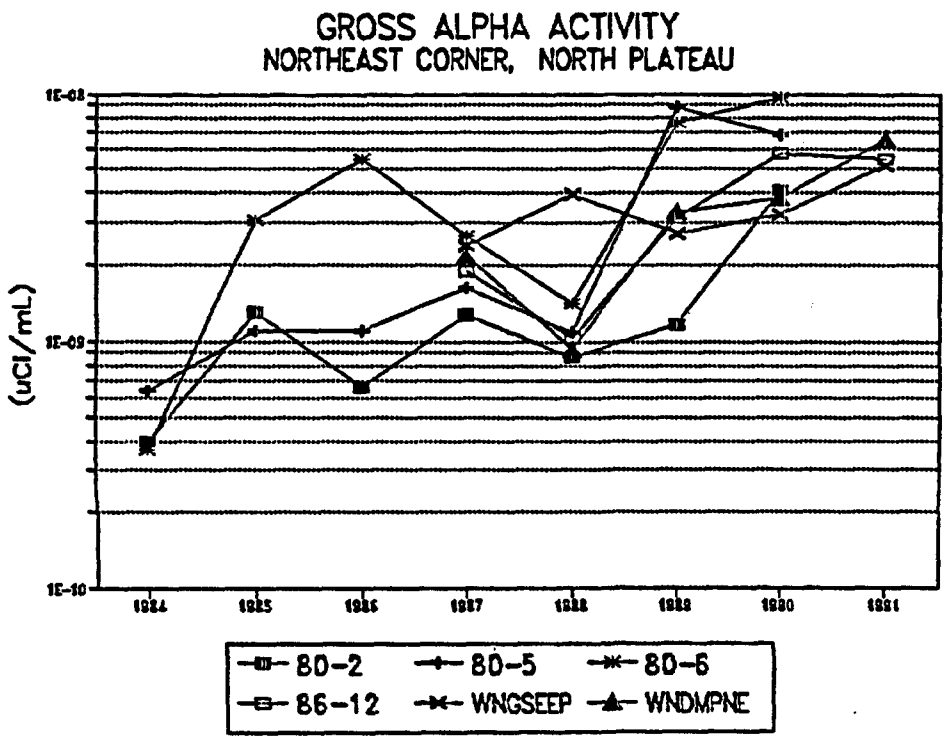


FIGURE 4-19

AVERAGE YEARLY GROSS BETA ACTIVITY (uCi/mL)
IN WVDP WELLS LAGOON AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	5.48E-09	5.49E-09	2.85E-09	2.50E-09	1.28E-09	1.39E-09 (6)		
86-3			8.69E-09	7.95E-09	8.57E-09	1.08E-08	1.66E-08	1.62E-08
86-4			9.03E-09	1.93E-08	3.07E-08	8.20E-08	4.90E-07	1.35E-06
86-5			1.65E-05	2.12E-05	2.25E-05	3.50E-05	2.76E-05	2.40E-05
86-6			1.82E-08	6.38E-09	7.55E-09	2.99E-09 (6)	5.99E-09 (2)	8.69E-09 (4)
WNSP008				3.07E-08	3.57E-08	4.68E-08	4.77E-08	4.05E-08

( ) = NUMBER SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

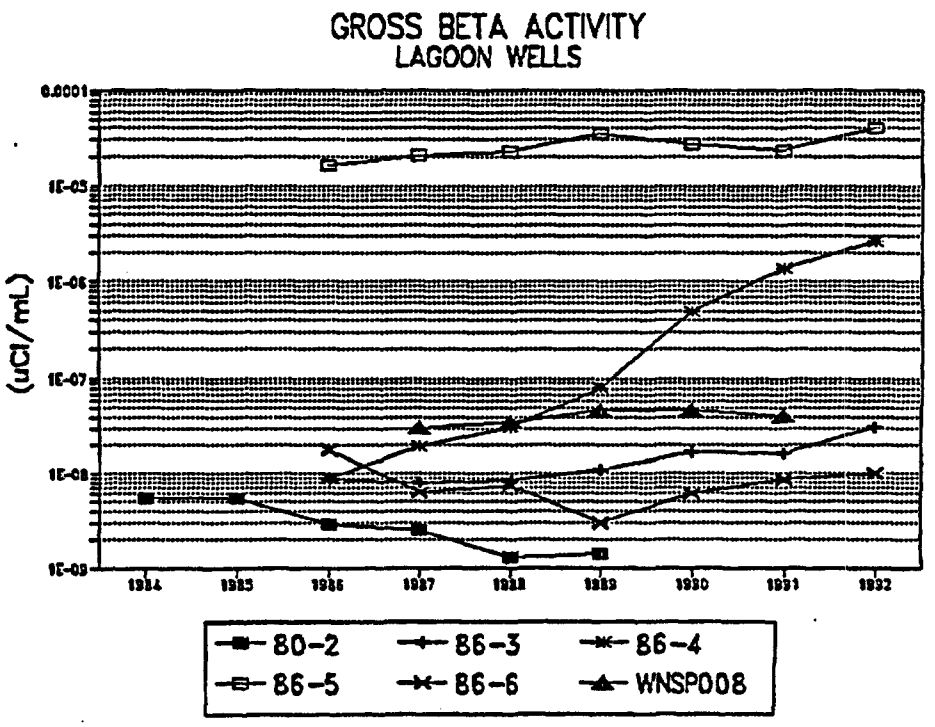


FIGURE 4-20

AVERAGE YEARLY GROSS BETA ACTIVITY (uCi/mL)
IN WVDP WELLS TANK FARM AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	5.48E-09	5.49E-09	2.85E-09	2.50E-09	1.28E-09	1.39E-09 (6)		
80-3	2.32E-07	3.09E-07	2.99E-07	2.87E-07	2.08E-07	2.37E-07	2.01E-07	
80-4	3.86E-09	1.76E-08	1.13E-08	1.03E-08	1.08E-08	2.06E-08	2.48E-08	
86-7			8.49E-09	5.47E-09	7.46E-09	5.14E-09	1.63E-08	1.12E-08
86-8			5.76E-09	1.24E-08	8.84E-09	1.07E-08	9.85E-09	9.39E-09
86-9			8.06E-08	1.28E-07	1.76E-07	2.04E-07	2.35E-07	2.51E-07

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

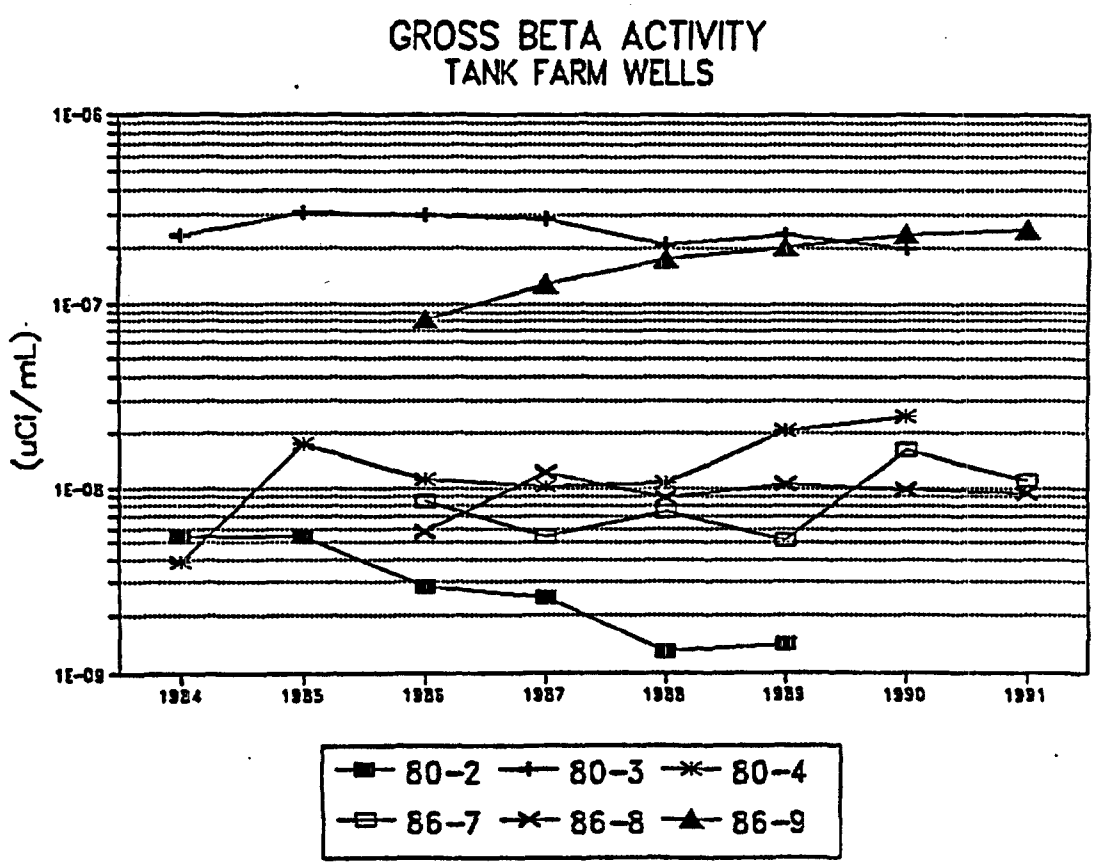


FIGURE 4-21

AVERAGE YEARLY GROSS BETA ACTIVITY (uCi/mL)
IN WUDP WELLS NORTHEASTERN MARGIN NORTH PLATEAU
(1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	5.48E-09	5.49E-09	2.85E-09	2.50E-09	1.28E-09	1.39E-09 (6)		
80-5	6.89E-09	2.70E-09	5.02E-09	5.80E-09	2.22E-09	3.35E-09		
80-6	3.55E-09	8.29E-09	7.76E-09	7.90E-09	3.43E-09	4.29E-09	5.23E-09	
86-12				1.45E-09	1.11E-09	1.99E-09 (6)	1.86E-09 (2)	2.25E-09 (3)
WNGSEEP				3.05E-09	7.14E-09	3.70E-09	4.00E-09	6.56E-09
WNDMPNE				9.88E-08	1.19E-07	1.14E-07	9.65E-08	1.79E-07

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

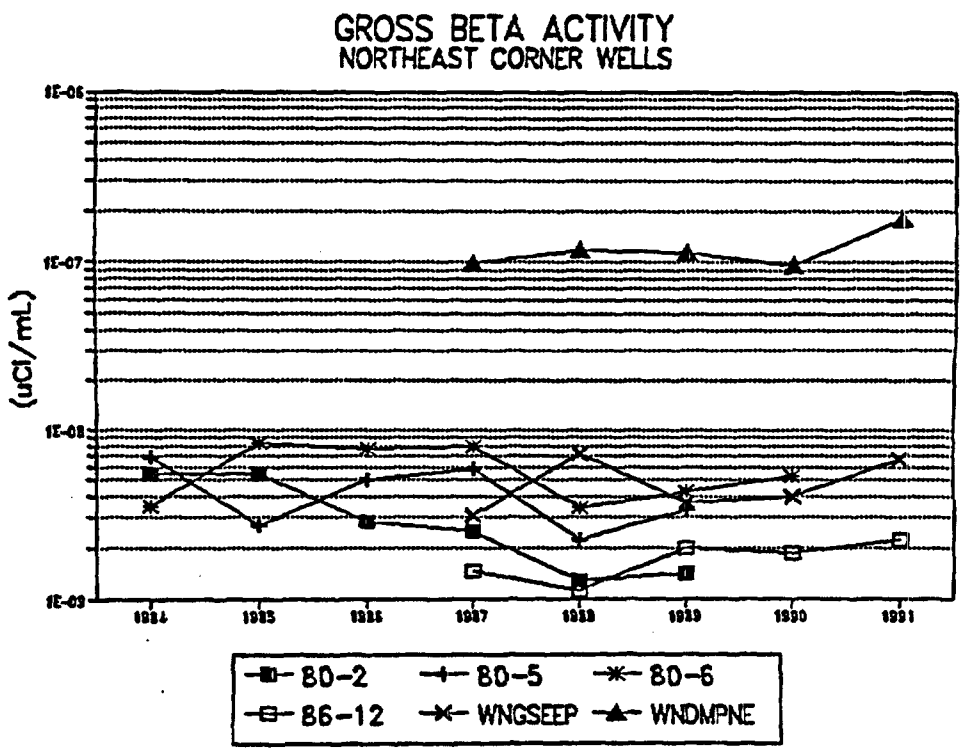


FIGURE 4-22

AVERAGE YEARLY TRITIUM ACTIVITY (uCi/mL)
IN WVDP WELLS LAGOON AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	<1.65E-07	1.46E-07	1.86E-07	1.06E-07	<1.00E-07	1.40E-07 (5)	1.39E-07 (2)	
86-3			1.98E-06	1.54E-06	1.24E-06	1.11E-06	1.12E-06	9.73E-07
86-4			2.06E-06	1.75E-06	1.43E-06	1.36E-06	1.28E-06	1.42E-06
86-5			2.64E-05	1.72E-05	1.61E-05	1.78E-05	1.66E-05	9.60E-06
86-6			7.87E-07	7.99E-08	5.00E-08	<1.18E-07	<1.18E-07	<1.00E-07
WNSP008				7.73E-06	7.30E-06	6.11E-06	5.00E-06	4.49E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

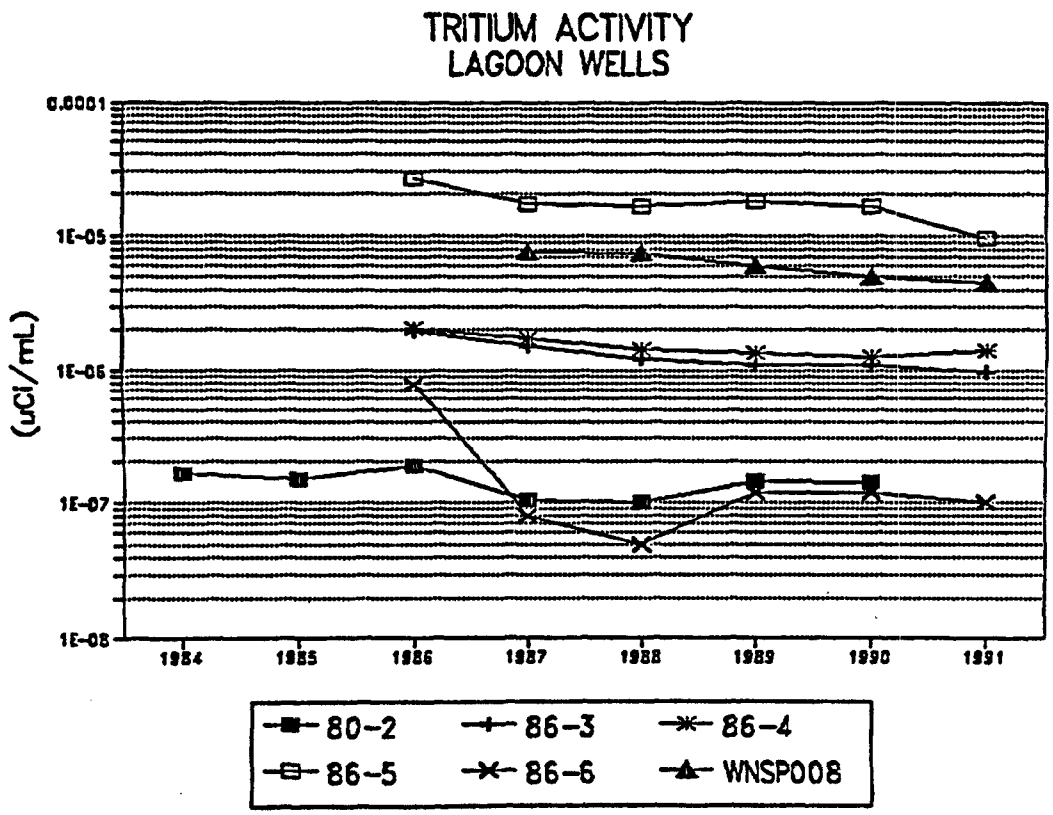


FIGURE 4-23

AVERAGE YEARLY TRITIUM ACTIVITY (uCi/mL)
IN WVDP WELLS TANK FARM AREA (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	1.65E-07	1.46E-07	1.86E-07	1.06E-07	1.00E-07	1.40E-07 (5)	1.39E-07 (2)	
80-3	1.70E-07	3.14E-07	2.01E-07	7.62E-07	1.24E-07	1.33E-07	1.12E-07 (1)	
80-4	2.77E-07	3.71E-07	5.87E-07	9.63E-07	1.73E-07	2.52E-07	1.10E-07	
86-7			4.56E-07	2.37E-07	5.89E-08	1.70E-07 (3)	1.35E-07 (3)	1.14E-07 (3)
86-8			2.92E-06	3.69E-06	2.66E-06	2.68E-07 (4)	2.76E-07 (5)	9.68E-07
86-9			4.08E-06	3.24E-06	2.18E-06	2.43E-06	1.91E-06	1.65E-06

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

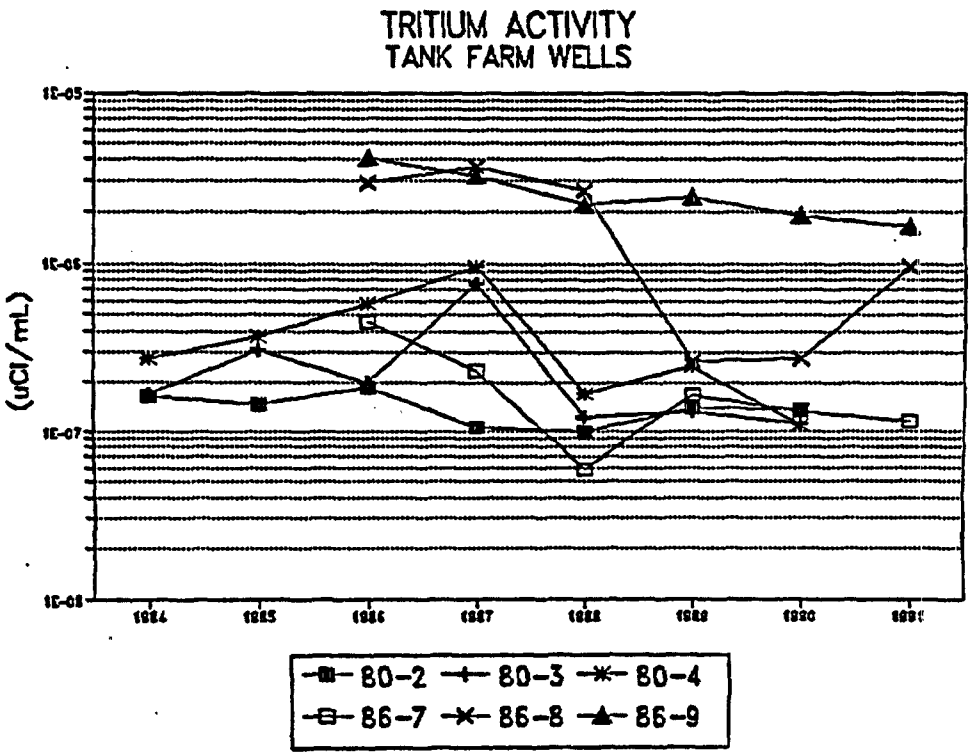


FIGURE 4-24

AVERAGE YEARLY TRITIUM ACTIVITY IN WVDP WELLS (uCi/mL)
NORTHEASTERN MARGIN NORTH PLATEAU (1984 - 1991)

WELL	1984	1985	1986	1987	1988	1989	1990	1991
80-2	<1.65E-07	1.46E-07	1.86E-07	1.06E-07	<1.00E-07	1.40E-07 (5)	1.39E-07 (2)	
80-5	5.68E-07	4.36E-07	3.08E-07	4.50E-07	5.86E-07	8.70E-07	1.33E-06	
80-6	5.02E-06	2.97E-06	1.78E-06	1.35E-06	7.98E-07	7.92E-07	1.00E-06	
86-12				4.96E-06	4.34E-06	3.62E-06	2.86E-06	2.20E-06
WNGSEEP				2.44E-06	1.39E-06	1.26E-06	7.88E-07	7.56E-07
WNDMPNE				6.36E-07	9.58E-07	6.87E-07	6.44E-07	4.76E-07

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

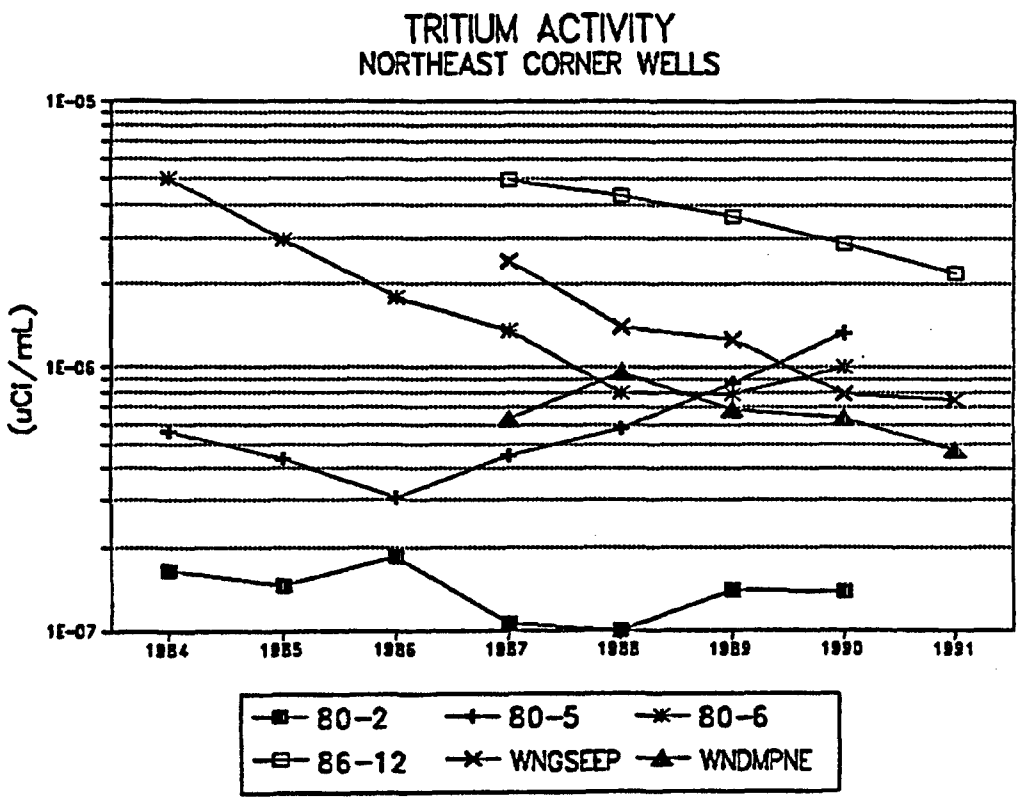


FIGURE 4-25

AVERAGE YEARLY pH IN
WVDP WELLS-LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	7.75	7.92	7.77	7.74	7.79	
86-3	7.37	7.34	7.32	7.25	7.31	7.30
86-4	7.23	7.25	7.18	7.18	7.25	7.25
86-5	6.72	6.76	6.85	6.64	6.69	6.64
86-6	6.66	6.71	6.76	6.62	6.63	6.56
WNSP008	6.91	6.84	6.99	6.80	6.87	6.87

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

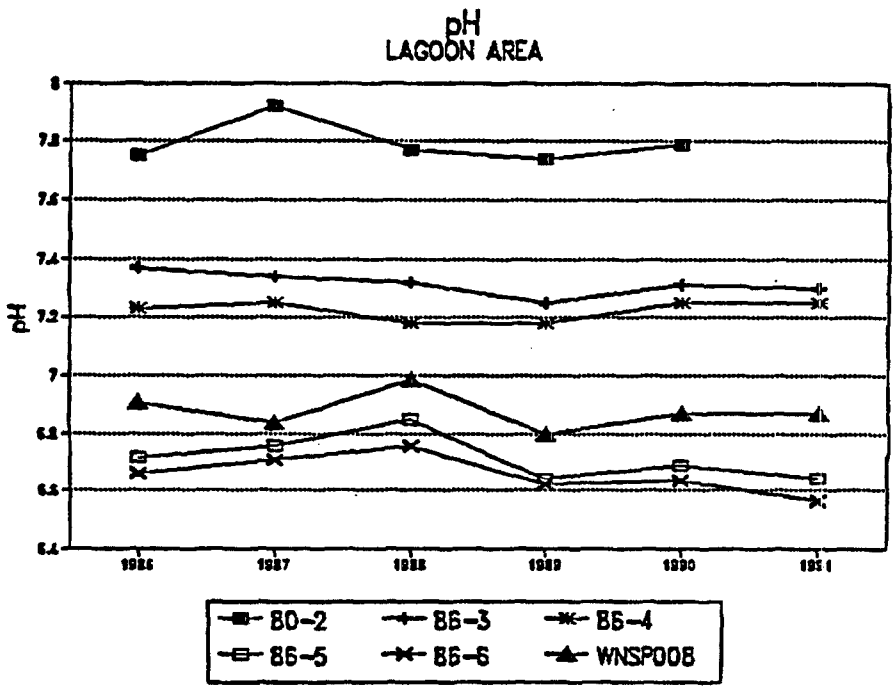


FIGURE 4-26

AVERAGE YEARLY pH
IN WVDP WELLS-TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	7.75	7.92	7.77	7.74	7.79	
80-3	6.86	7.02	7.46	7.14	6.97	
80-4	7.09	7.26	7.22	7.12	7.12	
86-7	6.40	6.76	6.76	6.33	6.15	6.37
86-8	6.26	6.79	6.80	6.69	6.71	6.69
86-9	6.97	7.15	7.23	7.09	7.14	7.11

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

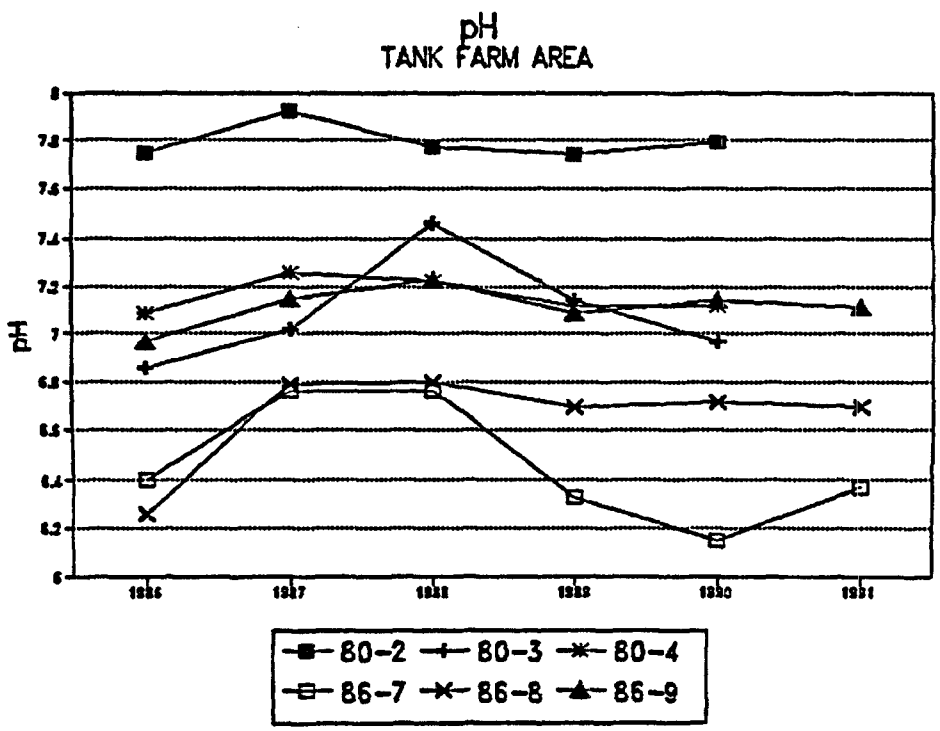


FIGURE 4-27

AVERAGE YEARLY pH
IN WVDP WELLS-NORTHEAST MARGIN, NORTH PLATEAU

WELL	1986	1987	1988	1989	1990	1991
80-2	7.75	7.92	7.77	7.74	7.79	
80-5	7.43	6.94	7.17	6.76	6.96	
80-6	6.73	6.27	6.38	6.29	6.49	
86-12		7.51	7.61	7.41	7.40	7.40
WNGSEEP	6.24	6.42	6.41	6.21	6.36	6.32
WNDMPNE		6.75	6.88	6.83	6.65	7.27

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

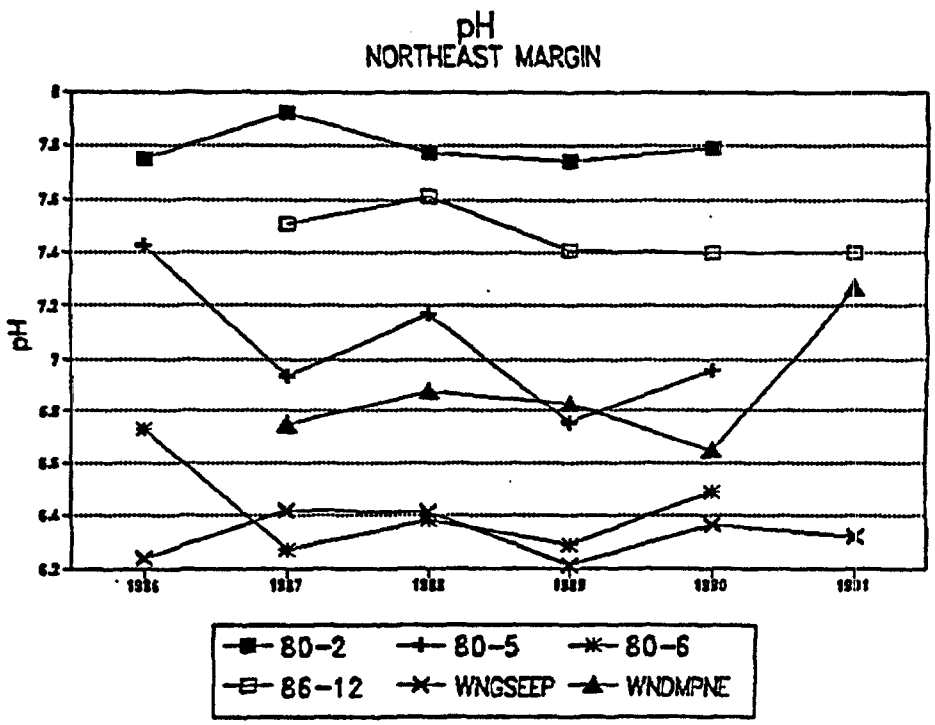


FIGURE 4-28

AVERAGE YEARLY SPECIFIC CONDUCTANCE (umhos/cm @ 25°C)
IN WVDP WELLS-LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	305	325	368	417	464	
86-3	726	761	840	883	939	953
86-4	703	753	824	880	931	977
86-5	693	661	765	862	798	838
86-6	2584	1621	2245	2577	1713	2408
WNSP008	846	832	940	922	942	922

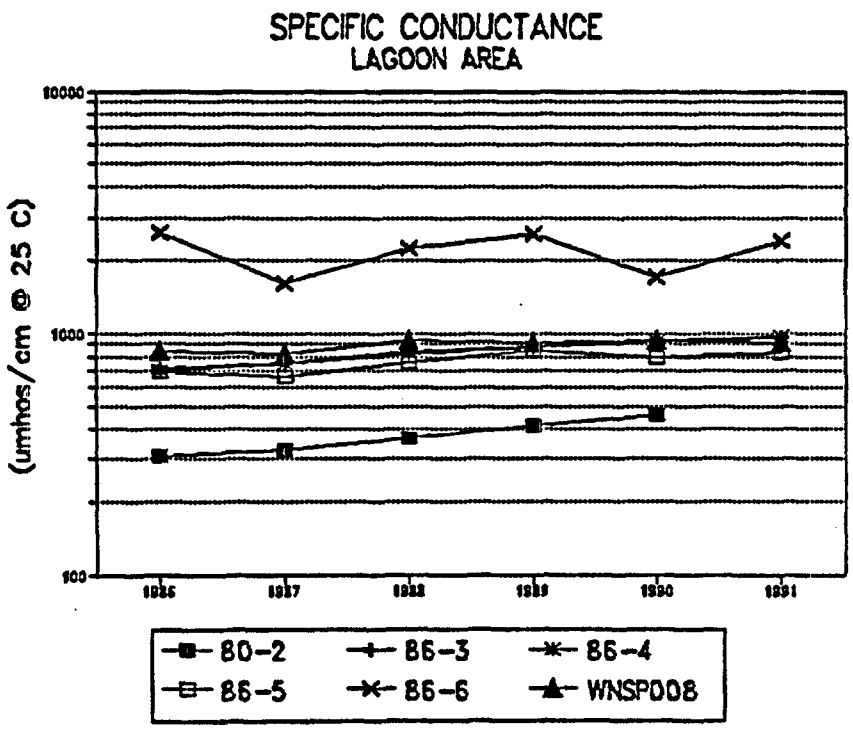


FIGURE 4-29

AVERAGE YEARLY SPECIFIC CONDUCTANCE (umhos/cm @ 25°C)
IN WVDP WELLS-TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	305	325	368	417	464	
80-3	488	571	465	583	498	
80-4	626	623	552	608	688	
86-7	1015	933	834	710	642	713
86-8	761	929	673	605	500	593
86-9	641	676	659	649	638	698

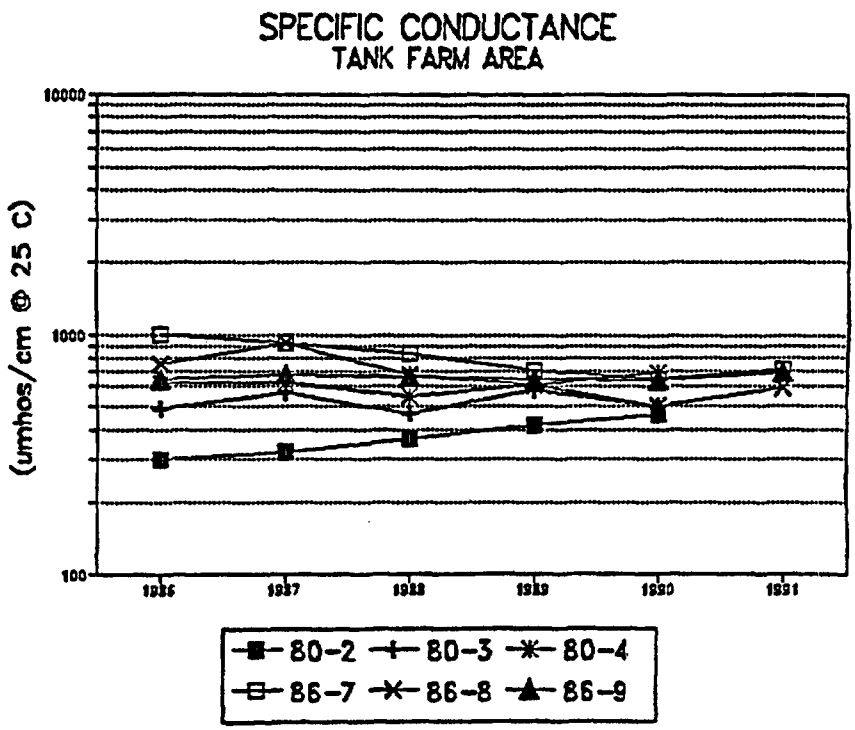


FIGURE 4-30

AVERAGE YEARLY SPECIFIC CONDUCTANCE (umhos/cm @ 25°C)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	305	325	368	417	464	
80-5	334	524	652	822	780	
80-6	1492	765	821	778	774	
86-12		506	601	643	714	764
WNGSEEP	430	456	520	596	612	647
WNDMPNE		551	592	625	605	640

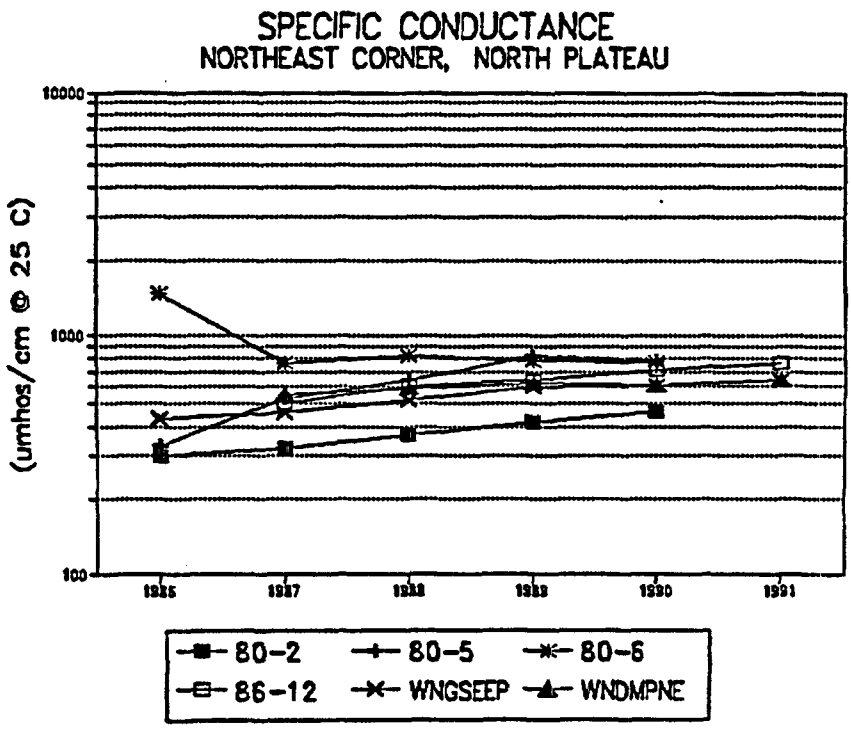


FIGURE 4-31

AVERAGE YEARLY TOC CONCENTRATION (mg/L)
IN WVDP WELLS - LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.40	3.98	1.67	<1.00	1.17 (3)	
86-3	0.10	4.88 (3)	1.57 (1)	4.16 (4)	1.99 (5)	3.14 (5)
86-4	<0.10	4.00	1.10 (1)	1.81 (3)	1.53 (1)	3.84 (6)
86-5	8.90	18.00	8.50	15.69 (7)	12.26	12.78
86-6	1.70	3.50	1.33 (2)	2.04 (7)	2.64	3.96
WNSP008	2.90	5.50	2.17	2.39	5.59	5.33

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

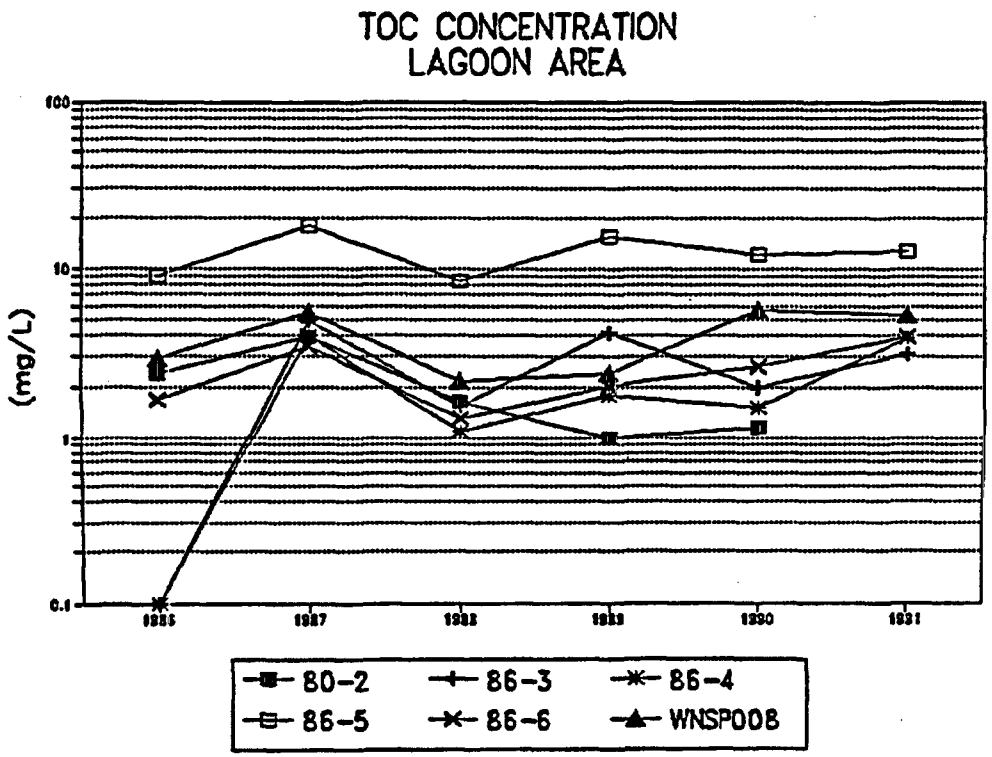


FIGURE 4-32

AVERAGE YEARLY TOC CONCENTRATION (mg/L)
IN WVDP WELLS - TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.40	3.98	1.67	<1.00	1.17 (3)	
86-7	2.60	3.13	1.37 (2)	2.39 (4)	1.43 (6)	6.75
86-8	10.00	10.05	2.90 (2)	5.20	7.18	7.00
86-9	3.20	4.88	1.33 (2)	4.90	3.26 (7)	5.15

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

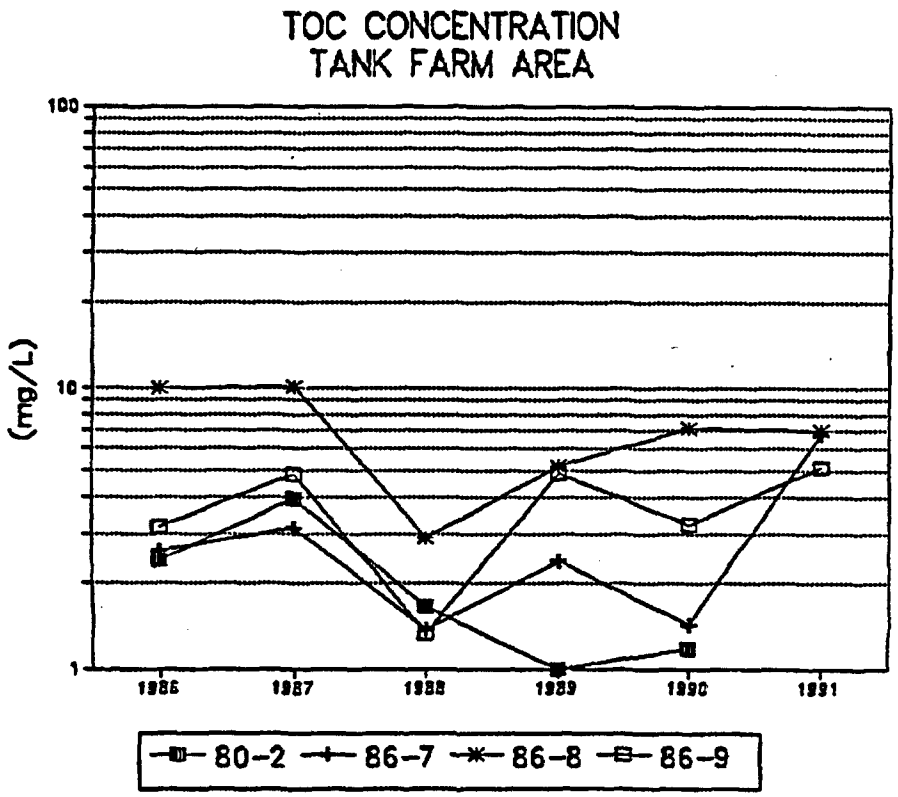


FIGURE 4-33

AVERAGE YEARLY TOC CONCENTRATION (mg/L)
IN WVDP WELLS - NORTHEAST MARGIN, NORTH PLATEAU
(1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.40	3.98	1.67	<1.00	1.17 (3)	
80-5	2.40	4.88 (3)	2.53 (2)	1.50 (3)	2.10 (5)	
80-6	4.40	4.75	2.63 (2)	3.55 (7)	2.71 (6)	
86-12		1.70	6.57 (2)	2.64 (3)	1.30 (2)	2.54 (5)
WNGSEEP	<2.00	2.25 (2)	1.13 (1)	1.94 (7)	1.94 (2)	5.21
WNDMPNE		5.60	2.70	4.75	5.20	5.20

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

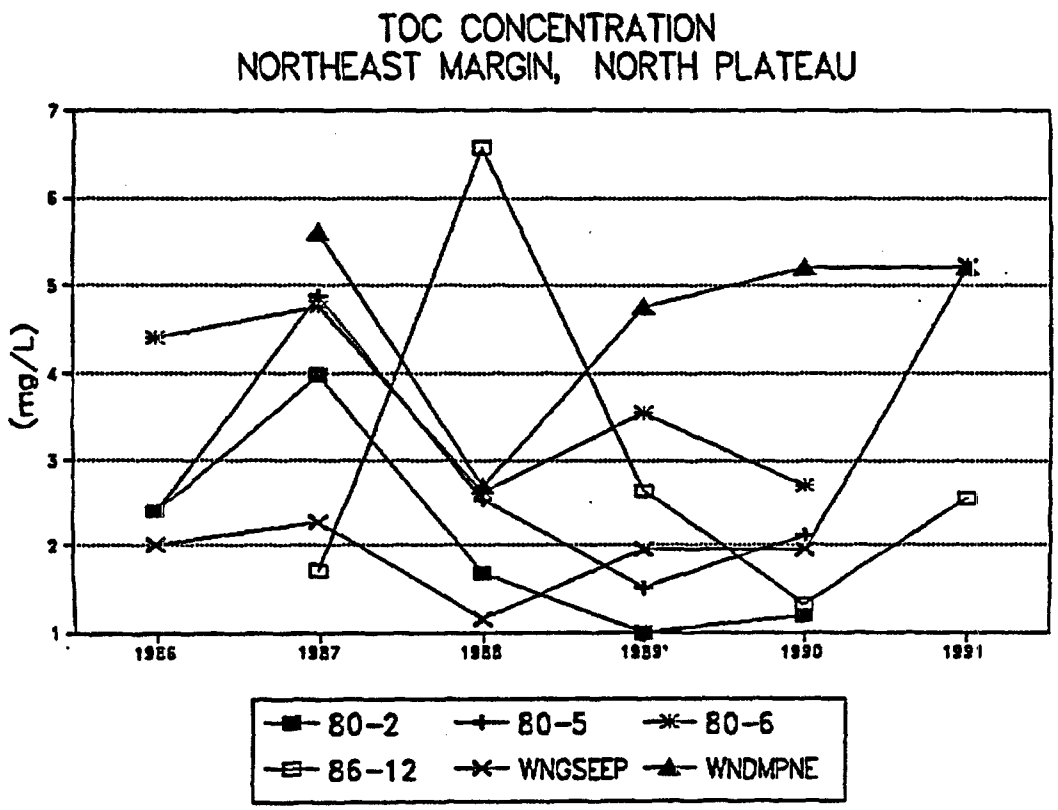


FIGURE 4-34

AVERAGE YEARLY TOX CONCENTRATION (mg/L)
IN WVDP WELLS - LAGOON AREA (1988 - 1991)

WELL	1988	1989	1990	1991
80-2	<0.010	0.011 (4)	0.007 (1)	
86-3	0.009	0.008 (2)	0.011 (5)	0.010 (4)
86-4	0.013	0.011 (1)	0.007 (3)	0.017 (5)
86-5	0.021	0.028 (5)	0.024 (4)	0.027
86-6	0.014	0.017 (7)	0.027 (6)	0.140
WNSP008	0.014	0.024 (5)	0.017 (7)	0.020

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

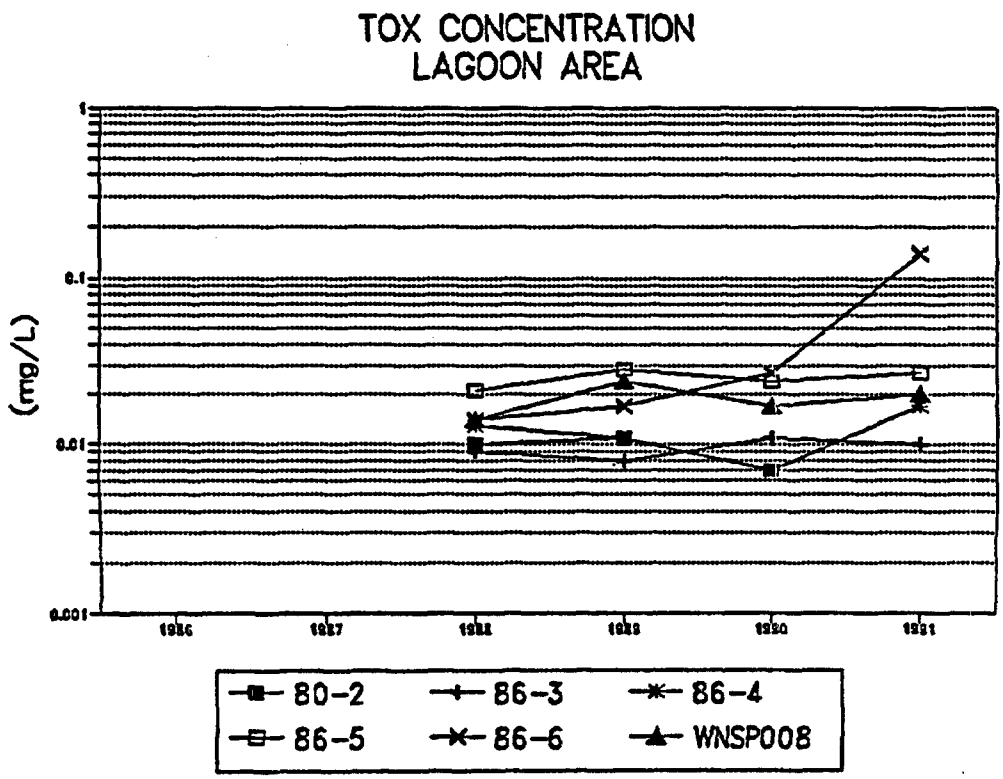


FIGURE 4-35

AVERAGE YEARLY TOX CONCENTRATION (mg/L)
IN WVDP WELLS - TANK FARM AREA (1988 - 1991)

WELL	1988	1989	1990	1991
80-2	<0.010	0.011 (4)	0.007 (1)	
86-7	0.007	0.024 (4)	0.018 (5)	0.008 (3)
86-8	0.014	0.016 (5)	0.012 (5)	0.009
86-9	0.011	0.016 (7)	0.015 (7)	0.015

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

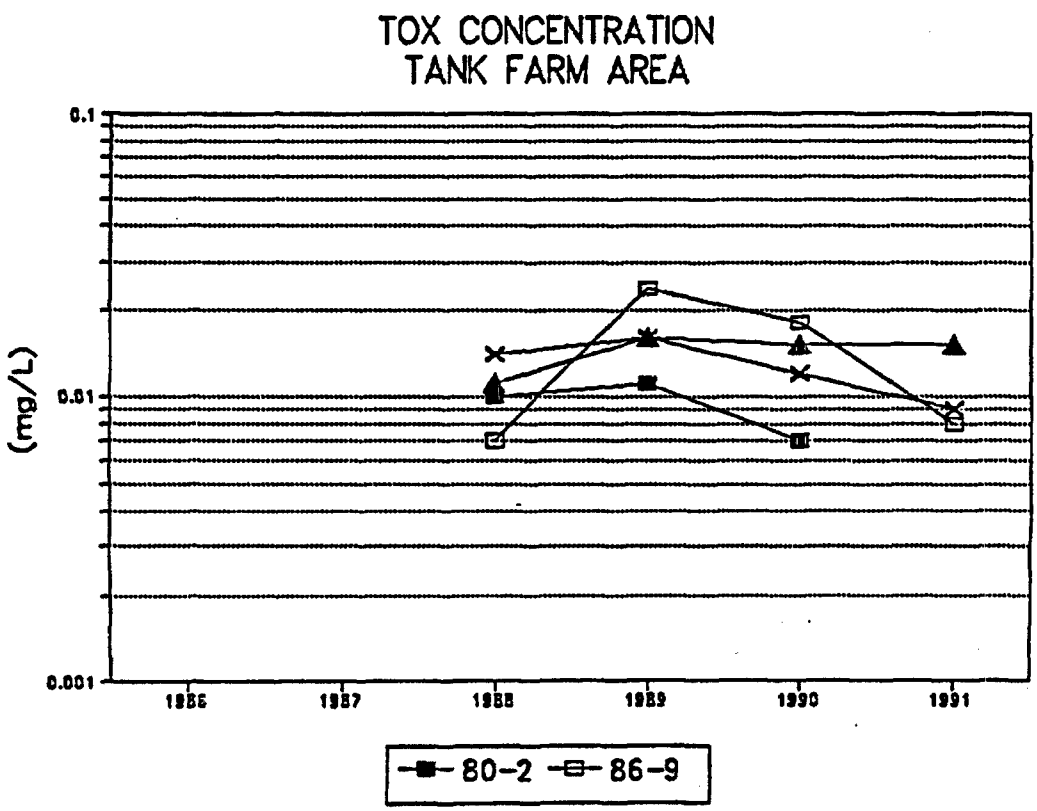


FIGURE 4-36

AVERAGE YEARLY TOX CONCENTRATION (mg/L)
IN WVDP WELLS – NORTHEAST MARGIN, NORTH PLATEAU
(1988 – 1991)

WELL	1988	1989	1990	1991
80-2	<0.010	0.011 (4)	0.007 (1)	
80-5	0.003 (1)	0.015 (3)	0.019 (5)	
80-6	0.040 (1)	0.010 (1)	0.014 (6)	
86-12	0.010 (1)	0.010 (2)	0.130 (5)	0.023
WNGSEEP	0.011	0.010 (2)	0.024 (7)	0.021
WNDMPNE	0.012 (1)	0.011 (4)	0.014 (6)	0.014 (7)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

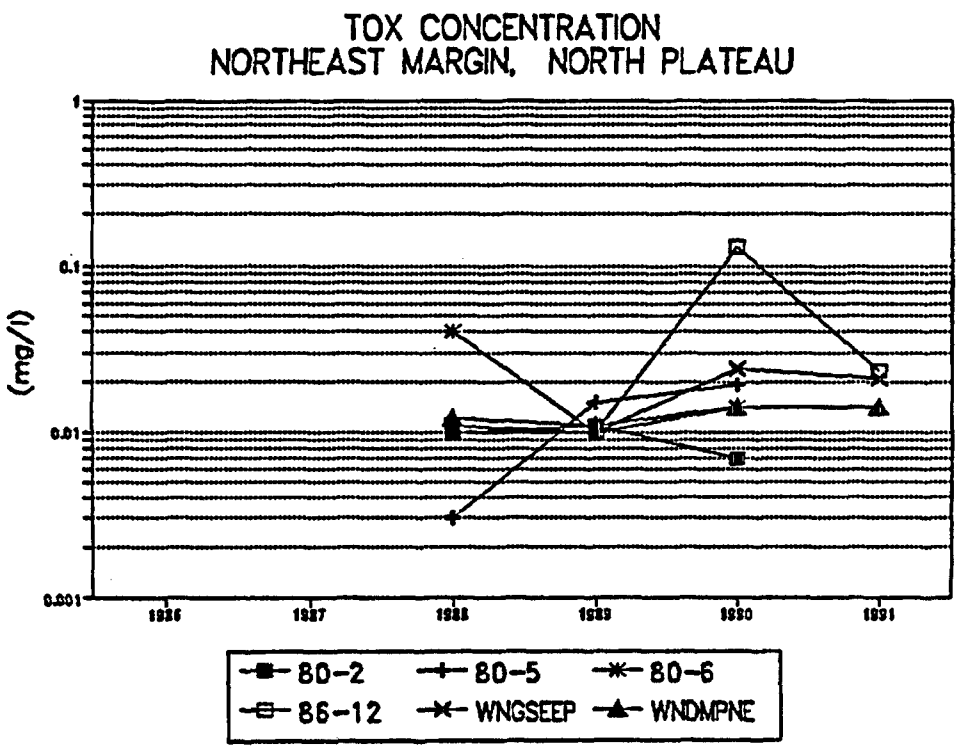


FIGURE 4-37

AVERAGE YEARLY CHLORIDE CONCENTRATION (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	16.70	24.80	36.43	49.00	61.00	
86-3	67.70	90.45	110.67	134.00	148.00	155.00
86-4	62.40	83.15	106.37	119.00	139.00	155.00
86-5	12.00	13.50	21.13	28.23	18.01	59.00
86-6	714.00	405.38	604.17	721.00	368.00	655.00
WNSP008	35.50	64.00	88.67	88.00	90.00	91.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

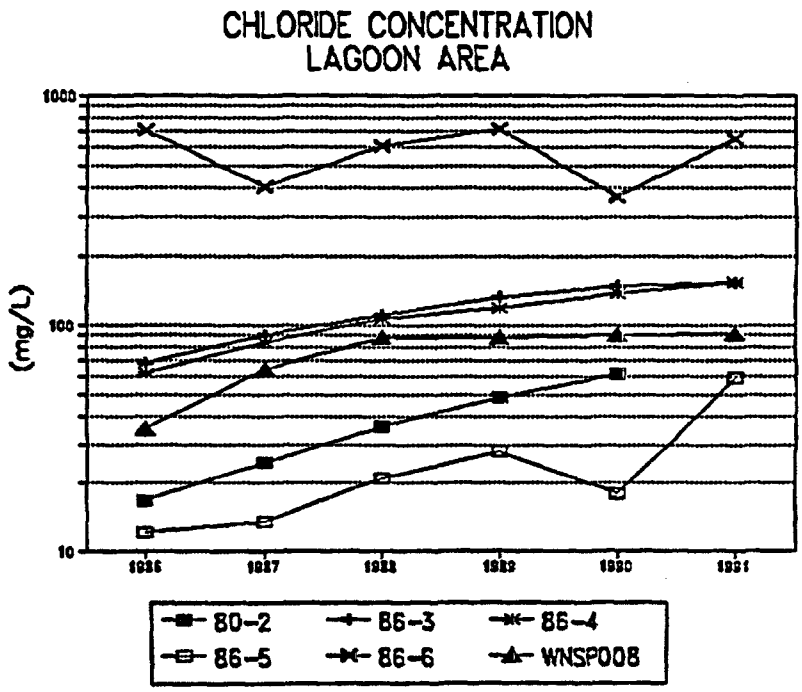


FIGURE 4-38

AVERAGE YEARLY CHLORIDE CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	16.70	24.80	36.43	49.00	61.00	
86-7	6.40	24.00	8.17	14.45	30.00	21.00
86-8	23.40	69.00	17.90	11.88	14.51	20.00
86-9	10.90	36.00	54.77	38.88	37.48	43.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

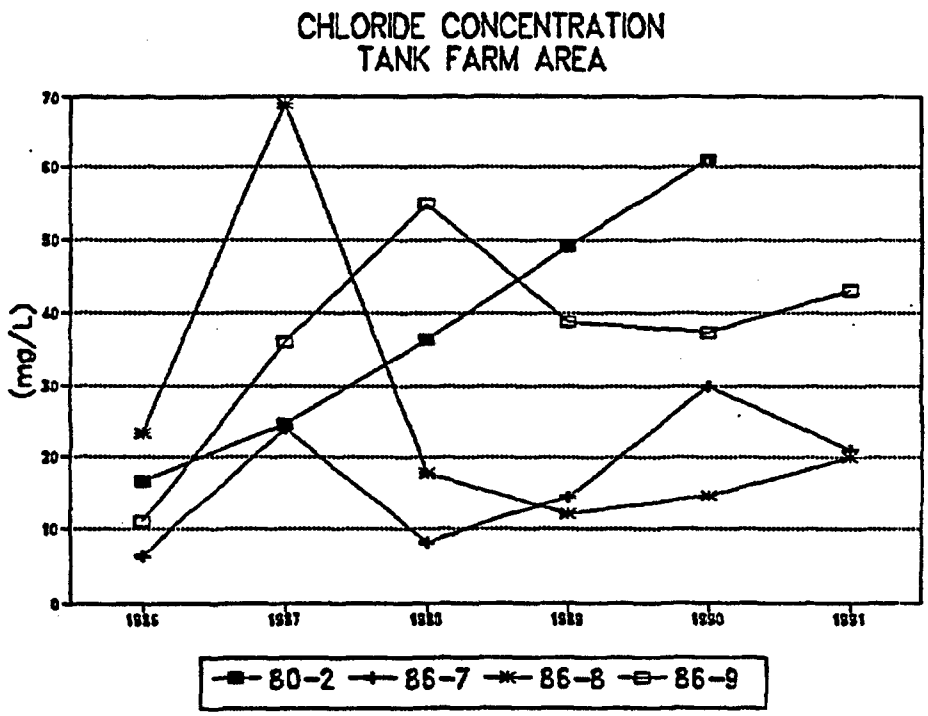


FIGURE 4-39

AVERAGE YEARLY CHLORIDE CONCENTRATION (mg/L)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	16.70	24.80	36.43	49.00	61.00	
80-5	19.10	39.10	74.33	99.00	101.00	
80-6	93.30	70.70	32.10	36.88	54.57	
86-12		31.58	37.67	47.00	55.34	73.00
WNGSEEP	30.90	32.30	53.03	72.00	68.00	88.00
WNDMPNE		47.35	57.50	60.00	54.00	75.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

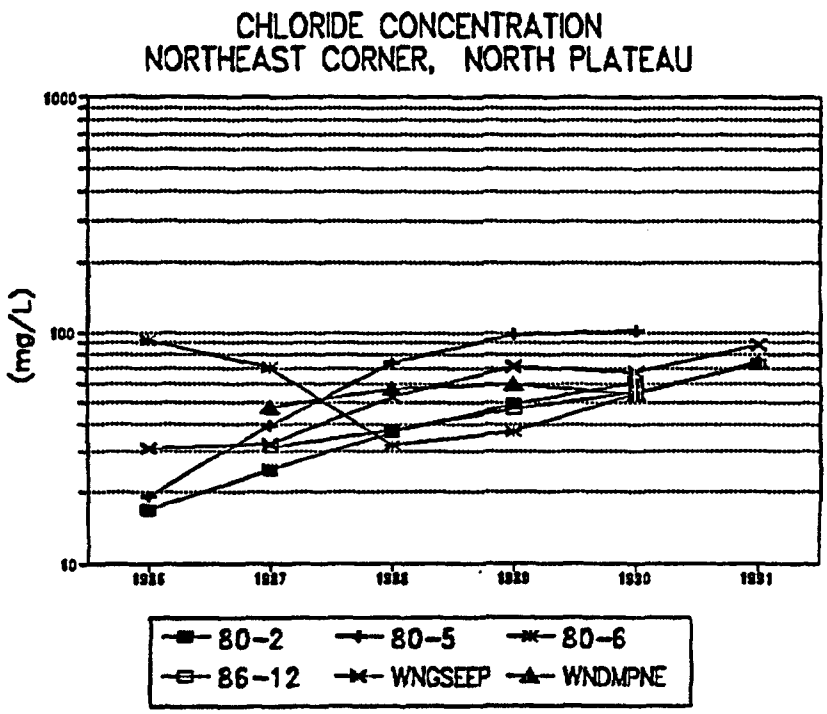


FIGURE 4-40

AVERAGE YEARLY SULFATE CONCENTRATIONS (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	9.50	10.25	25.00	21.00	23.84	
86-3	36.60	33.89	38.00	39.00	37.00	32.00
86-4	35.90	34.94	39.67	53.00	50.00	36.00
86-5	54.60	42.79	57.00	103.00	58.31	138.00
86-6	50.30	41.67	33.00	40.25	70.40	98.00
WNSP008	70.50	73.21	76.00	70.00	64.50	58.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

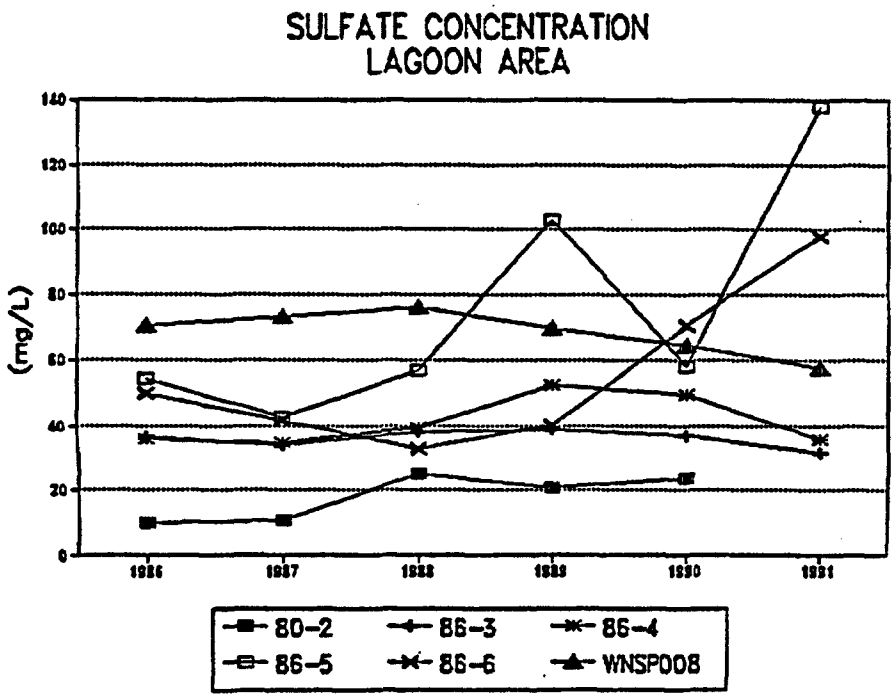


FIGURE 4-41

AVERAGE YEARLY SULFATE CONCENTRATIONS (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	9.50	10.25	25.00	21.00	23.84	
86-7	227.00	174.00	175.34	149.00	131.00	200.00
86-8	168.00	183.00	145.00	136.00	143.00	115.00
86-9	38.40	35.00	35.34	48.00	42.25	37.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

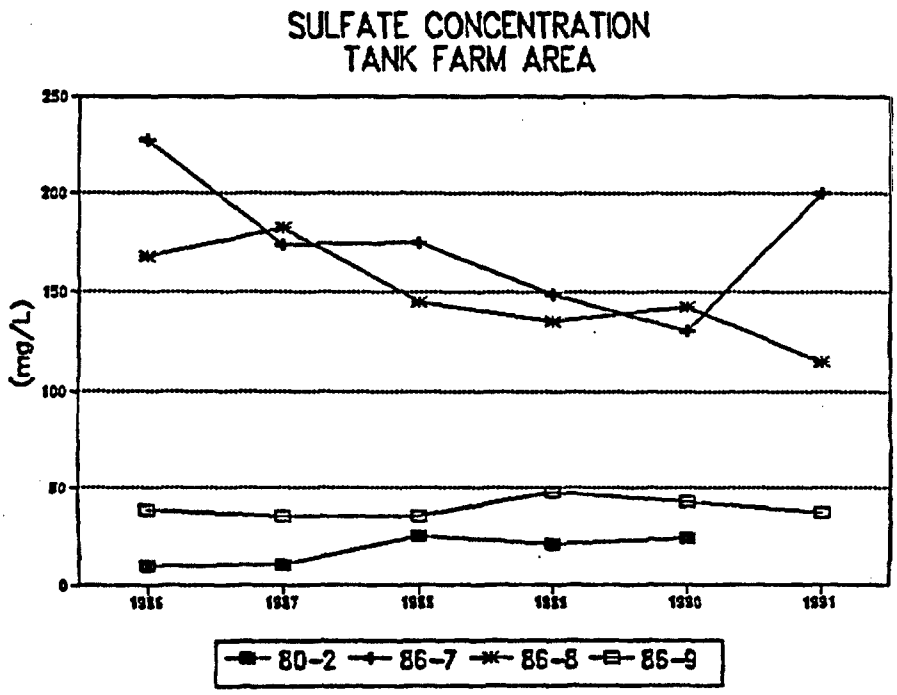


FIGURE 4-42

AVERAGE YEARLY SULFATE CONCENTRATIONS (mg/L)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	9.50	10.25	25.00	21.00	23.84	
80-5	31.00	40.76	49.34	69.00	54.29	
80-6	288.00	122.50	177.00	127.00	125.00	
86-12		50.00	56.00	63.00	65.45	75.00
WNGSEEP	50.30	47.16	48.00	58.00	57.39	61.00
WNDMPNE		47.00	54.67	57.00	54.00	56.00

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

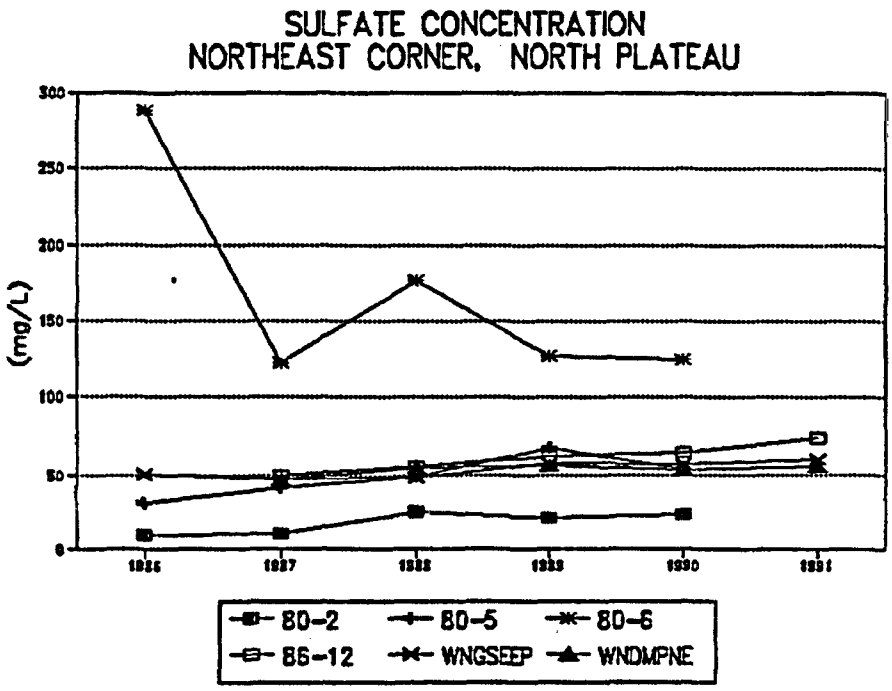


FIGURE 4-43

AVERAGE YEARLY NITRATE CONCENTRATIONS (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.00	2.11	0.53	0.51	0.60	
86-3	4.60	6.46	1.24	1.34	1.12	1.95
86-4	2.70	4.95	1.26	1.36	0.92	1.16
86-5	3.00	0.33	0.06	<0.1	<0.1	<0.05
86-6	1.00	0.16	0.13	0.10	1.06	0.33
WNSP008	3.40	6.00	1.20	0.72	0.54	0.12

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

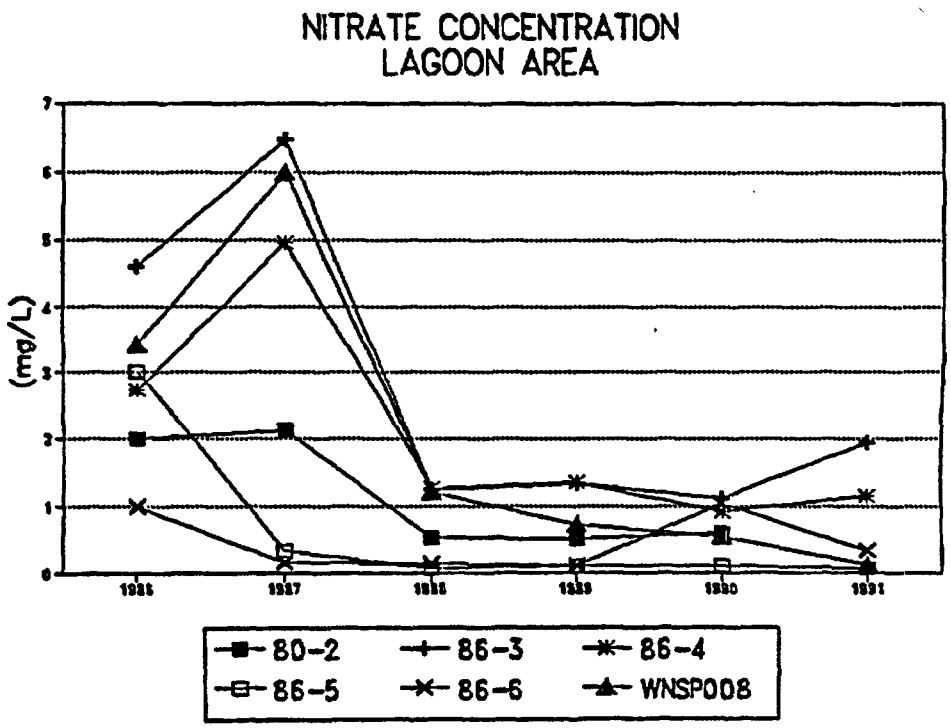


FIGURE 4-44

AVERAGE YEARLY NITRATE CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.00	2.11	0.53	0.51	0.60	
86-7	6.30	3.27	0.85	1.12	0.92	6.65
86-8	4.90	<0.1	0.08	0.17	0.16	2.25
86-9	7.30	6.87	1.95	1.25	1.82	5.50

BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

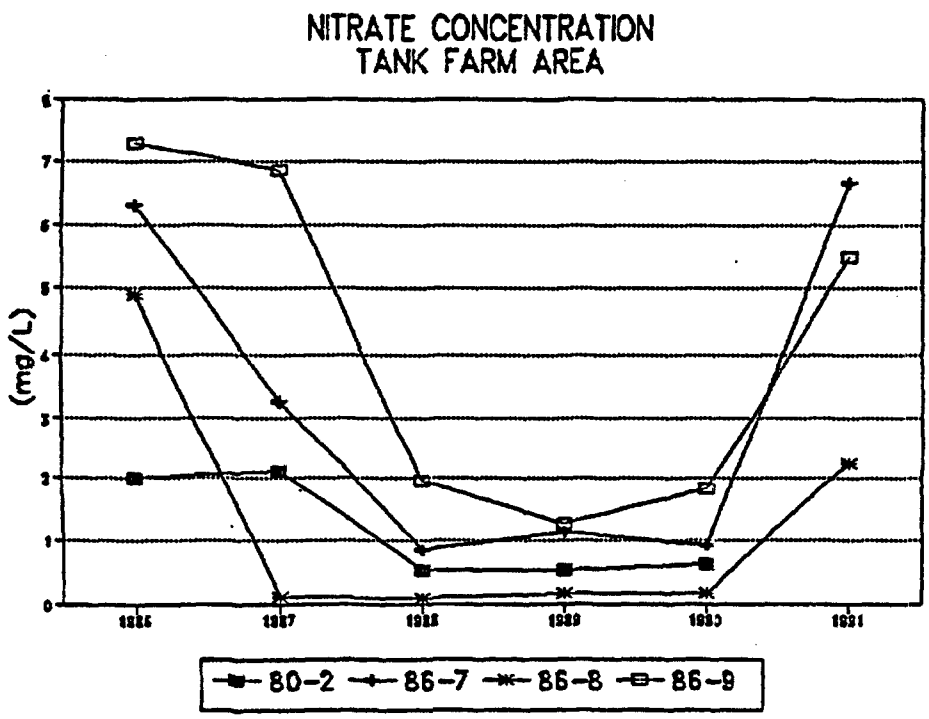


FIGURE 4-45

AVERAGE YEARLY NITRATE CONCENTRATIONS (mg/L)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU
(1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	2.00	2.11	0.53	0.51	0.60	
80-5	2.00	1.45	0.67	0.43	0.37	
80-6	2.10	0.73	0.12	0.15	0.57	
86-12		0.38	0.08	0.07	0.08	(5) <0.05
WNGSEEP	2.80	4.26	0.93	0.60	0.66	0.45
WNDMPNE		3.52	1.07	0.88	0.81	0.92

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

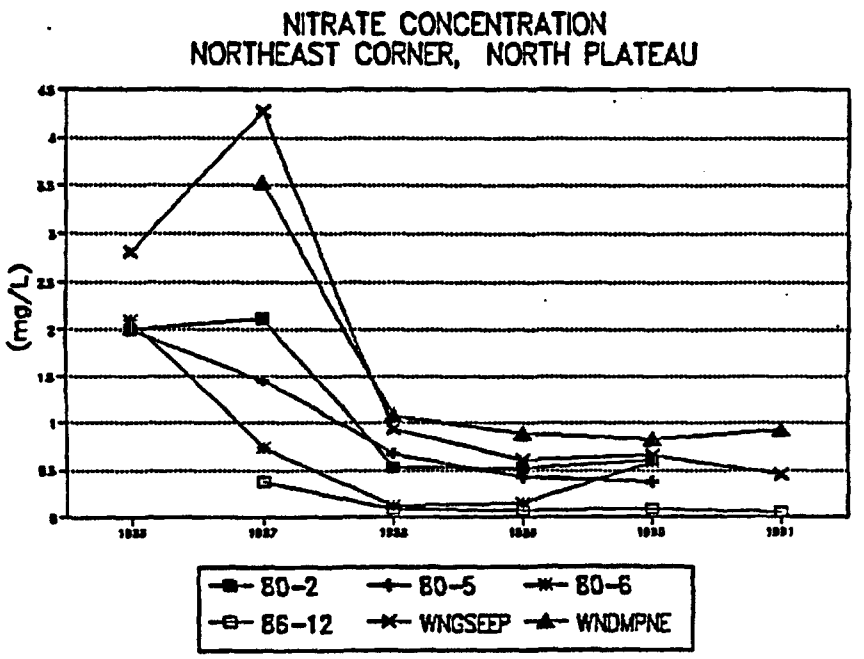


FIGURE 4-46

AVERAGE YEARLY FLUORIDE CONCENTRATIONS (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.10	0.58	<0.10	<0.10	0.10
86-3	<0.10	0.18	<0.10	<0.10	<0.10
86-4	<0.10	0.18	<0.10	<0.10	<0.10
86-5	<0.10	0.24	0.13	0.12	0.12
86-6	0.11	<0.20	<0.10	<0.10	0.10 (1)
WNSP008	<0.10	0.19	<0.10	0.10 (1)	0.10 (2)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
FLUORIDE NOT ANALYZED IN 1991

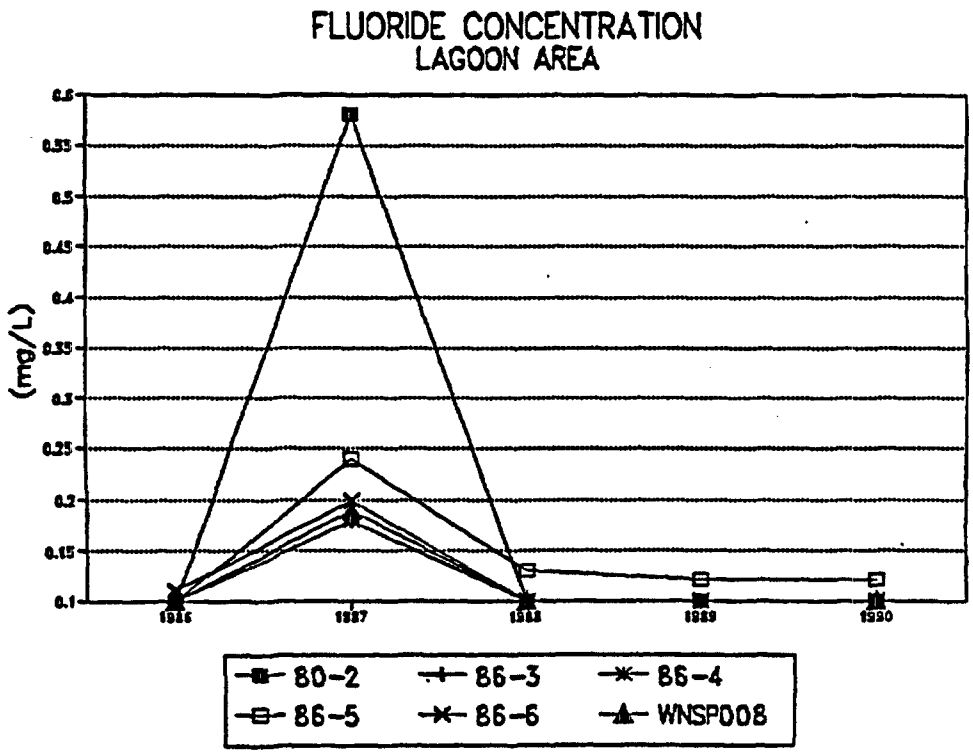


FIGURE 4-47

AVERAGE YEARLY FLUORIDE CONCENTRATIONS (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990	
80-2	<0.10	0.58	<0.10	<0.10	0.10	(1)
86-7	<0.10	0.28	<0.10	<0.10	<0.10	
86-8	<0.10	0.19	<0.10	<0.10	0.12	(6)
86-9	<0.10	0.18	<0.10	<0.10	<0.10	

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
FLUORIDE NOT ANALYZED IN 1991

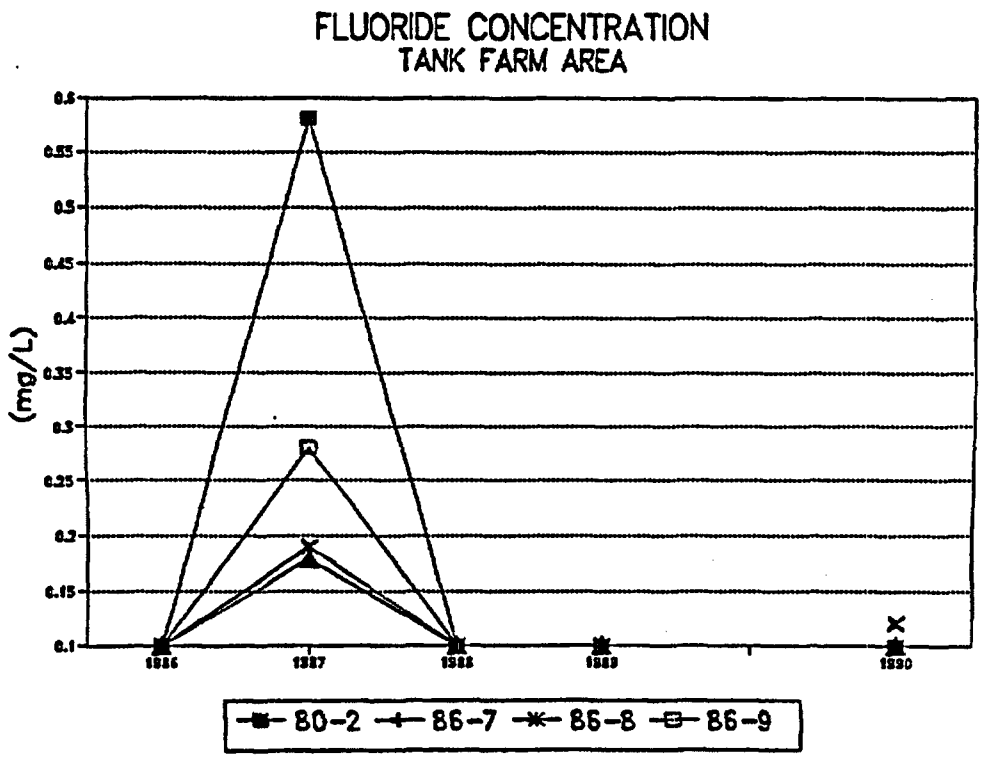


FIGURE 4-48

AVERAGE YEARLY FLUORIDE CONCENTRATIONS (mg/L)
IN WVDP WELLS-NORTHEAST CORNER, NORTH PLATEAU (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.10	0.58	<0.10	<0.10	0.10 (1)
80-5	<0.10	0.28	0.09	<0.10	0.13 (6)
80-6	<0.10	0.24	<0.10	0.10 (2)	0.11 (5)
86-12		0.25	<0.10	<0.10	0.10 (1)
WNGSEEP	<0.10	0.17	<0.10	<0.10	<0.10
WNDMPNE		0.18	<0.10	<0.10	0.10 (2)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR
FLUORIDE NOT ANALYZED IN 1991

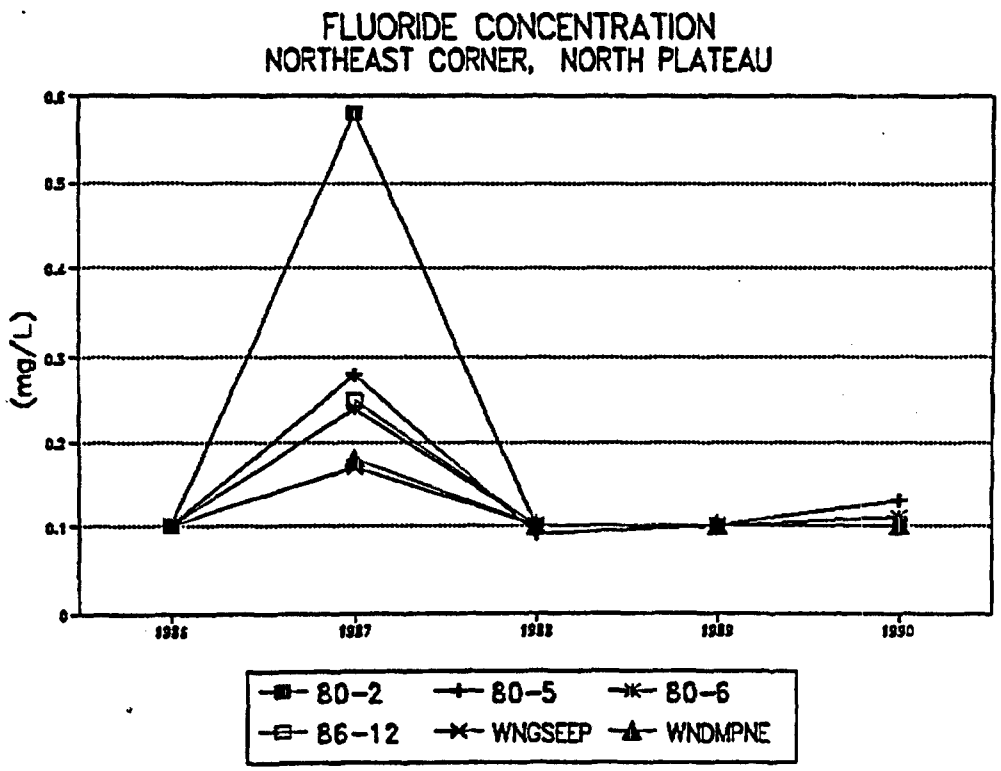


FIGURE 4-49

AVERAGE YEARLY TOTAL PHENOL CONCENTRATION (mg/L)
IN WVDP WELLS - LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	<0.100	0.013 (1)	<0.010	0.007 (1)	<0.009	
86-3	<0.100	0.015 (1)	0.010 (1)	0.018 (1)	<0.008	<0.005
86-4	<0.100	0.010 (1)	<0.010	<0.020	0.012 (1)	<0.010
86-5	<0.100	<0.010	0.013 (1)	0.013 (3)	0.016 (3)	0.002 (1)
86-6	<0.100	0.010 (1)	<0.010	0.021 (4)	0.230 (3)	<0.005
WNSP008	0.100	<0.020	0.010 (1)	<0.020	0.008 (1)	0.006 (1)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

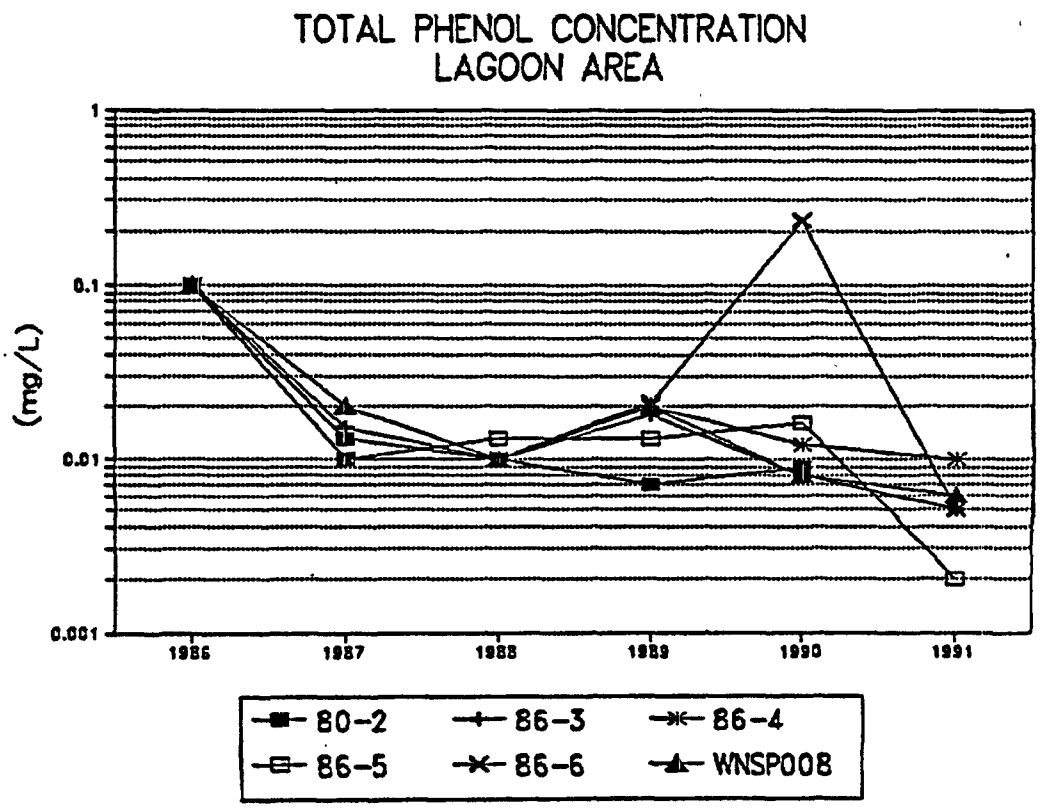


FIGURE 4-50

AVERAGE YEARLY TOTAL PHENOL CONCENTRATION (mg/L)
IN WVDP WELLS - TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	<0.100	0.013 (1)	<0.010	0.007 (1)	<0.009	
86-7	<0.100	0.011 (1)	<0.010	0.011 (1)	0.013 (1)	0.005 (1)
86-8	<0.100	0.012 (1)	<0.010	0.016 (1)	<0.020	0.005 (1)
86-9	<0.100	0.011 (1)	<0.010	0.016 (2)	0.01 (1)	0.016 (1)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

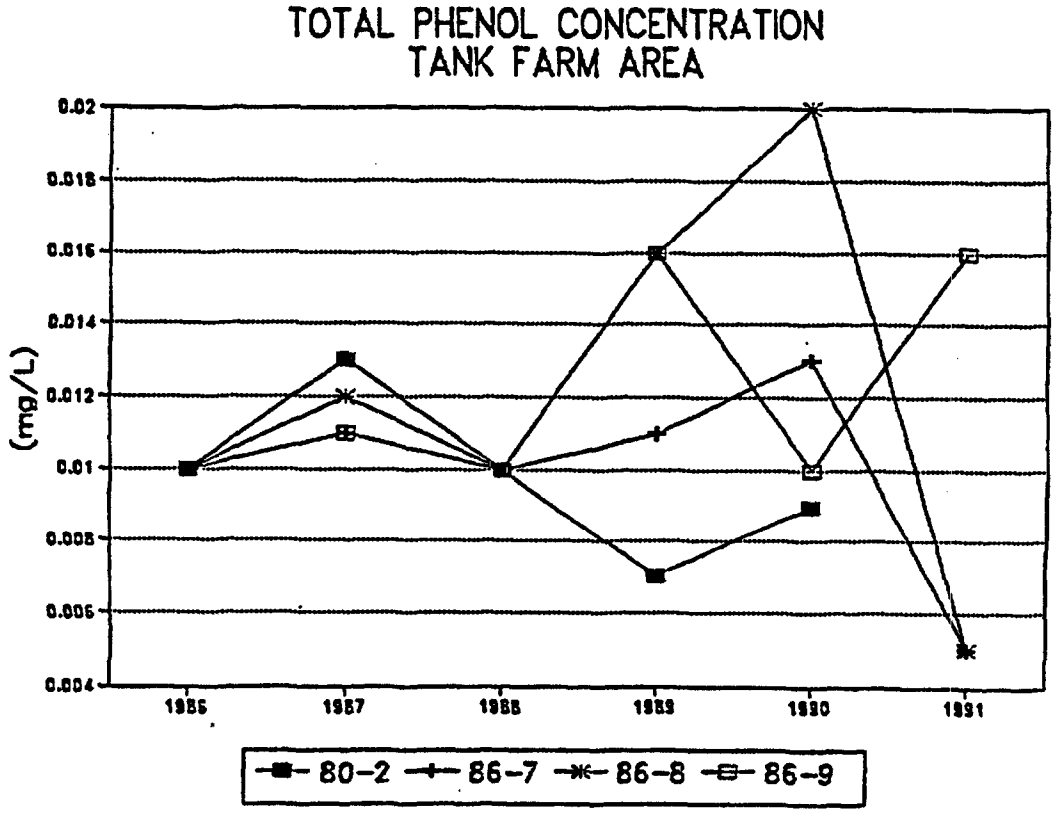


FIGURE 4-51

AVERAGE YEARLY TOTAL PHENOL CONCENTRATION (mg/L)
IN WVDP WELLS - NORTHEAST MARGIN, NORTH PLATEAU
(1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	<0.100	0.013 (1)	<0.010	0.007 (1)	<0.009	
80-5	<0.100	0.015 (1)	0.010 (1)	<0.020	0.008 (1)	
80-6	<0.100	<0.010	<0.010	<0.020	0.010 (2)	
86-12		<0.013	<0.010	0.007 (1)	0.008 (1)	<0.010
WNGSEEP	<0.100	0.010 (1)	0.010 (1)	<0.020	0.008 (1)	0.008 (1)
WNDMPNE		0.016 (2)	<0.010	0.013 (1)	0.023 (1)	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

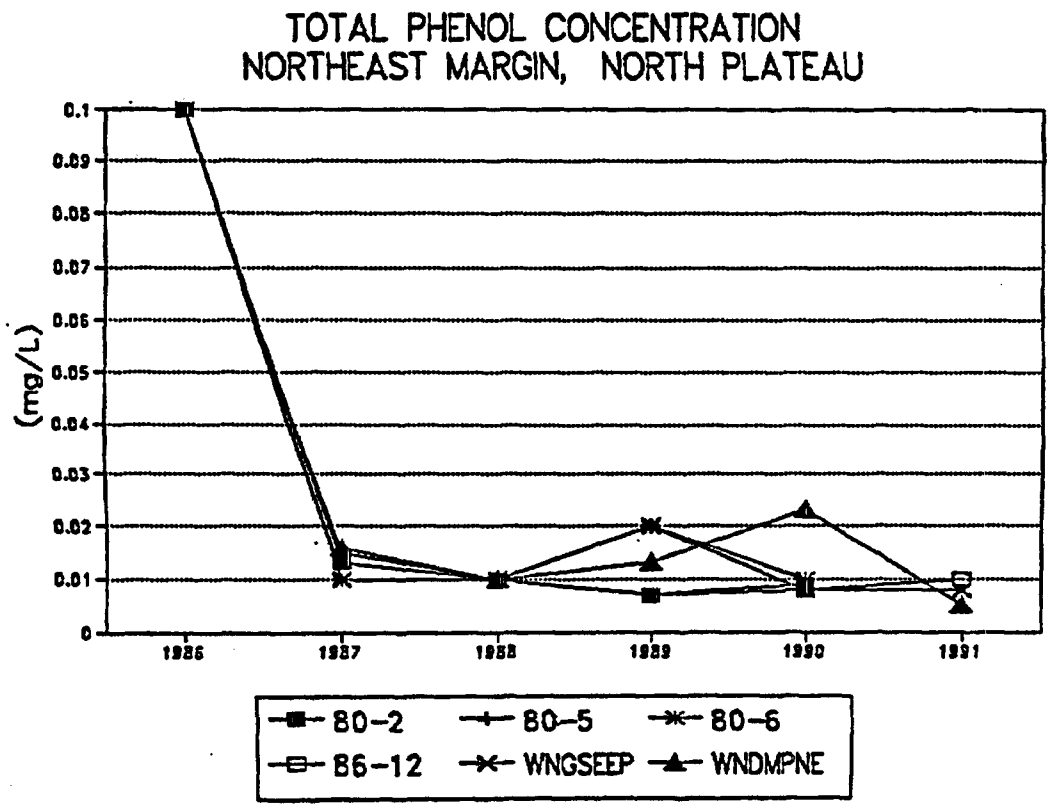


FIGURE 4-52

AVERAGE YEARLY ARSENIC CONCENTRATION (mg/L)
IN WVDP WELLS-LAGOON AREA (1986-1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.005 (1)	<0.005	0.007 (1)	<0.005
86-3	<0.01	0.006 (1)	<0.005	0.006 (1)	0.005 (1)
86-4	<0.01	<0.006	<0.005	0.006 (2)	0.006 (4)
86-5	<0.01	<0.058	0.006	0.009	0.013 (7)
86-6	<0.01	0.007 (1)	0.007	0.007 (2)	0.009 (1)
WNSP008	<0.01	<0.006	<0.005	0.010 (2)	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

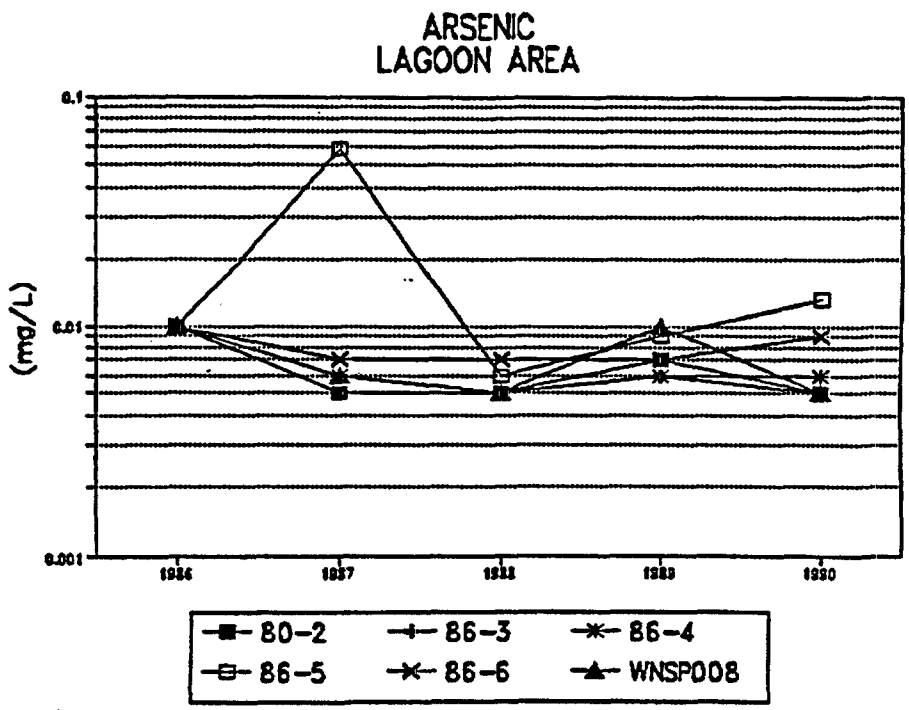


FIGURE 4-53

AVERAGE YEARLY ARSENIC CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.005 (1)	<0.005	0.007 (1)	<0.005
86-7	<0.01	<0.005	0.005 (1)	0.009 (2)	0.009 (1)
86-8	<0.01	<0.005	0.004 (1)	0.008 (5)	0.016 (4)
86-9	<0.01	<0.005	0.004 (1)	0.009 (5)	0.011 (3)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

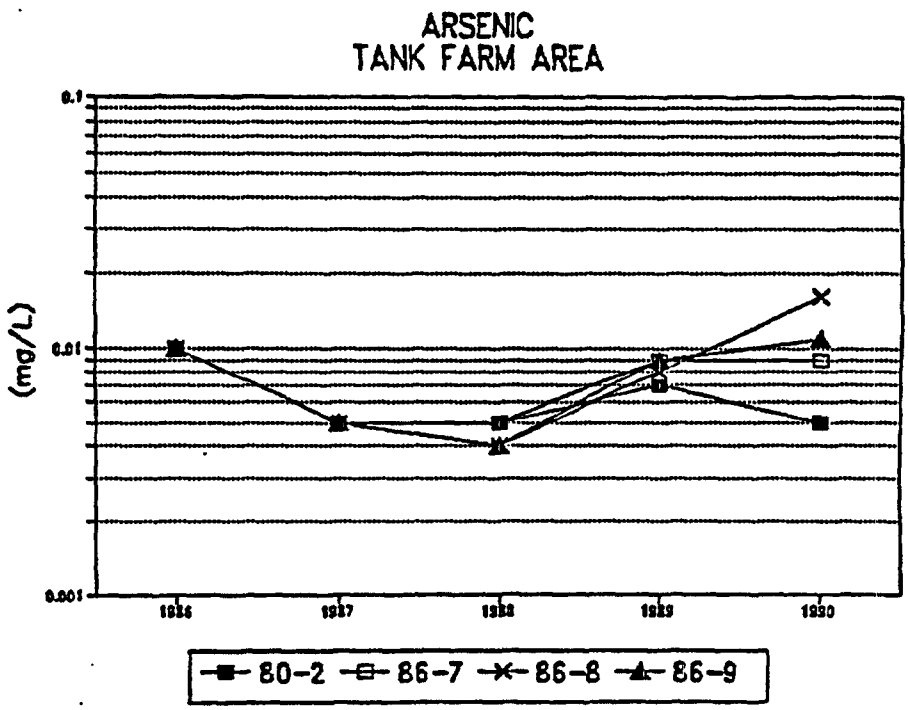


FIGURE 4-54

AVERAGE YEARLY ARSENIC CONCENTRATION (mg/L)
IN WVDP WELLS-NORTHEAST MARGIN, NORTH PLATEAU (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.005 (1)	<0.005	0.007 (1)	<0.005
80-5	<0.01	0.006 (1)	<0.005	0.008 (3)	<0.005
80-6	<0.01	<0.006	0.003	0.008 (2)	<0.005
86-12		<0.005	0.005 (2)	0.006 (1)	0.006 (2)
WNGSEEP	<0.01	0.006 (1)	<0.005	0.007 (2)	<0.005
WNDMPNE		0.007 (2)	<0.005	0.009 (3)	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

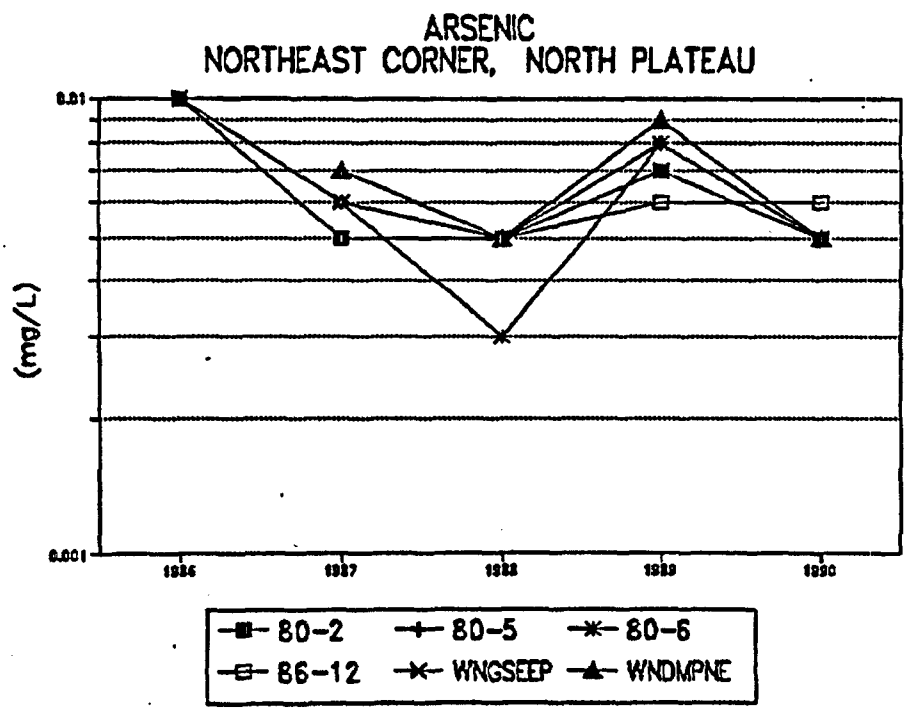


FIGURE 4-55

AVERAGE YEARLY BARIUM CONCENTRATION (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.05	0.08	0.09	0.08 (7)	0.01 (6)
86-3	0.15	0.18	0.22	0.17	0.25
86-4	0.21	0.25	0.22	0.24	0.36
86-5	0.08	0.10	0.11	0.12	0.10
86-6	0.01	0.08	0.10	0.09 (5)	0.09
WNSP008	0.07	0.07	0.09	0.07 (6)	0.09 (7)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

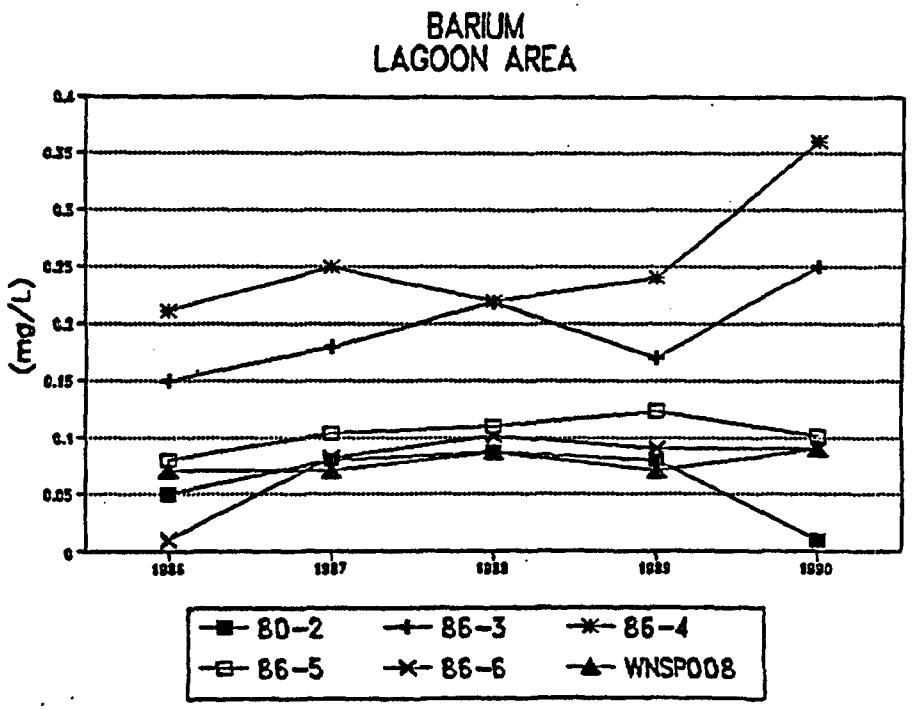


FIGURE 4-56

AVERAGE YEARLY BARIUM CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.05	0.08	0.09	0.08 (7)	0.01 (6)
86-7	0.07	0.07 (3)	0.07	0.06 (1)	0.02 (2)
86-8	0.01	0.24	0.09	0.11	0.19
86-9	0.02	0.21	0.21	0.29 (7)	0.24

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

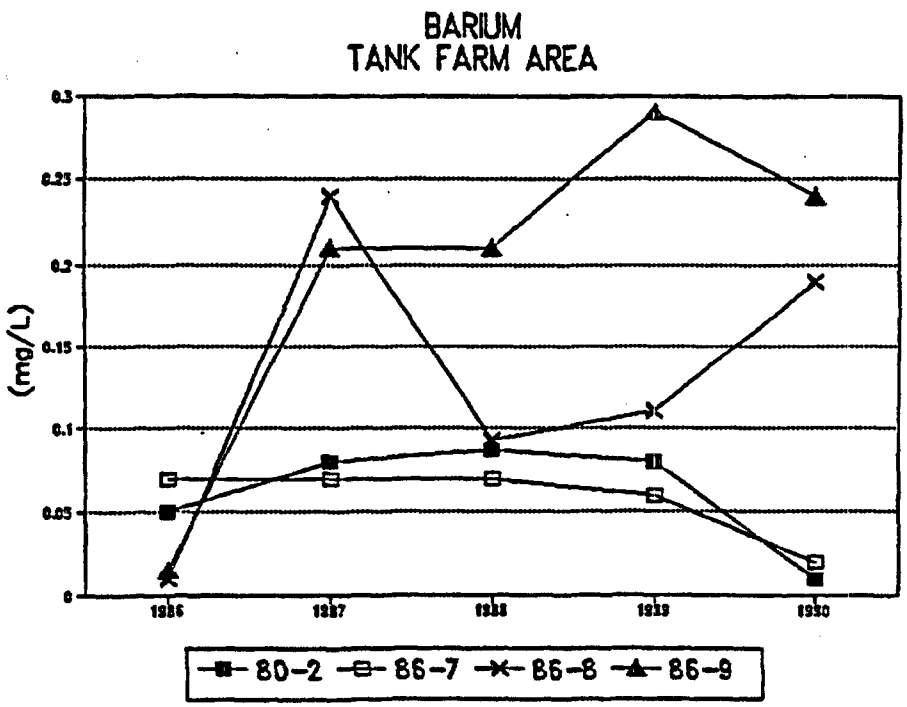


FIGURE 4-57

AVERAGE YEARLY BARIUM CONCENTRATION (mg/L)
IN WVDP WELLS-NORTHEAST MARGIN, NORTH PLATEAU (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.05	0.08	0.09	0.08 (7)	0.01 (6)
80-5	0.03	0.10	0.10	0.12	0.13
80-6	0.04	0.06	0.06	0.09 (5)	0.08 (7)
86-12		0.26	0.32	0.35	0.39
WNGSEEP	0.07	0.12	0.12	0.07	0.11
WNDMPNE		0.09	0.10	0.10 (6)	0.11 (6)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

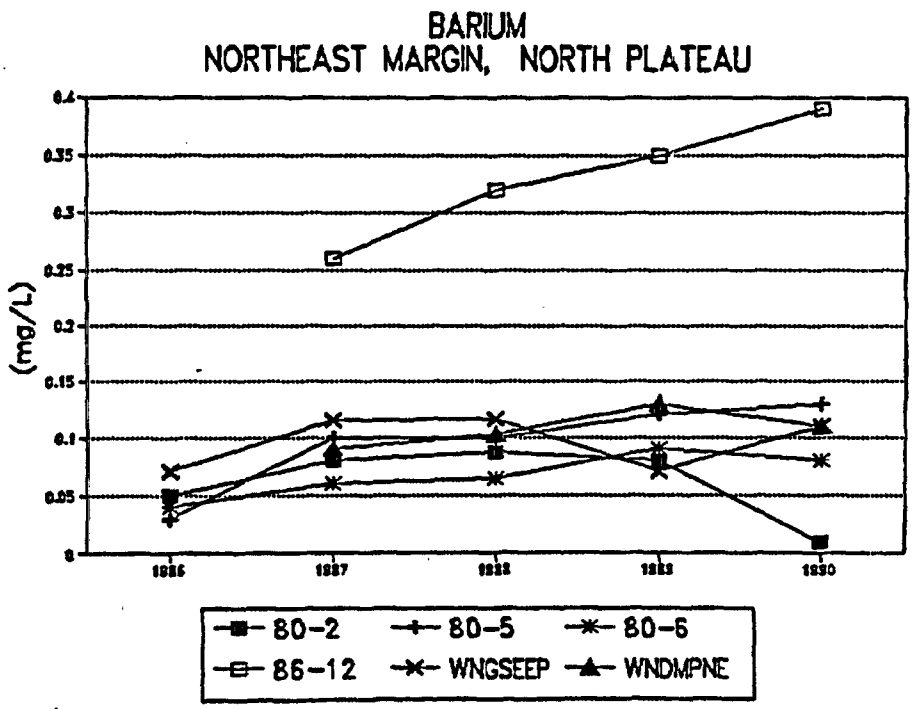


FIGURE 4-58

AVERAGE YEARLY CADMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.010	0.005 (1)	0.008 (2)	0.007 (3)	0.006 (4)
86-3	<0.010	<0.010	0.004	0.008 (7)	0.007 (6)
86-4	<0.010	<0.010	0.004	0.009 (6)	0.008 (6)
86-5	<0.010	<0.010	<0.002	0.003 (3)	0.003
86-6	0.010	0.006 (3)	0.005	0.007 (5)	0.006 (4)
WNSP008	<0.010	0.005 (2)	0.006	0.008 (5)	0.007 (5)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

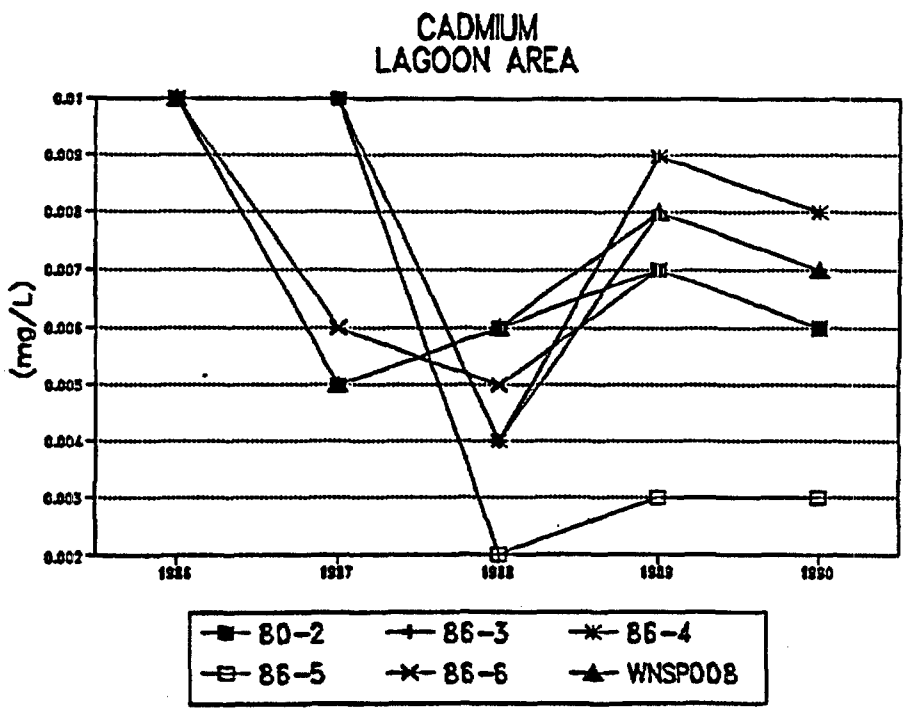


FIGURE 4-59

AVERAGE YEARLY CADMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.010	0.005 (1)	0.008 (2)	0.007 (3)	0.006 (4)
86-7	<0.010	0.007 (2)	0.009 (1)	0.007 (4)	0.006 (4)
86-8	<0.010	<0.005	0.009 (1)	0.006 (4)	0.008 (4)
86-9	<0.010	0.009 (2)	0.009 (1)	0.008 (5)	0.009 (4)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

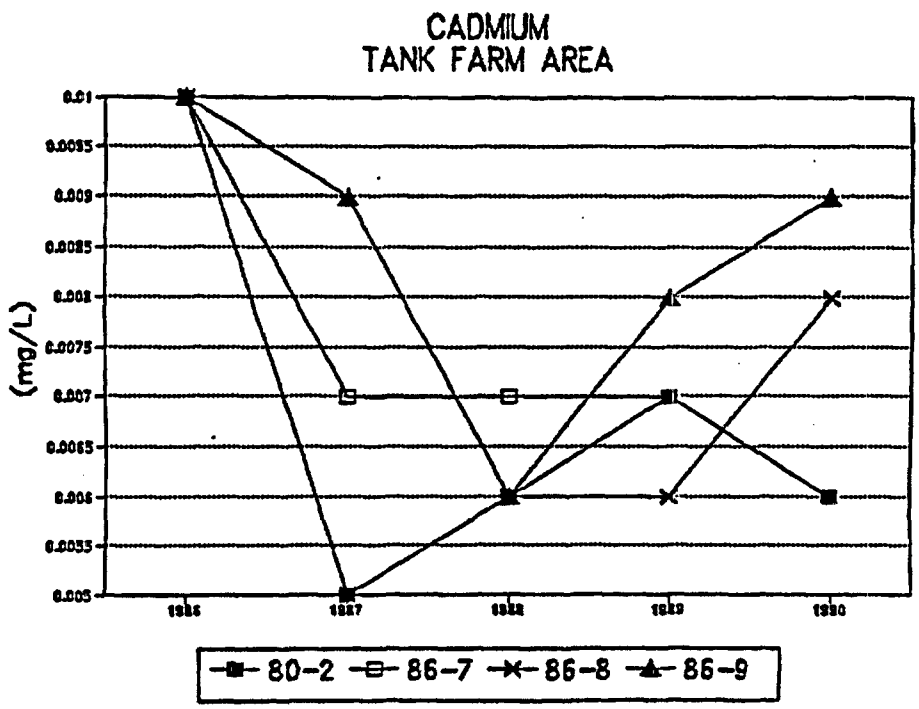


FIGURE 4-60

AVERAGE YEARLY CADMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-NORTHEAST MARGIN, NORTH PLATEAU (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.005 (1)	0.008 (2)	0.007 (3)	0.006 (4)
80-5	<0.01	<0.008	0.006	0.008 (4)	0.008 (5)
80-6	<0.01	<0.010	0.007	0.007 (4)	0.006 (3)
86-12		<0.005	0.008 (1)	0.007 (4)	0.007 (4)
WNGSEEP	<0.01	0.042 (1)	0.006	0.008 (5)	0.006 (4)
WNDMPNE		0.005 (1)	0.006 (2)	0.007 (3)	0.005 (3)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

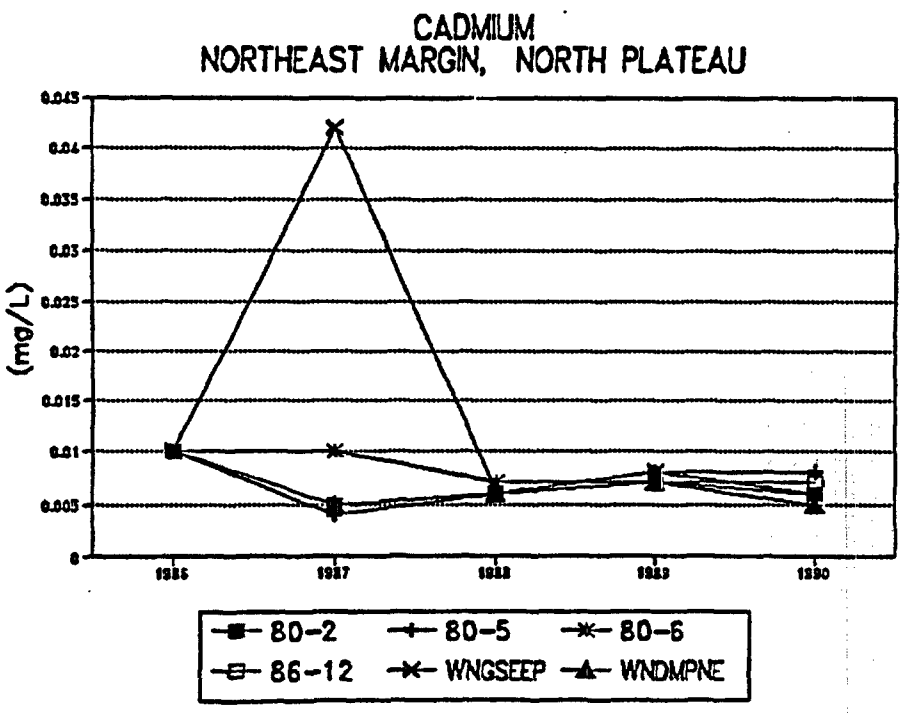


FIGURE 4-61

AVERAGE YEARLY CHROMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.010	0.010 (3)	0.006 (2)	0.012 (2)	0.012 (2)
86-3	<0.020	0.006 (1)	0.008	0.015 (4)	0.011 (3)
86-4	<0.020	0.006 (1)	0.005	0.018 (7)	0.013 (2)
86-5	0.020	0.027 (1)	<0.020	0.039	0.018
86-6	0.010	0.021	0.005	0.015 (3)	<0.010
WNSP008	<0.020	0.006 (2)	0.005	0.015 (4)	<0.010

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

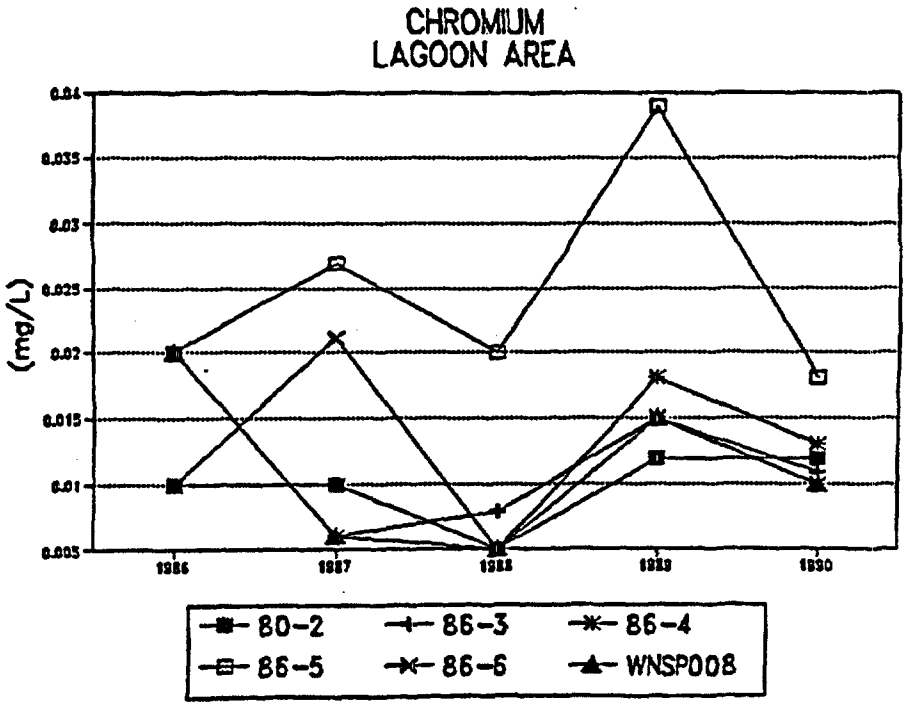


FIGURE 4-62

AVERAGE YEARLY CHROMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.010	0.010 (3)	0.006 (2)	0.012 (2)	0.012 (2)
86-7	0.010	0.030 (3)	0.013	0.013 (2)	0.010 (1)
86-8	0.020	0.010 (3)	0.011 (2)	0.018 (3)	0.018 (5)
86-9	0.010	0.012	0.010	0.026 (6)	0.013 (1)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

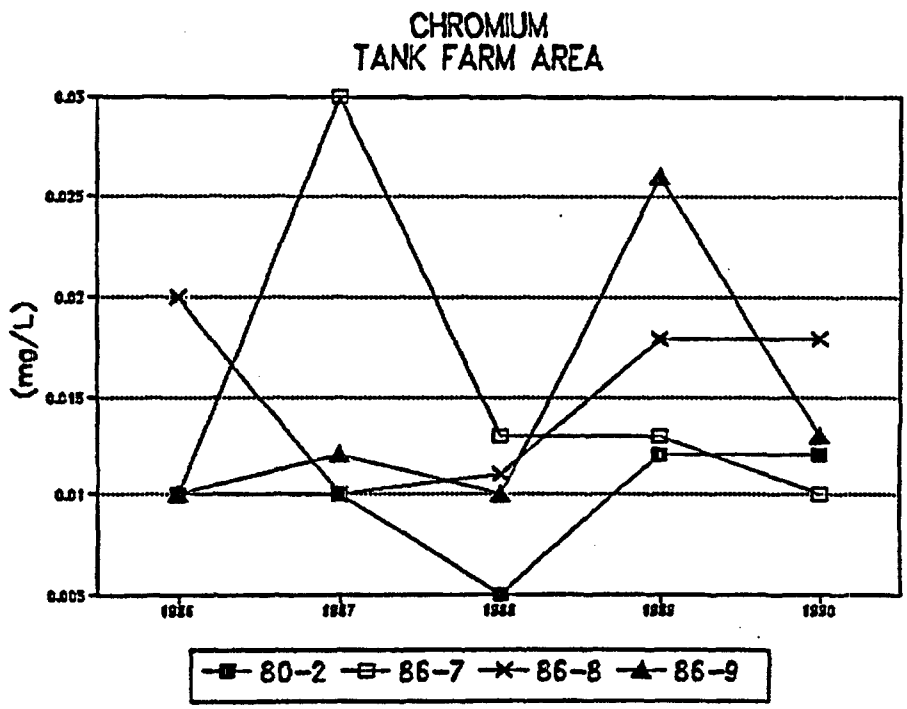


FIGURE 4-63

AVERAGE YEARLY CHROMIUM CONCENTRATION (mg/L)
IN WVDP WELLS-NORTHEAST MARGIN, NORTH PLATEAU (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.010	0.010 (3)	0.006 (2)	0.012 (2)	0.012 (2)
80-5	<0.010	0.009 (1)	0.004	0.016 (4)	0.012 (2)
80-6	<0.020	0.015 (2)	0.011	0.014 (4)	<0.010
86-12		0.005 (3)	0.012 (2)	0.013 (3)	<0.010
WNGSEEP	0.010	0.009 (2)	0.006	0.013 (1)	<0.010
WNDMPNE		0.008 (3)	<0.020	0.016 (2)	0.011 (2)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

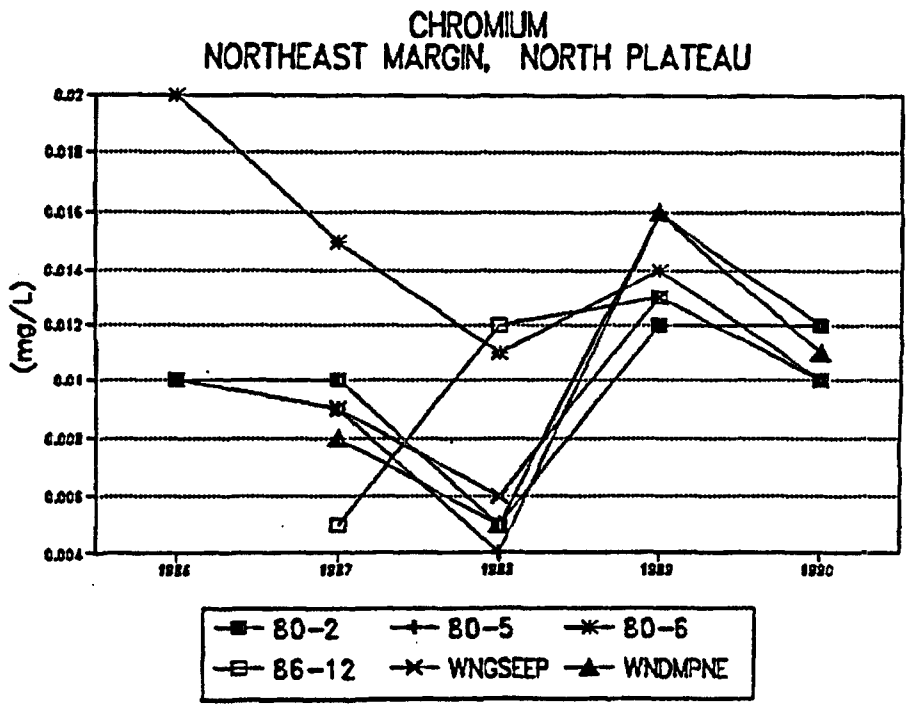


FIGURE 4-64

AVERAGE YEARLY IRON CONCENTRATION (mg/L)
IN WVDP WELLS, LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.55	2.80	1.03	3.41	4.11
86-3	0.03	0.18	0.07	2.57	4.16
86-4	0.12	2.61	1.68	11.37	12.45
86-5	1.20	2.63	4.12	5.45	4.07
86-6	0.11	1.20	0.21	0.45	1.66
WNSP008	0.09	0.09	0.07	0.06	8.67

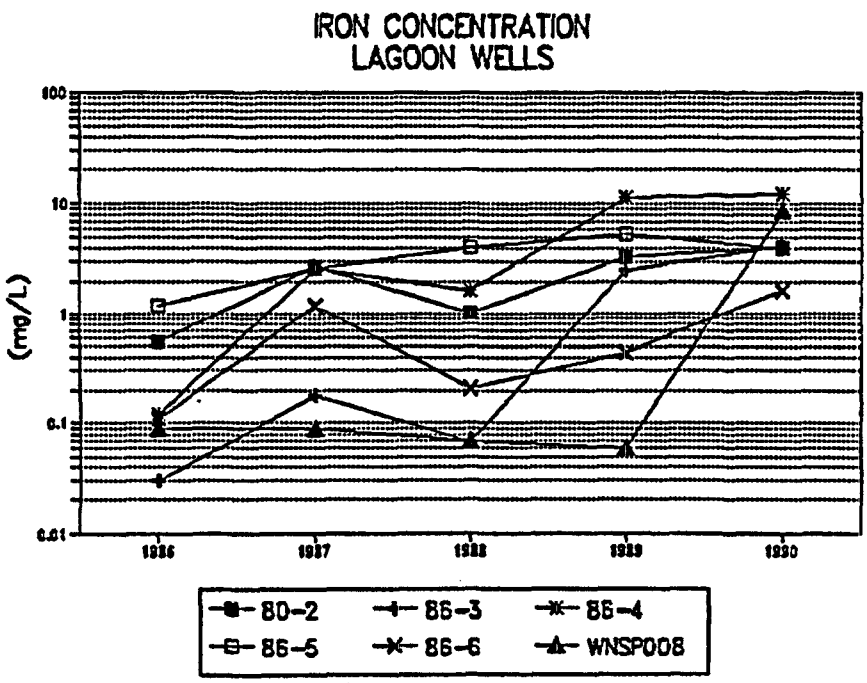


FIGURE 4-65

AVERAGE YEARLY IRON CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.55	2.80	1.03	3.41	4.11
86-7	0.05	0.90	1.58	0.98	0.68
86-8	4.70	2.75	3.85	8.24	21.39
86-9	0.06	2.97	5.95	24.38	8.20

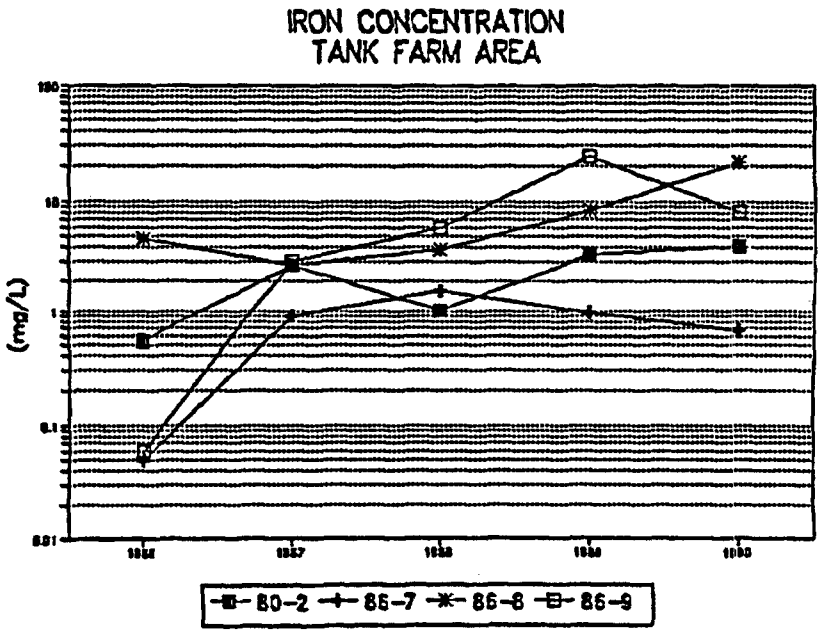


FIGURE 4-66

AVERAGE YEARLY IRON CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986-1990)

WELL	1986	1987	1988	1989	1990	
80-2	0.55	2.80	1.03	3.41	4.11	
80-5	0.09	8.37	2.31	8.25	22.54	
80-6	0.31	2.61	0.62	0.49	1.03	
86-12		0.27	0.72	1.45	2.75	
WNGSEEP	0.02	1.06	1.07	0.06	0.07	(2)
WNDMPNE		0.84	1.38	4.66	2.59	

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

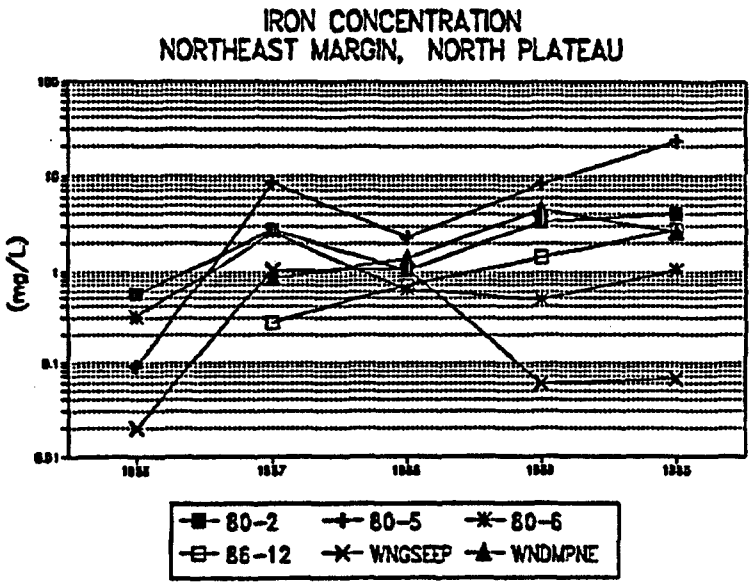


FIGURE 4-67

AVERAGE LEAD CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.010	0.030	0.027 (1)	0.008 (4)	0.005 (5)
86-3	<0.010	0.020 (3)	0.028 (1)	0.006 (2)	0.006 (4)
86-4	0.010	0.020 (3)	0.027 (1)	0.011	0.010 (6)
86-5	0.010	0.060 (1)	<0.050	0.004 (4)	0.003 (2)
86-6	0.010	0.020 (3)	0.016 (2)	0.005 (1)	0.004 (1)
WNSP008	0.010	0.030 (2)	0.010 (1)	0.007 (2)	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

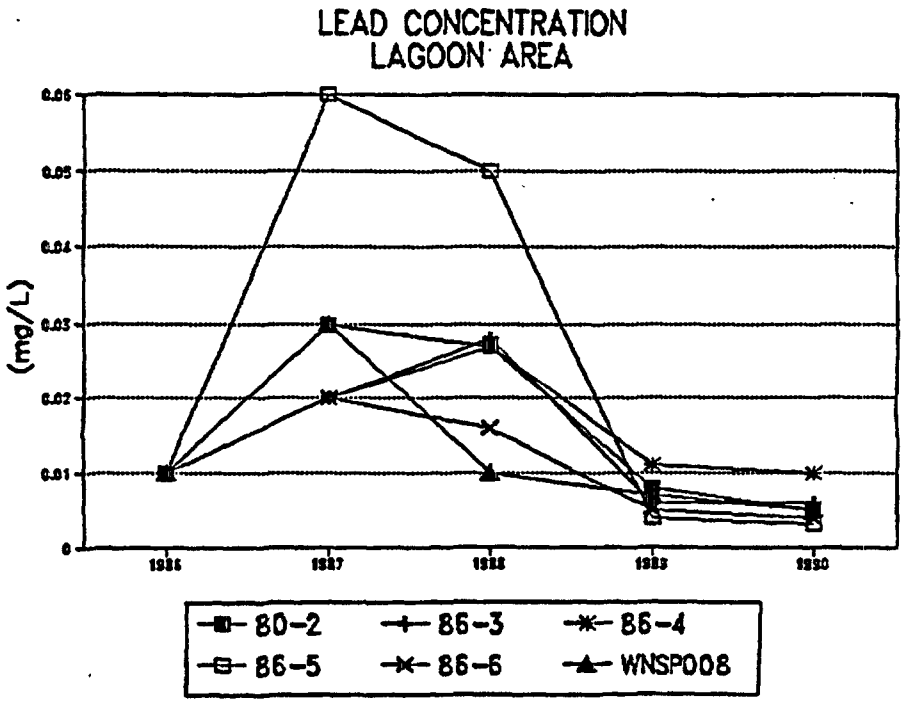


FIGURE 4-68

AVERAGE YEARLY LEAD CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.001	0.030	0.027 (1)	0.008 (4)	0.005 (5)
86-7	0.010	0.015 (2)	0.017 (2)	0.005 (2)	0.005 (2)
86-8	0.010	0.050 (2)	0.026 (2)	0.070 (6)	0.112
86-9	<0.010	0.019	0.016 (1)	0.022 (7)	0.009

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

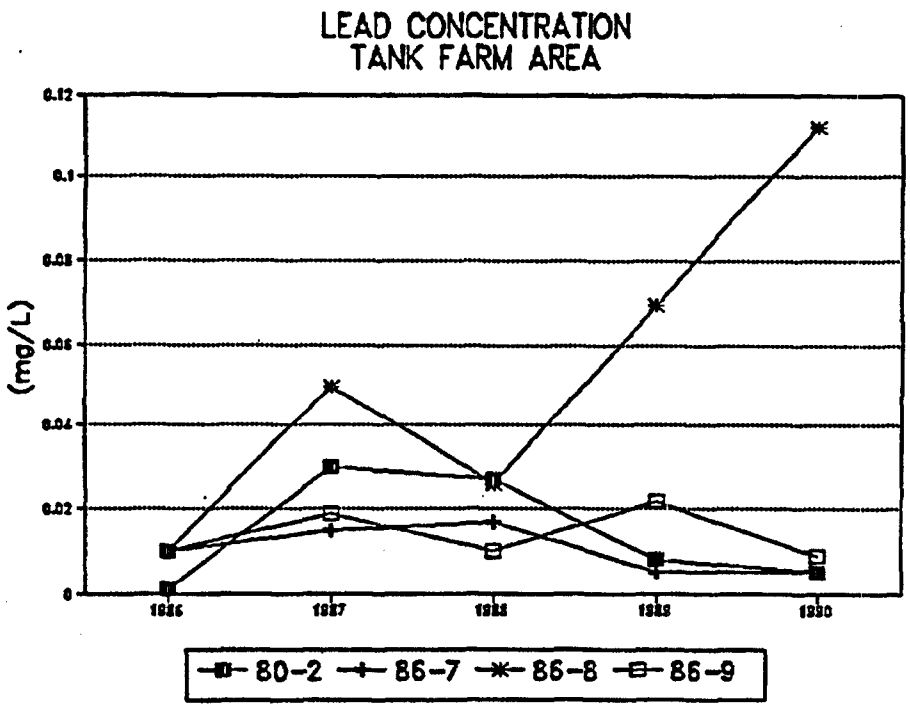


FIGURE 4-69

AVERAGE YEARLY LEAD CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986-1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.010	0.030	0.027 (1)	0.008 (4)	0.005 (5)
80-5	0.010	0.030	0.028 (1)	0.009 (5)	0.009
80-6	0.020	0.020 (2)	0.024 (1)	0.013 (5)	0.005 (1)
86-12		0.014 (3)	0.015 (1)	<0.006	0.006 (2)
WNGSEEP	<0.010	0.040 (1)	0.023 (1)	0.005 (2)	0.006 (1)
WNDMPNE		0.020 (2)	0.009 (1)	0.038 (3)	0.006 (3)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

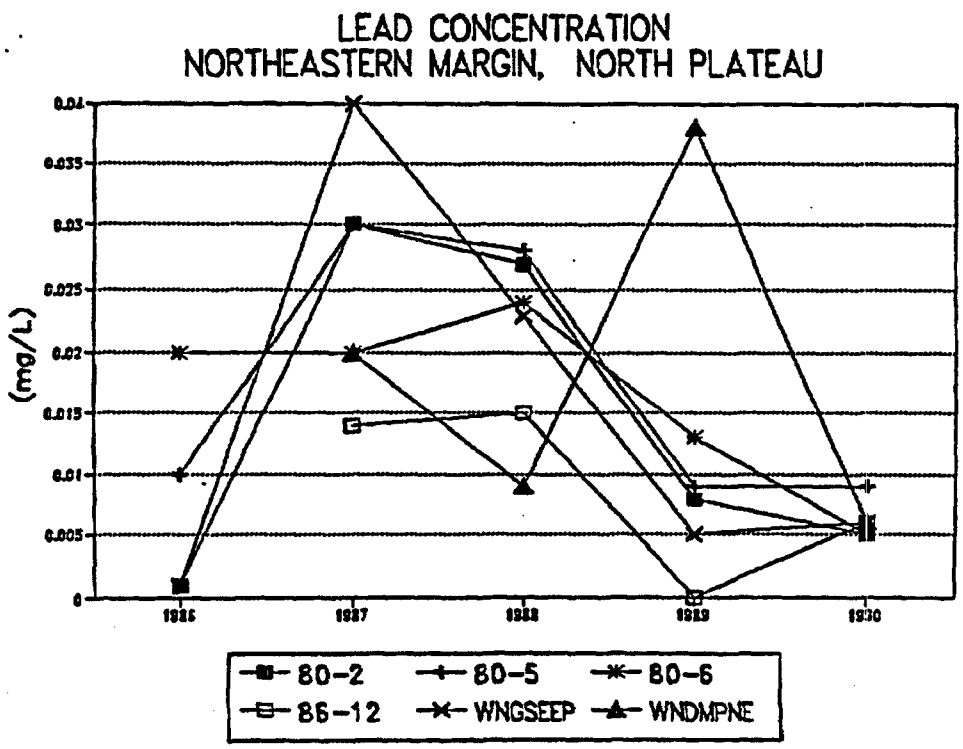


FIGURE 4-70

AVERAGE YEARLY MERCURY CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1985 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	<0.0005	<0.0005	<0.0004	0.0005 (2)
86-3	<0.01	<0.0125	<0.0005	0.0005 (3)	0.0008 (1)
86-4	<0.01	0.006 (1)	<0.0005	0.0008 (3)	<0.0008
86-5	<0.01	0.003 (1)	<0.0002	0.0003 (3)	0.0002
86-6	<0.01	0.003 (1)	<0.0005	<0.0004	0.0014 (3)
WNSP008	<0.01	<0.010	<0.0005	<0.0004	0.0009 (2)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

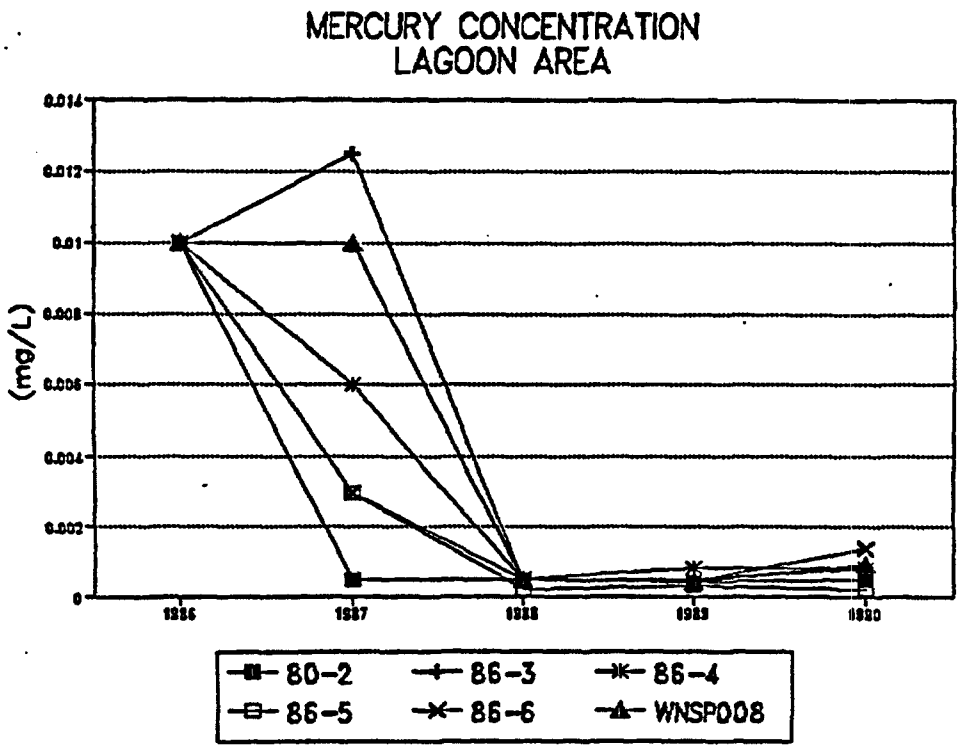


FIGURE 4-71

AVERAGE YEARLY MERCURY CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	<0.0005	<0.0005	<0.0004	0.0005 (2)
86-7	<0.01	<0.0005	0.0014 (1)	<0.0004	<0.0004
86-8	<0.01	<0.0005	<0.0008 (1)	<0.0004	0.0005 (1)
86-9	<0.01	<0.0005	0.0011 (1)	<0.0004	0.0006 (1)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

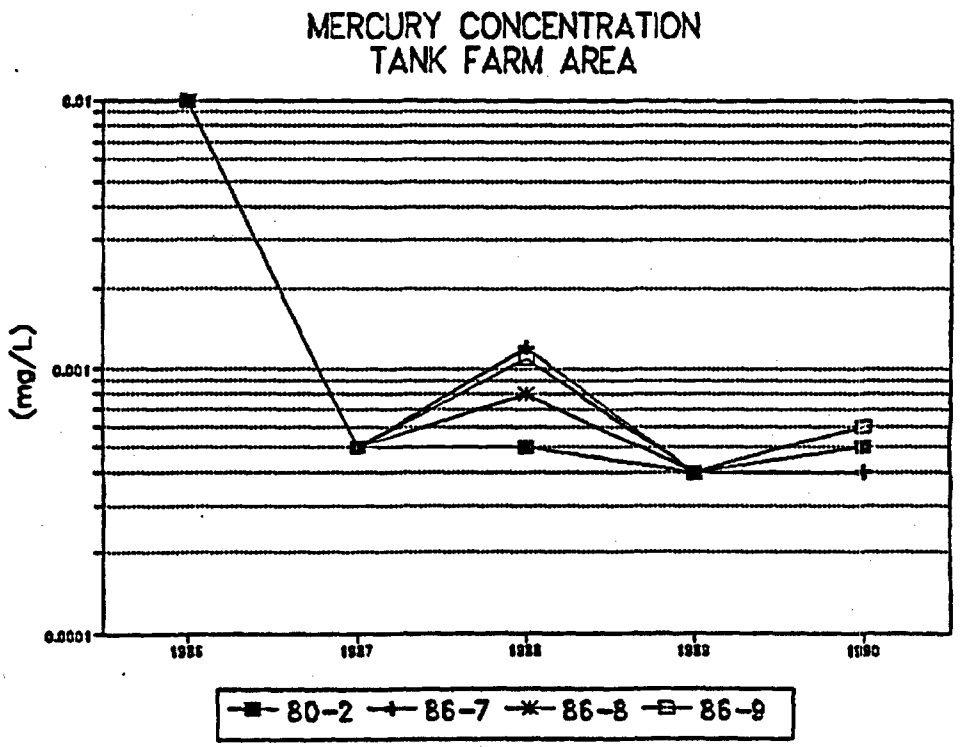


FIGURE 4-72

AVERAGE YEARLY MERCURY CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	<0.0005	<0.0005	<0.0004	0.0005 (2)
80-5	<0.01	0.003 (2)	0.0021 (1)	0.0006 (1)	<0.0004
80-6	<0.01	<0.010	<0.0005	<0.0004	0.0005 (1)
86-12		<0.0005	<0.0005	<0.0004	<0.0004
WNGSEEP	<0.01	0.002 (1)	0.0006 (1)	<0.0004	<0.0004
WNDMPNE		<0.0005	<0.0005	<0.0004	<0.0004

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

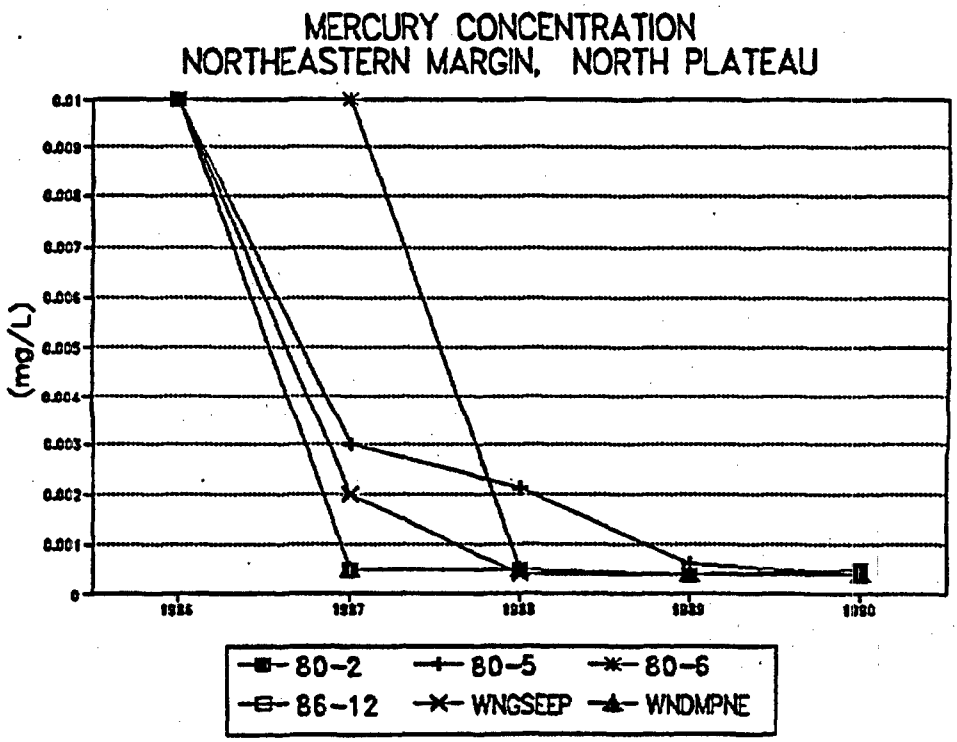


FIGURE 4-73

AVERAGE YEARLY MANGANESE CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.060	0.140	0.053	0.072	0.061
86-3	<0.010	0.010 (3)	0.010 (2)	0.070	0.061
86-4	0.050	0.070	0.060	0.220	0.250
86-5	4.450	8.070	8.800	10.030	9.470
86-6	3.000	2.560	3.200	3.050	2.470
WNSP008	1.830	1.640	2.260	2.060	1.880

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

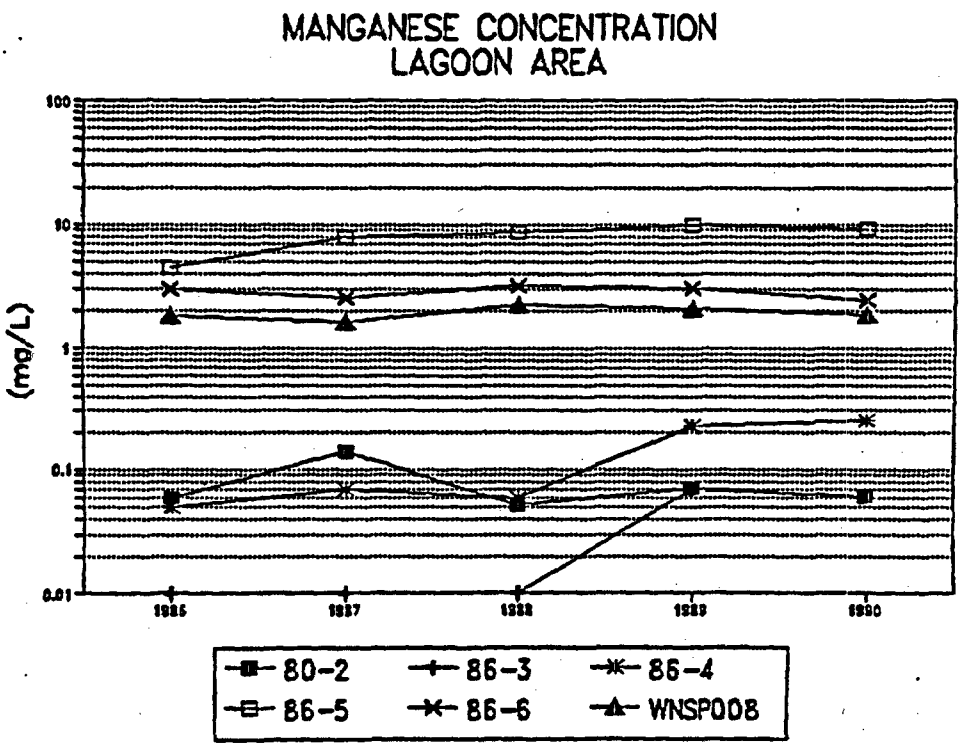


FIGURE 4-74

AVERAGE YEARLY MANGANESE CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.060	0.140	0.053	0.072	0.061
86-7	0.430	0.230	0.360	0.470	0.460
86-8	31.000	12.000	5.170	8.050	7.900
86-9	0.040	0.190	0.210	0.910	0.250

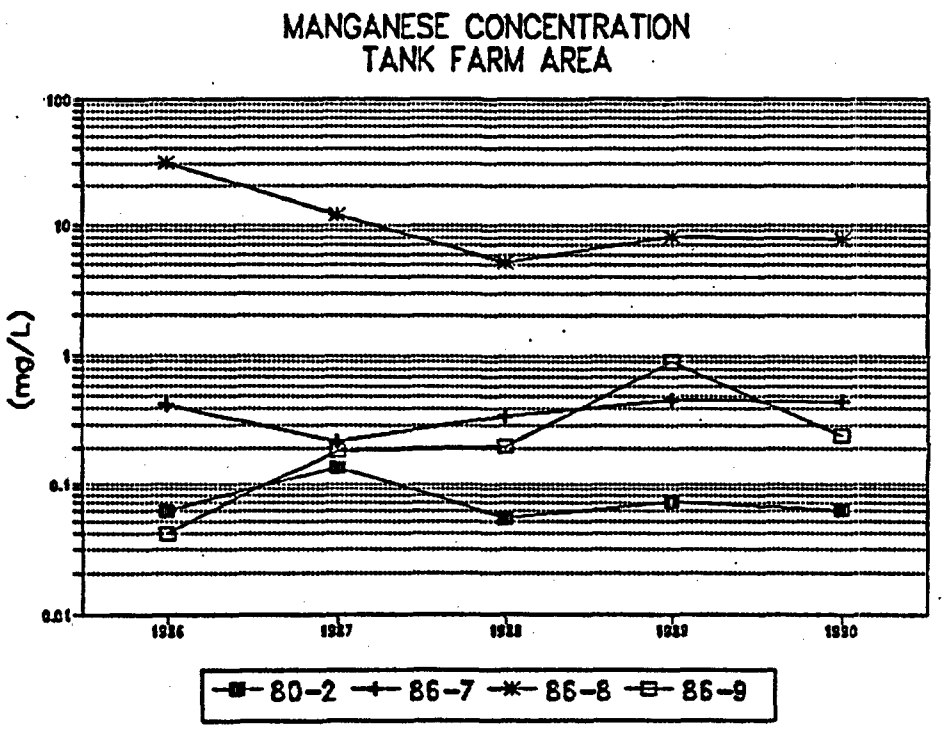


FIGURE 4-75

AVERAGE YEARLY MANGANESE CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.060	0.140	0.053	0.072	0.061
80-5	0.030	0.190	0.090	0.120	0.079
80-6	1.260	5.880	8.200	6.010	4.360
86-12		0.070	0.090	0.100	0.130
WNGSEEP	<0.01	0.003 (3)	0.030 (2)	0.008 (2)	0.007 (2)
WNDMPNE		0.040	0.100	0.220	0.180

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

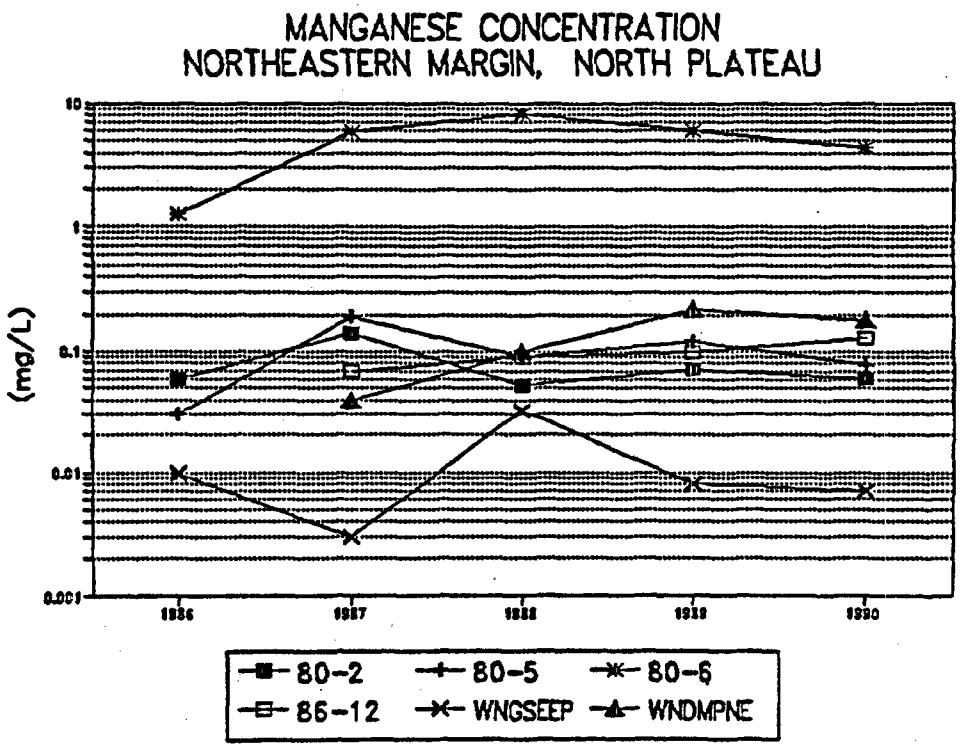


FIGURE 4-76

AVERAGE YEARLY SELENIUM CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.01	<0.005	<0.005	<0.005	<0.005
86-3	<0.01	0.008 (1)	<0.005	<0.005	0.006 (1)
86-4	<0.01	<0.010	<0.005	<0.005	<0.005
86-5	<0.01	<0.200	<0.002	<0.002	0.002 (1)
86-6	0.01	<0.005	<0.005	0.007 (1)	<0.005
WNSP008	<0.01	<0.010	<0.005	0.005 (1)	0.005 (1)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

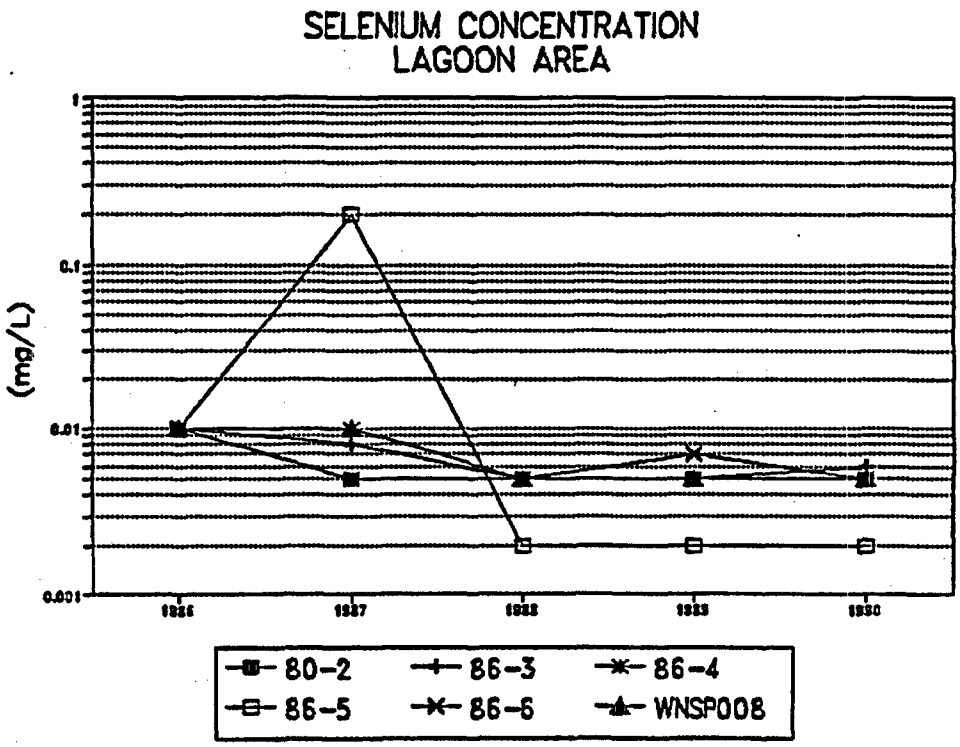


FIGURE 4-77

AVERAGE YEARLY SELENIUM CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.010	<0.005	<0.005	<0.005	<0.005
86-7	<0.010	0.006 (1)	<0.005	<0.005	<0.005
86-8	<0.010	0.006 (1)	<0.005	<0.005	<0.005
86-9	<0.010	<0.005	<0.005	<0.005	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

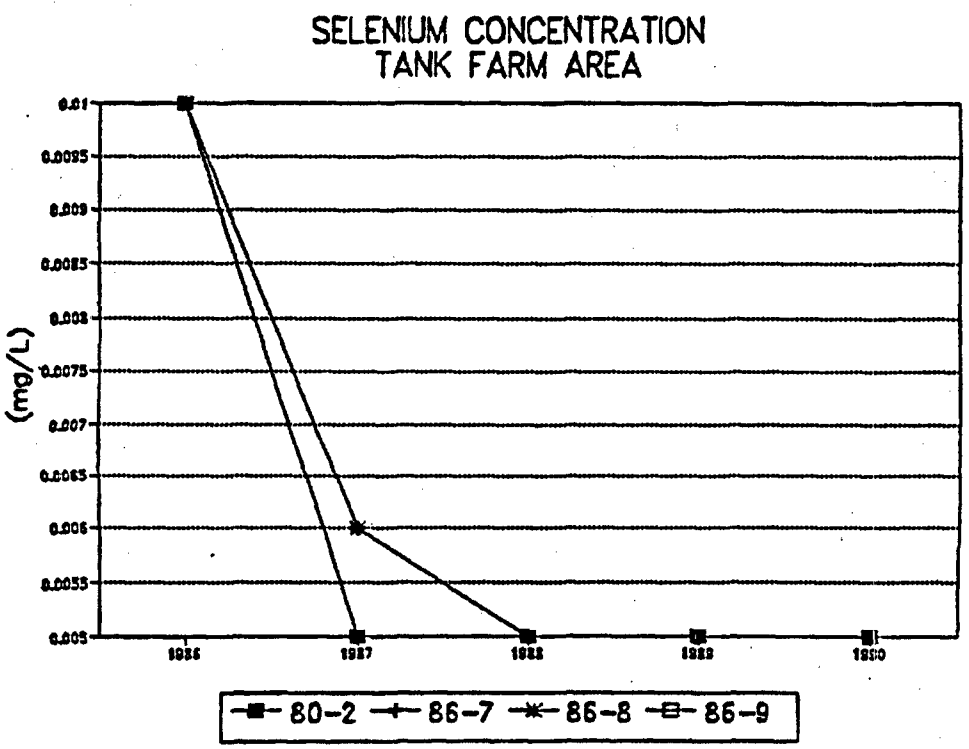


FIGURE 4-78

AVERAGE YEARLY SELENIUM CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	0.01	<0.005	<0.005	<0.005	<0.005
80-5	<0.01	<0.005	<0.005	<0.005	<0.005
80-6	0.01	<0.010	<0.005	<0.005	<0.005
86-12		0.004 (1)	<0.005	<0.005	<0.005
WNGSEEP	<0.02	<0.005	<0.005	0.006 (2)	<0.005
WNDMPNE		<0.005	<0.005	<0.005	<0.005

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

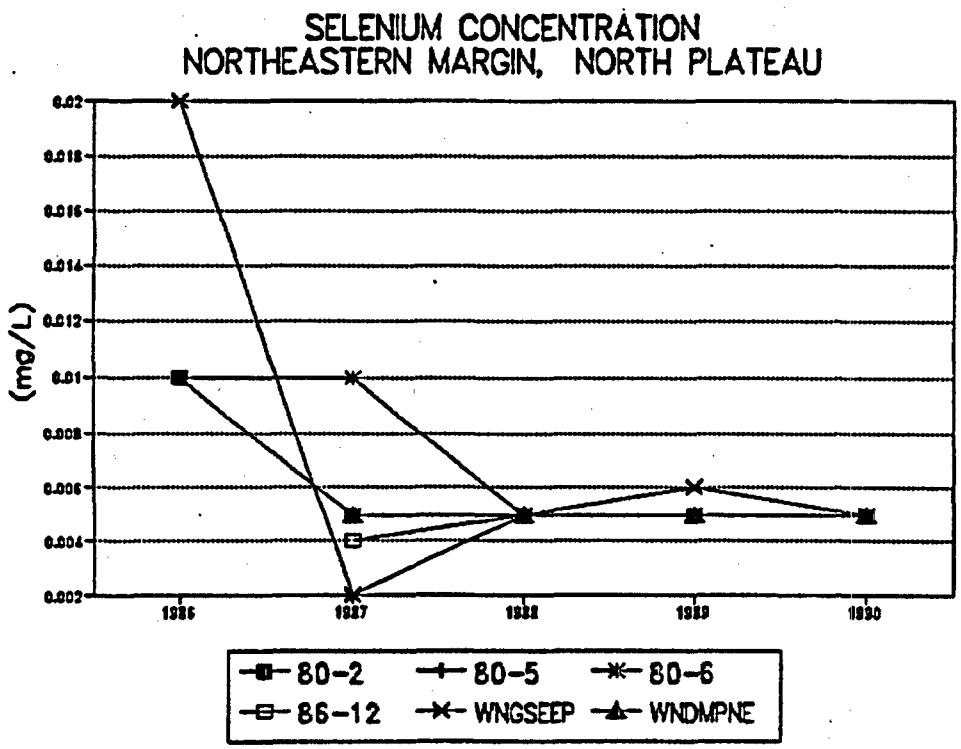


FIGURE 4-79

AVERAGE YEARLY SILVER CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.004	<0.005	<0.010	<0.010
86-3	<0.01	<0.010	<0.005	0.008 (3)	0.007 (2)
86-4	<0.01	<0.010	<0.005	0.007 (3)	0.005 (3)
86-5	<0.01	0.023 (1)	<0.010	0.051	0.013 (6)
86-6	<0.01	0.005 (1)	<0.005	0.007 (4)	0.007 (2)
WNSP008	<0.01	0.004 (1)	<0.005	0.007 (2)	0.014 (2)

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
1986 - ONE SAMPLING EVENT

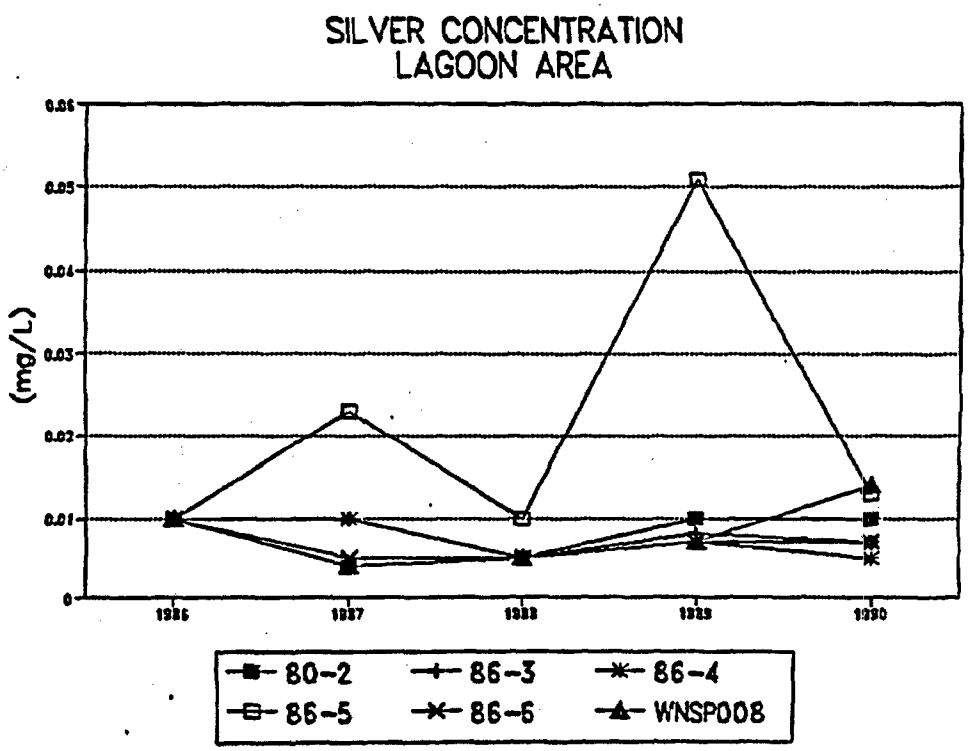


FIGURE 4-80

AVERAGE YEARLY SILVER CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1990)

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.004	<0.005	<0.010	<0.010
86-7	<0.01	<0.005	<0.005	0.007 (4)	0.008 (1)
86-8	<0.01	<0.005	<0.005	<0.010	0.007 (1)
86-9	<0.01	0.005 (1)	0.007 (1)	0.008 (5)	<0.010

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION

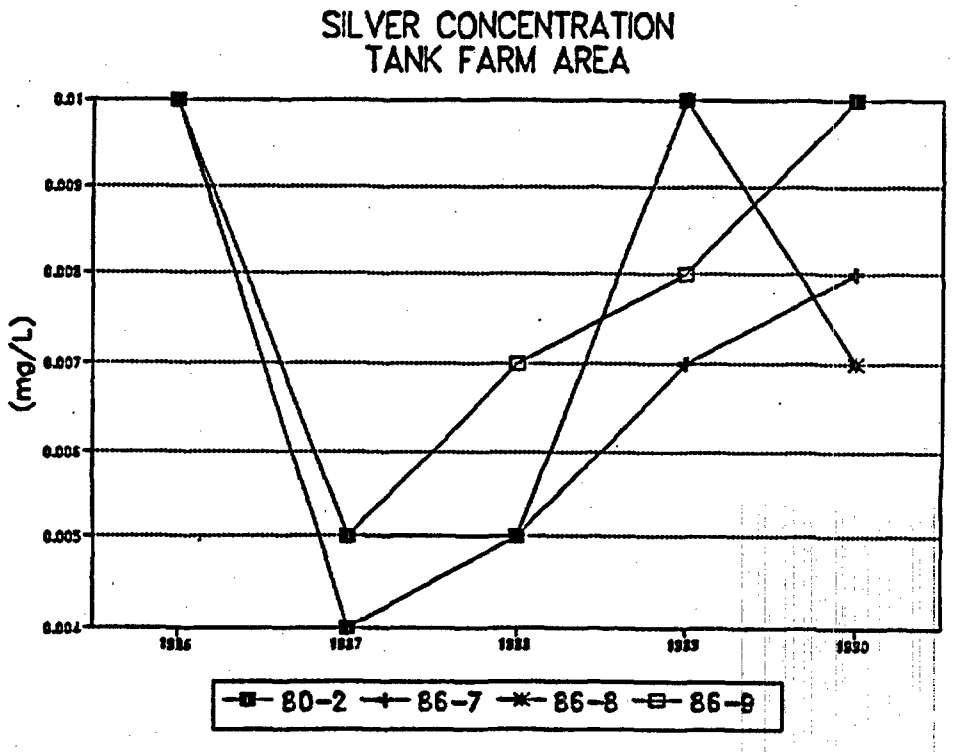


FIGURE 4-81

AVERAGE YEARLY SILVER CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU

WELL	1986	1987	1988	1989	1990
80-2	<0.01	0.004	<0.005	<0.010	<0.010
80-5	<0.01	<0.005	<0.005	0.009 (3)	<0.010
80-6	<0.01	<0.010	0.009 (1)	<0.010	0.008 (2)
86-12		0.006 (2)	<0.005	0.006 (4)	<0.010
WNGSEEP	<0.01	<0.005	0.005 (1)	0.007 (2)	<0.010
WNDMPNE		0.004 (1)	<0.005	0.007 (4)	<0.010

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

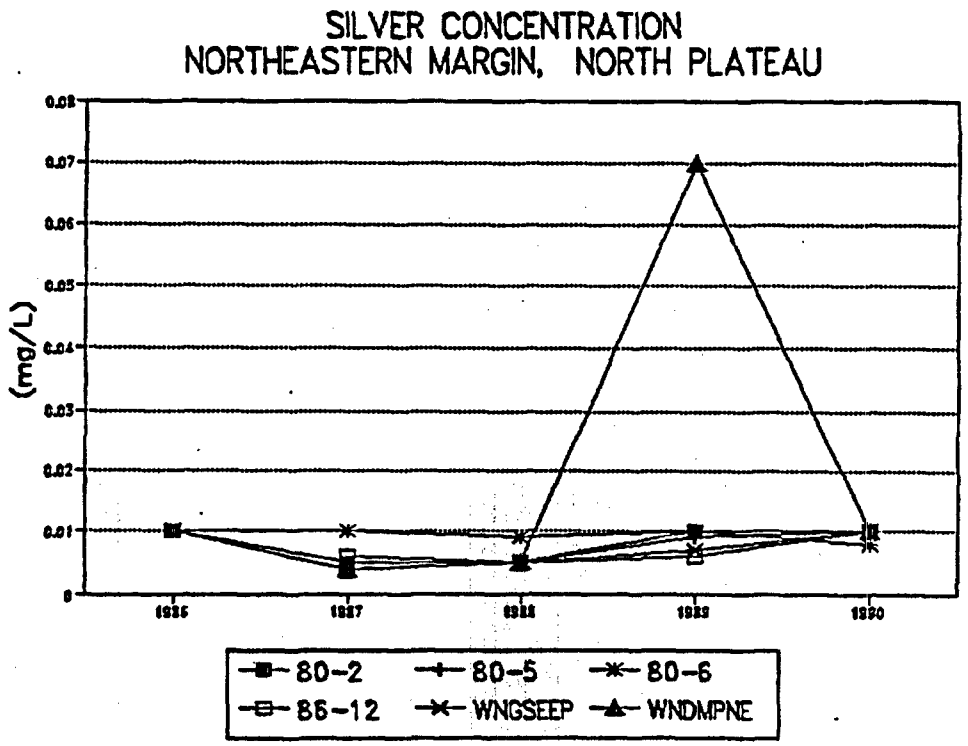


FIGURE 4-82

AVERAGE YEARLY SODIUM CONCENTRATION (mg/L)
IN WVDP WELLS LAGOON AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	3.98	3.78 (3)	5.43 (2)	4.79	4.95	
86-3	17.90	20.00	26.33	26.25	30.94	35.00
86-4	17.10	21.00	26.67	27.63	31.80	42.00
86-5	25.28	34.00	45.33	57.00	53.00	67.00
86-6	257.00	178.00	319.00	400.00	245.00	405.00
WNSP008	39.90	46.25	52.00	49.63	51.24	59.00

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

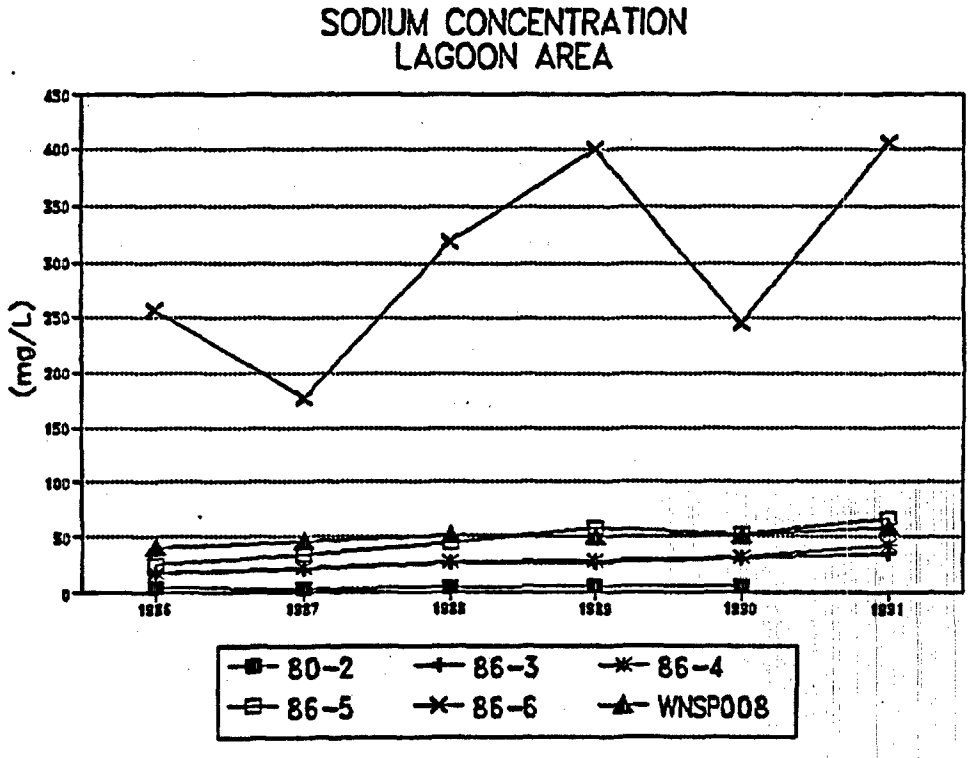


FIGURE 4-83

AVERAGE YEARLY SODIUM CONCENTRATION (mg/L)
IN WVDP WELLS TANK FARM AREA (1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	3.98	3.78 (3)	5.43 (2)	4.79	4.95	
86-7	11.70	9.53	13.33	11.49	18.81	16.00
86-8	7.60	8.95	8.43	7.85	13.47	12.00
86-9	7.93	7.10	7.30	10.20	10.79	11.00

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR

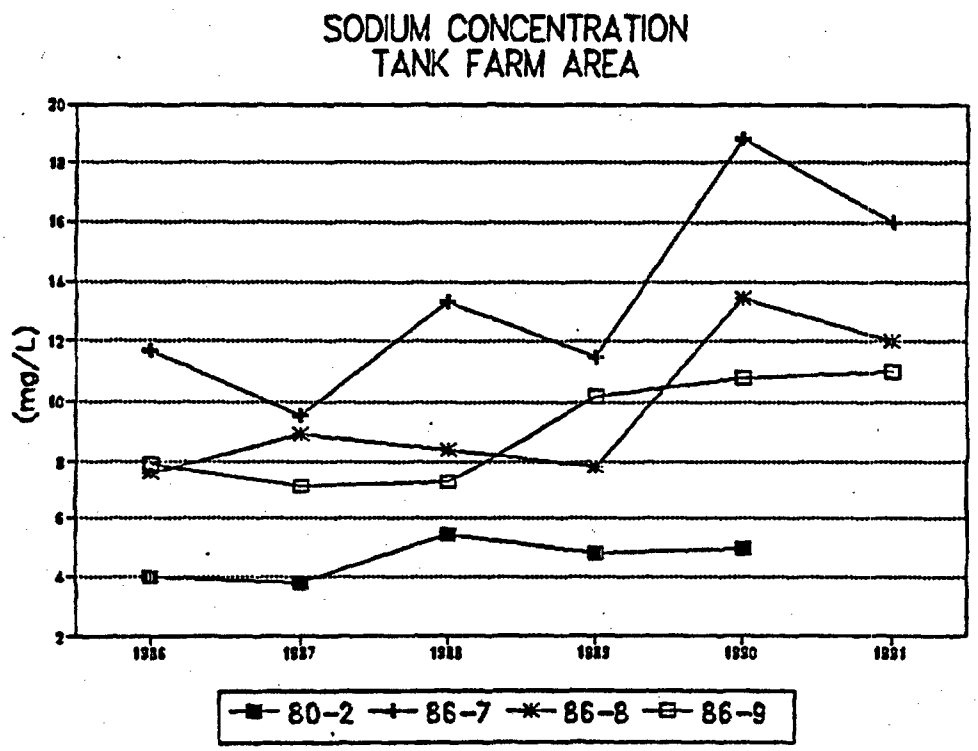
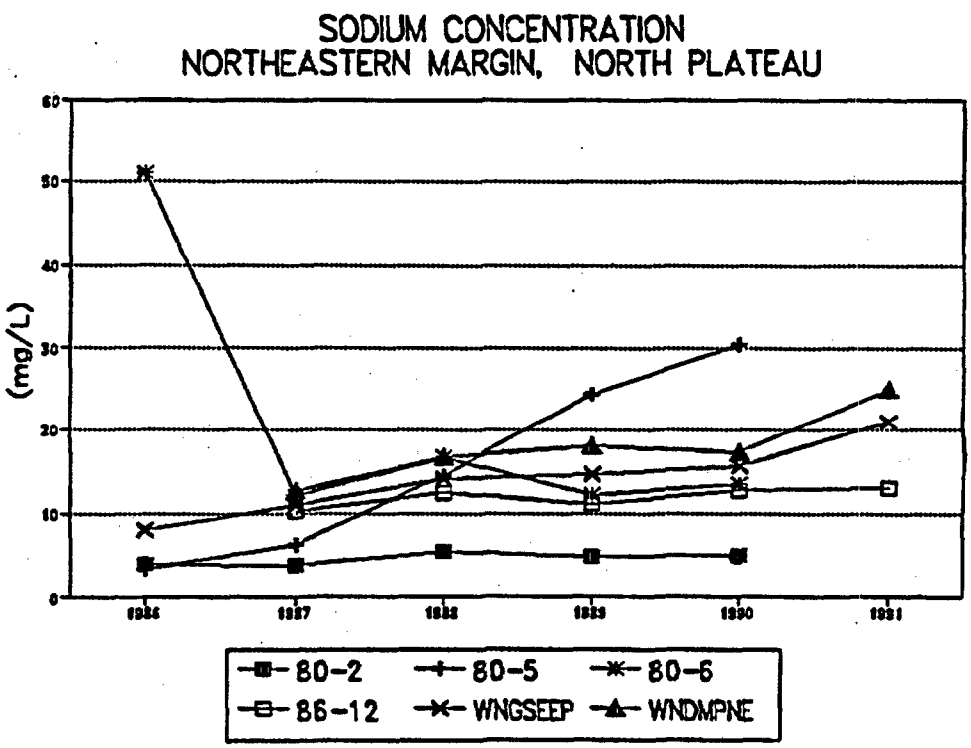


FIGURE 4-84

AVERAGE YEARLY SODIUM CONCENTRATION (mg/L)
IN WVDP WELLS NORTHEASTERN MARGIN, NORTH PLATEAU
(1986 - 1991)

WELL	1986	1987	1988	1989	1990	1991
80-2	3.98	3.78 (3)	5.43 (2)	4.79	4.95	
80-5	3.30	6.25	14.33	24.50	30.39	
80-6	51.00	12.00	16.67	12.13	13.38	
86-12		10.20	12.30	11.13	12.68	13.00
WNGSEEP	8.10	11.00	14.00	14.50	15.65	21.00
WNDMPNE		12.50	16.63	17.88	17.09	25.00

( )= NUMBER OF SAMPLING EVENTS ABOVE THE LOWER LIMIT OF DETECTION
BLANK ENTRY INDICATES PARAMETER NOT ANALYZED DURING THE YEAR



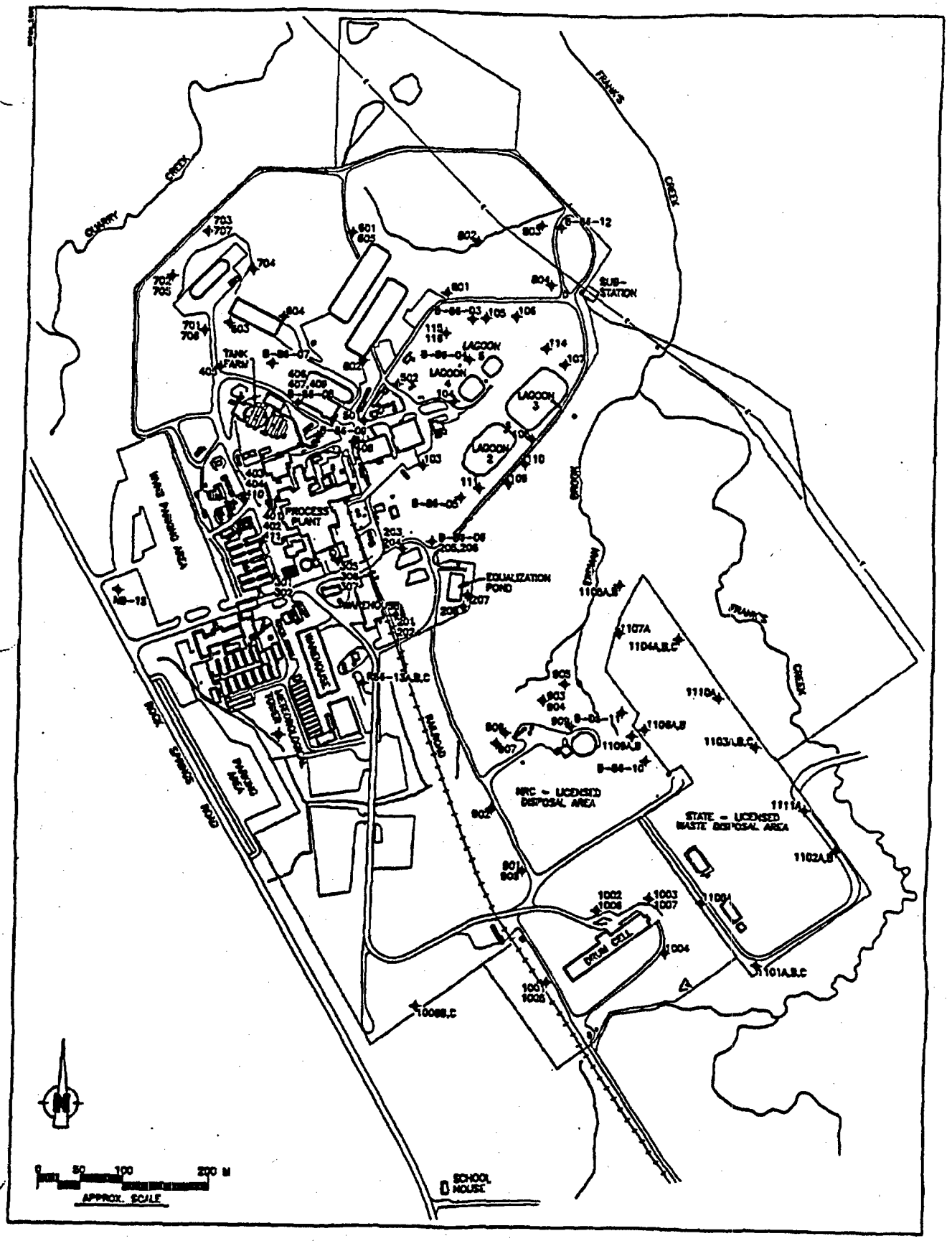


Figure 4-85 Expanded monitoring program well locations

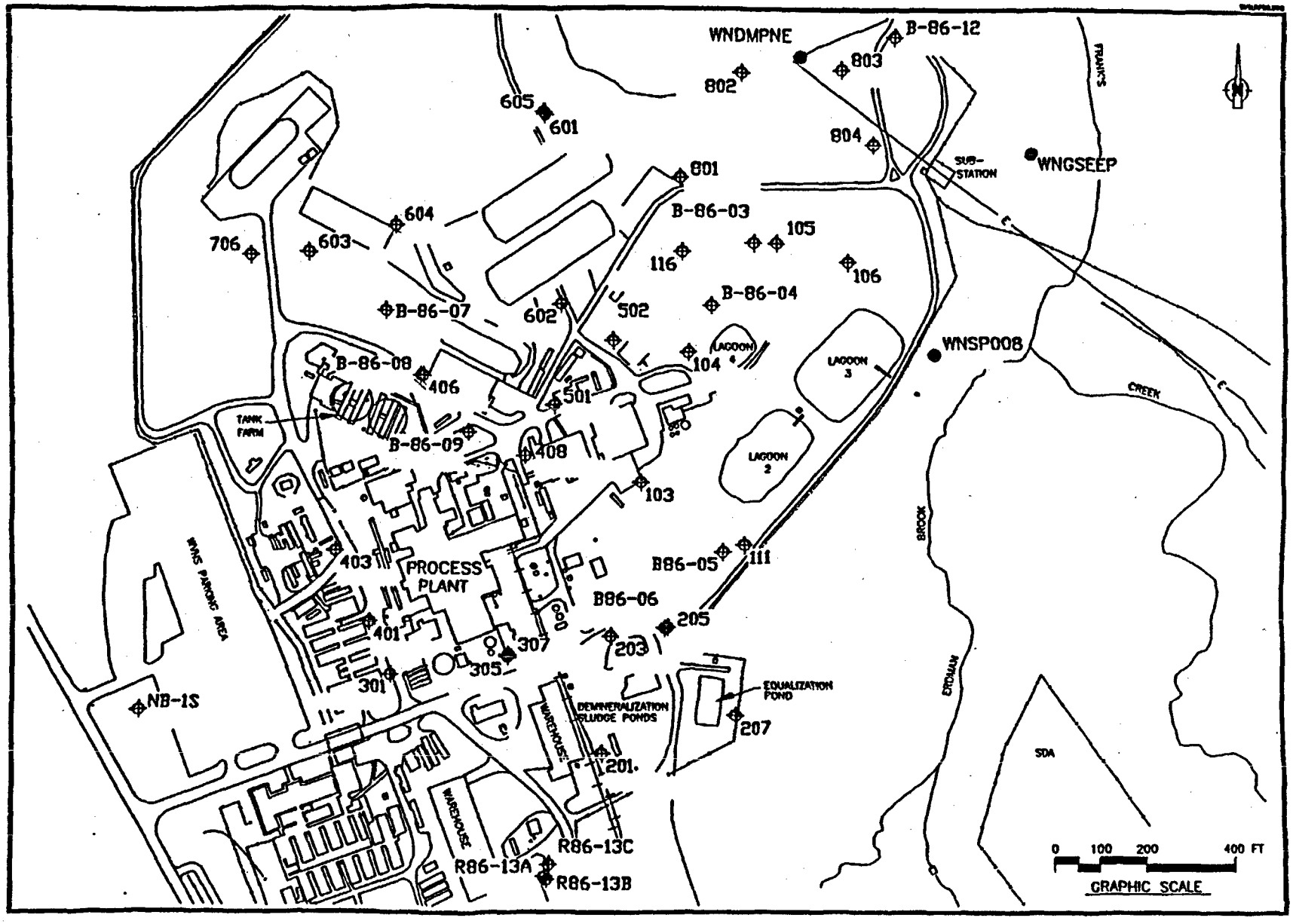


Figure 4-86 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program.

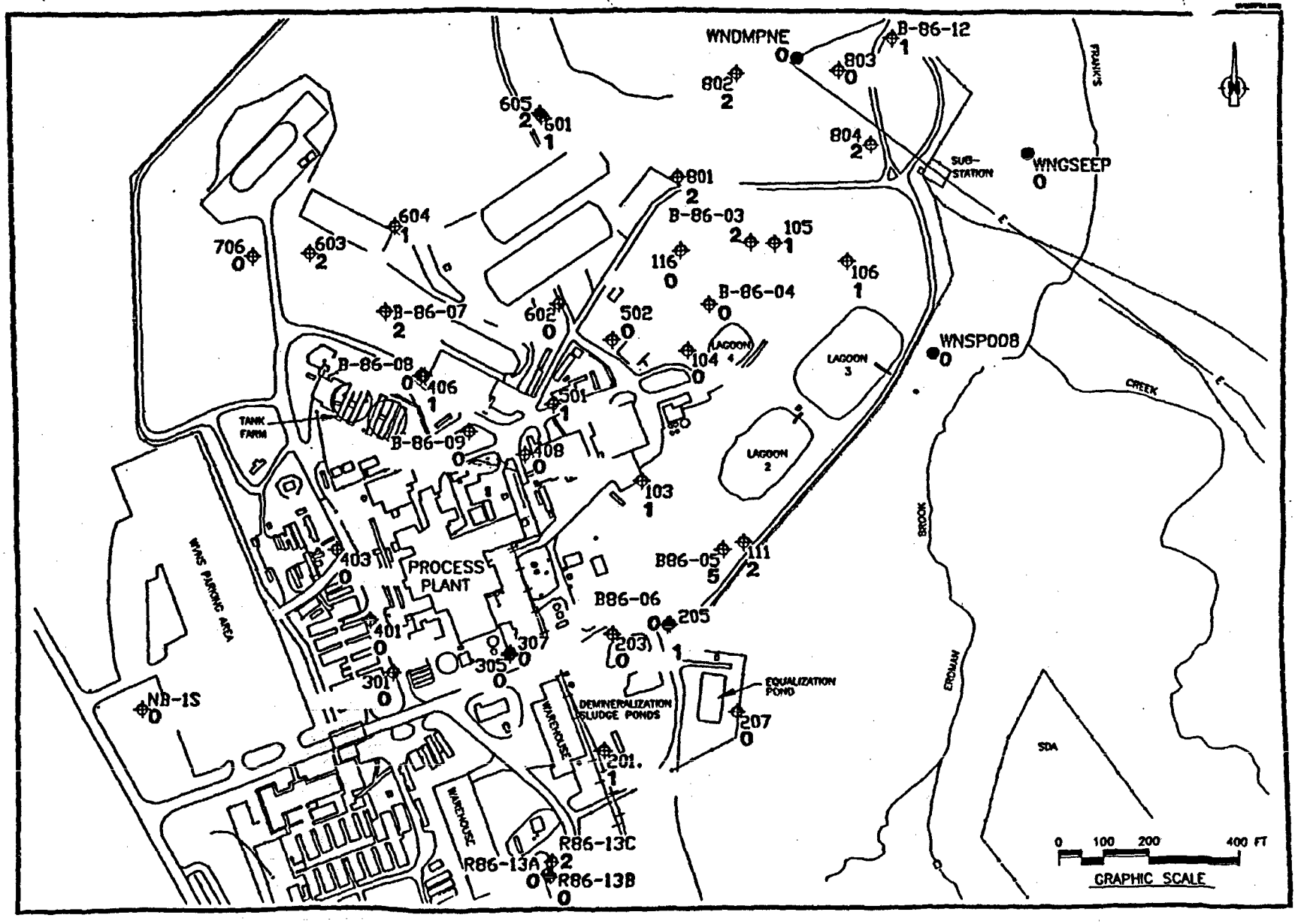


Figure 4-87 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Gross Alpha – Number of Detections Above The LLD.

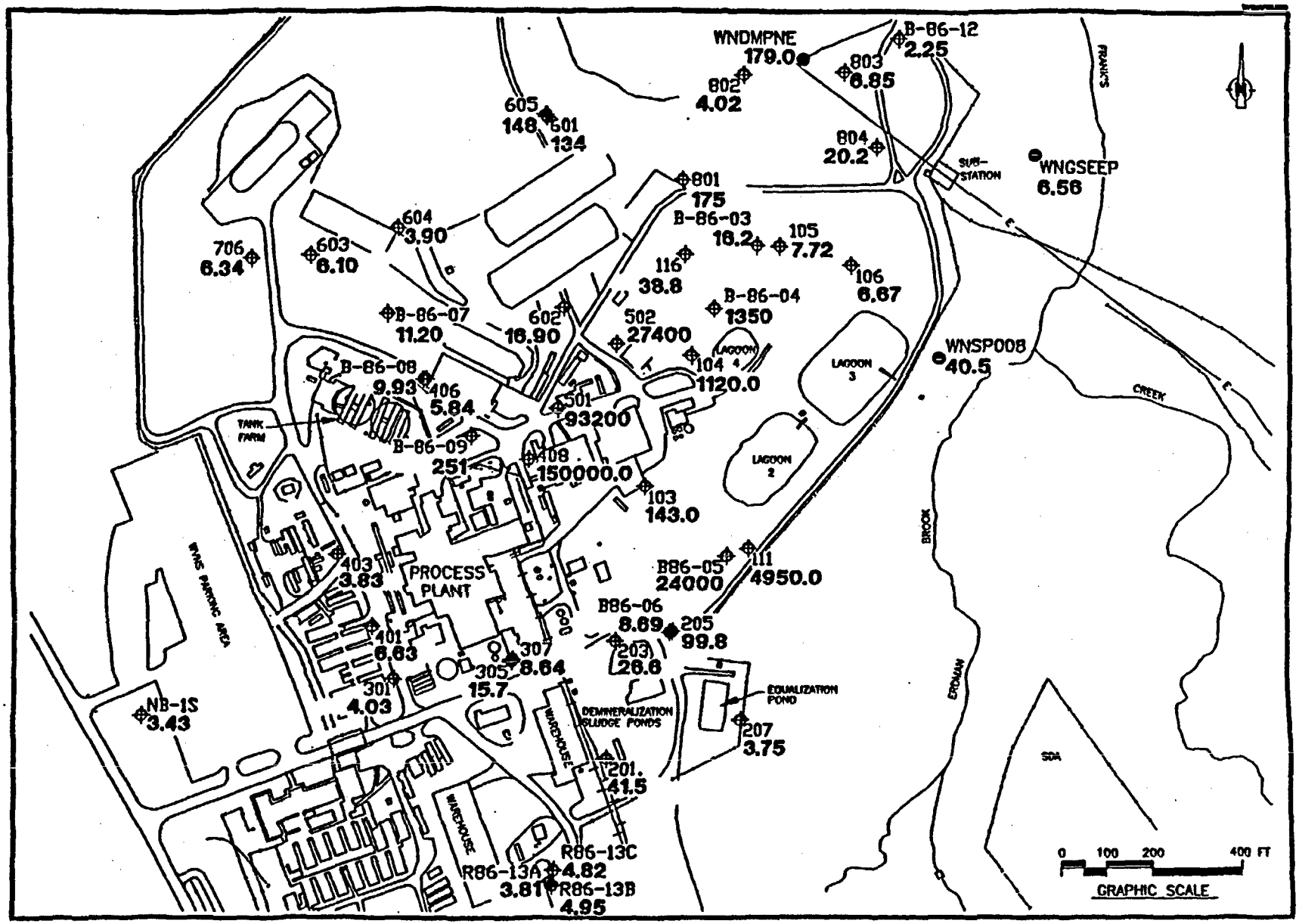


Figure 4-88 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Gross Beta Activity (to E-09 uCi/ml) Levels.

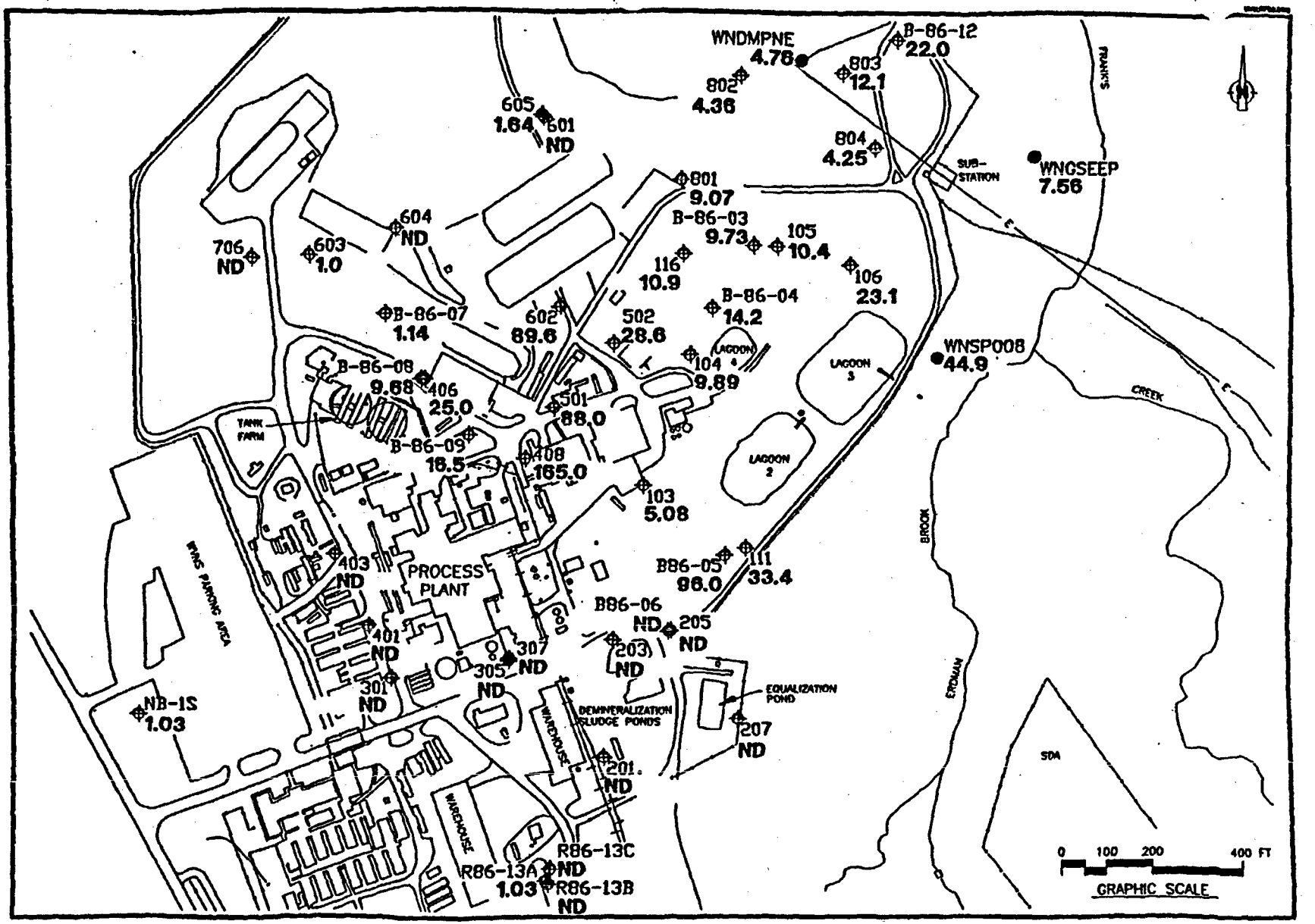


Figure 4-89 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Tritium Activity (to E-07 uCi/ml)(ND = Non-Detected).

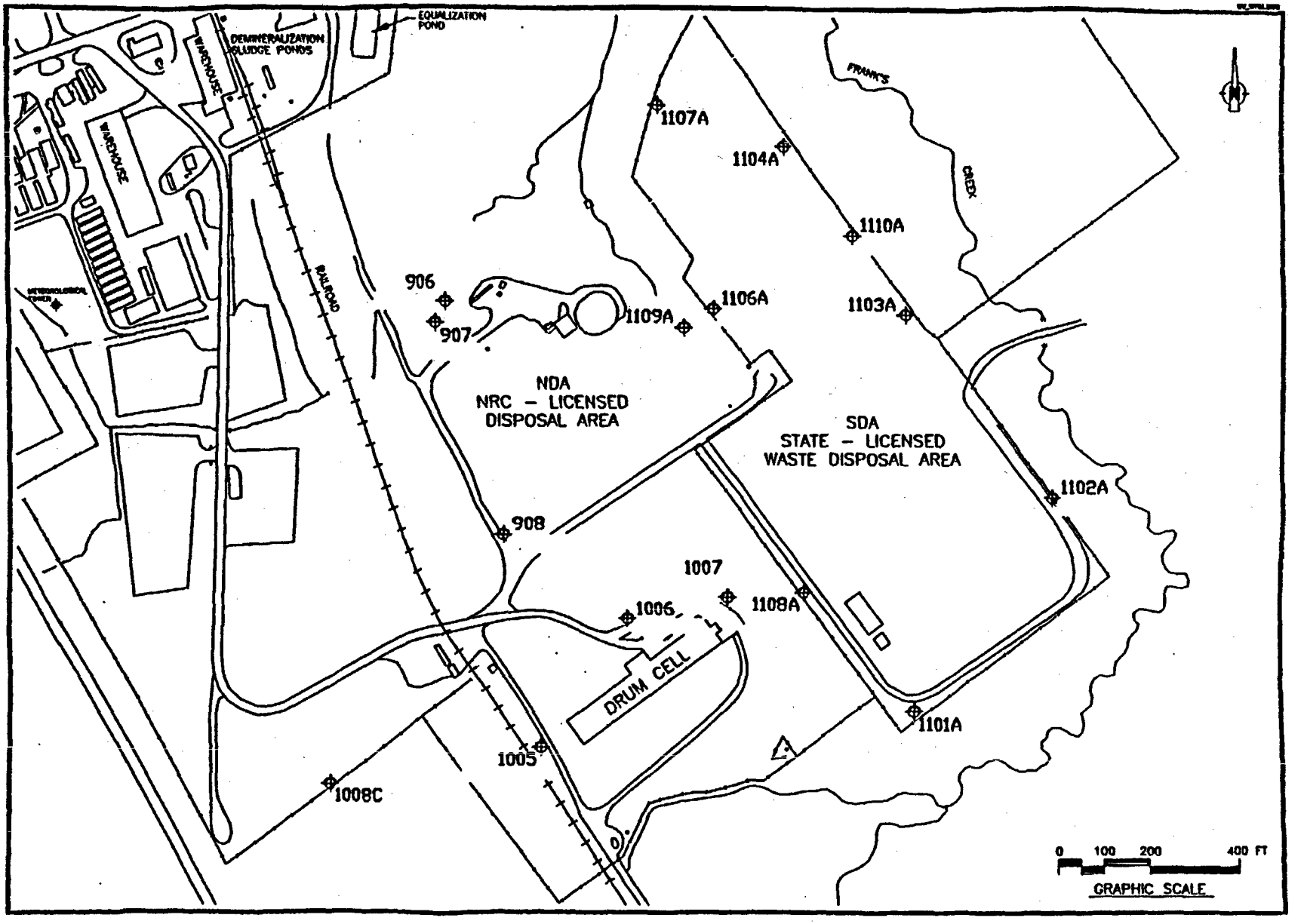


Figure 4-90 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program.

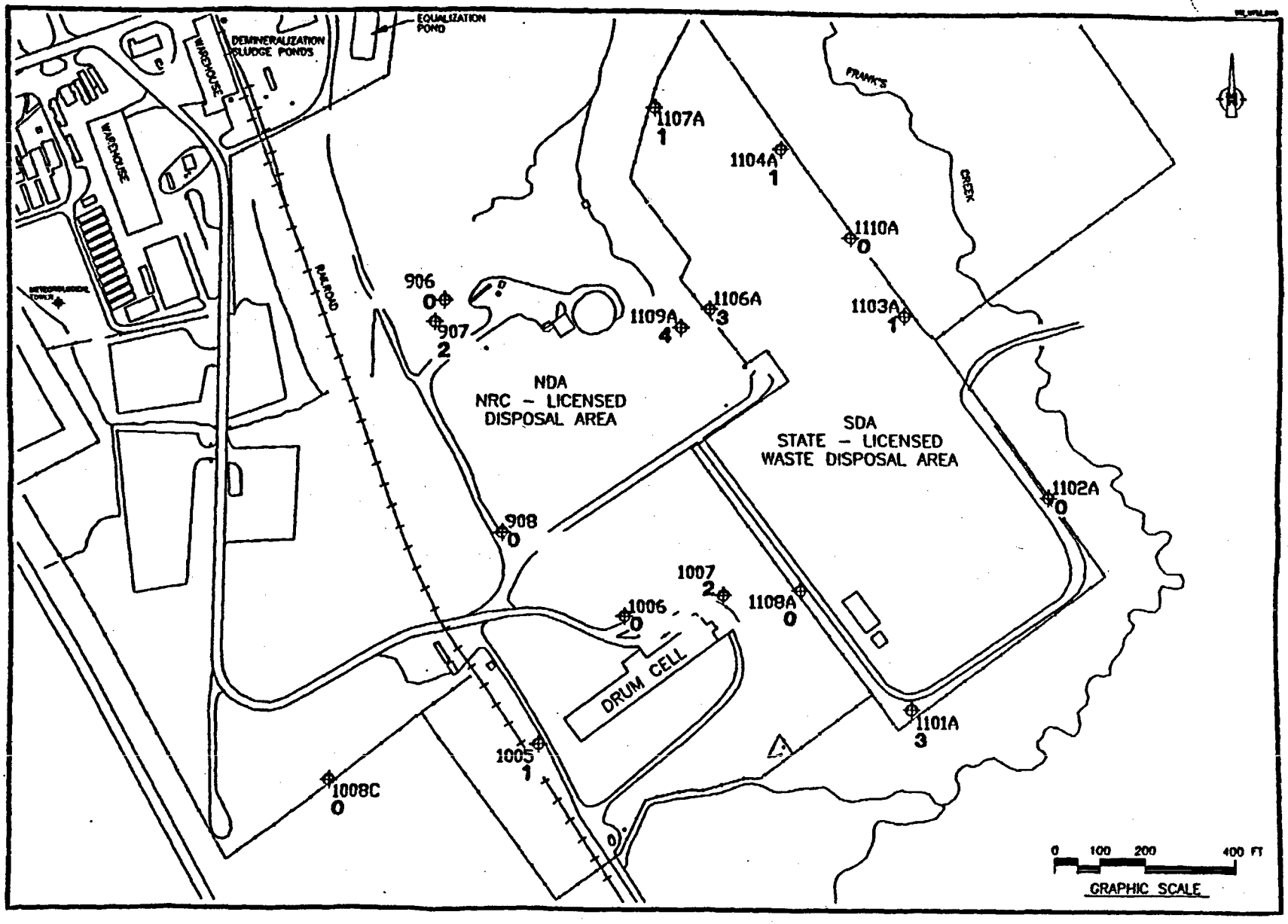


Figure 4-91 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Gross Alpha – Number of Detections Above The LLD.

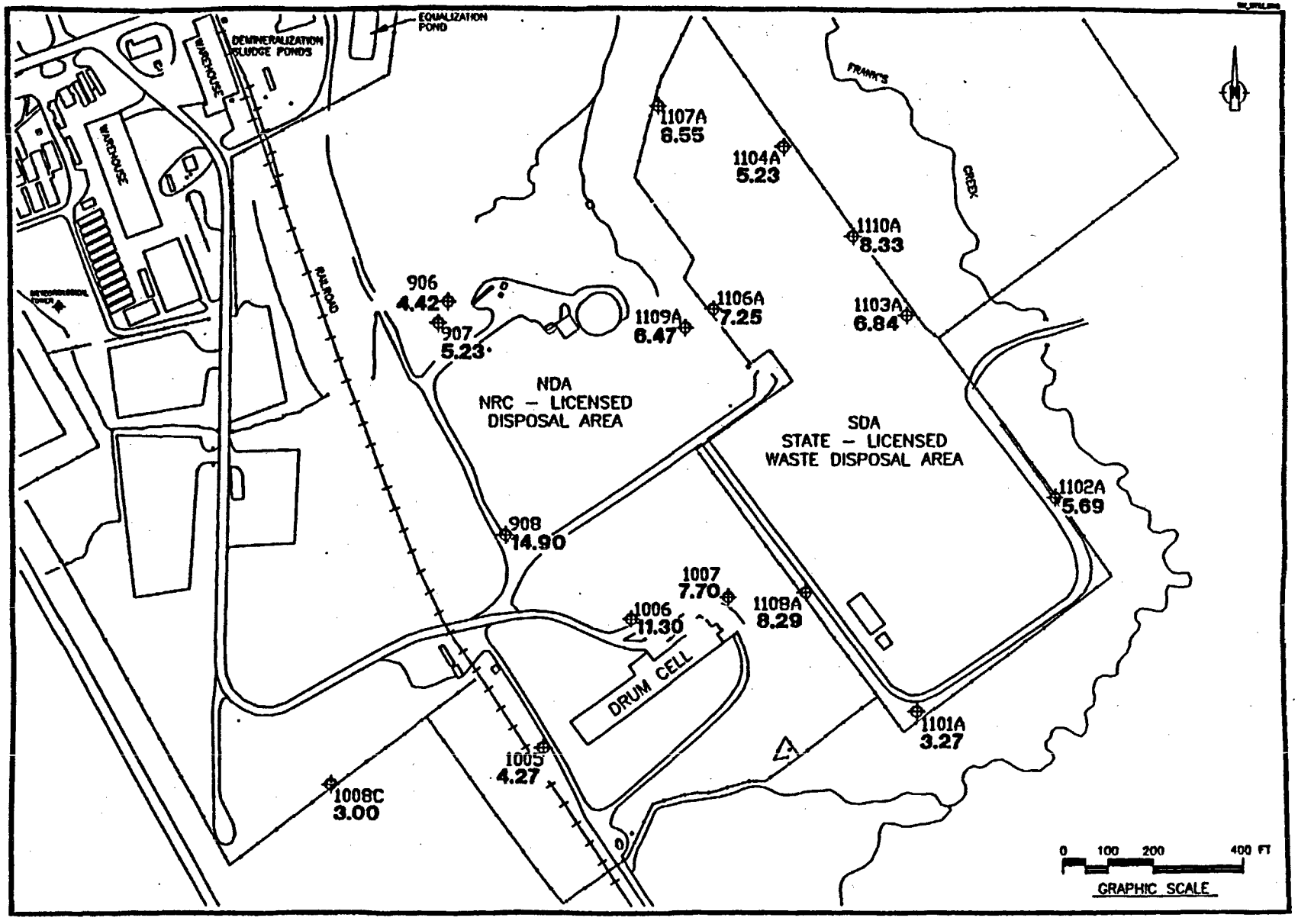


Figure 4-92 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Gross Beta Activity (to E–09 uCi/ml) Levels.

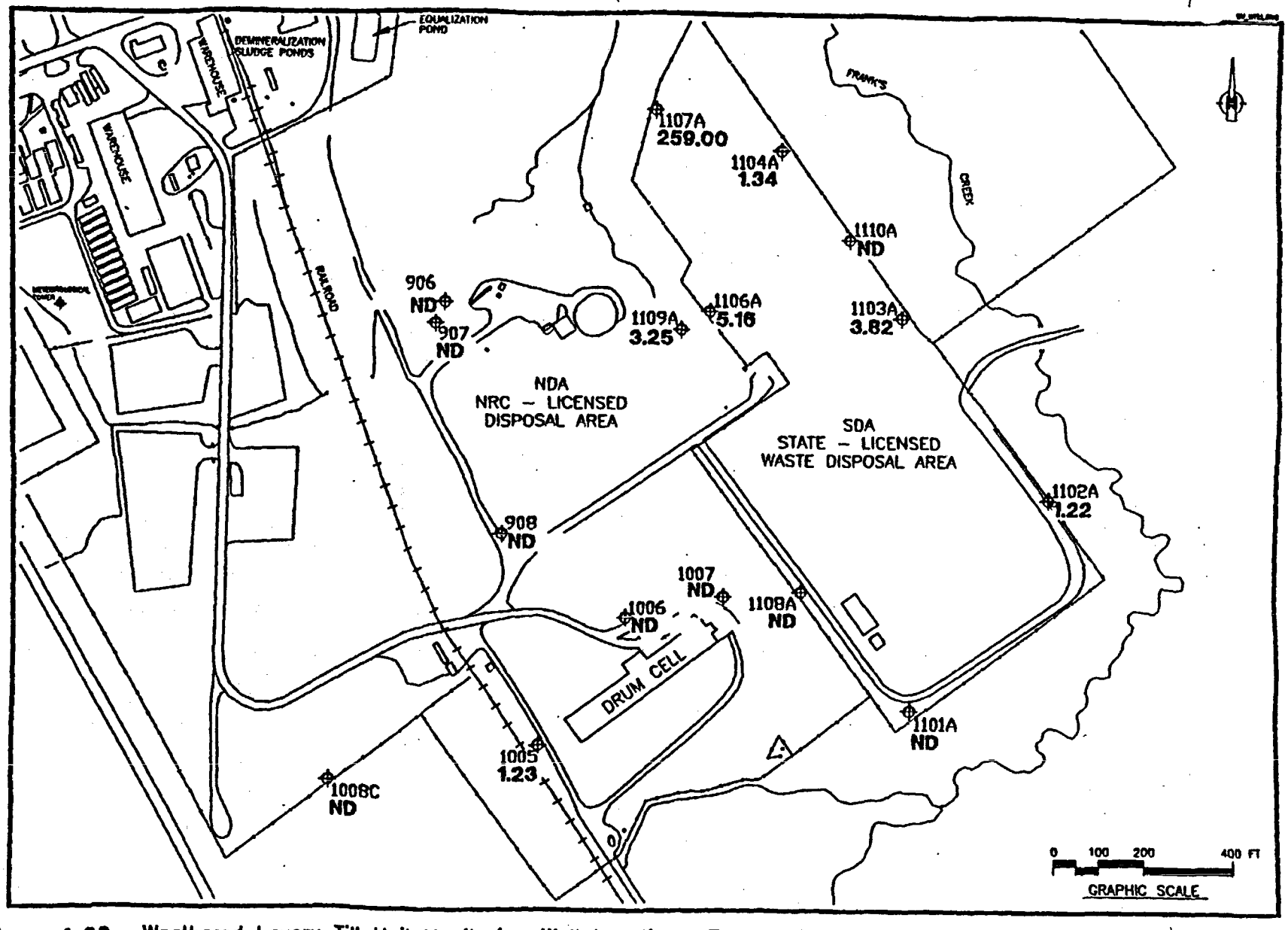


Figure 4-93 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Tritium Activity (to E-07 uCi/ml) (ND = Non-Detected).

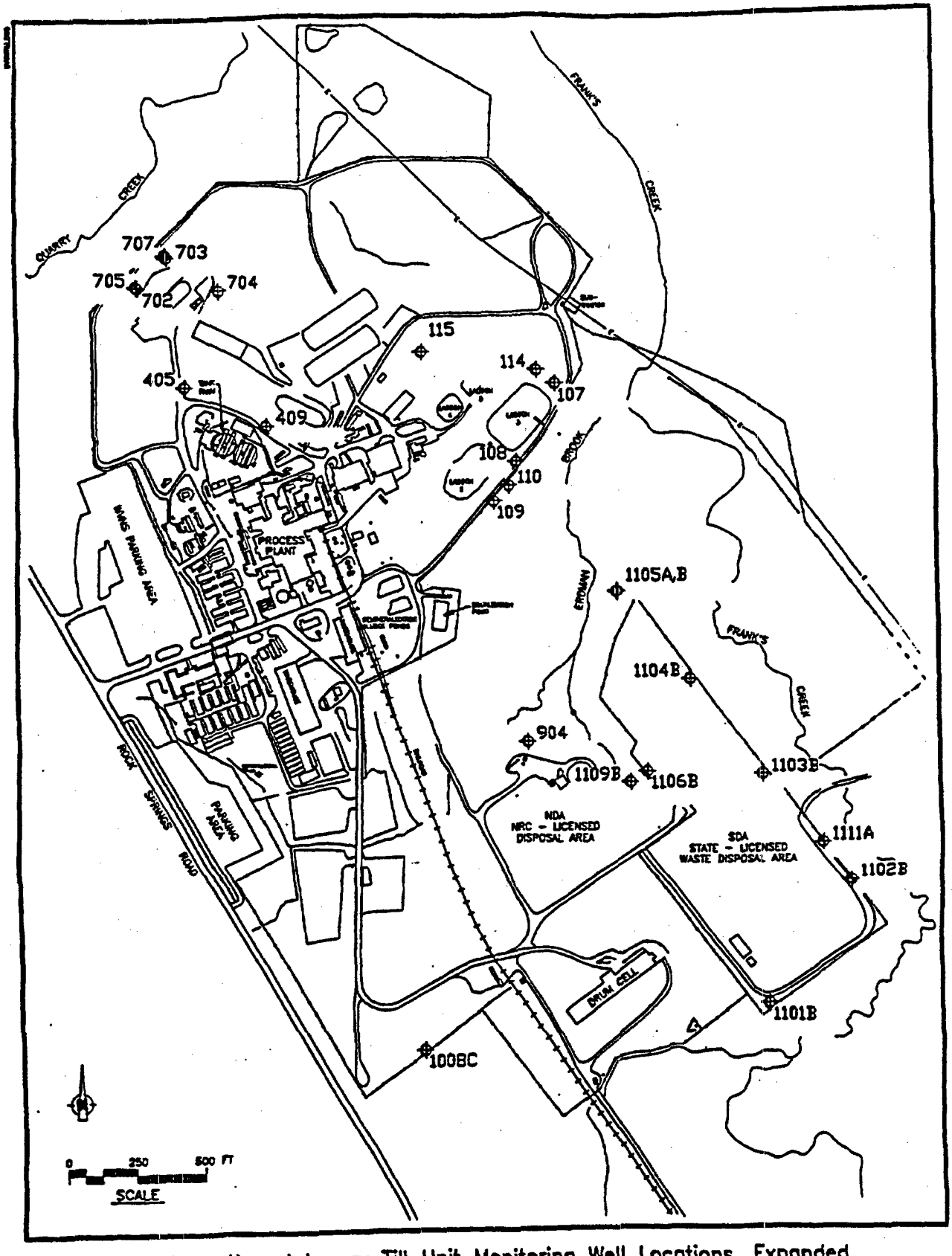


Figure 4-94 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program.

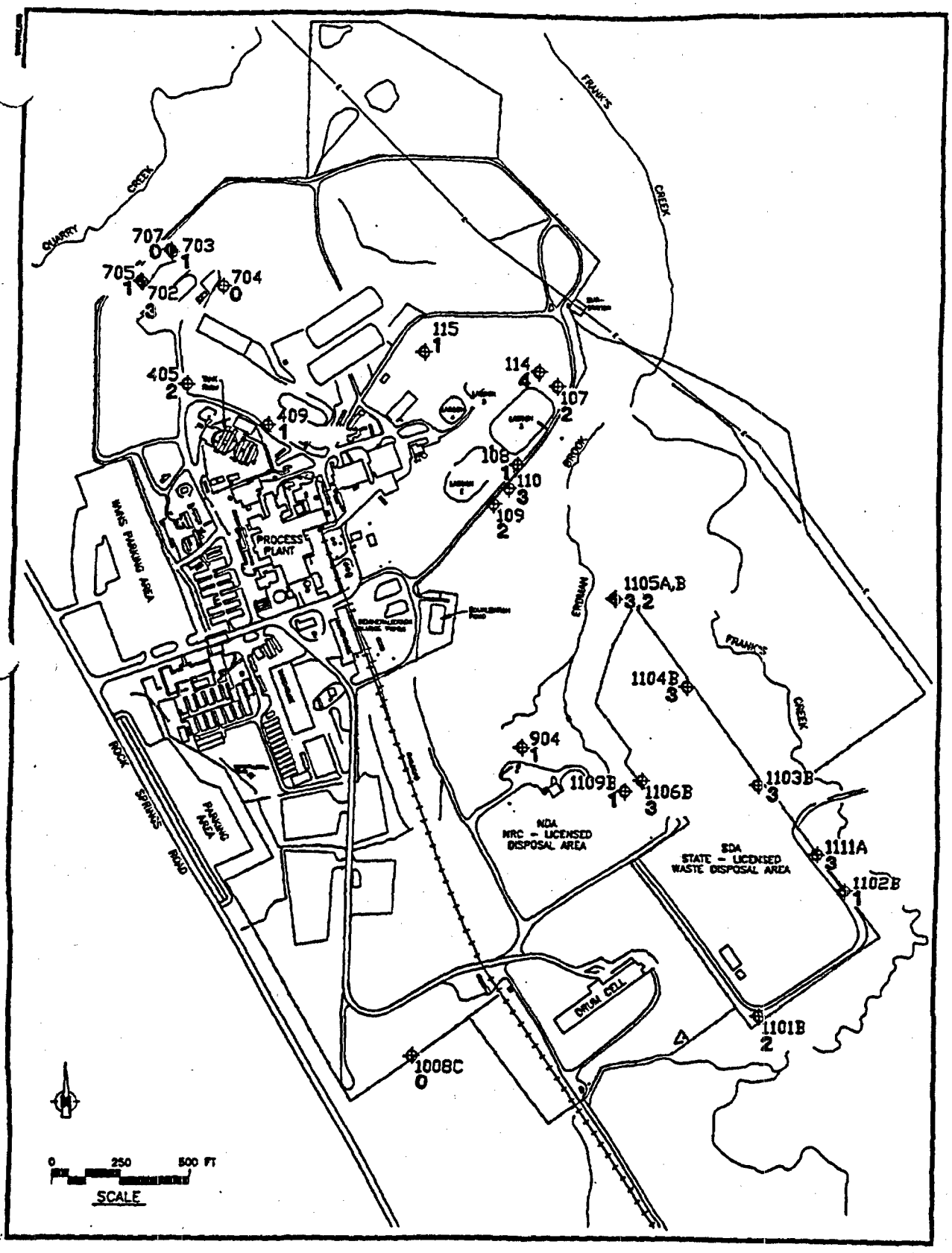


Figure 4-95 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Gross Alpha – Number of Detections Above The LLD.

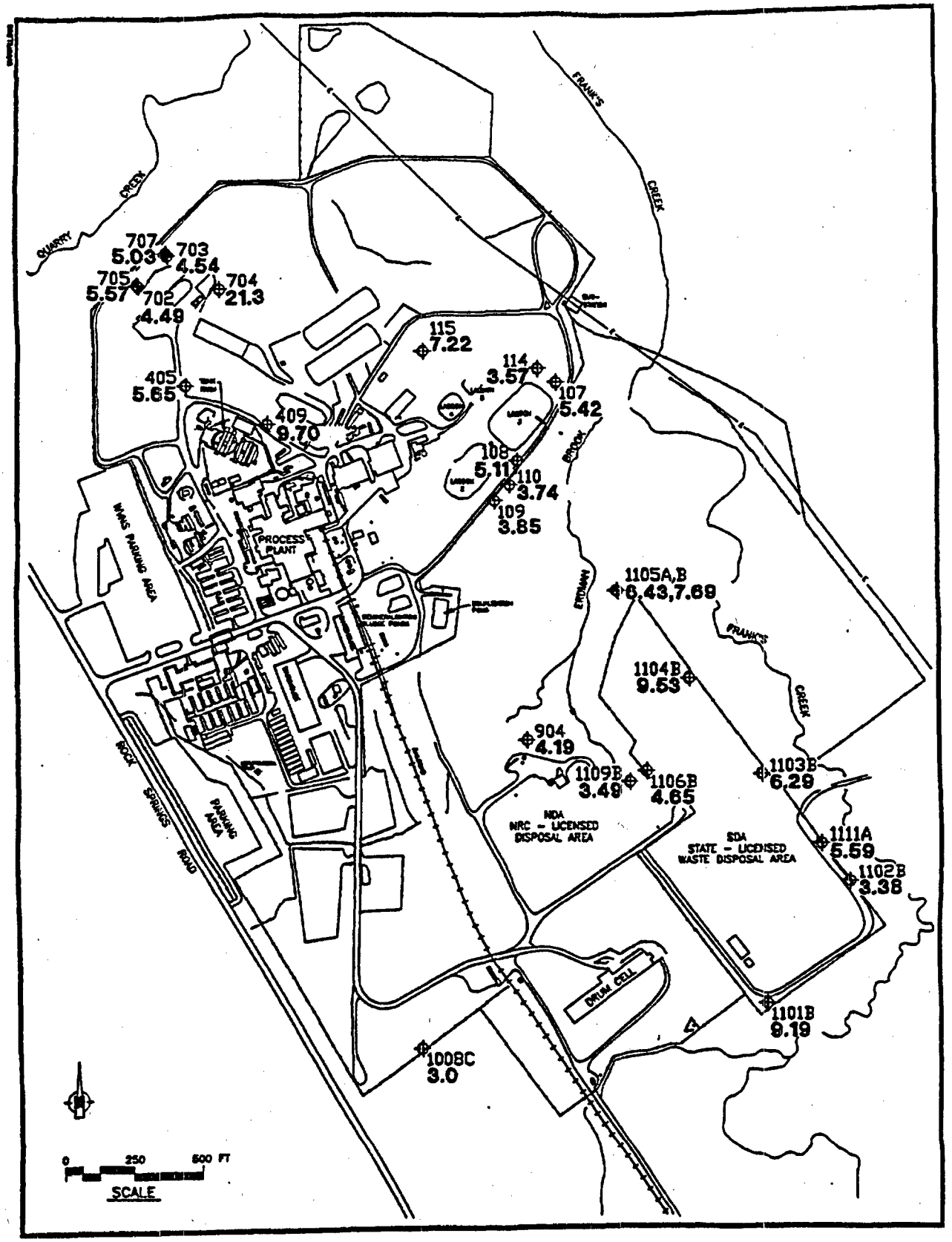


Figure 4-96 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Gross Beta Activity (to E-09 uCi/ml).

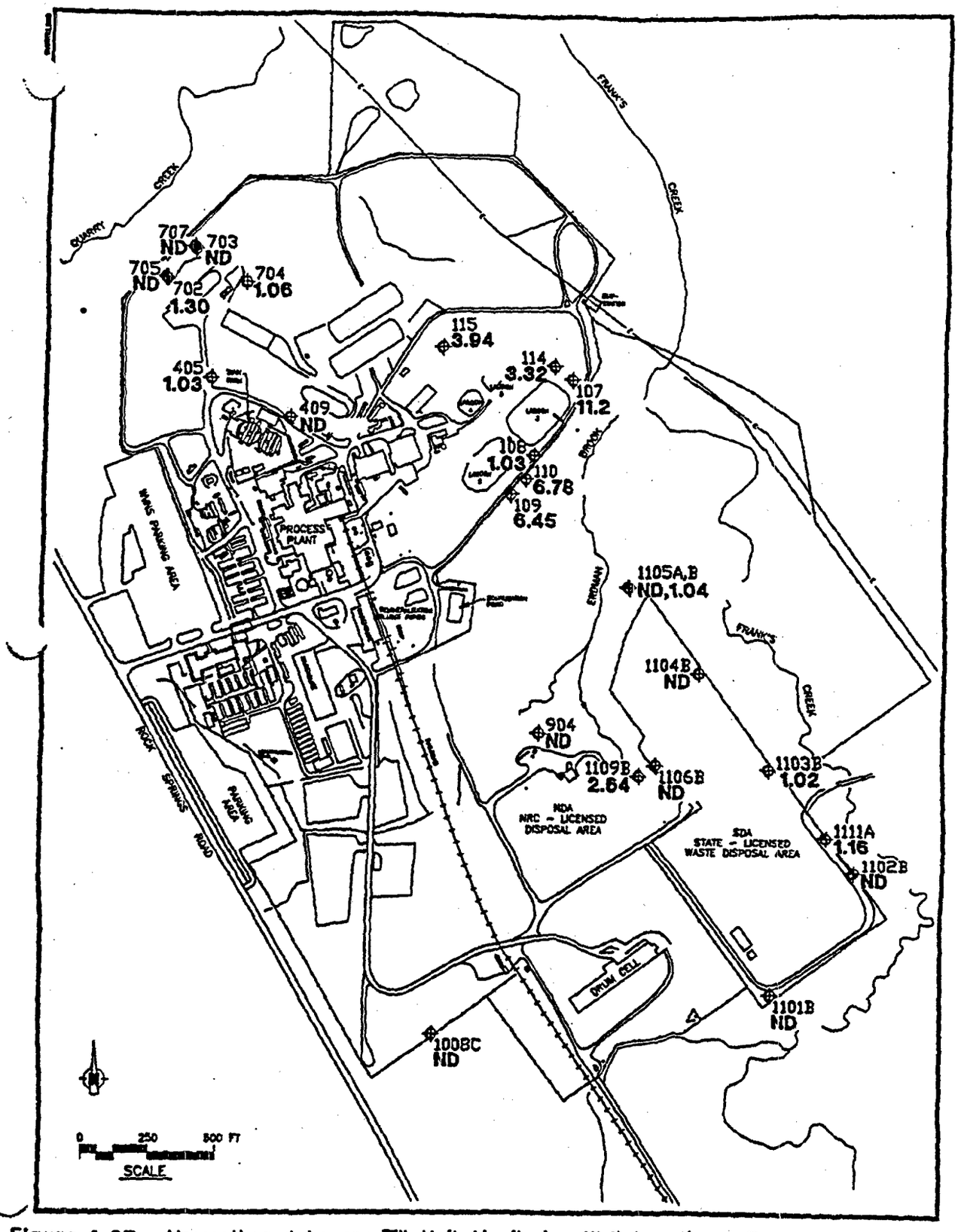


Figure 4-97 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Tritium Activity (to E-07 uCi/ml) (ND = Non-Detected).

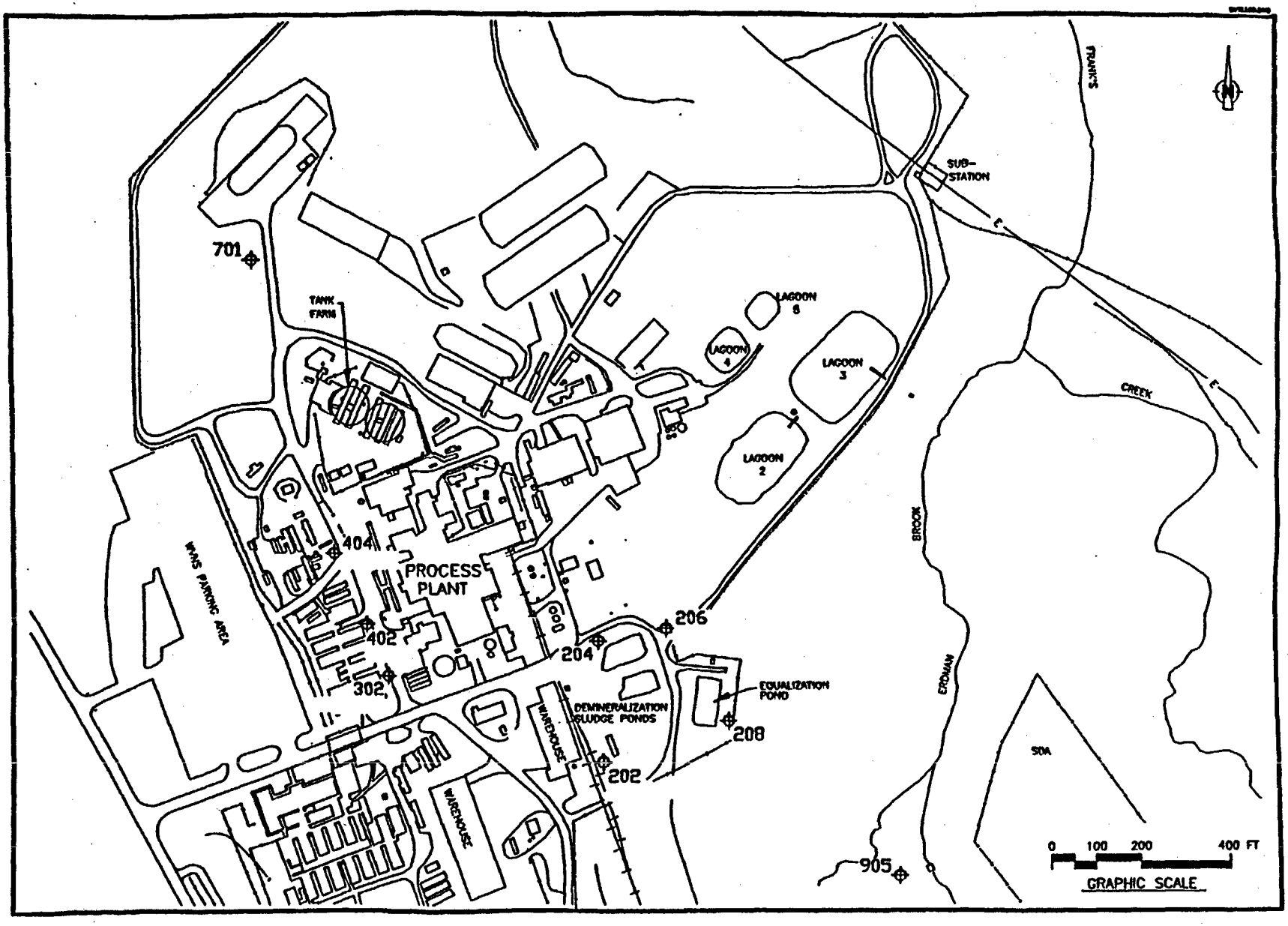


Figure 4-98 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program.

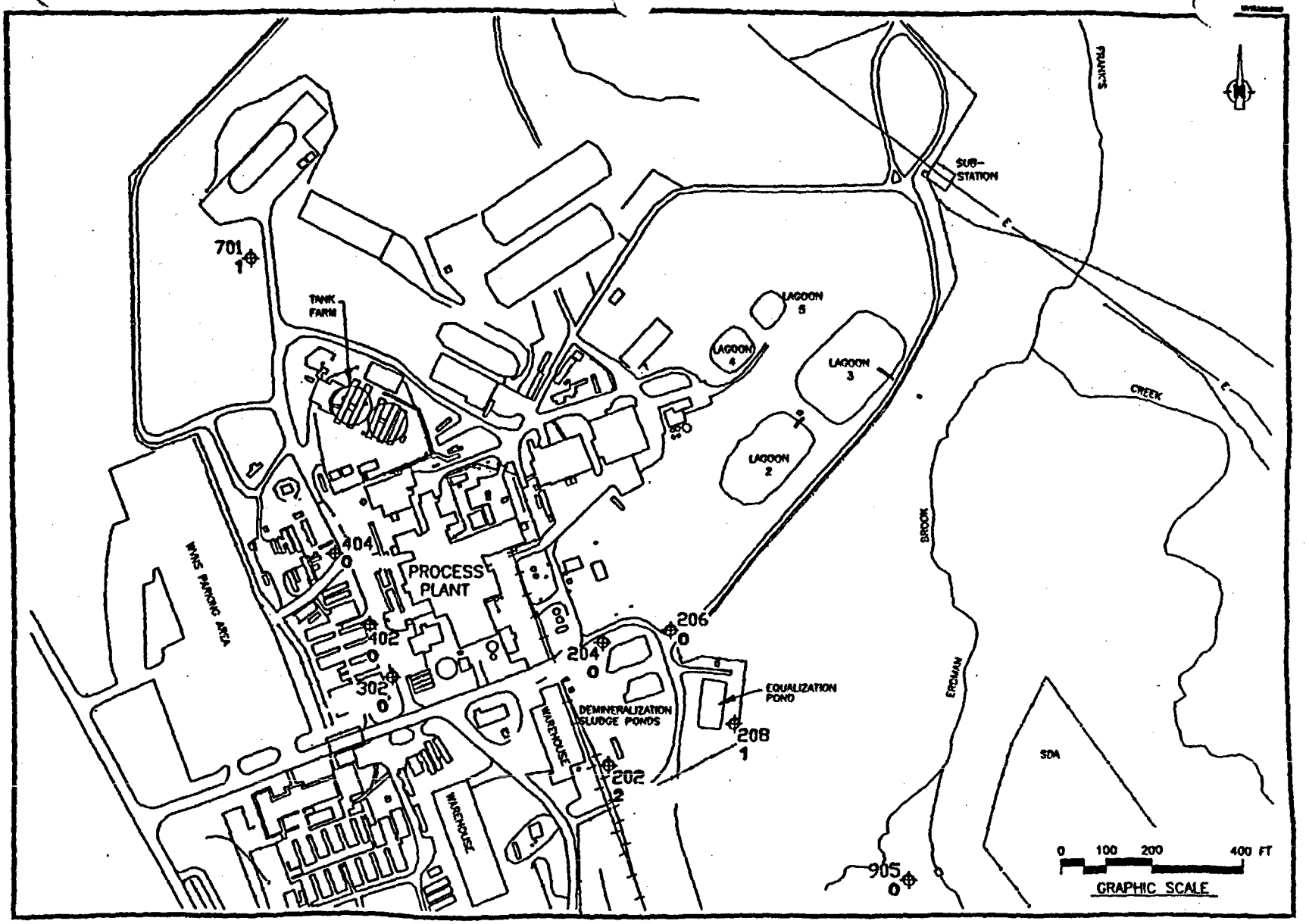


Figure 4-99 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Gross Alpha – Number of Detections Above The LLD.

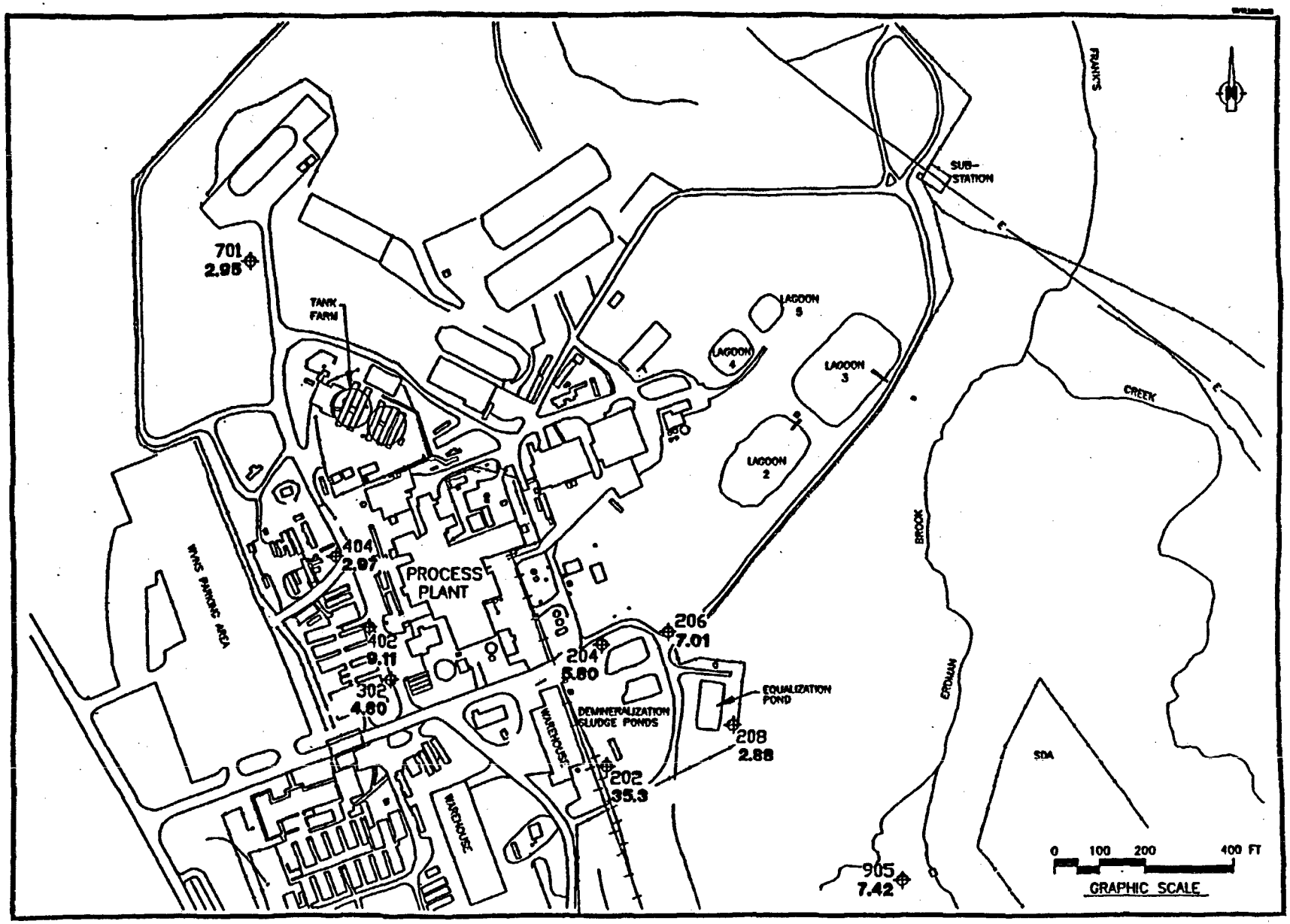


Figure 4-100 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Gross Beta Activity (to E−09 uCi/ml).

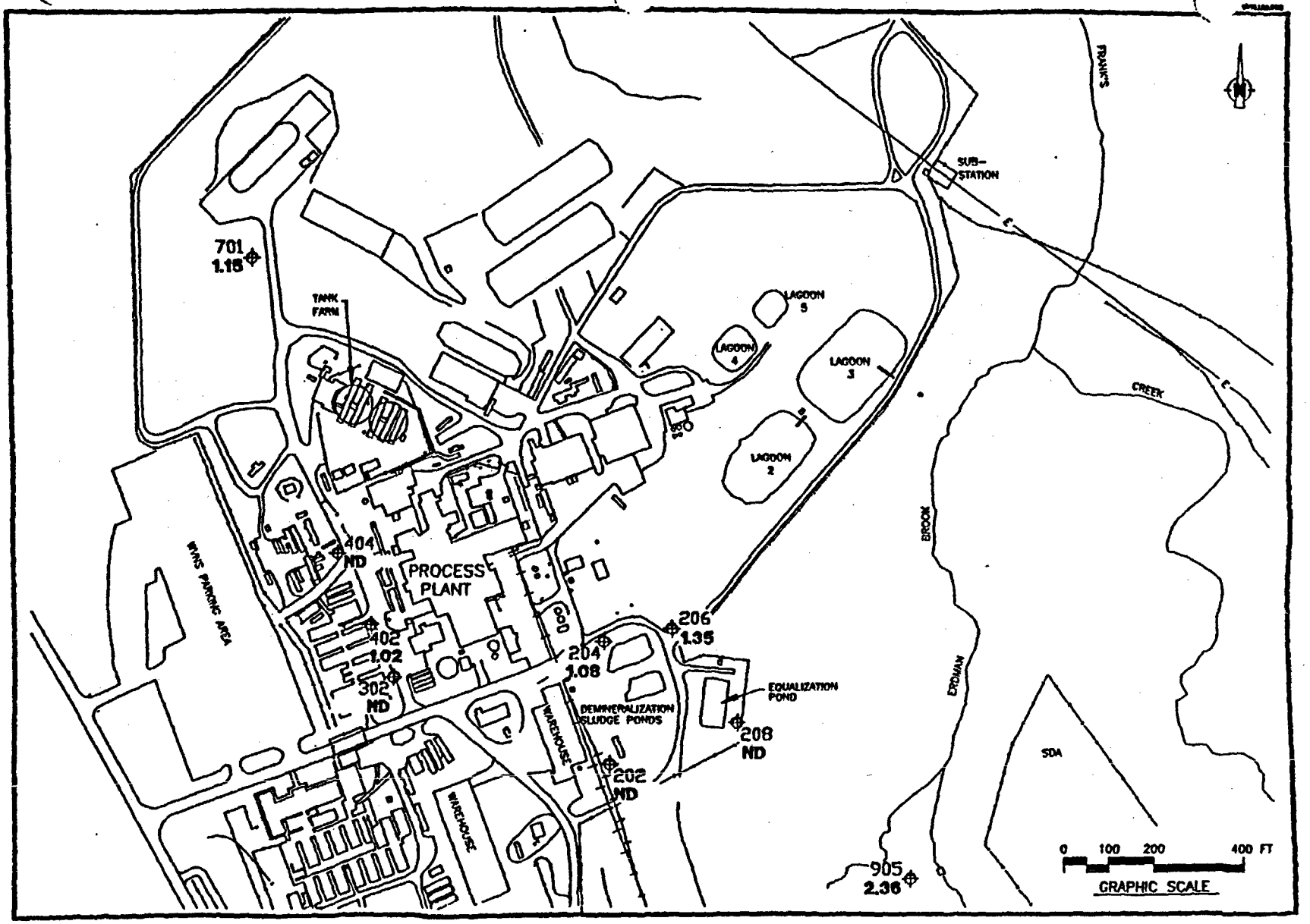


Figure 4-101 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Tritium Activity (to E-07 uCi/ml) (ND = Non-Detected).

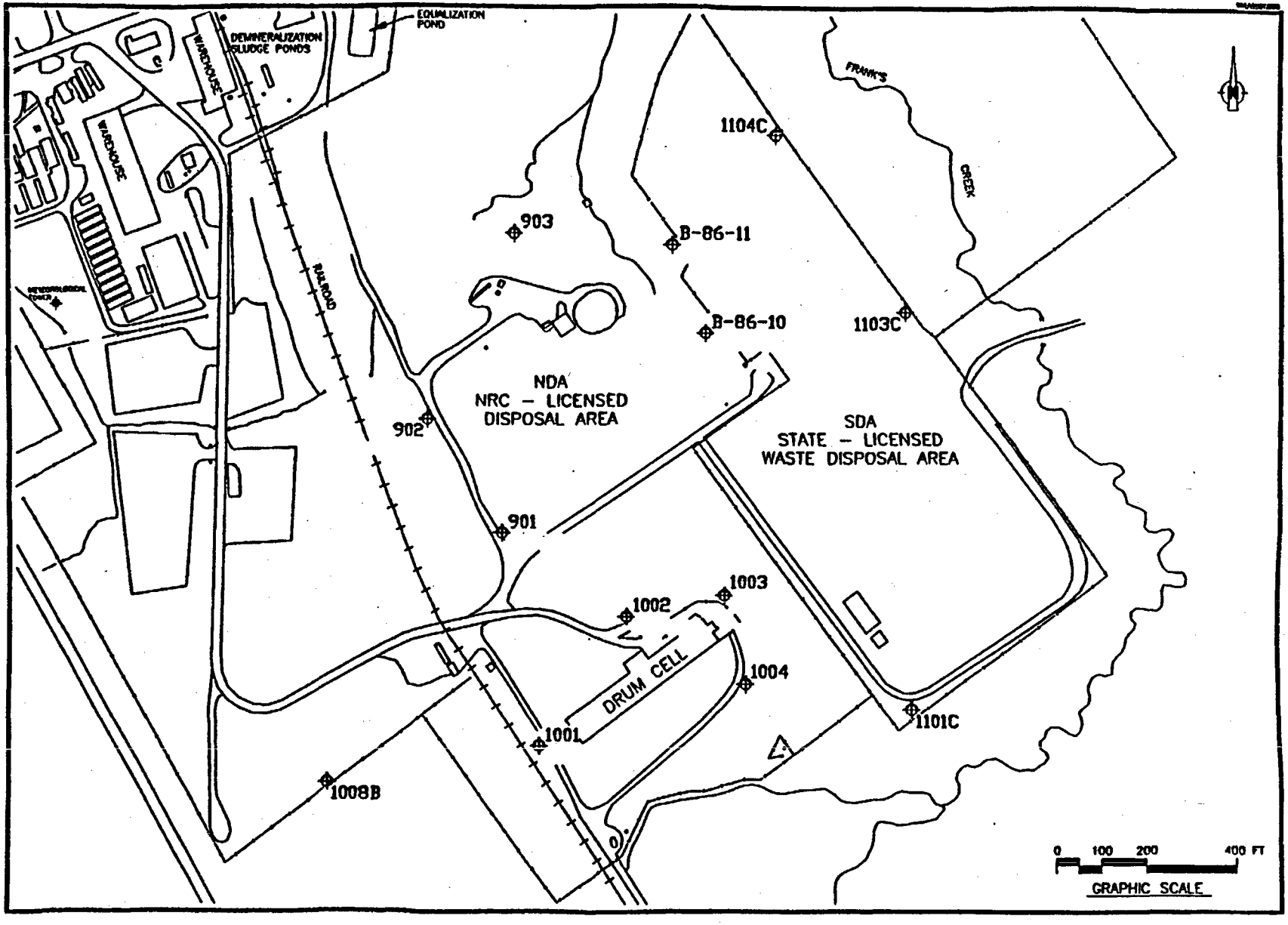


Figure 4-102 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program.

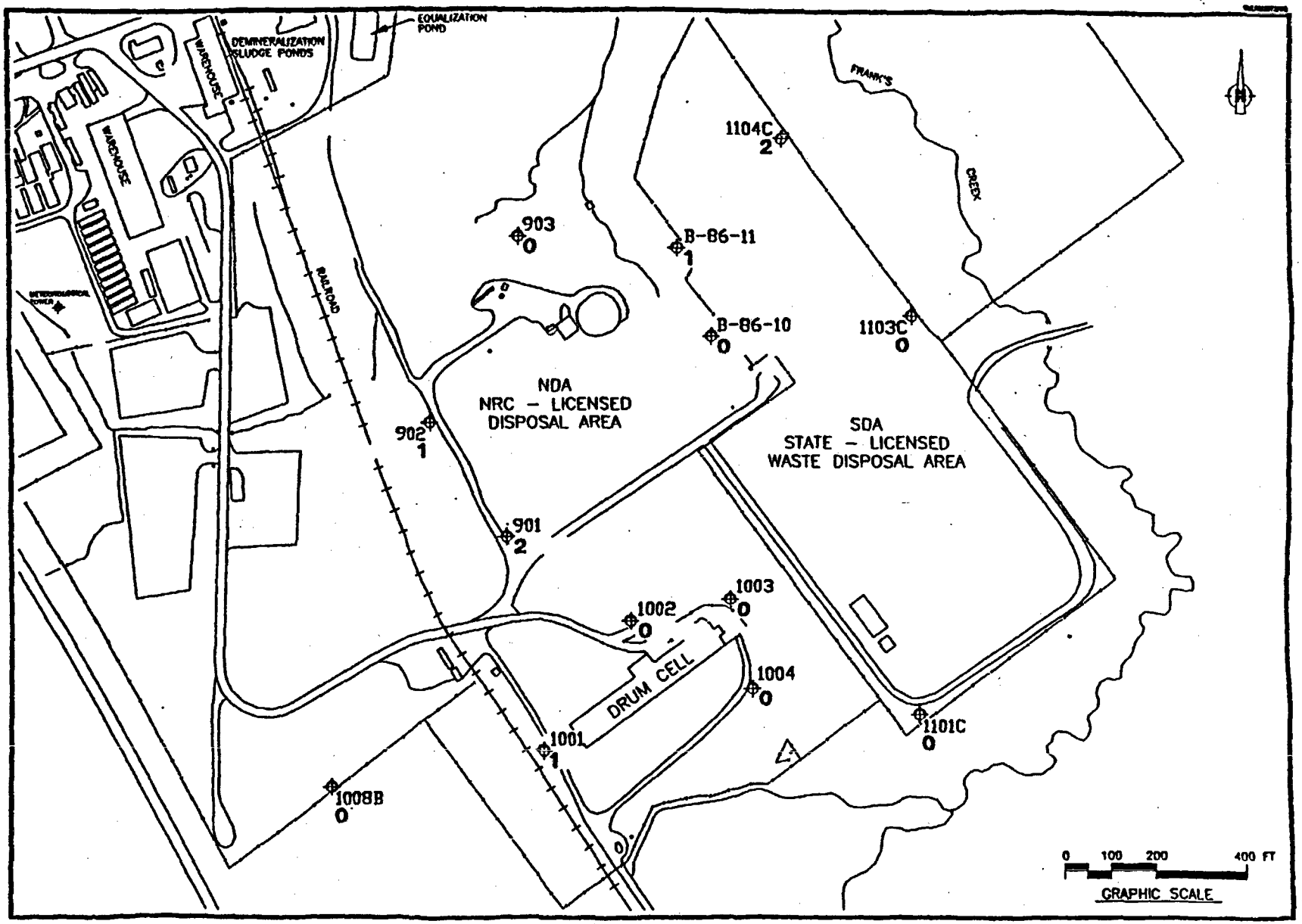


Figure 4-103 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Gross Alpha – Number of Detections Above The LLD.

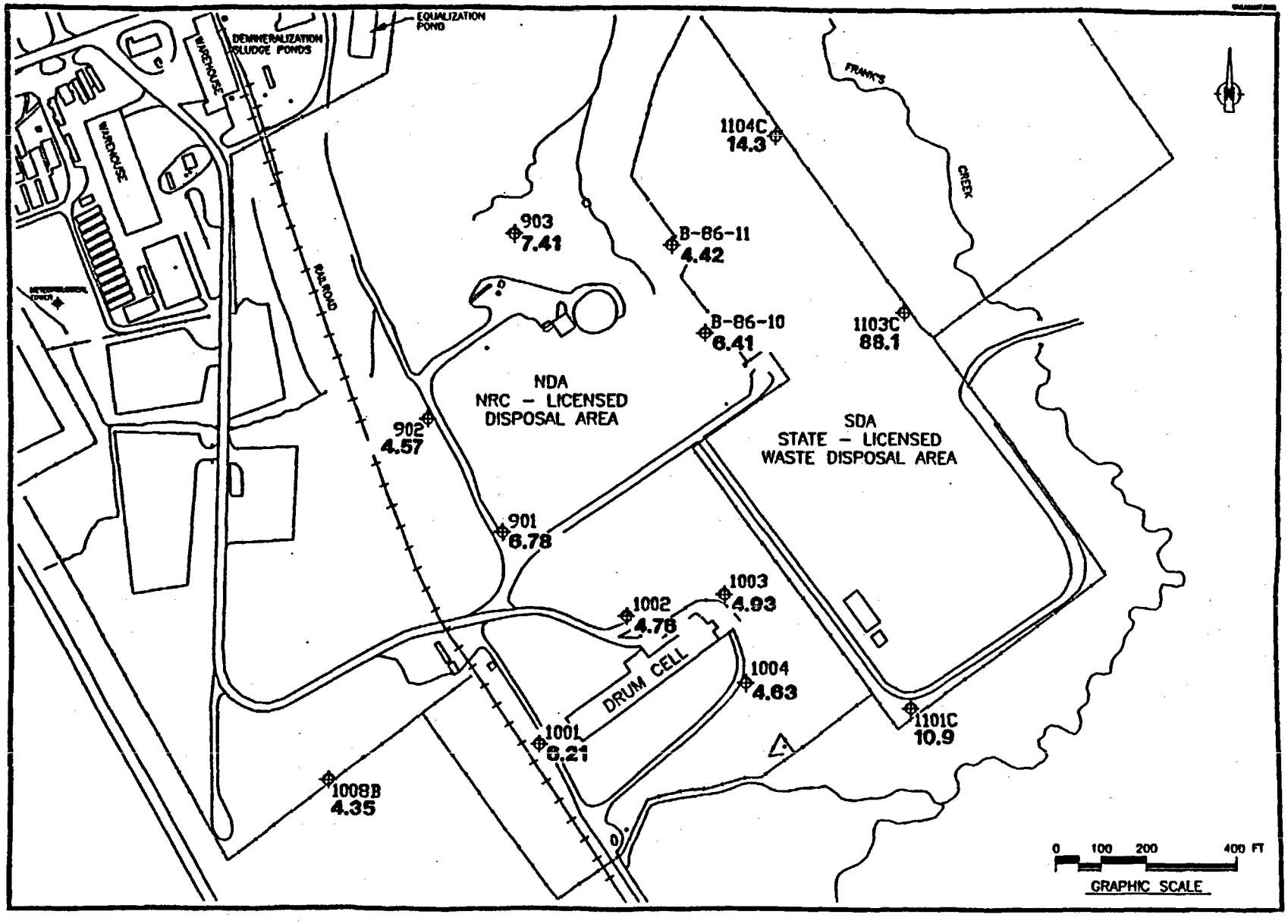


Figure 4-104 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Gross Beta Activity (to E-09 uCi/ml).

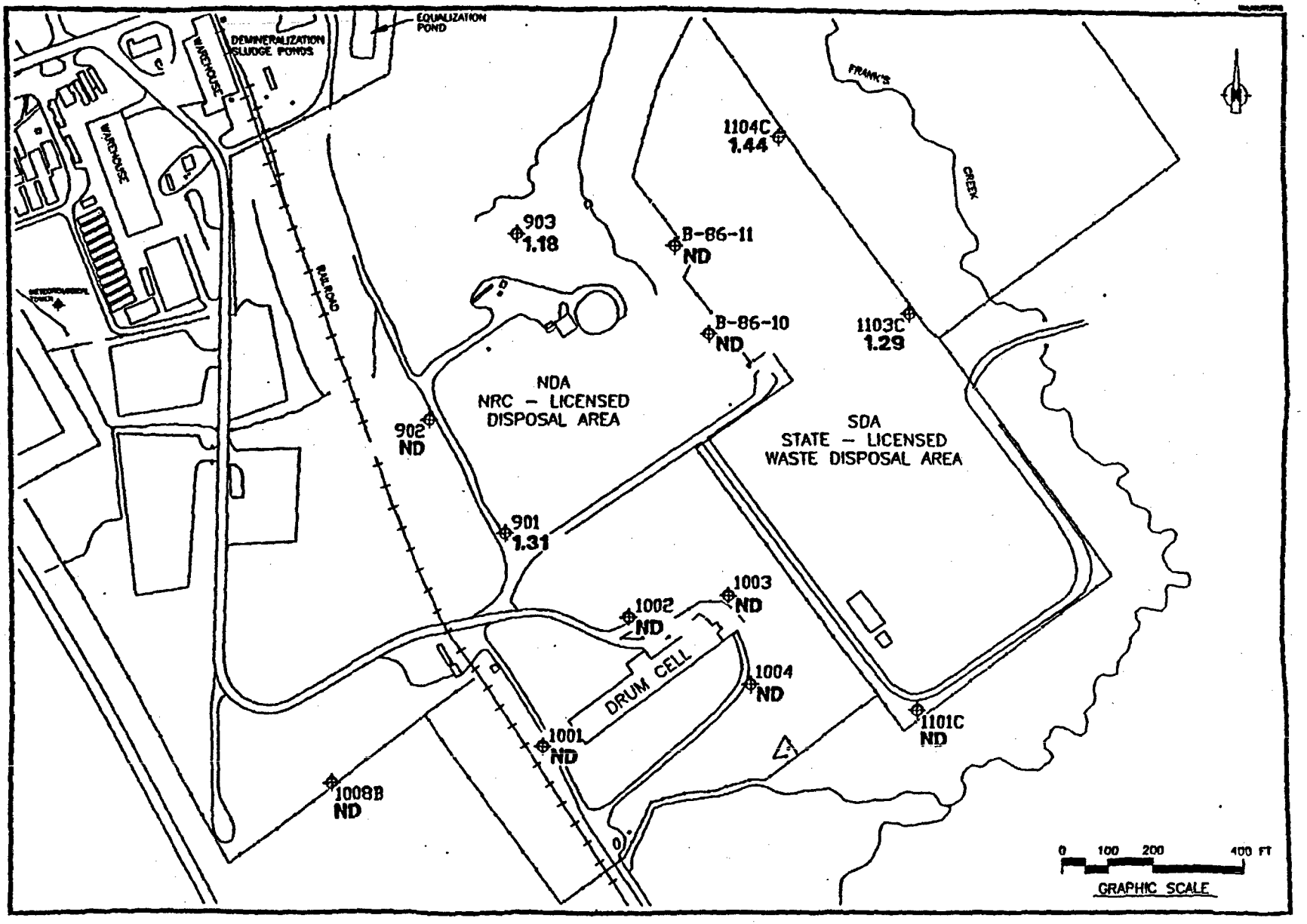


Figure 4-105 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Tritium Activity (to E-07 uCi/ml) (ND = Non-Detected).

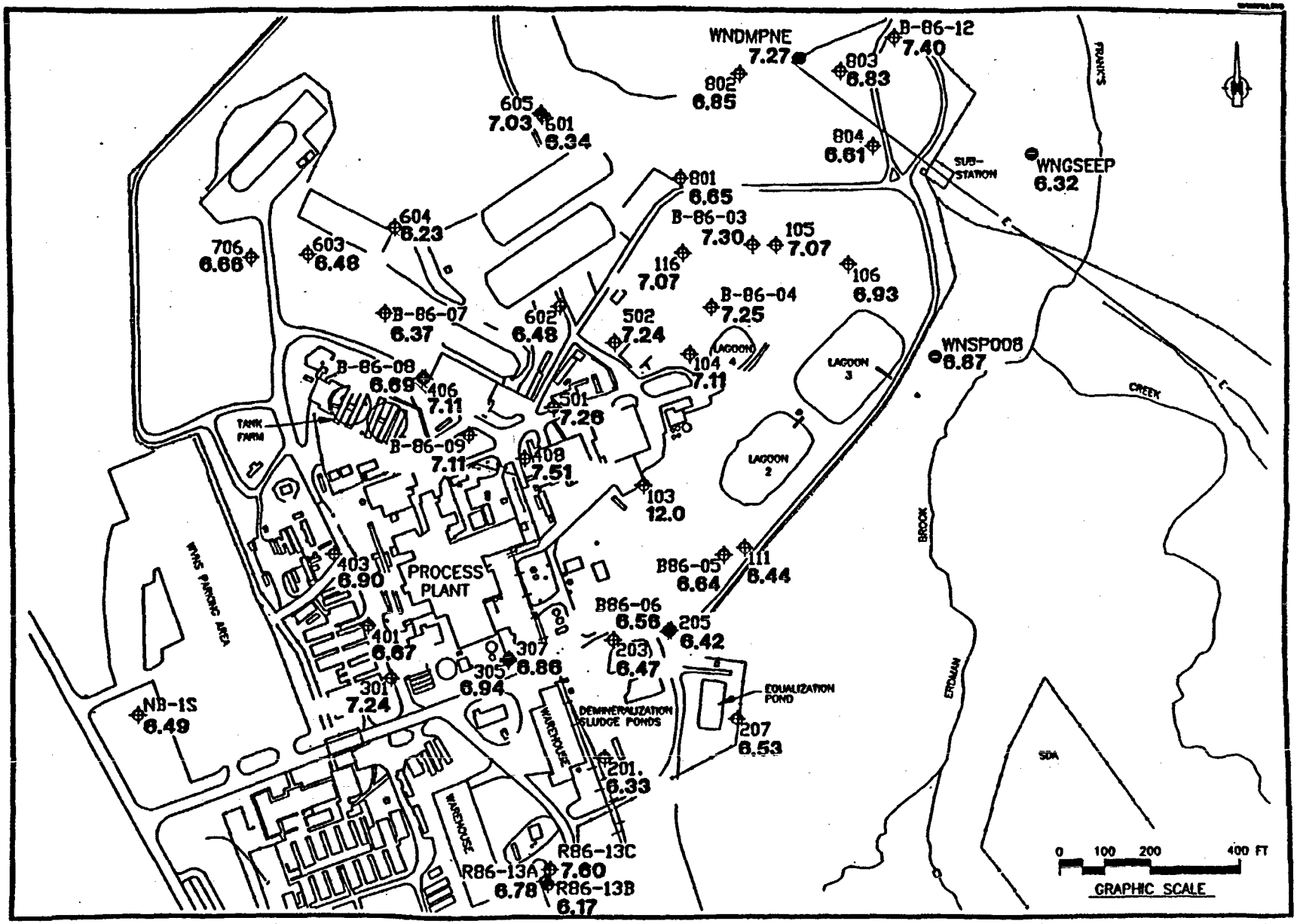


Figure 4-106 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean pH Levels.

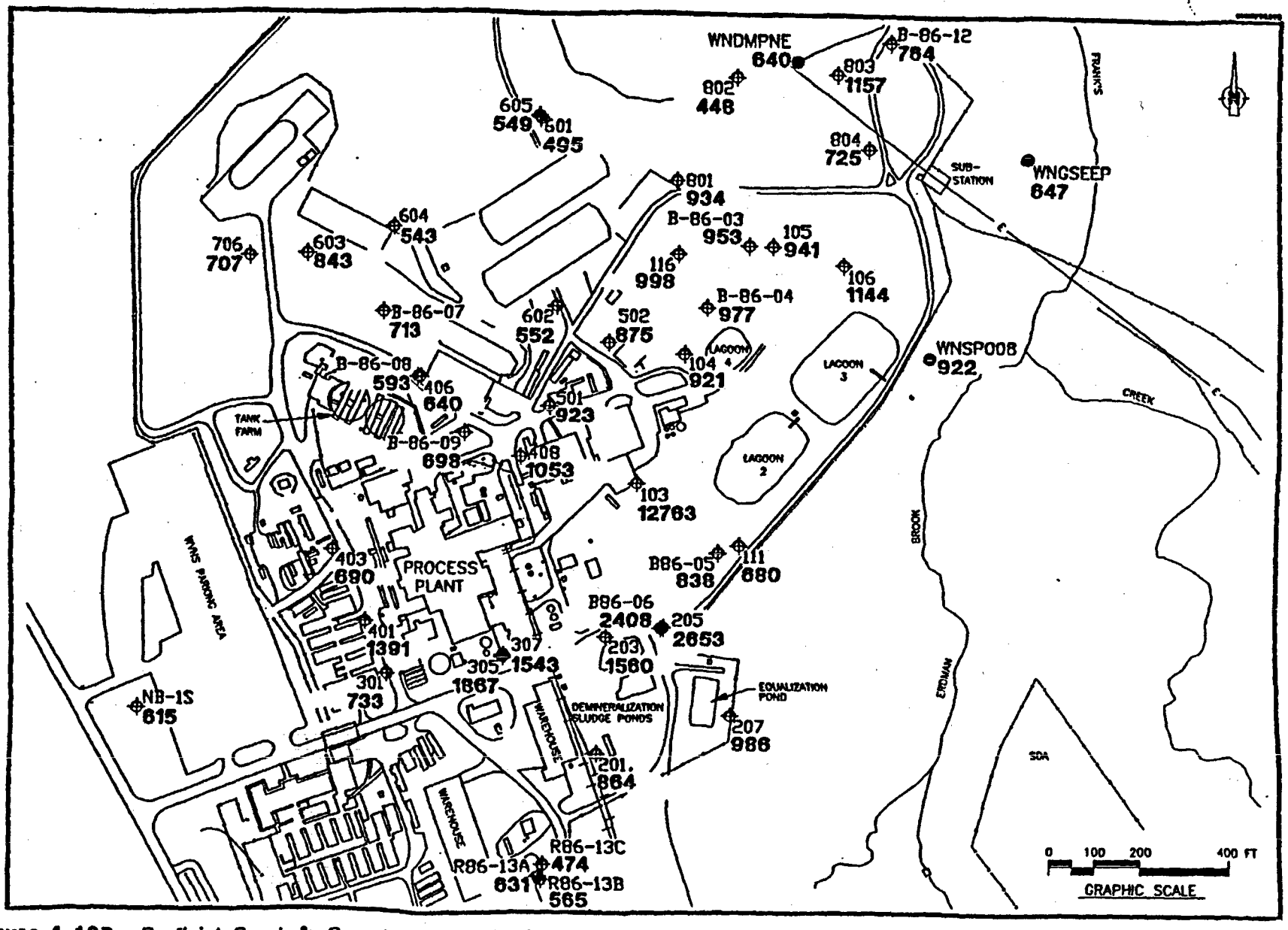


Figure 4-107 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Specific Conductivity (umhos/cm @ 25°C).

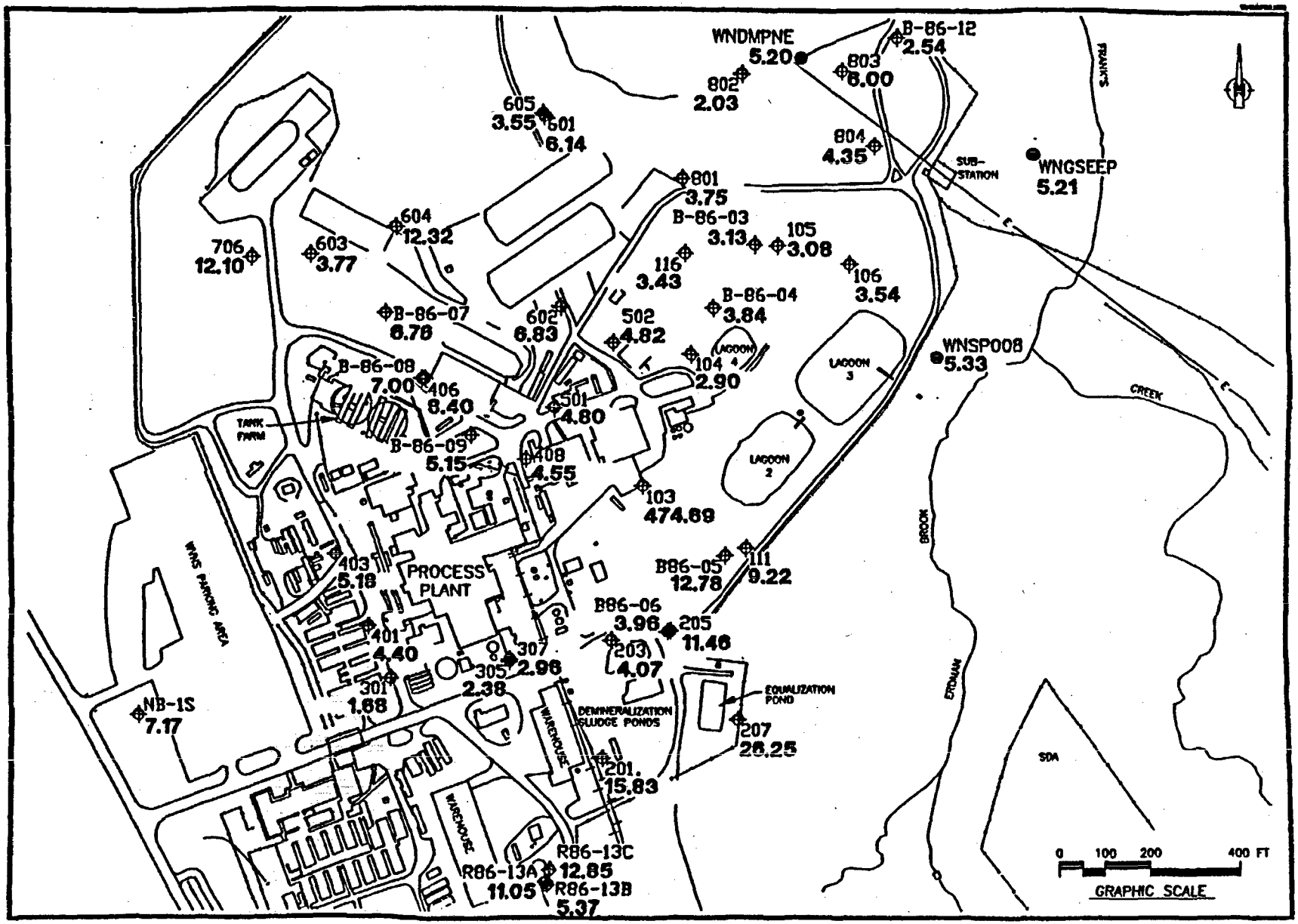


Figure 4-108 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Carbon (TOC) Concentrations (mg/l).

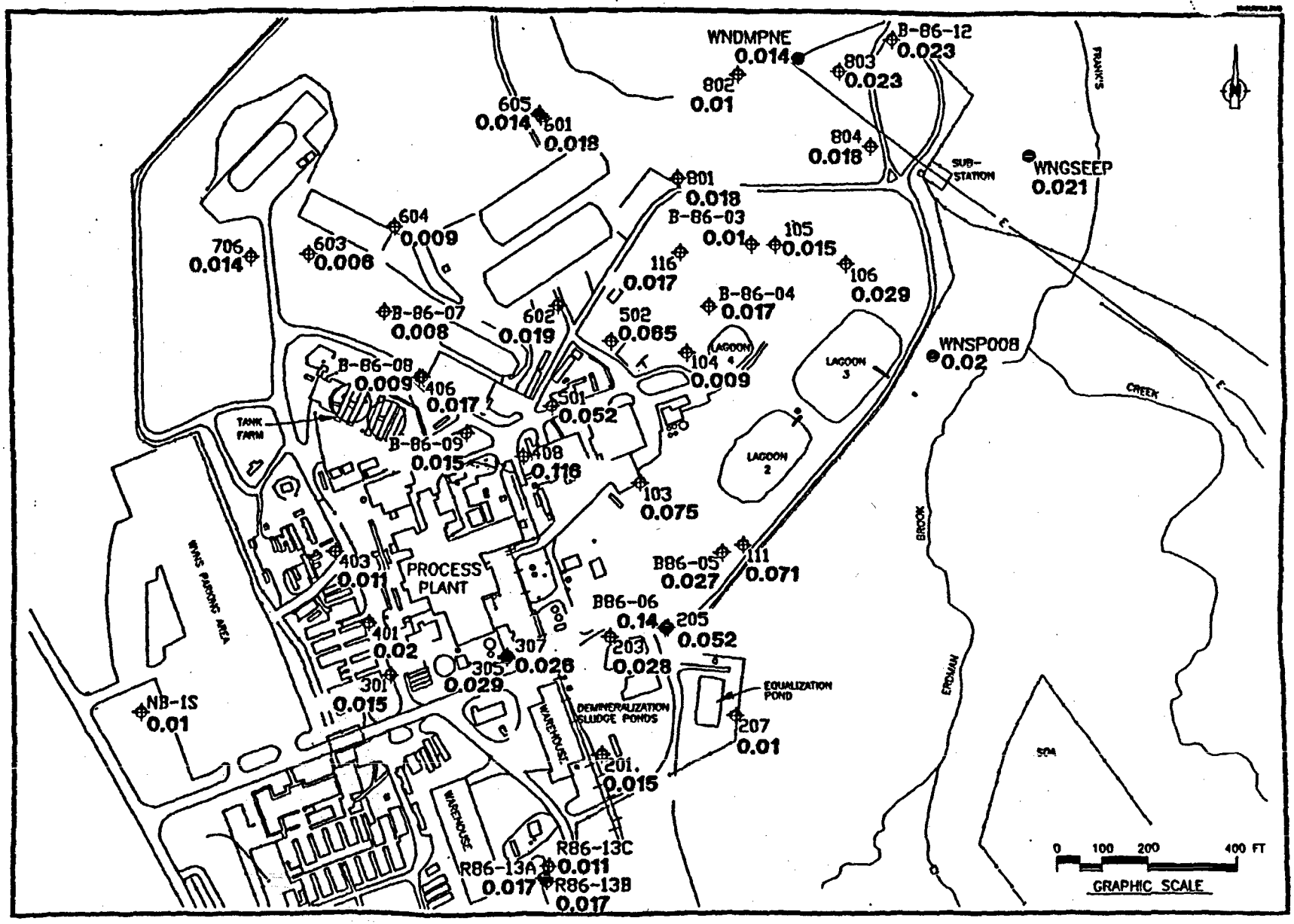


Figure 4-109 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Halogen (TOX) Concentrations (mg/l).

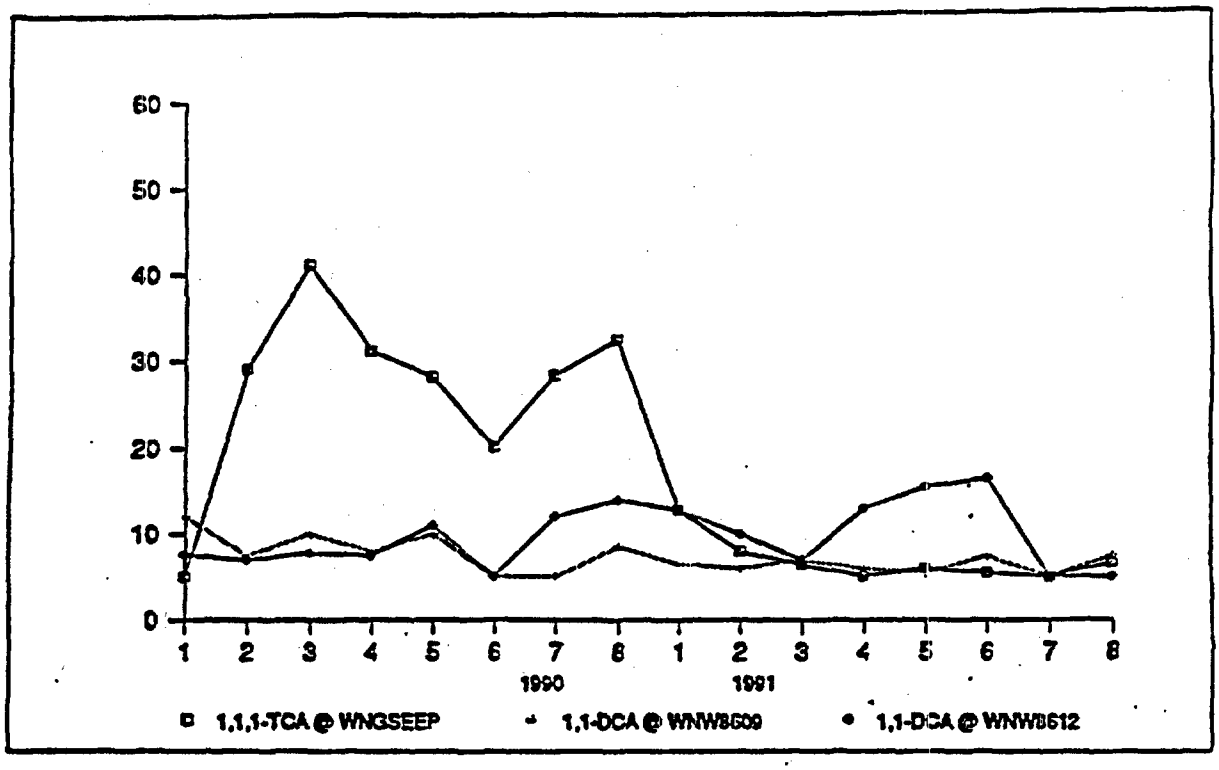


Figure 4-110 Concentrations (mg/L) of 1,1,1-TCA and 1,1-DCA at WNGSEEP, WNW8609, and WNW8612 (1990-1991)

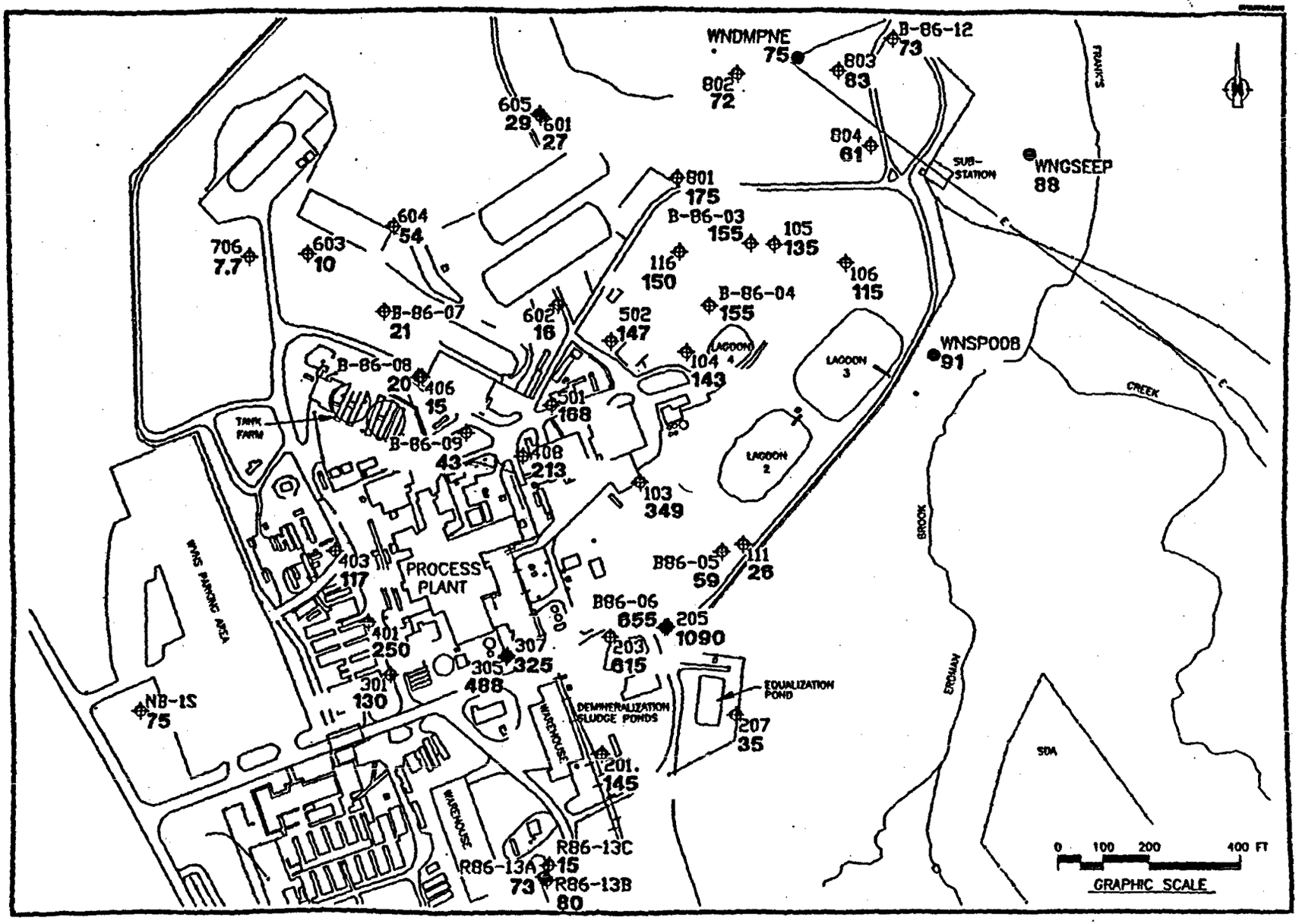


Figure 4-111 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Chloride Concentrations (mg/l).

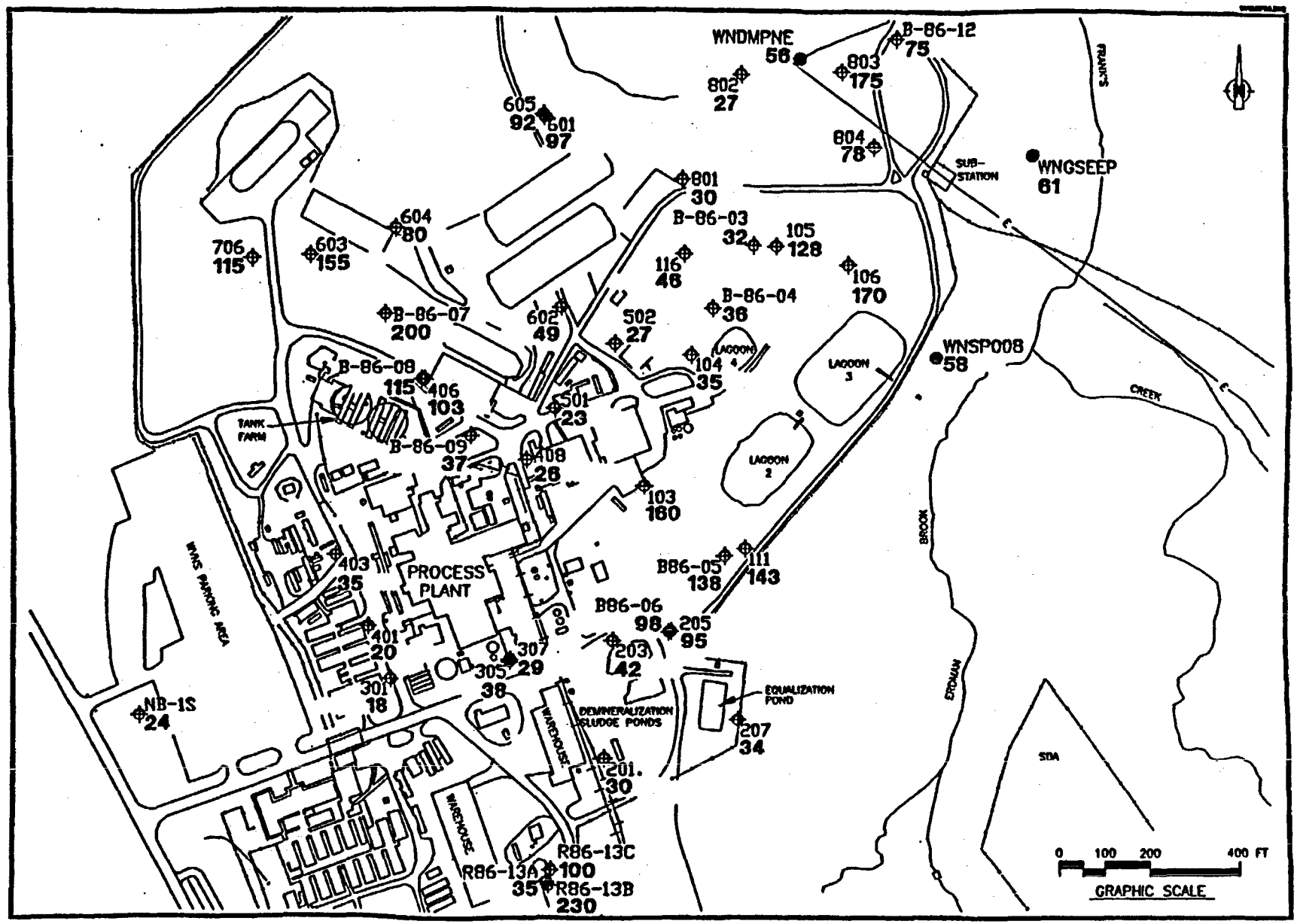


Figure 4-112 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sulfate Concentrations (mg/l).

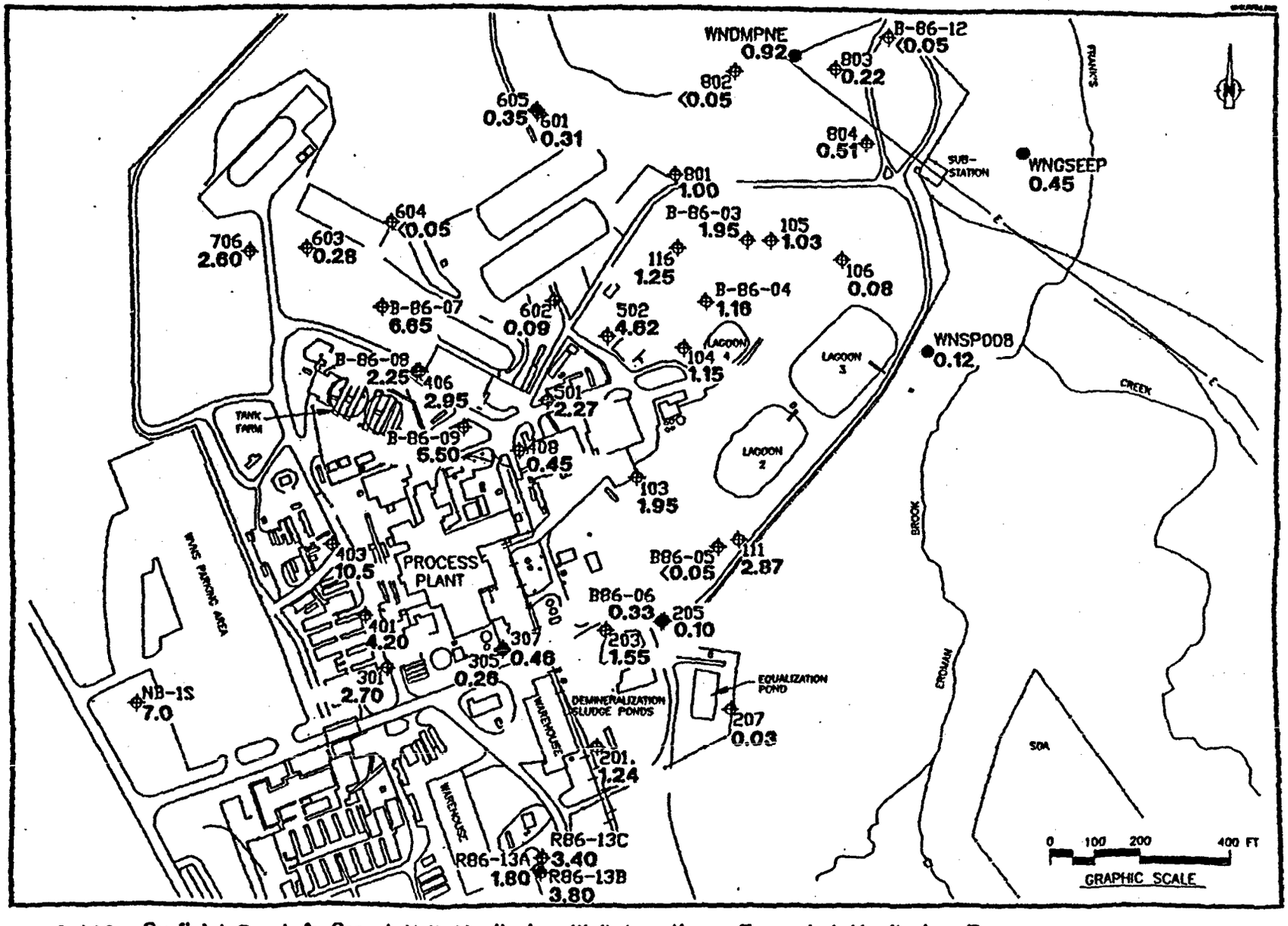


Figure 4-113 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Nitrate + Nitrite – N Concentrations (mg/l).

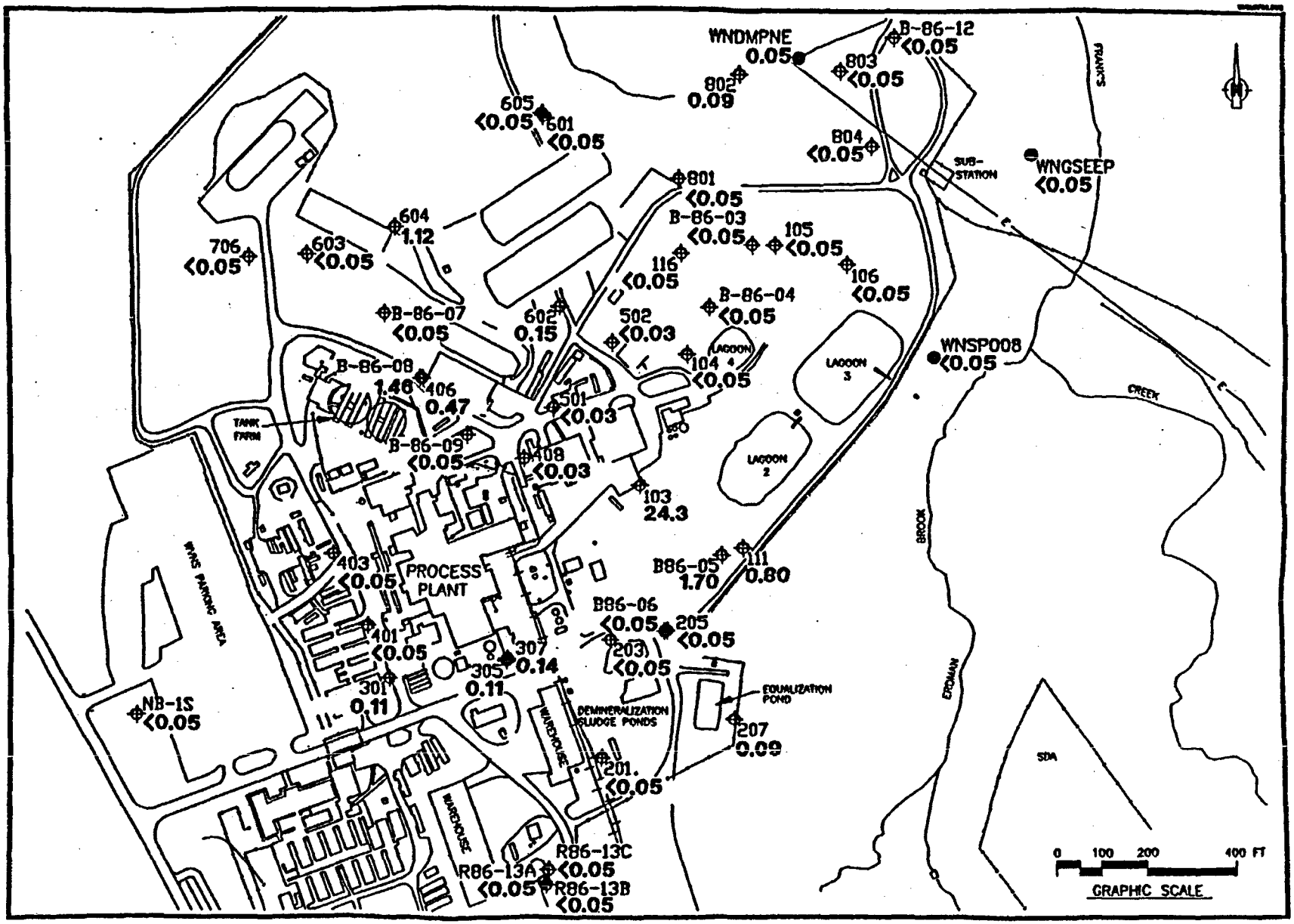


Figure 4-114 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Ammonia Concentrations (mg/l).

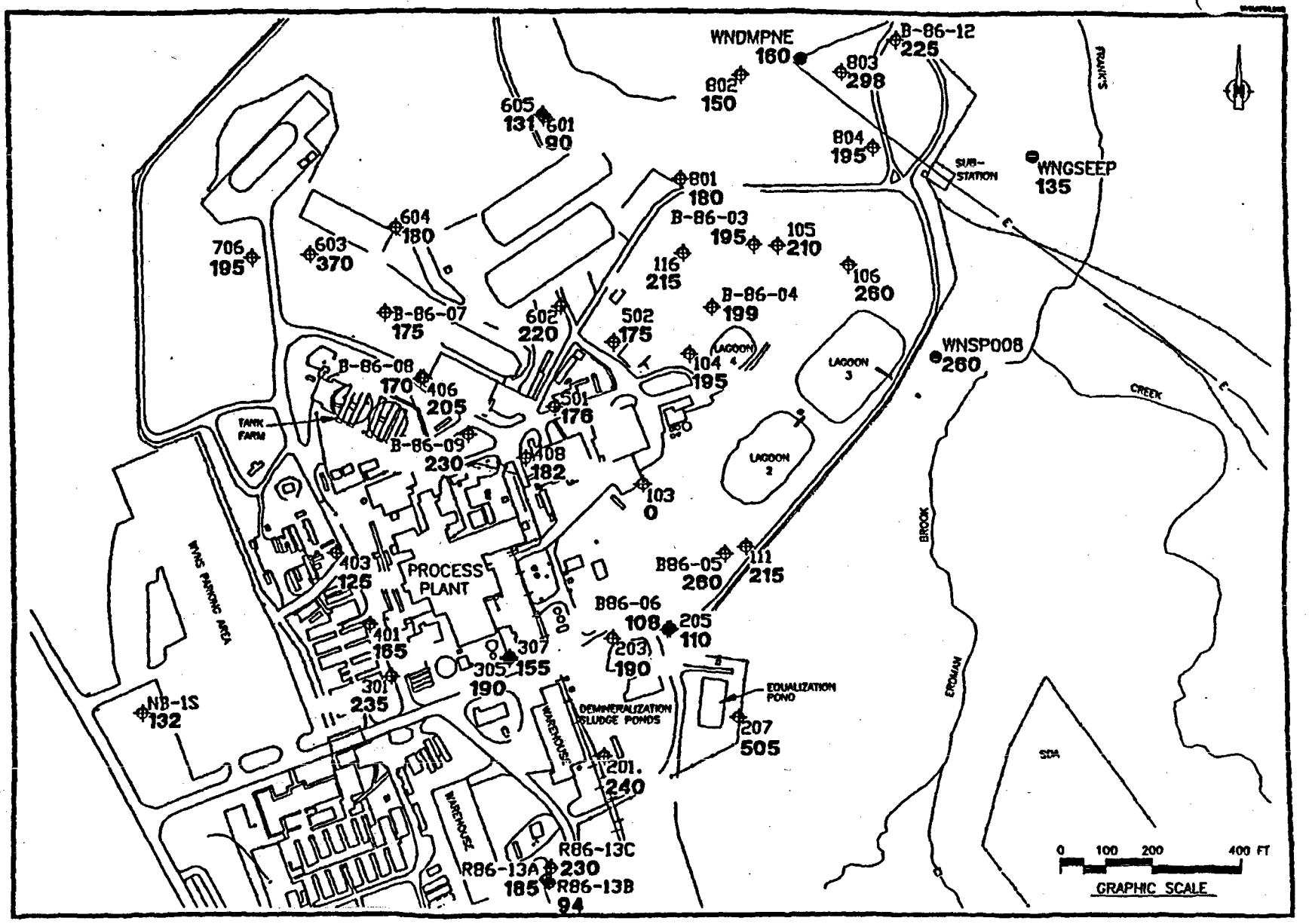


Figure 4-115 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Bicarbonate Alkalinity Levels (mg/l).

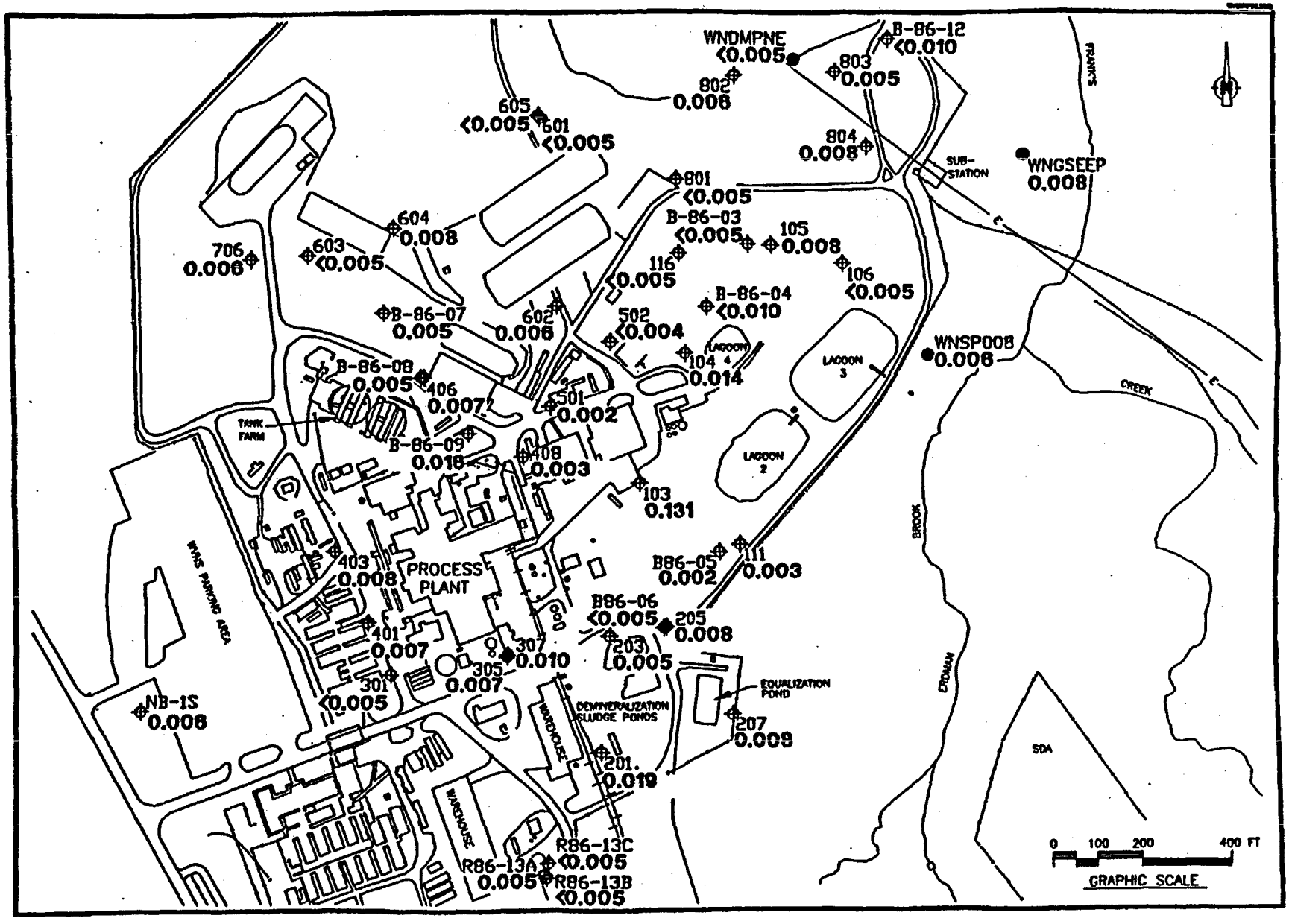


Figure 4-116 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Phenol Concentrations (mg/l).

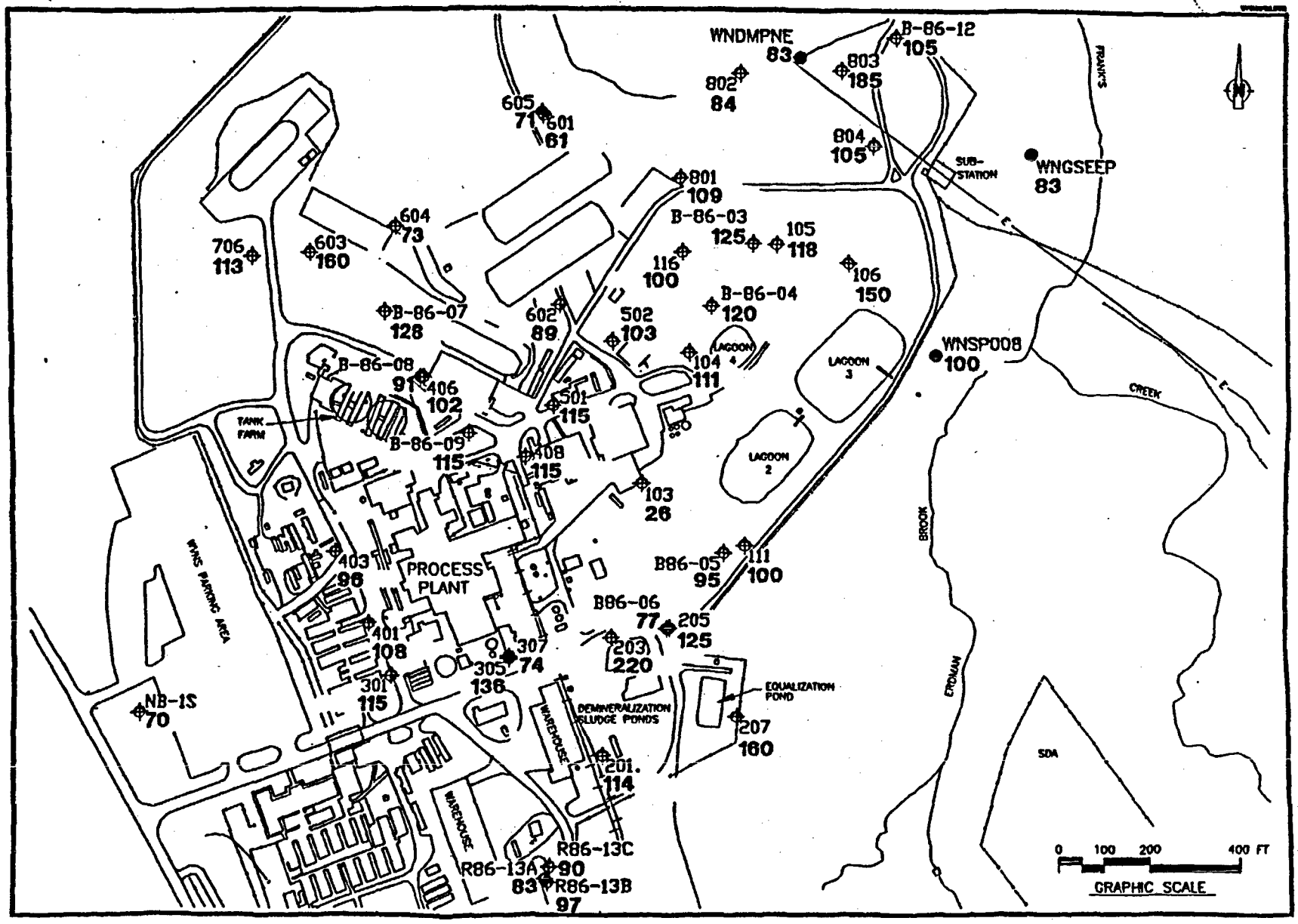


Figure 4-117 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Calcium Concentrations (mg/l).

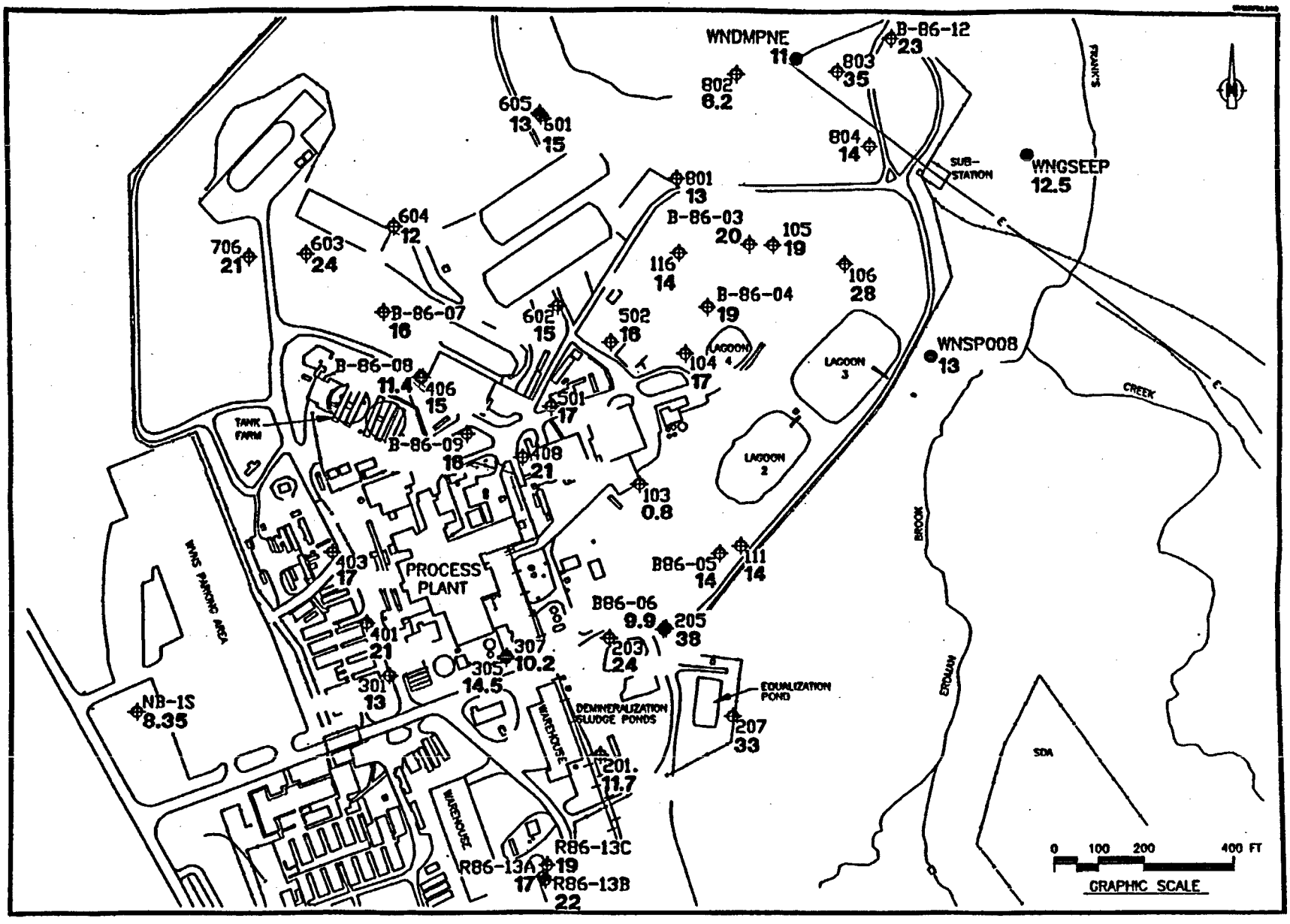


Figure 4-118 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Magnesium Concentrations (mg/l).

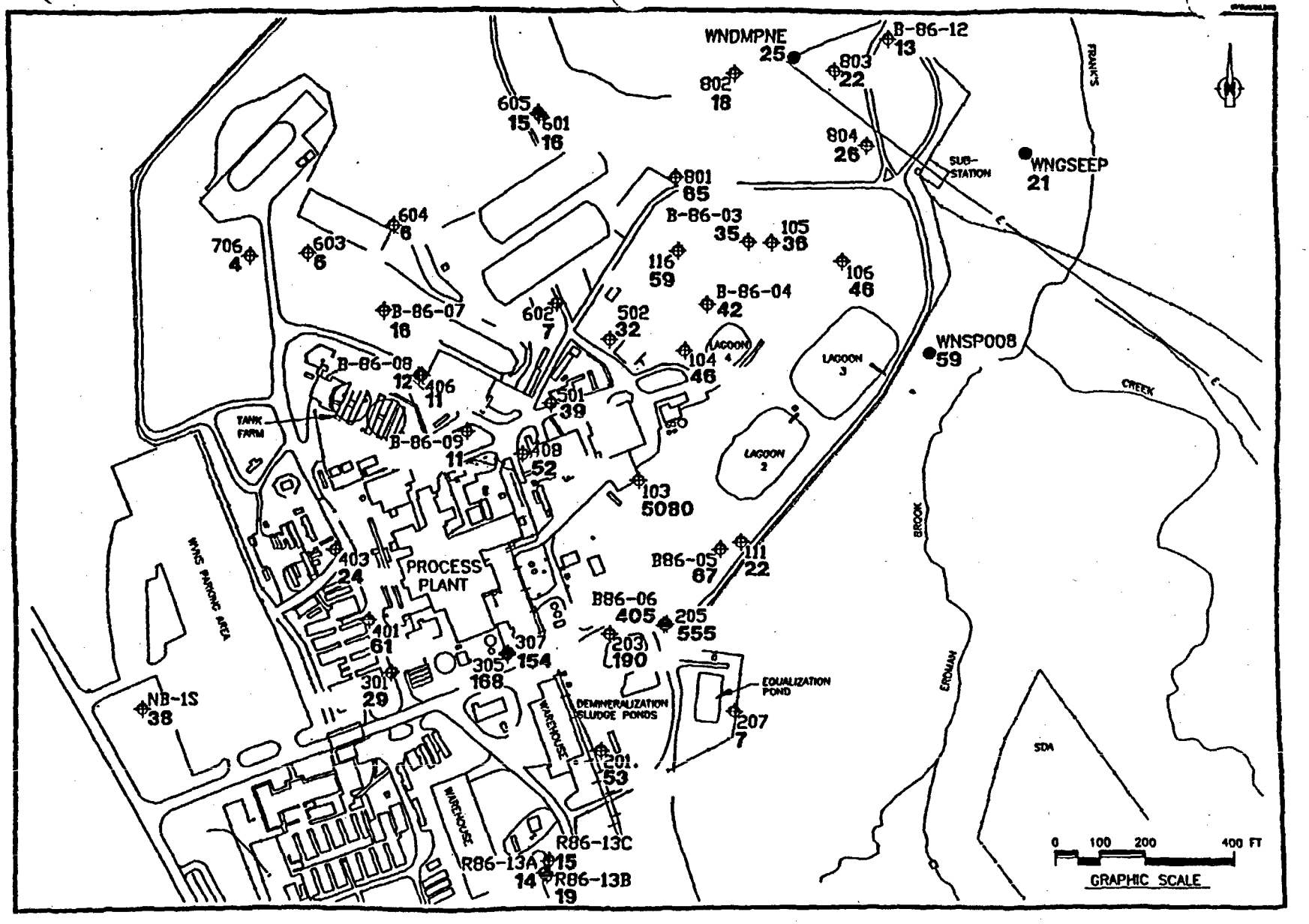


Figure 4-119 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sodium Concentrations (mg/l).

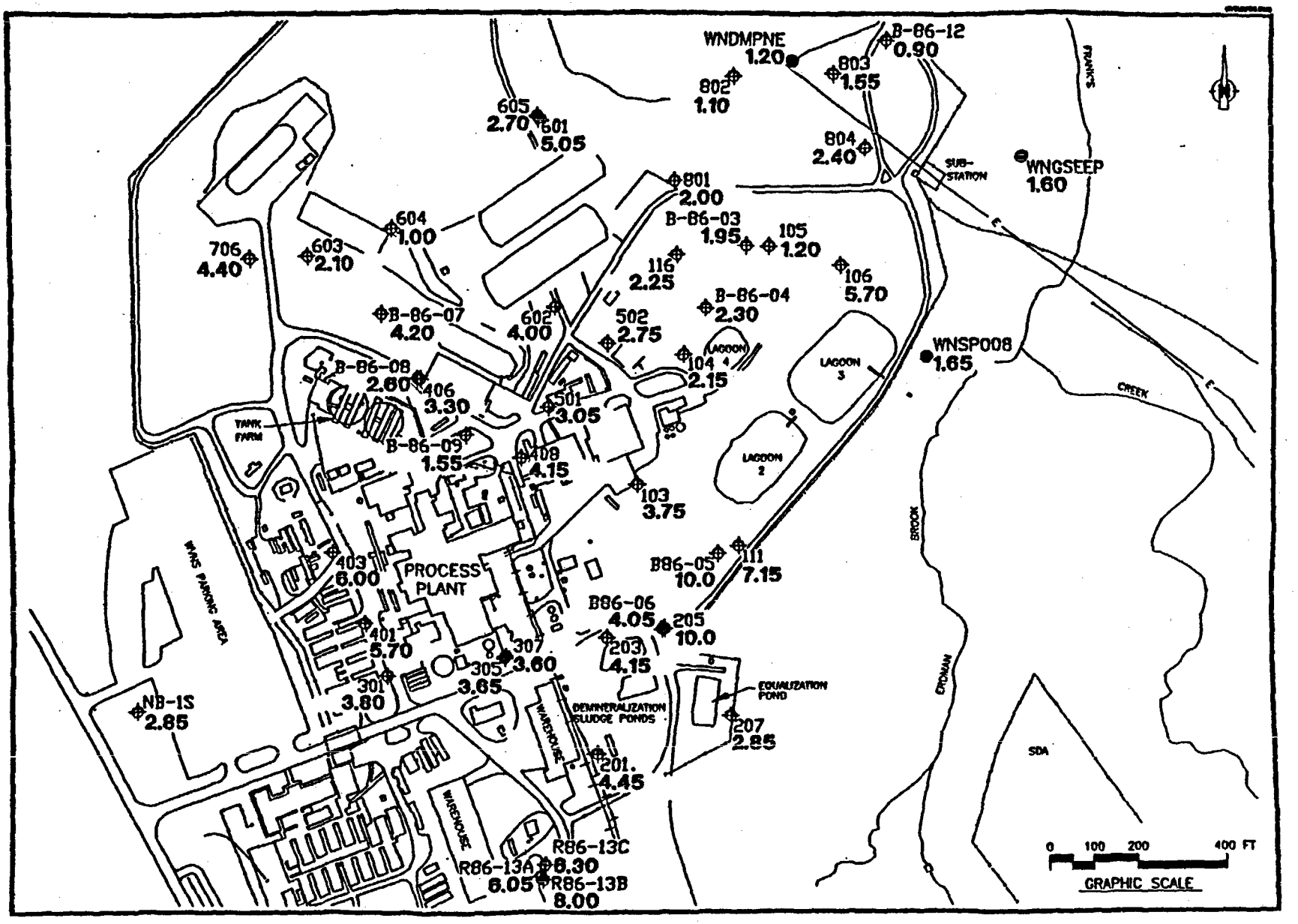


Figure 4-120 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Potassium Concentrations (mg/l).

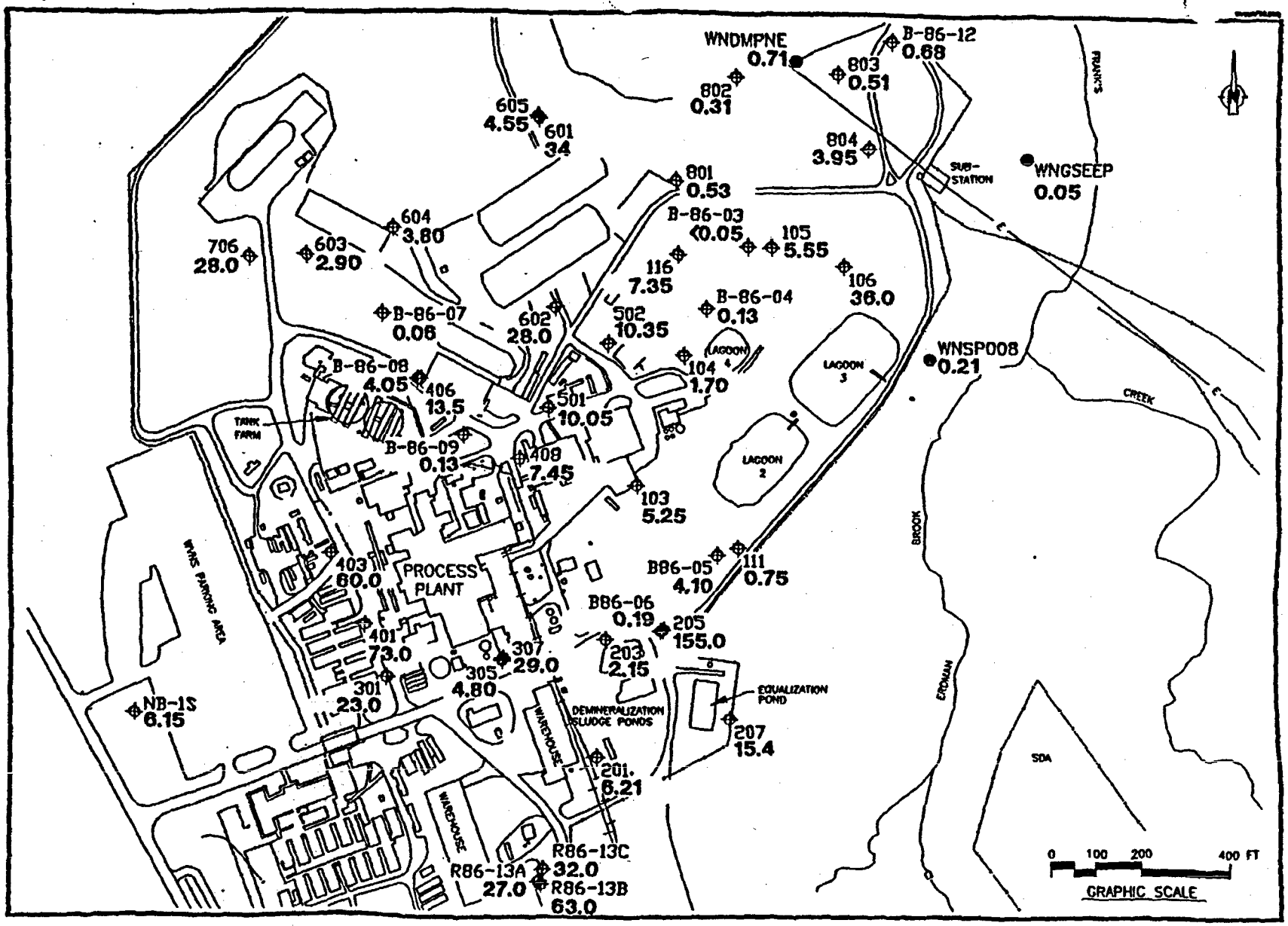


Figure 4-121 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Iron Concentrations (mg/l).

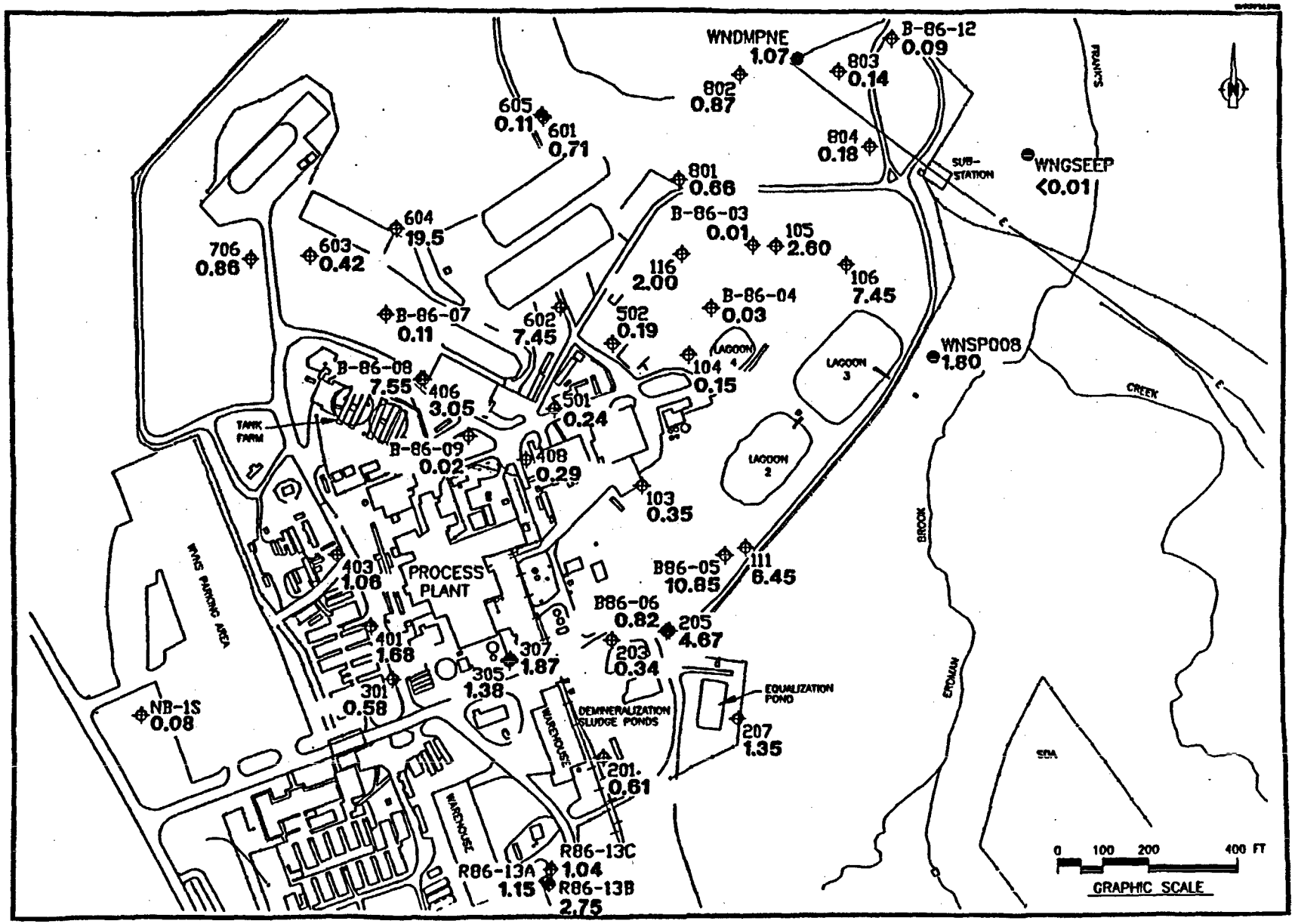


Figure 4-122 Surficial Sand & Gravel Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Manganese Concentrations (mg/l).

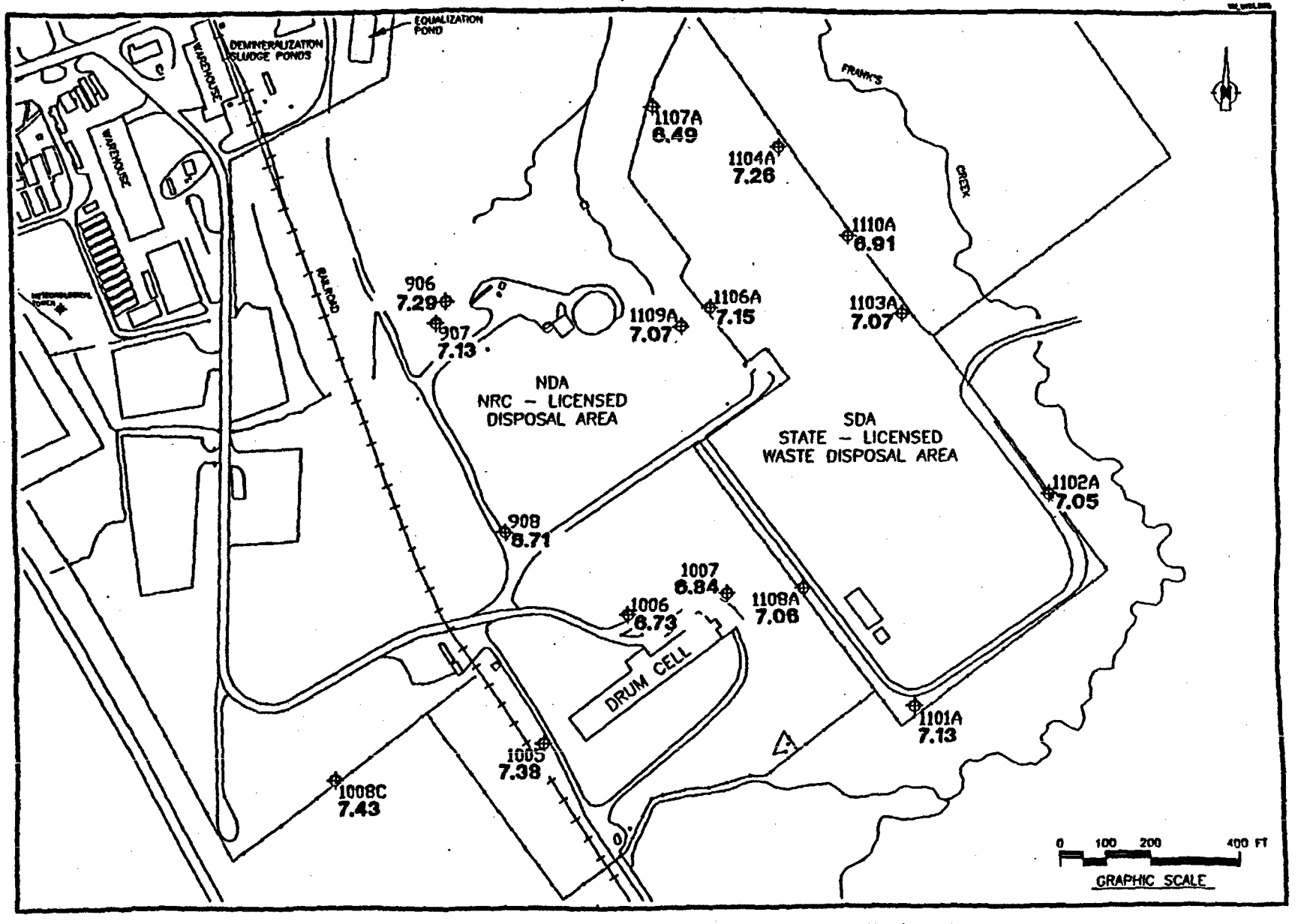


Figure 4-123 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean pH Levels.

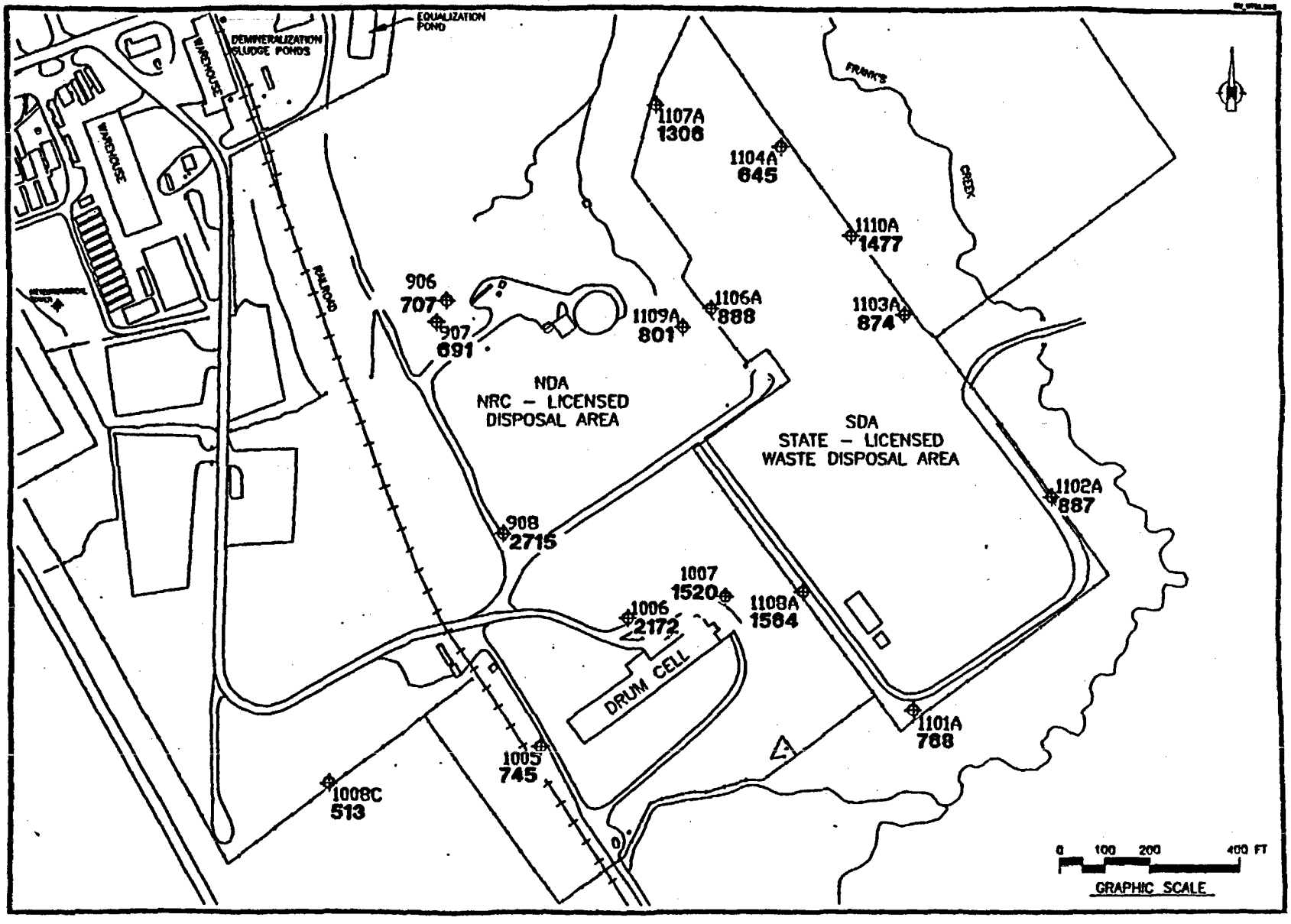


Figure 4-124 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Specific Conductivity (umhos/cm @25°C).

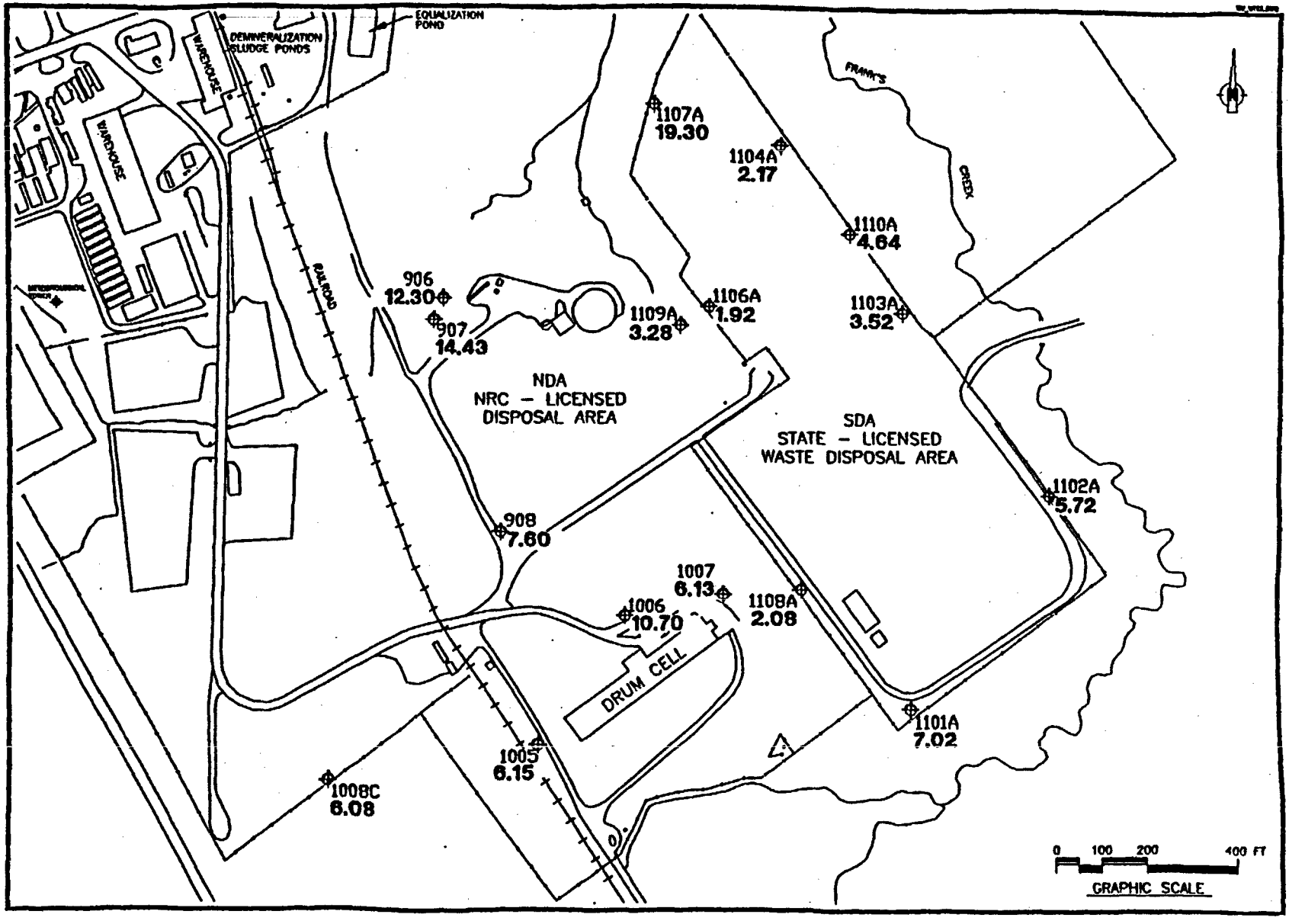


Figure 4-125 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Carbon (TOC) Concentrations (mg/l).

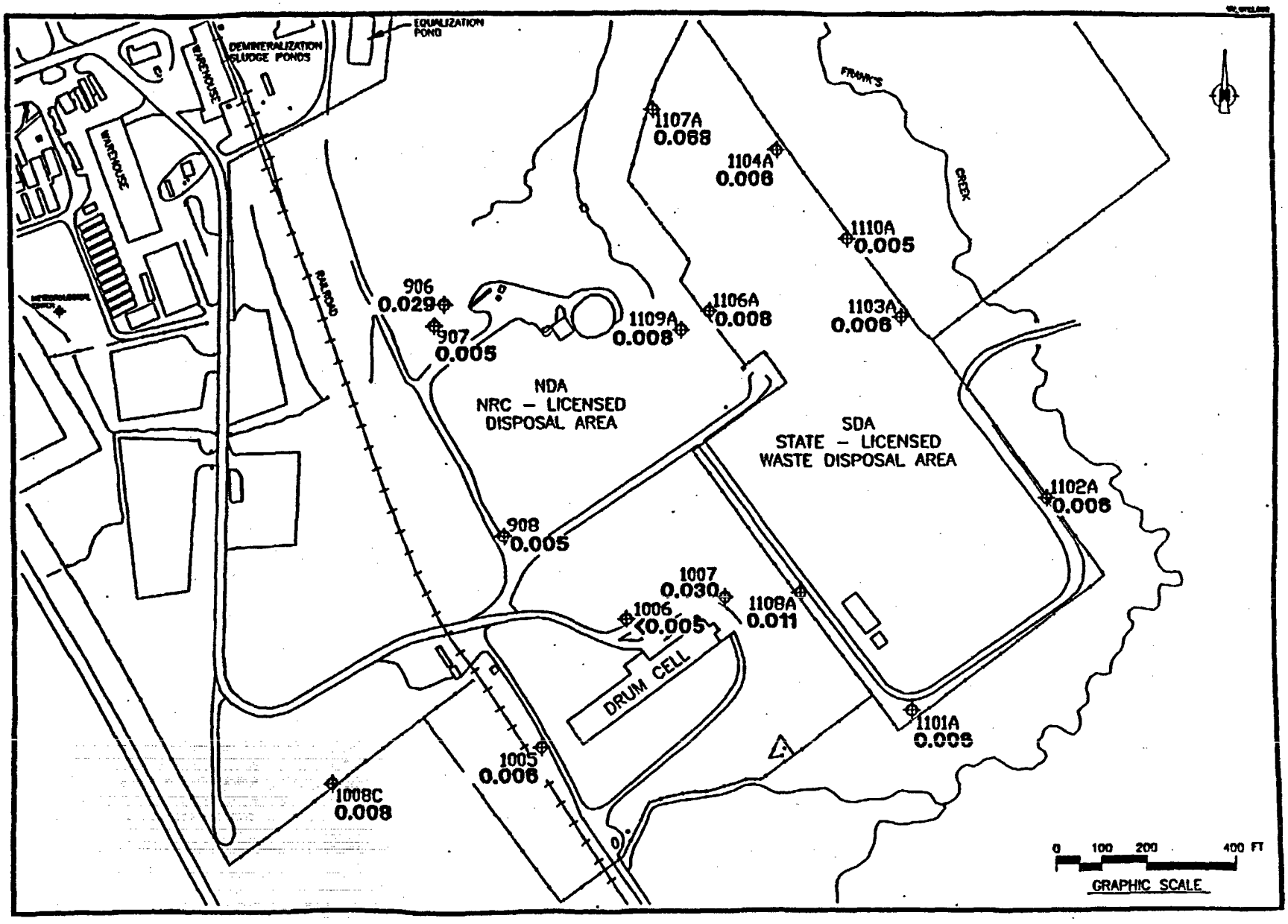


Figure 4-126 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Halogen (TOX) Concentrations (mg/l).

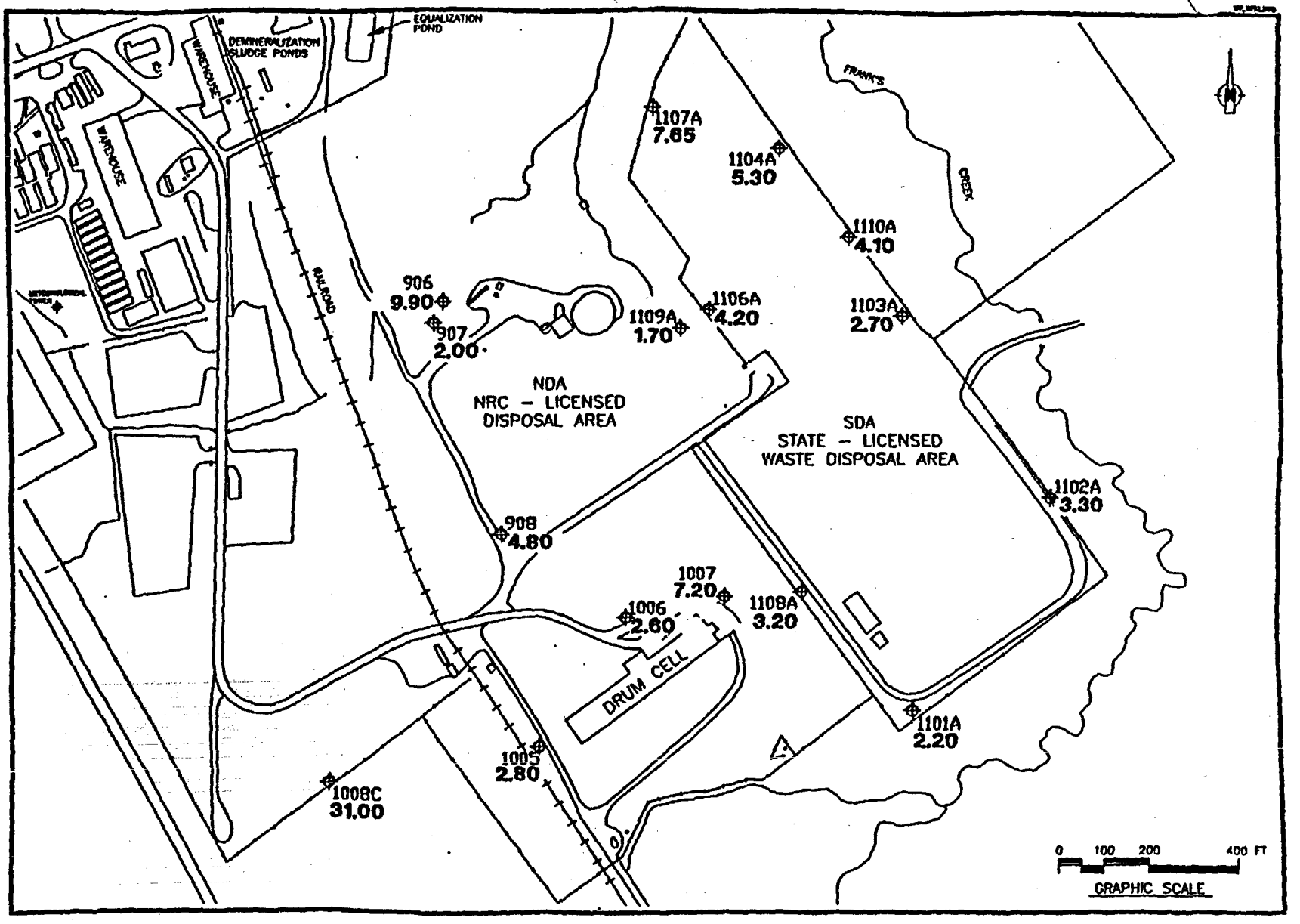


Figure 4-127 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Chloride Concentrations (mg/l).

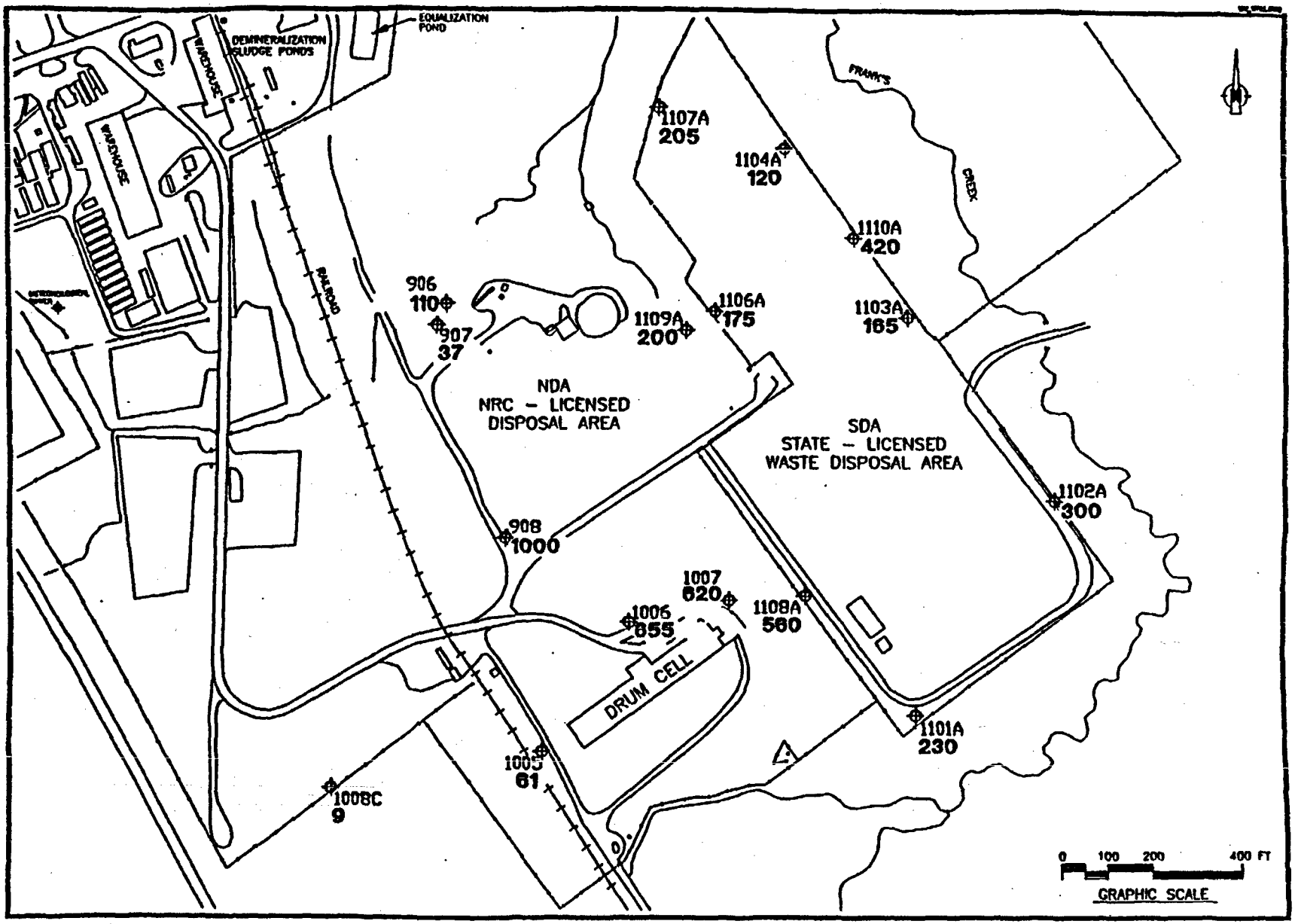


Figure 4-128 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sulfate Concentrations (mg/l).

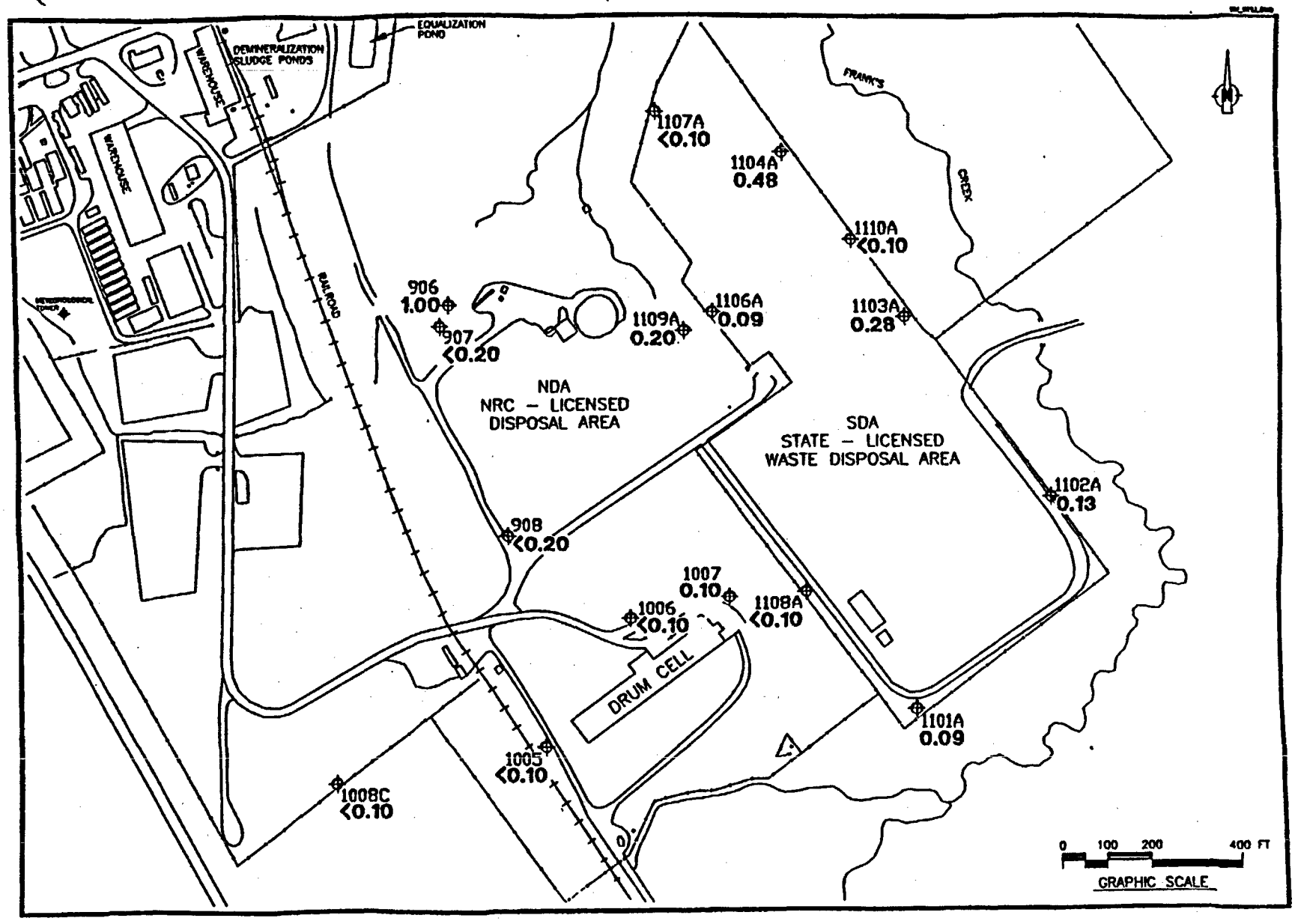


Figure 4-129 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Nitrate + Nitrite – N Concentrations (mg/l).

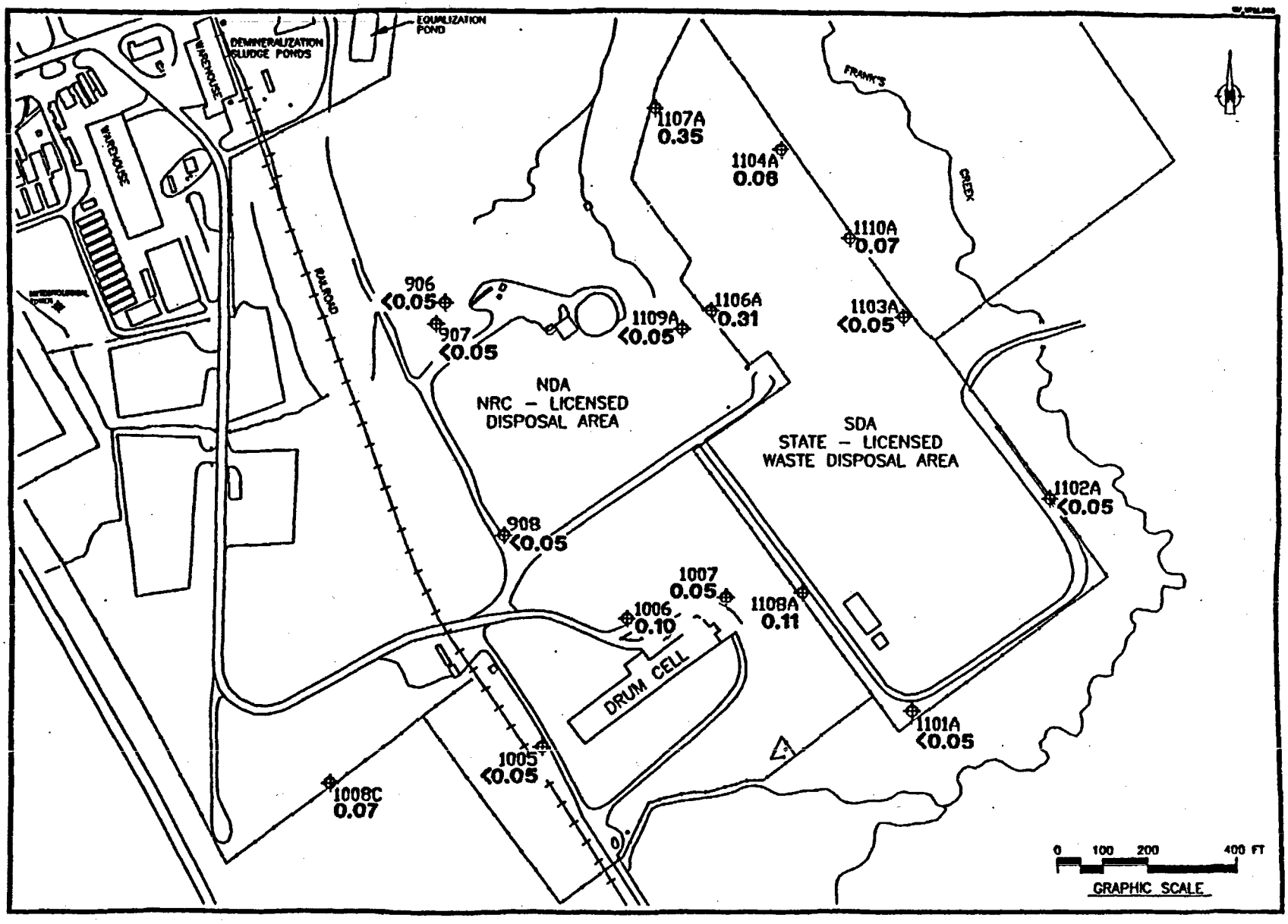


Figure 4-130 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Ammonia Concentrations (mg/l).

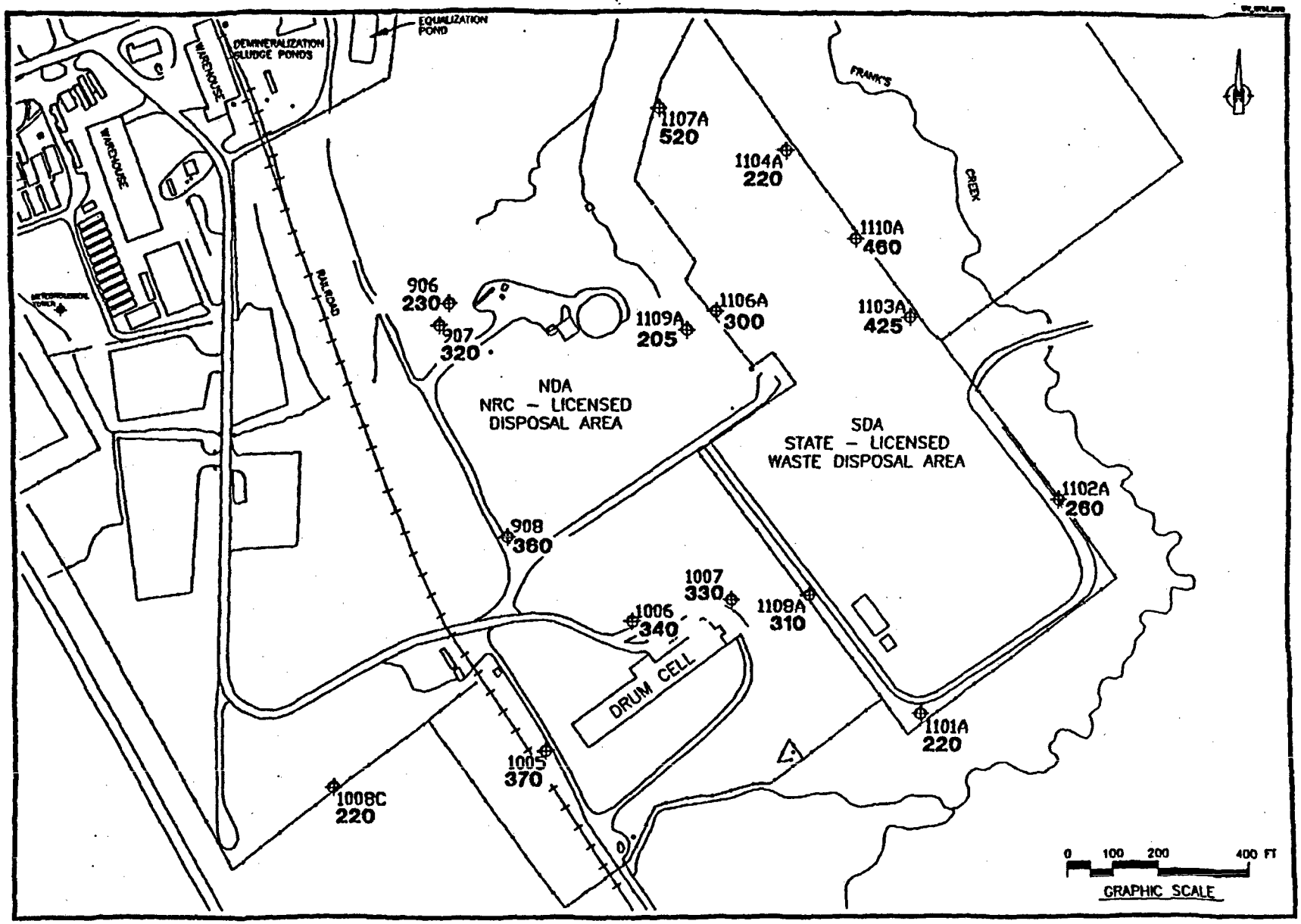


Figure 4-131 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Bicarbonate Alkalinity Levels (mg/l).

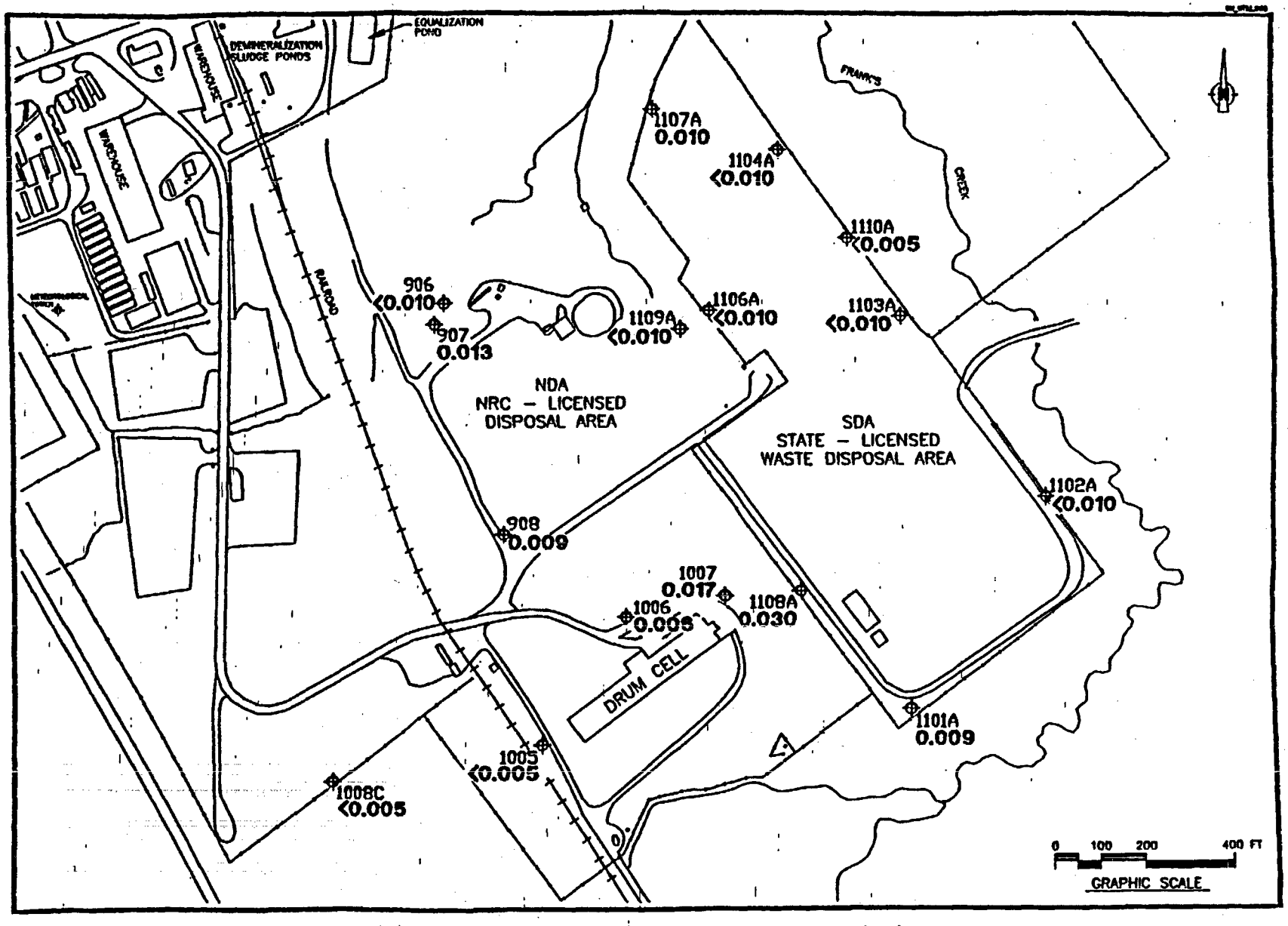


Figure 4-132 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Phenol Concentrations (mg/l).

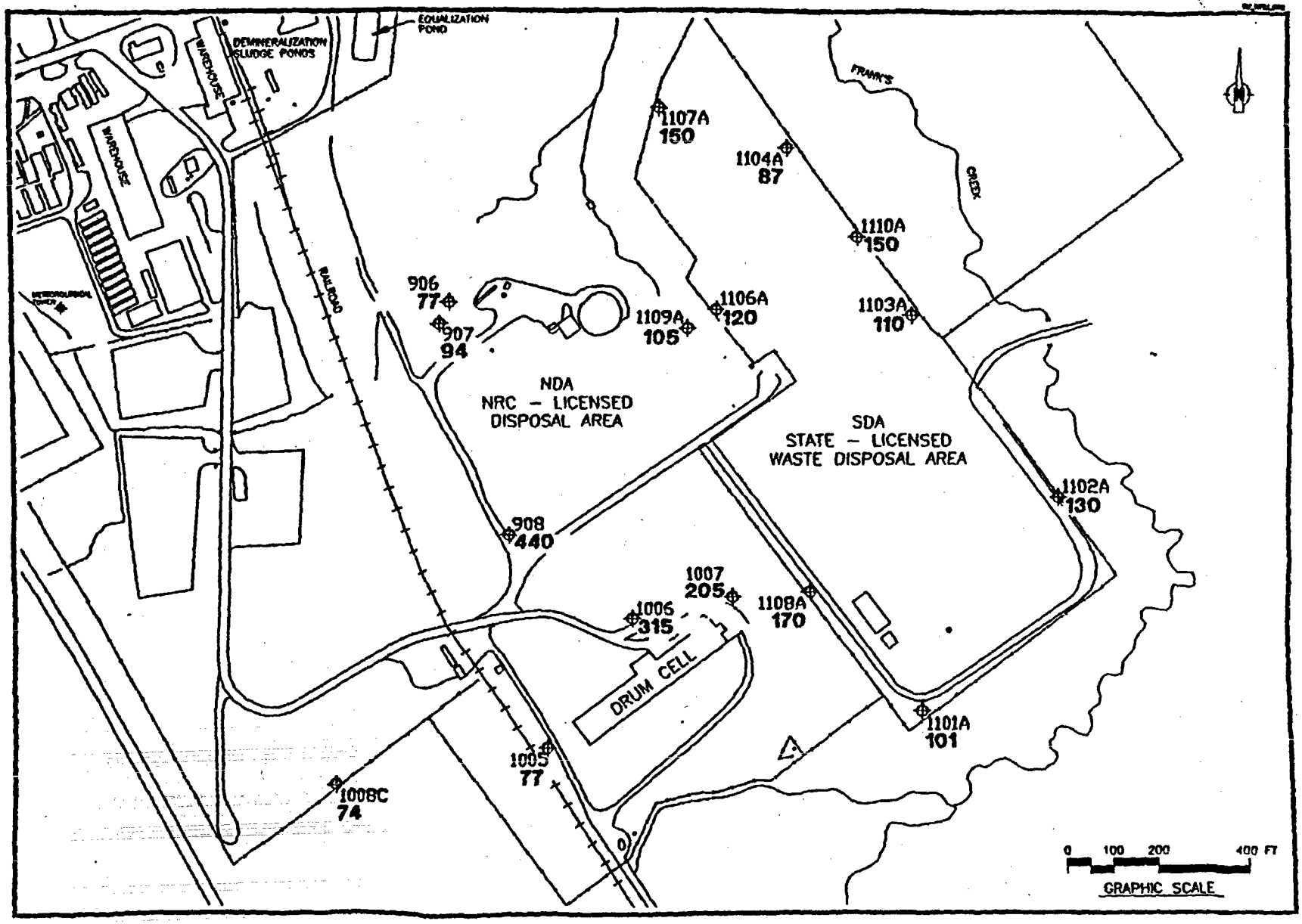


Figure 4-133 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Calcium Concentrations (mg/l).

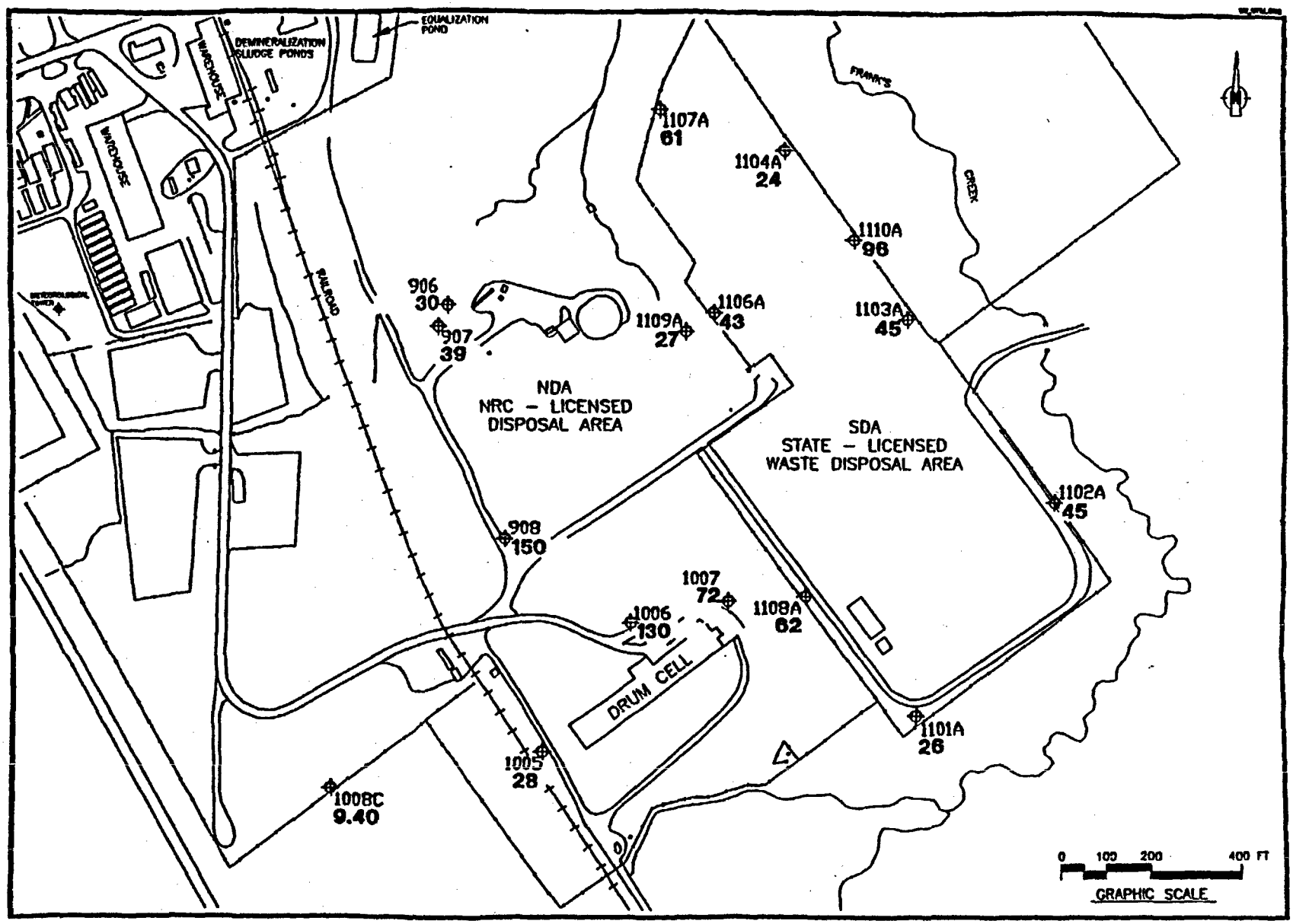


Figure 4-134 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Magnesium Concentrations (mg/l).

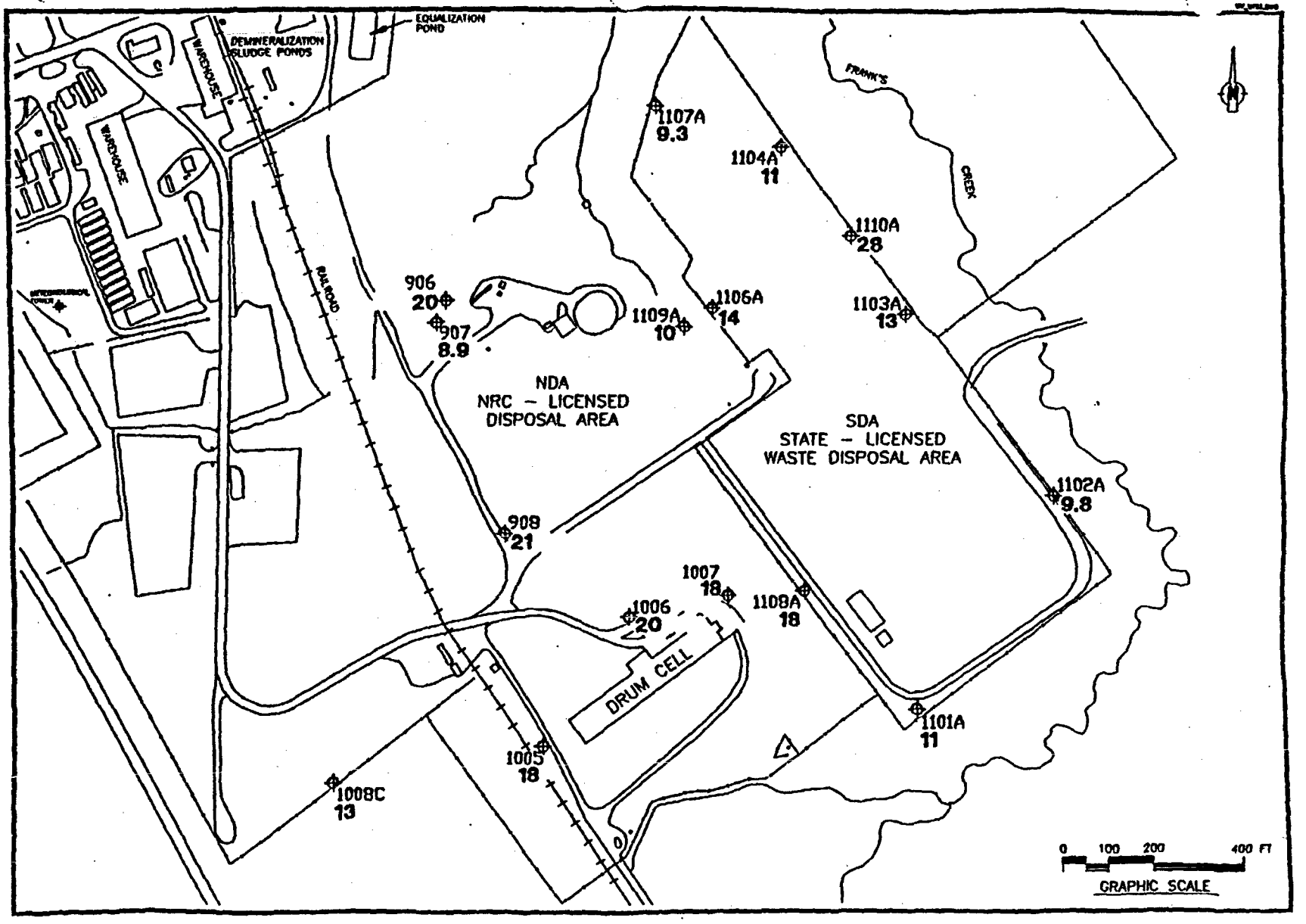


Figure 4-135 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sodium Concentrations (mg/l).

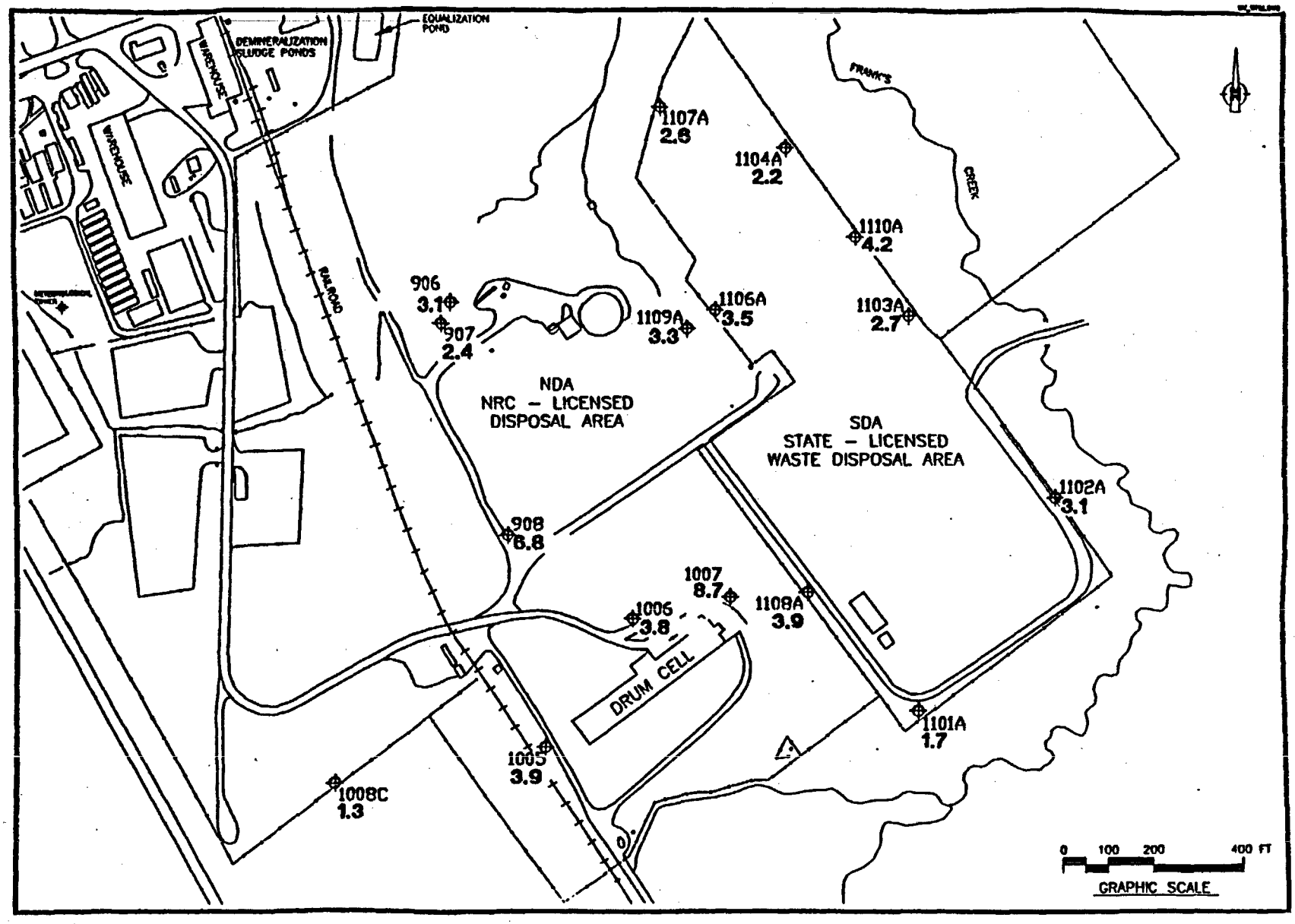


Figure 4-136 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Potassium Concentrations (mg/l).

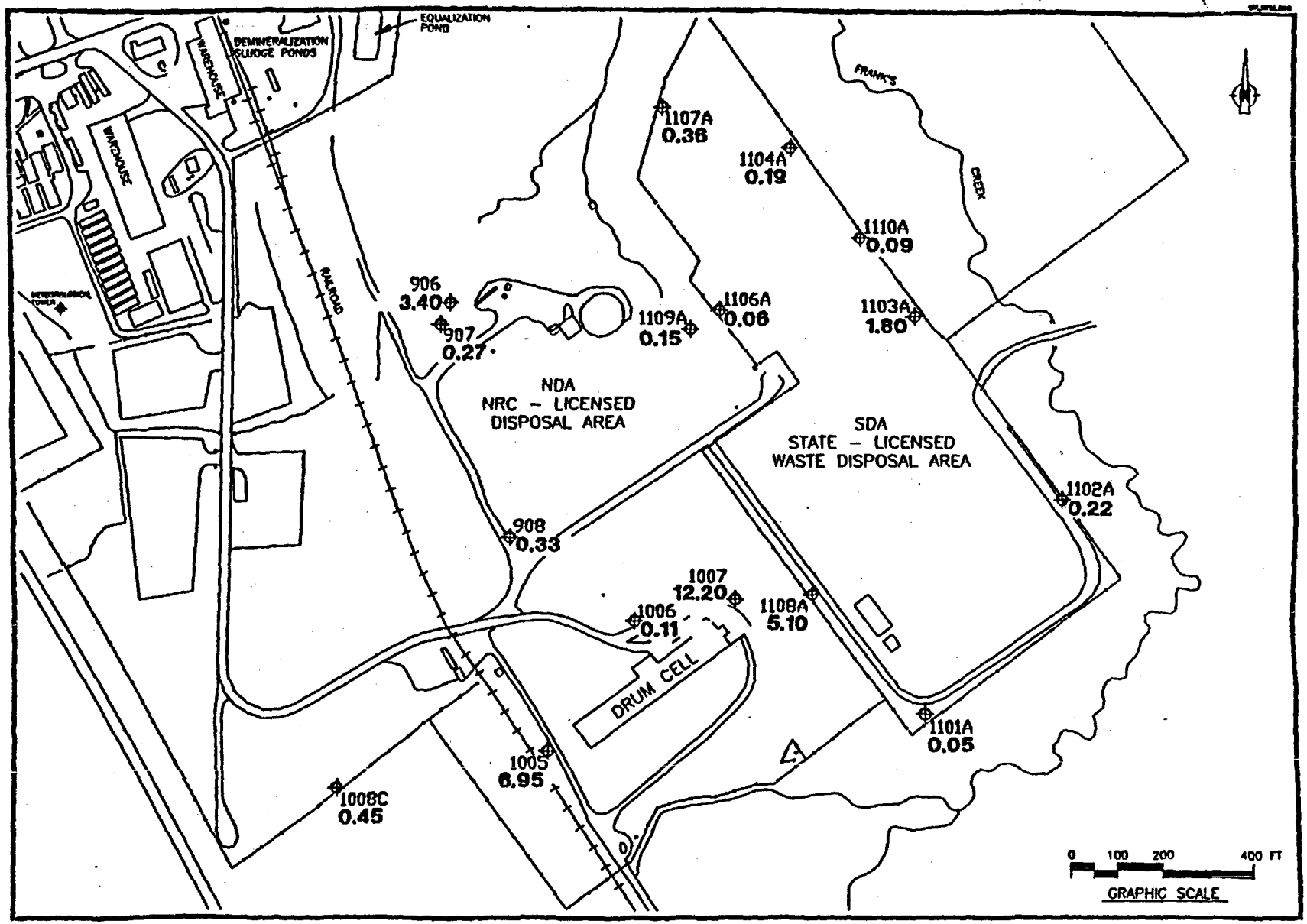


Figure 4-137 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Iron Concentrations (mg/l).

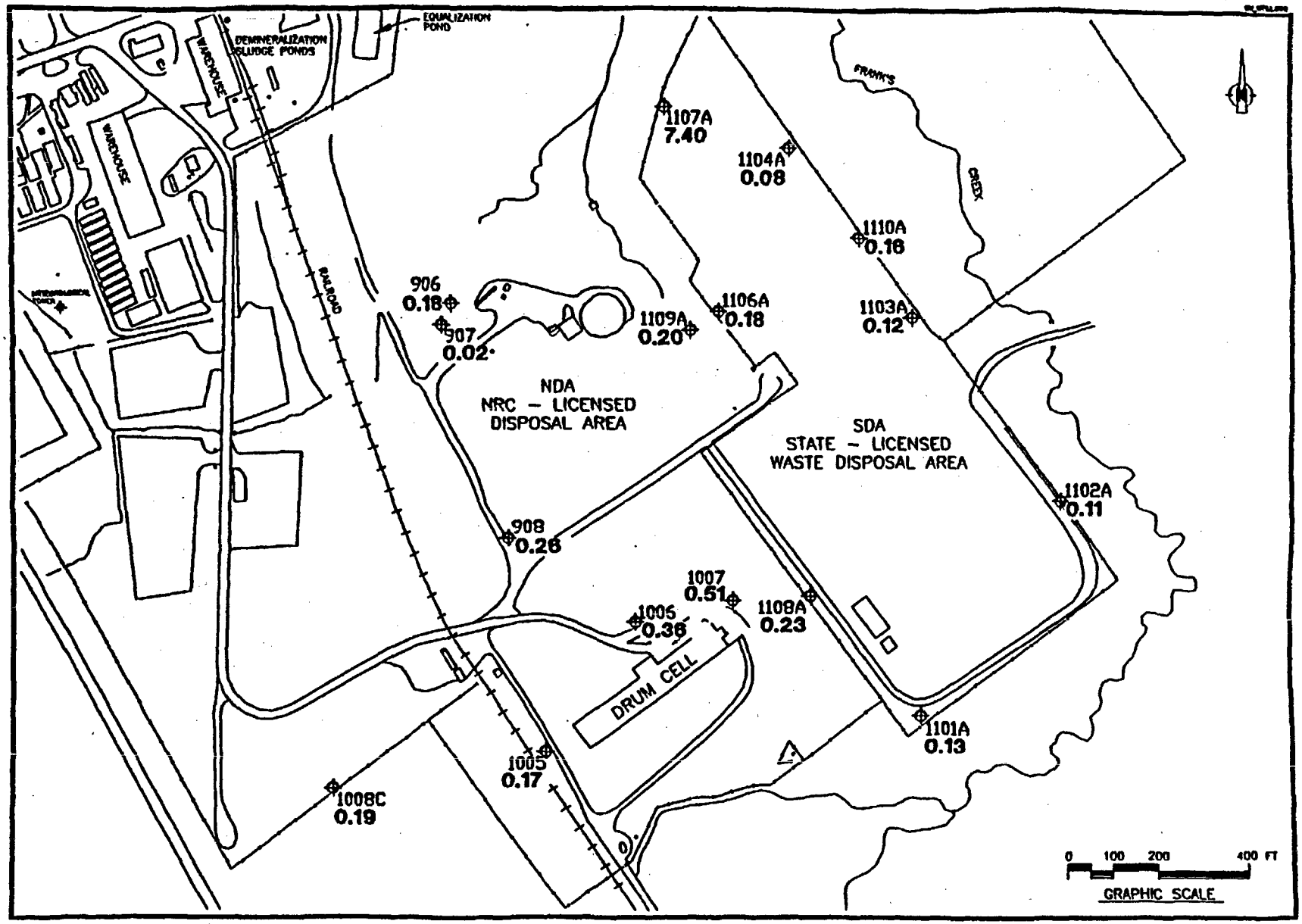


Figure 4-138 Weathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Manganese Concentrations (mg/l).

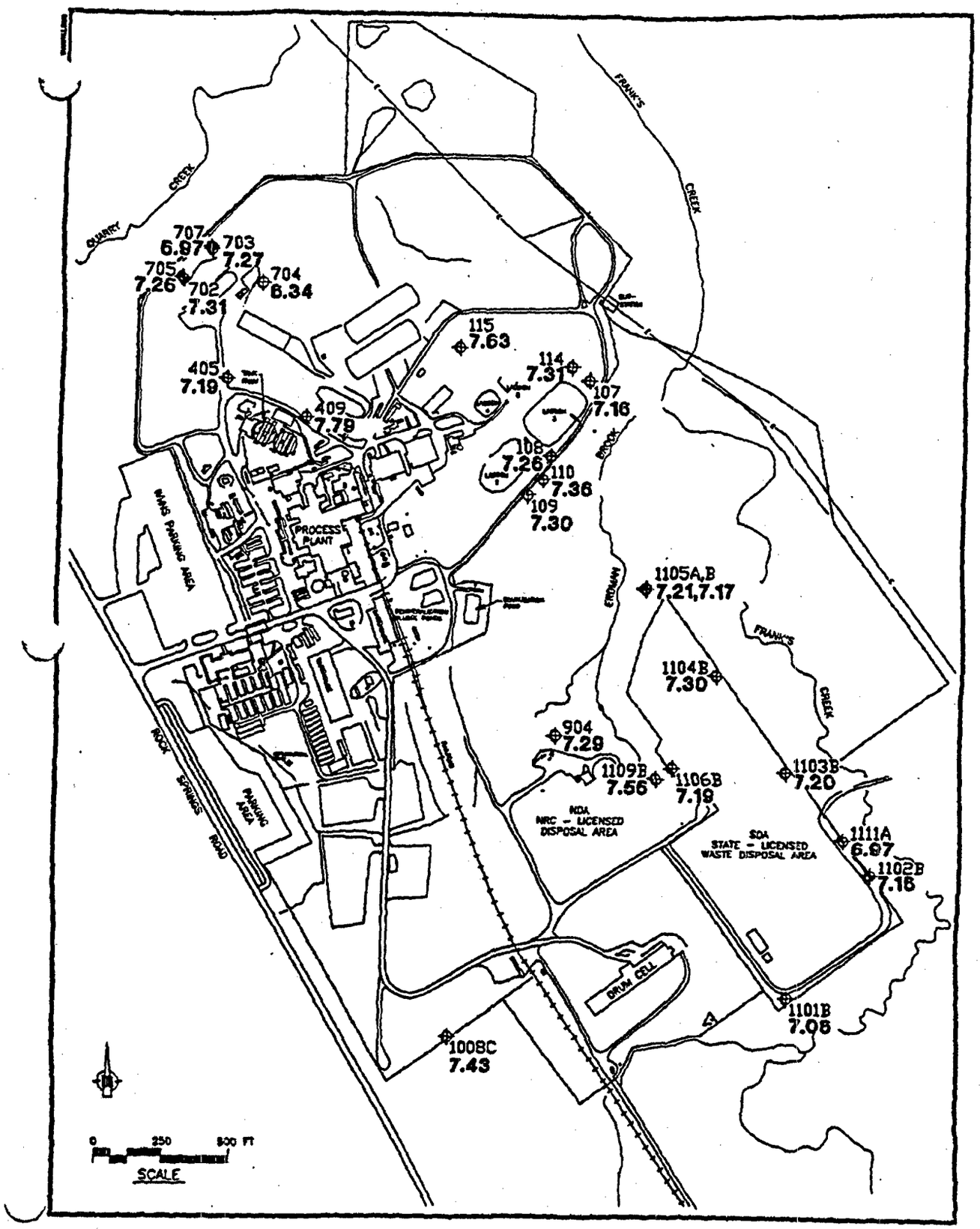


Figure 4-139 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean pH Levels.

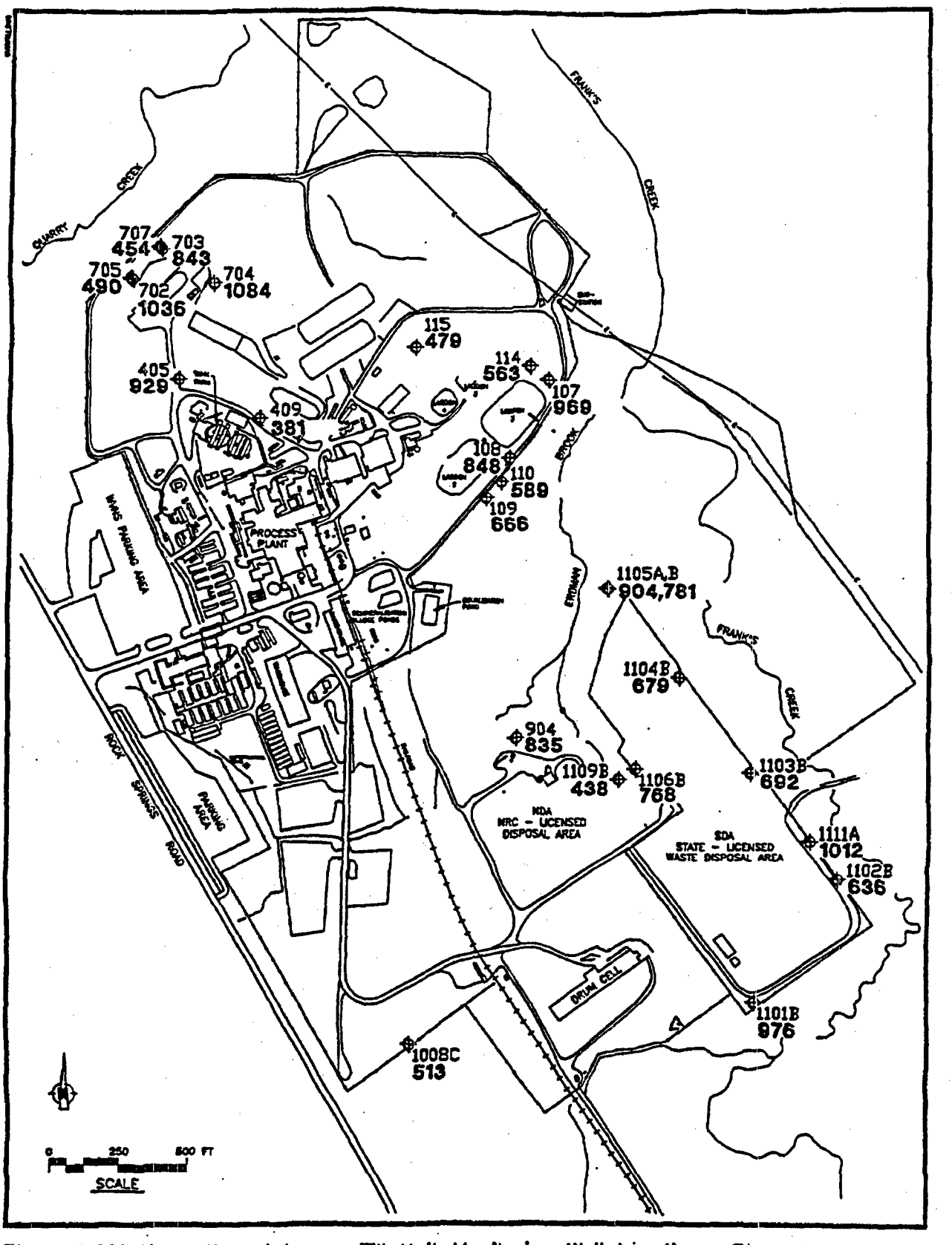


Figure 4-140 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Specific Conductivity (umhos/cm @ 25°C).

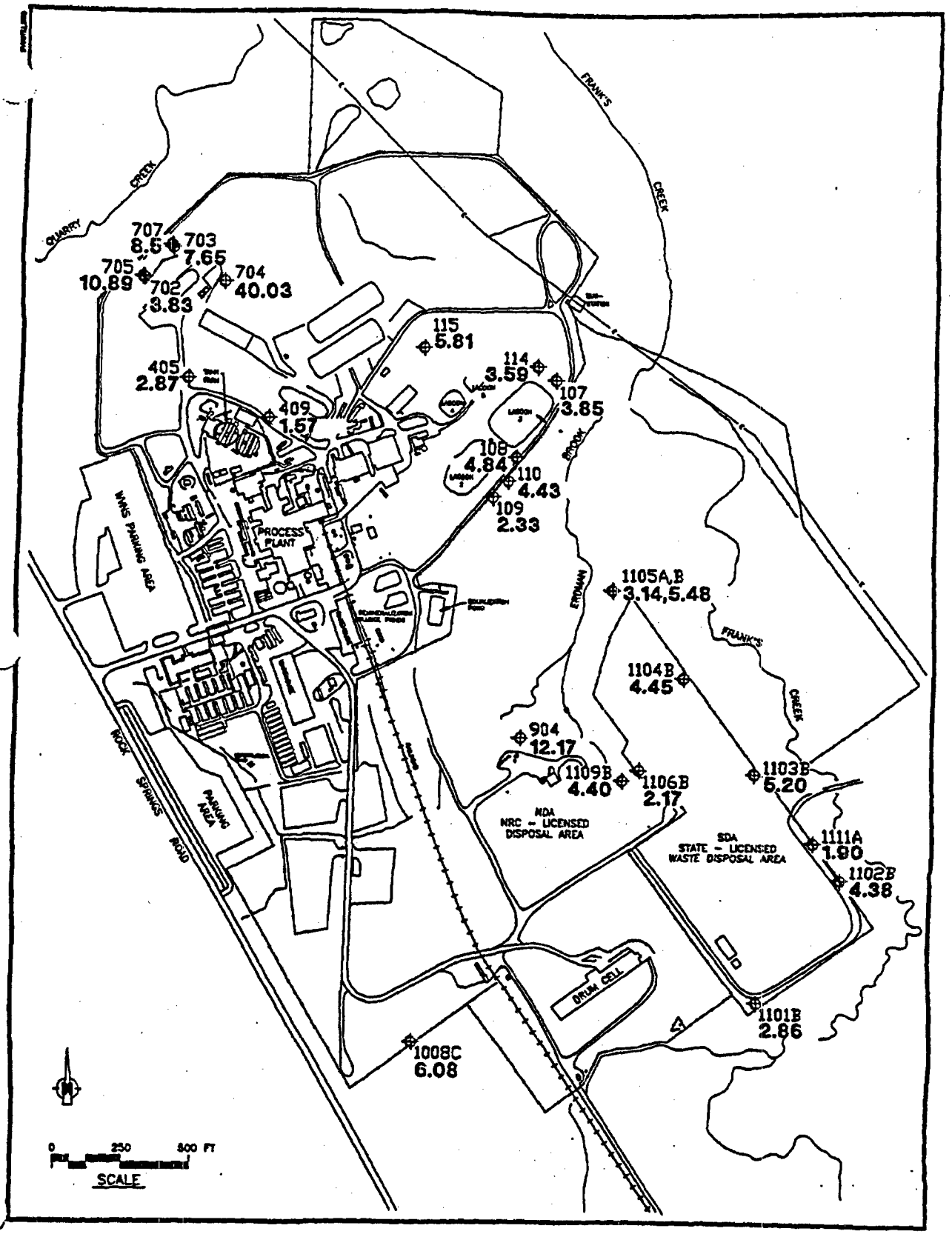


Figure 4-141 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Carbon (TOC) Concentrations (mg/l).

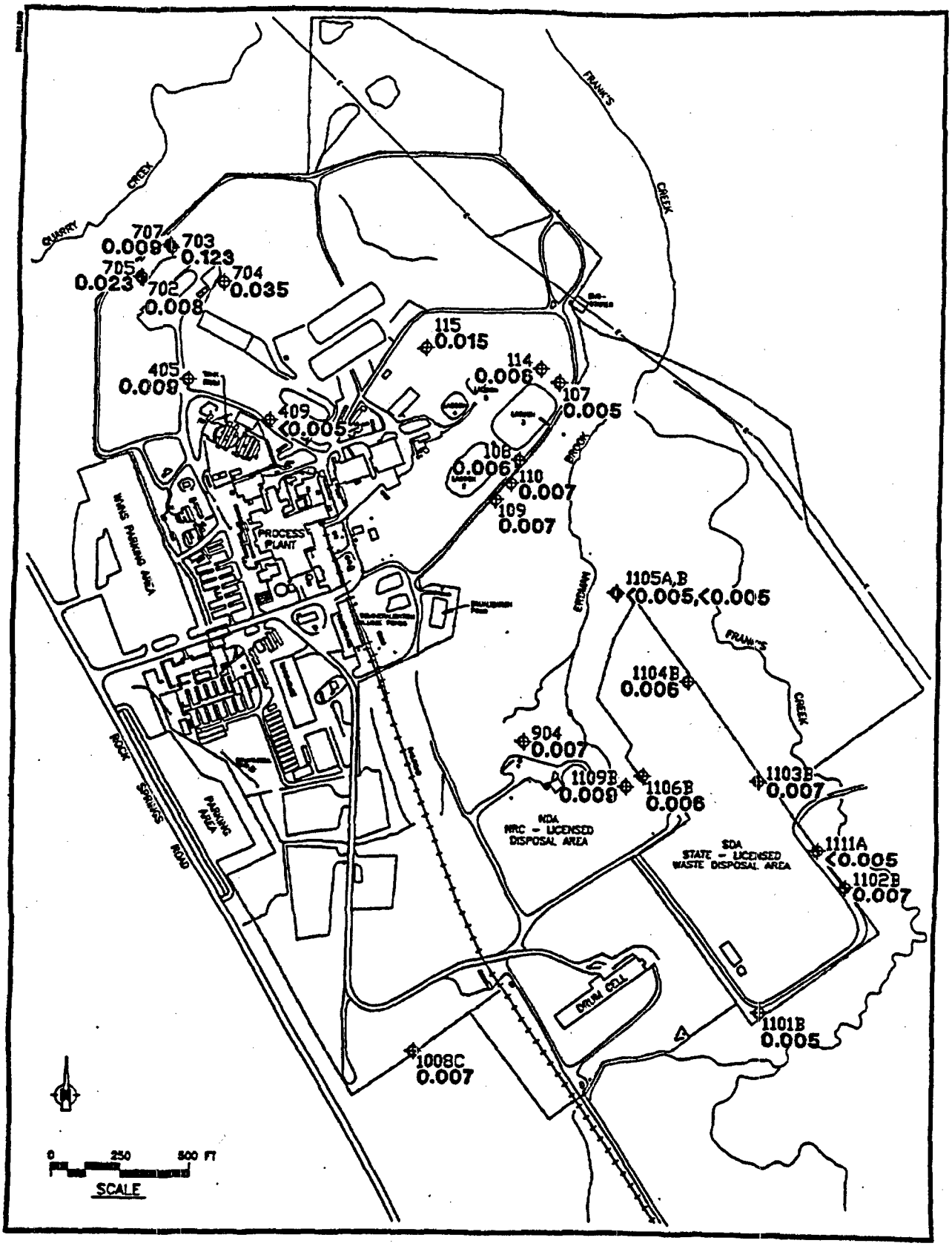


Figure 4-142 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Halogen (TOX) Concentrations (mg/l).

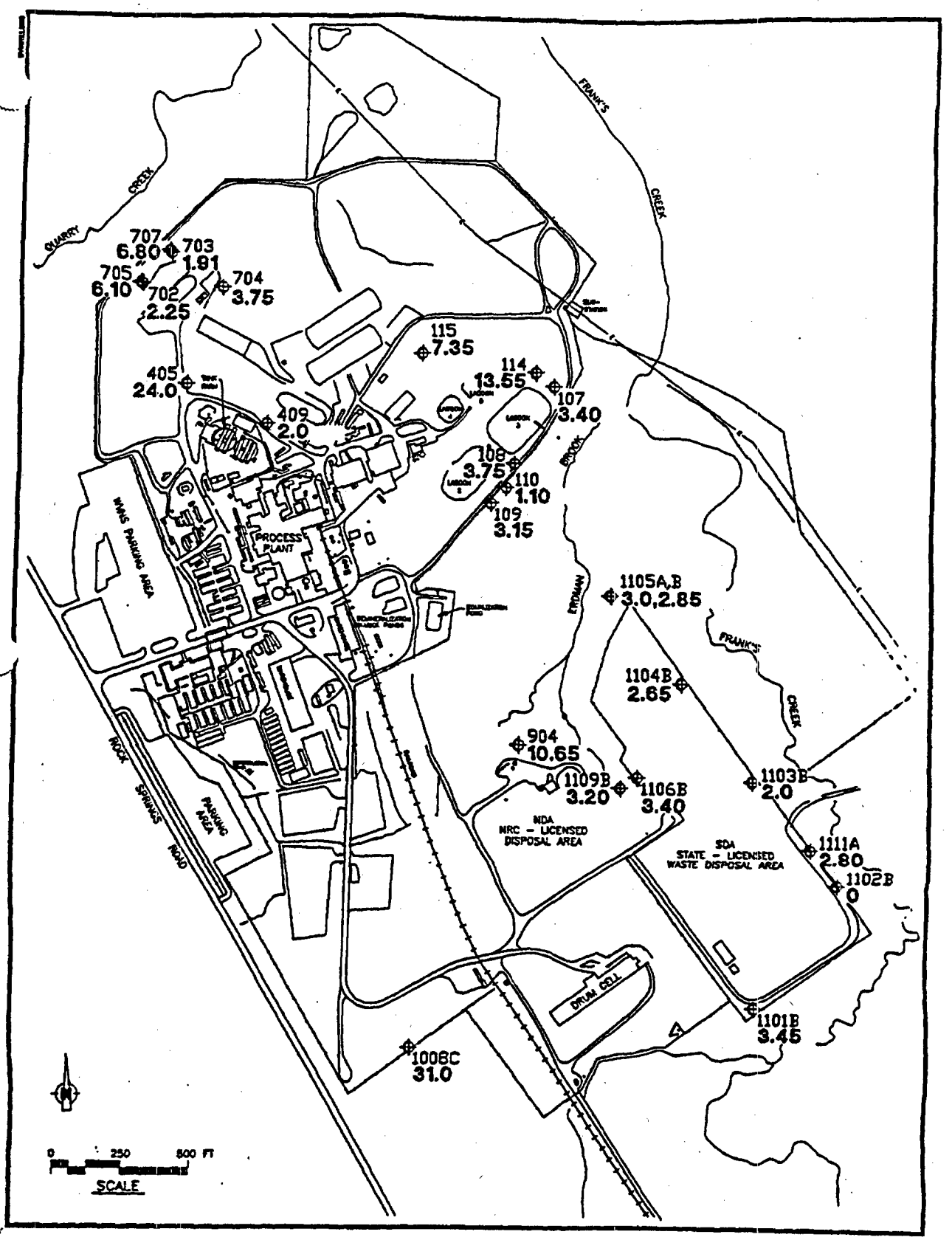


Figure 4-143 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Chloride Concentrations (mg/l).

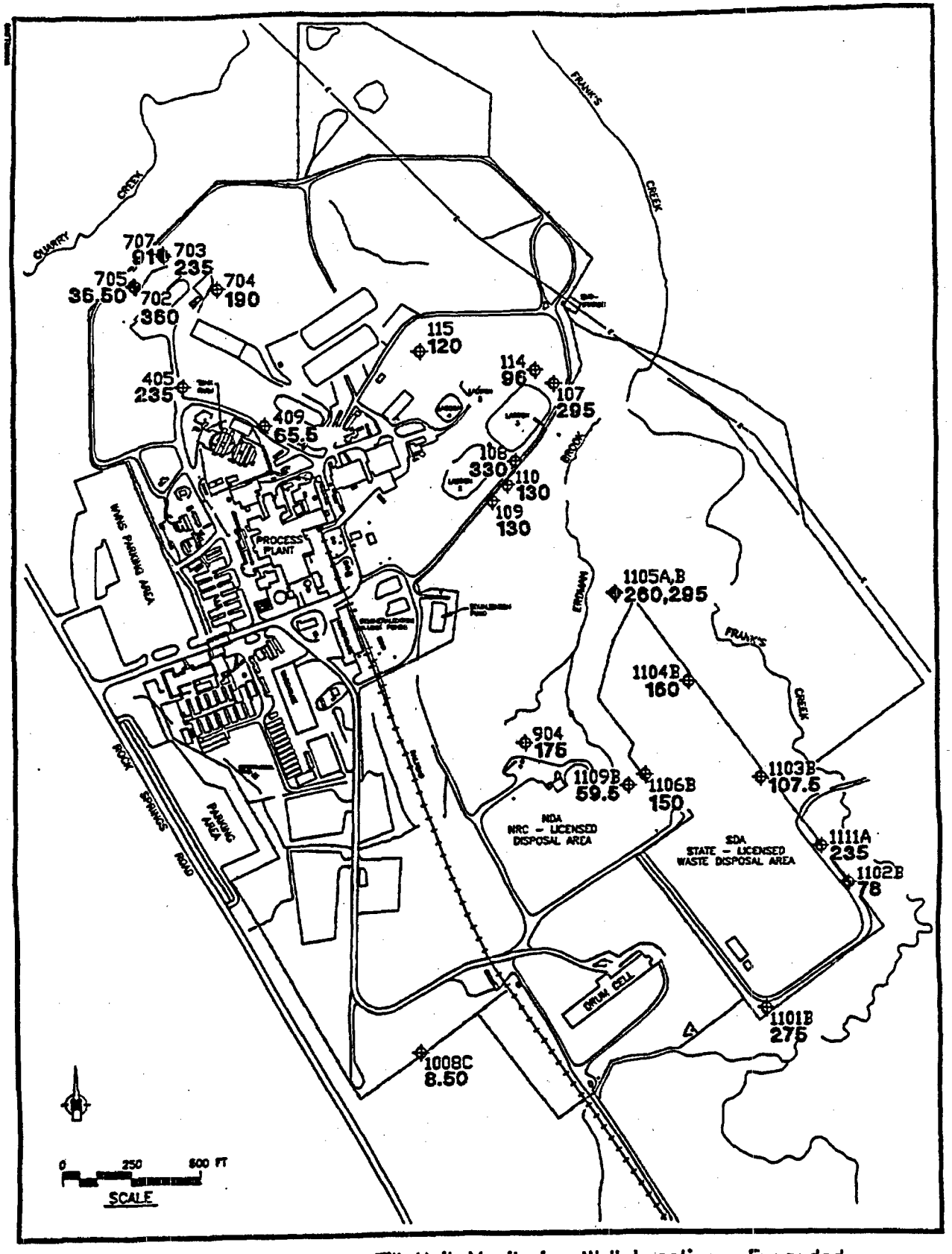


Figure 4-144 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sulfate Concentrations (mg/l).

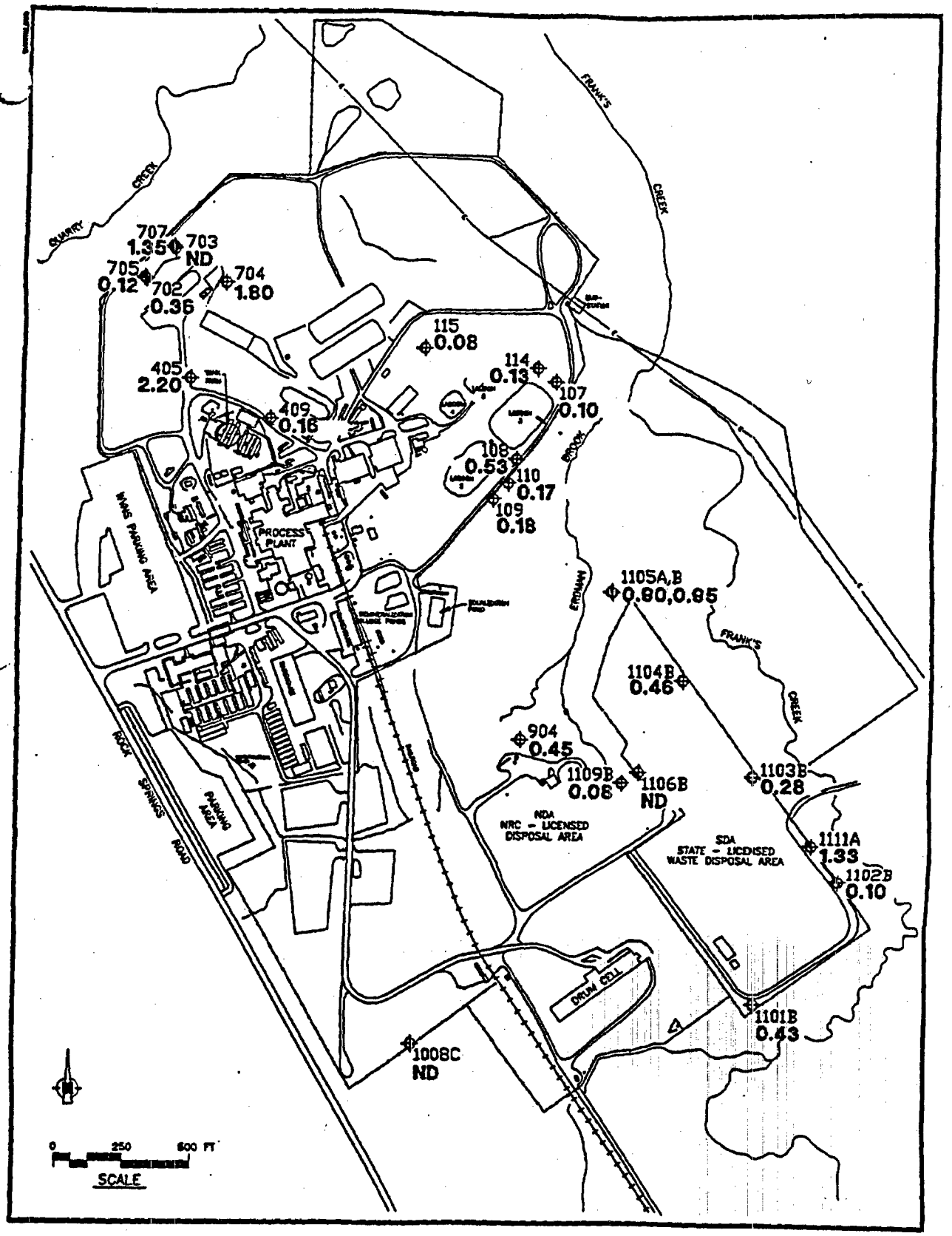


Figure 4-145 Unweathered Lovery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Nitrate Concentrations (mg/l) (ND = Non-Detected).

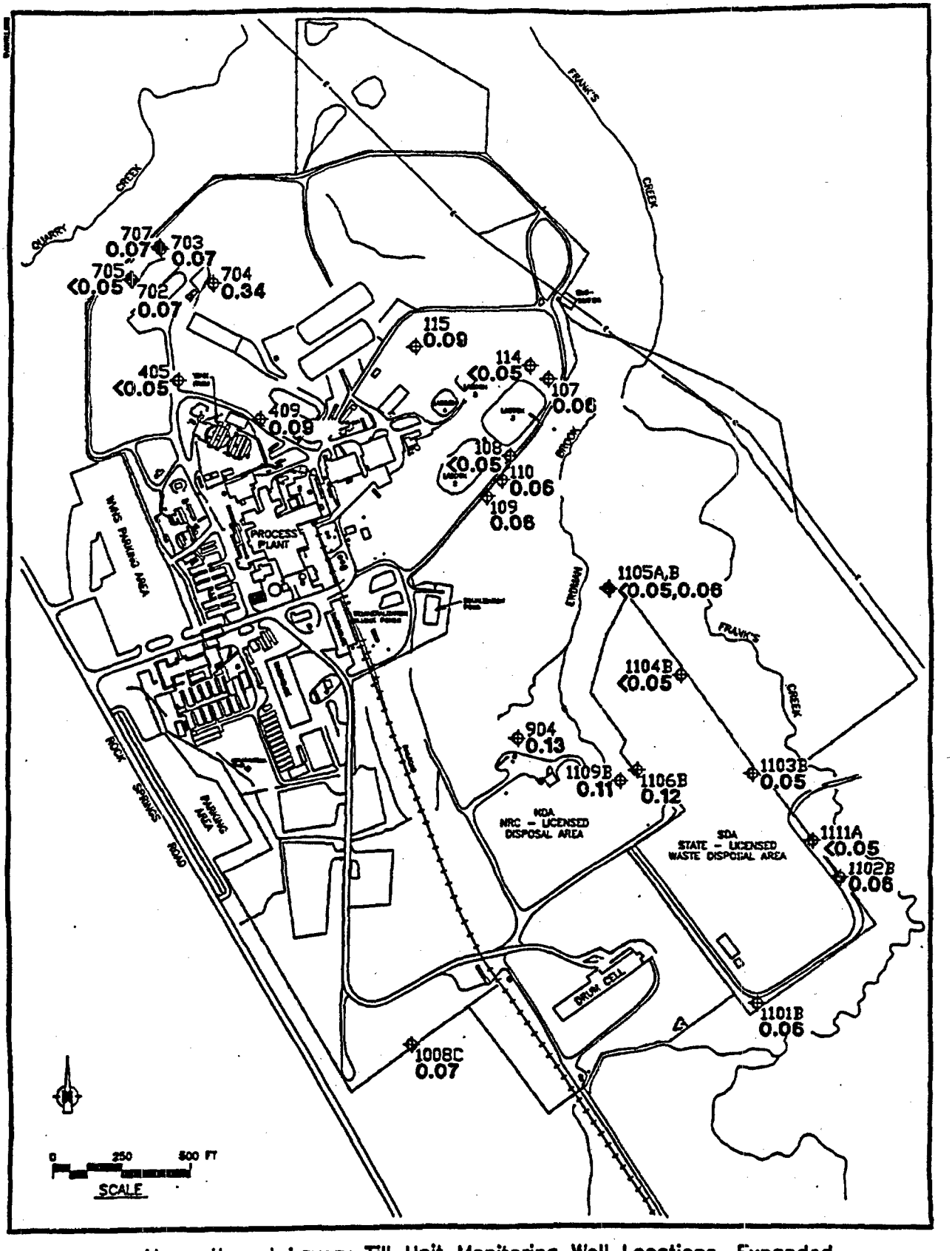


Figure 4-146 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Ammonia Concentrations (mg/l).

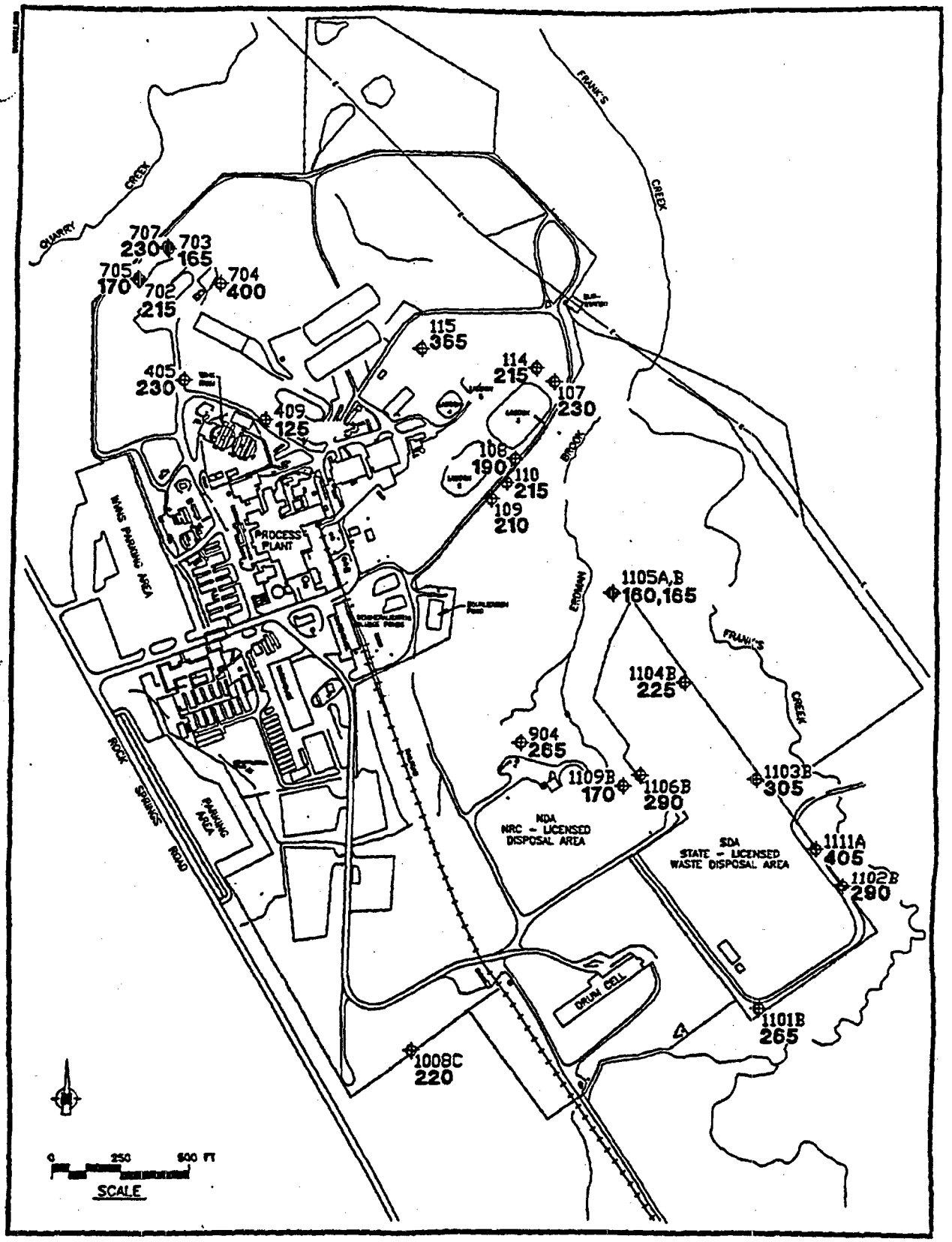


Figure 4-147 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Bicarbonate Alkalinity Levels (mg/l).

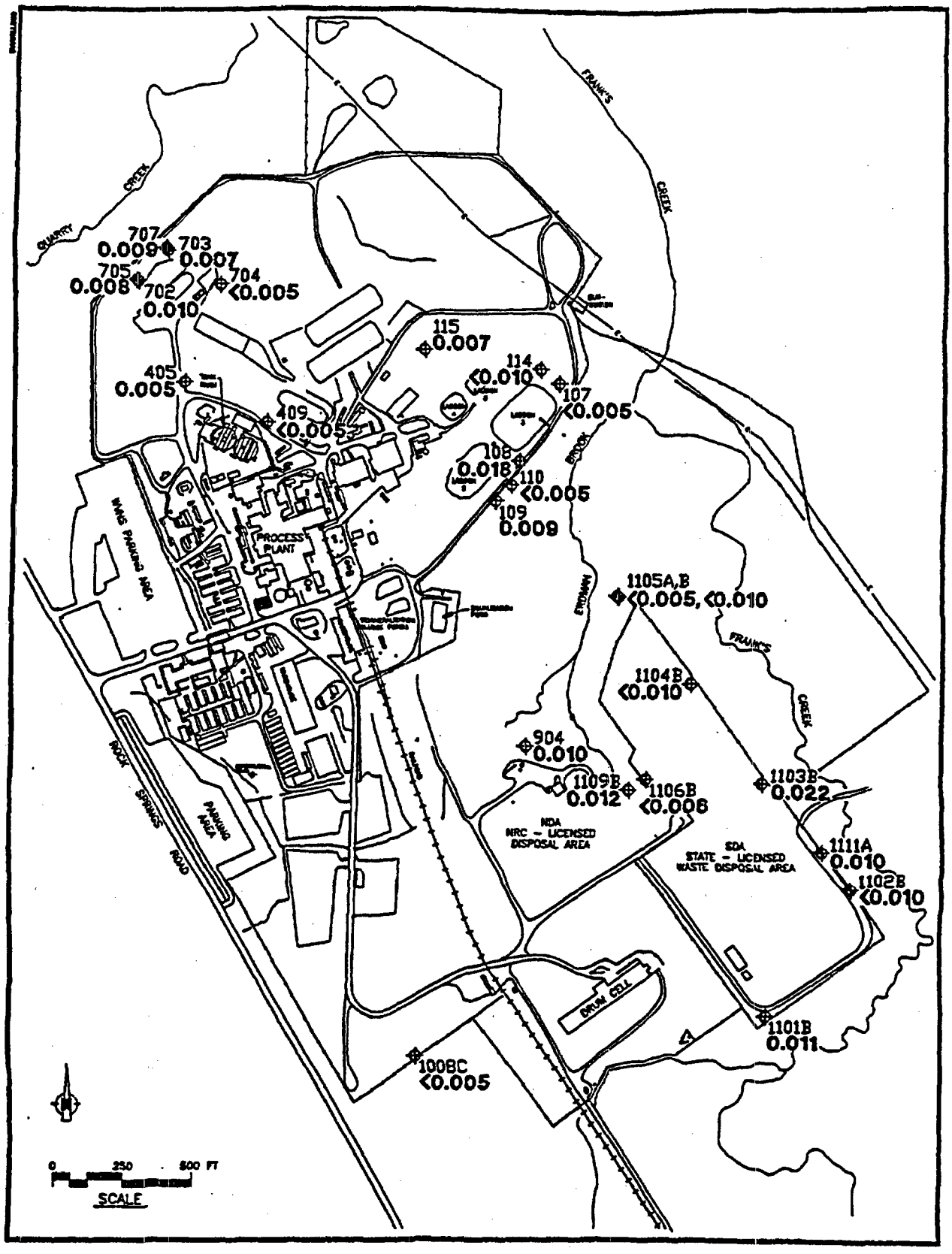


Figure 4-148 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Phenol Concentrations (mg/l).

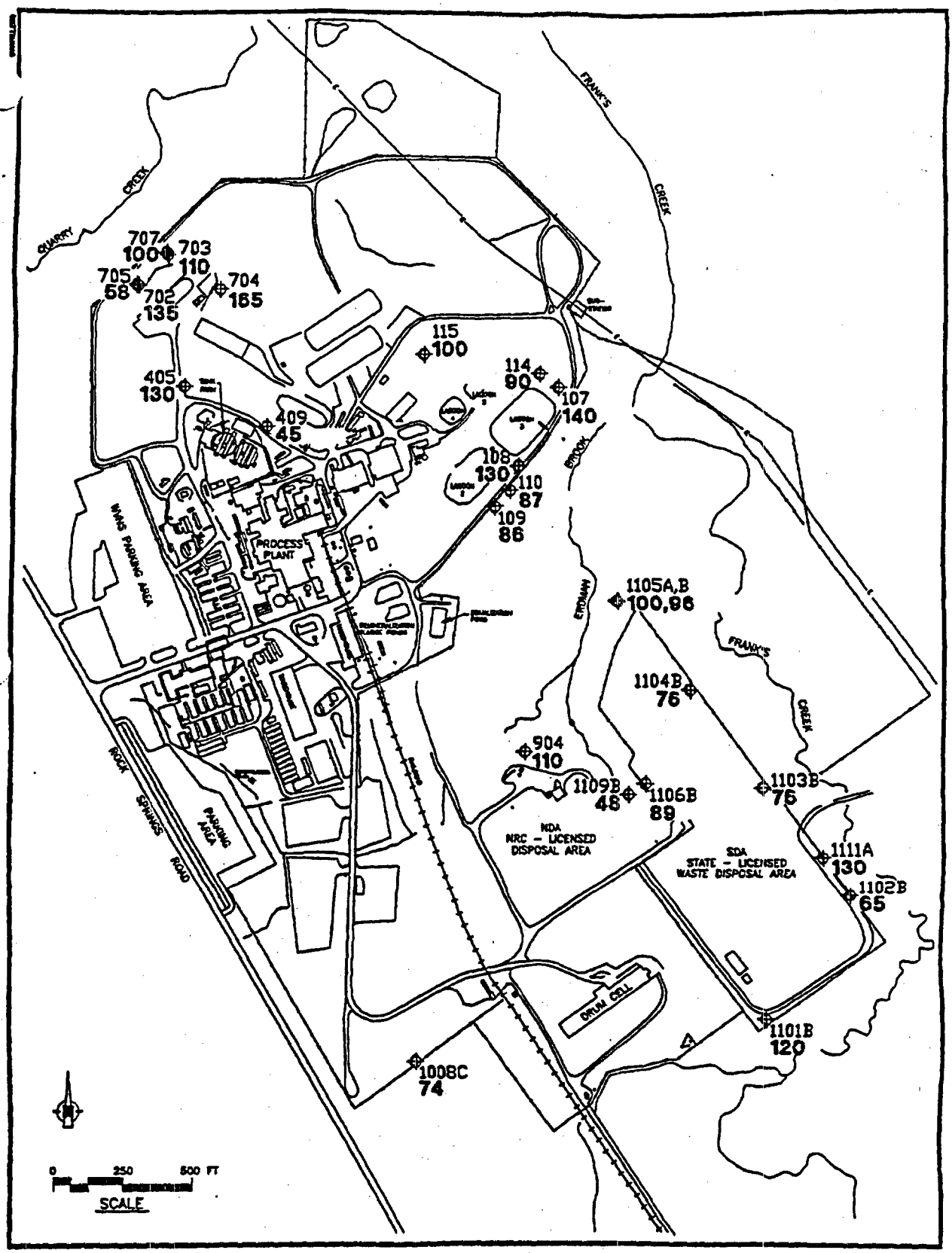


Figure 4-149 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Calcium Concentrations (mg/l).

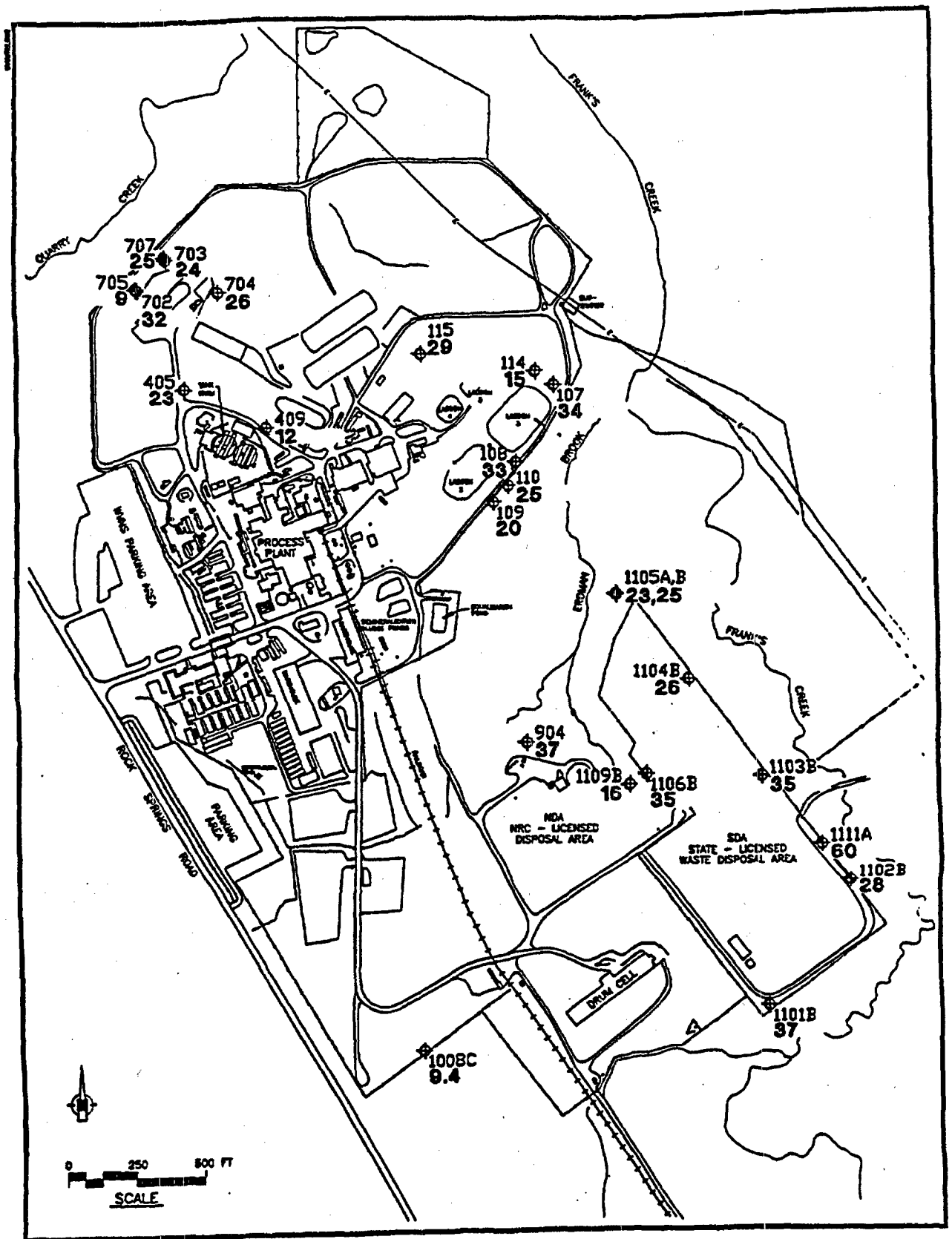


Figure 4-150 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Magnesium Concentrations (mg/l).

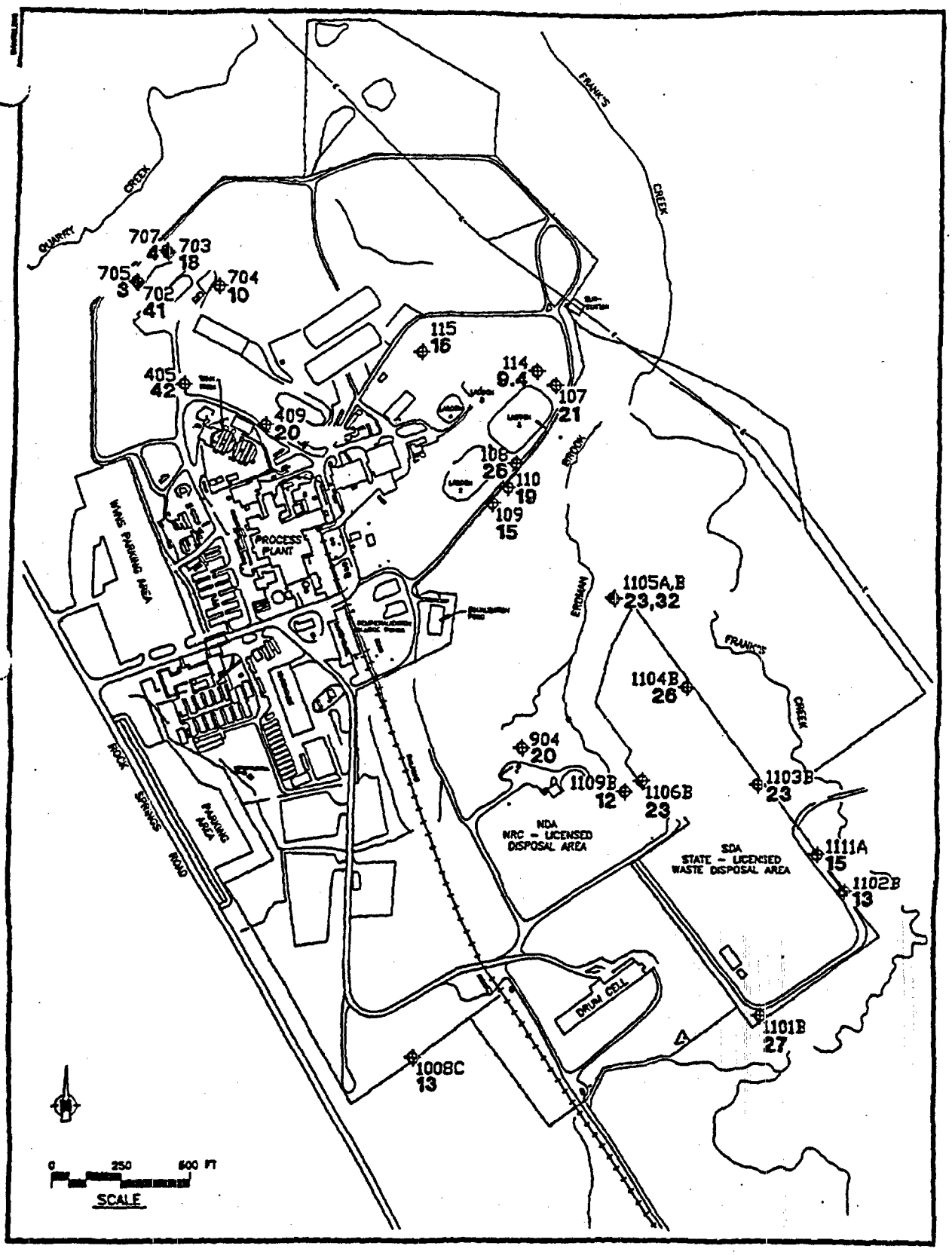


Figure 4-151 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sodium Concentrations (mg/l).

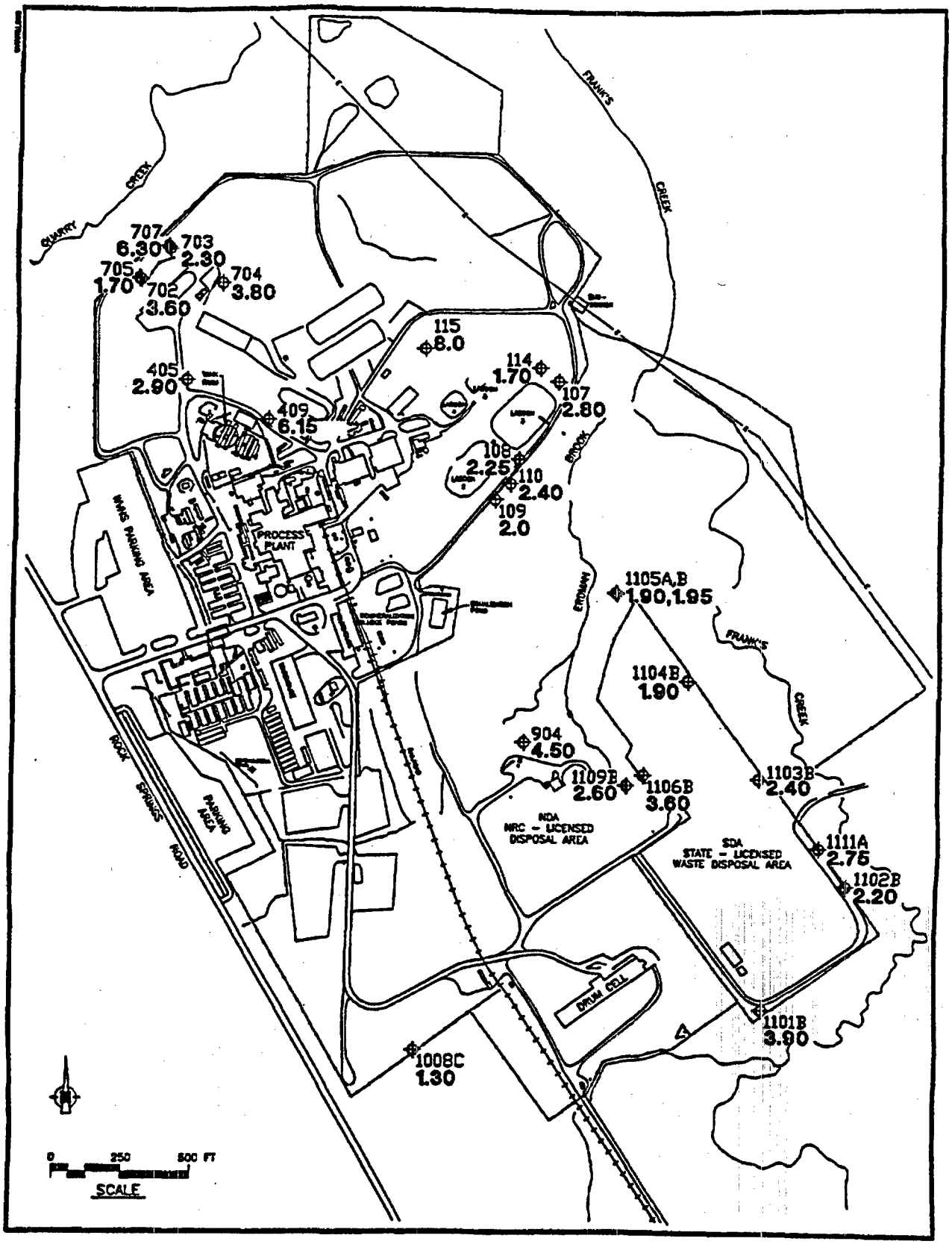


Figure 4-152 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Potassium Concentrations (mg/l).

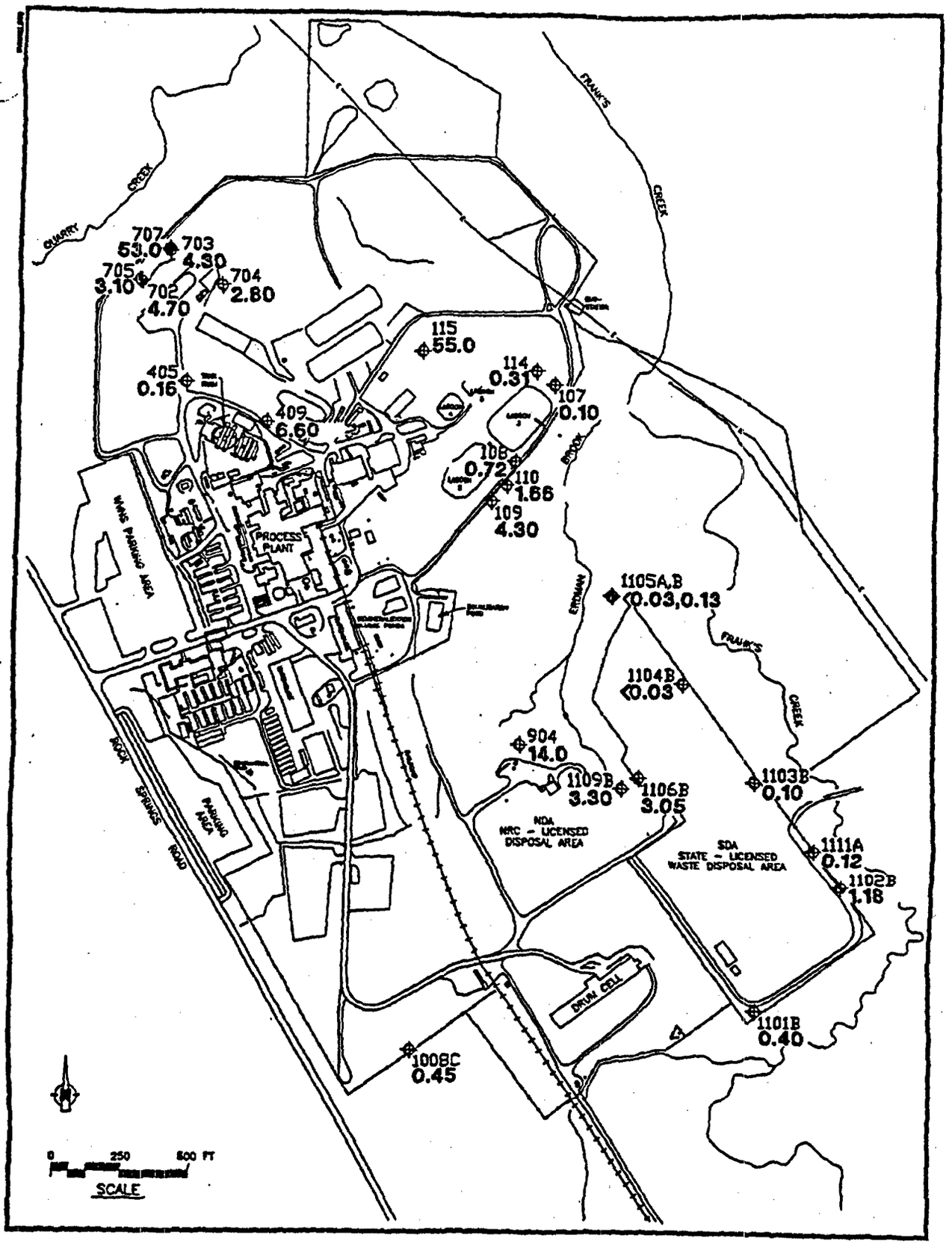


Figure 4-153 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Iron Concentrations (mg/l).

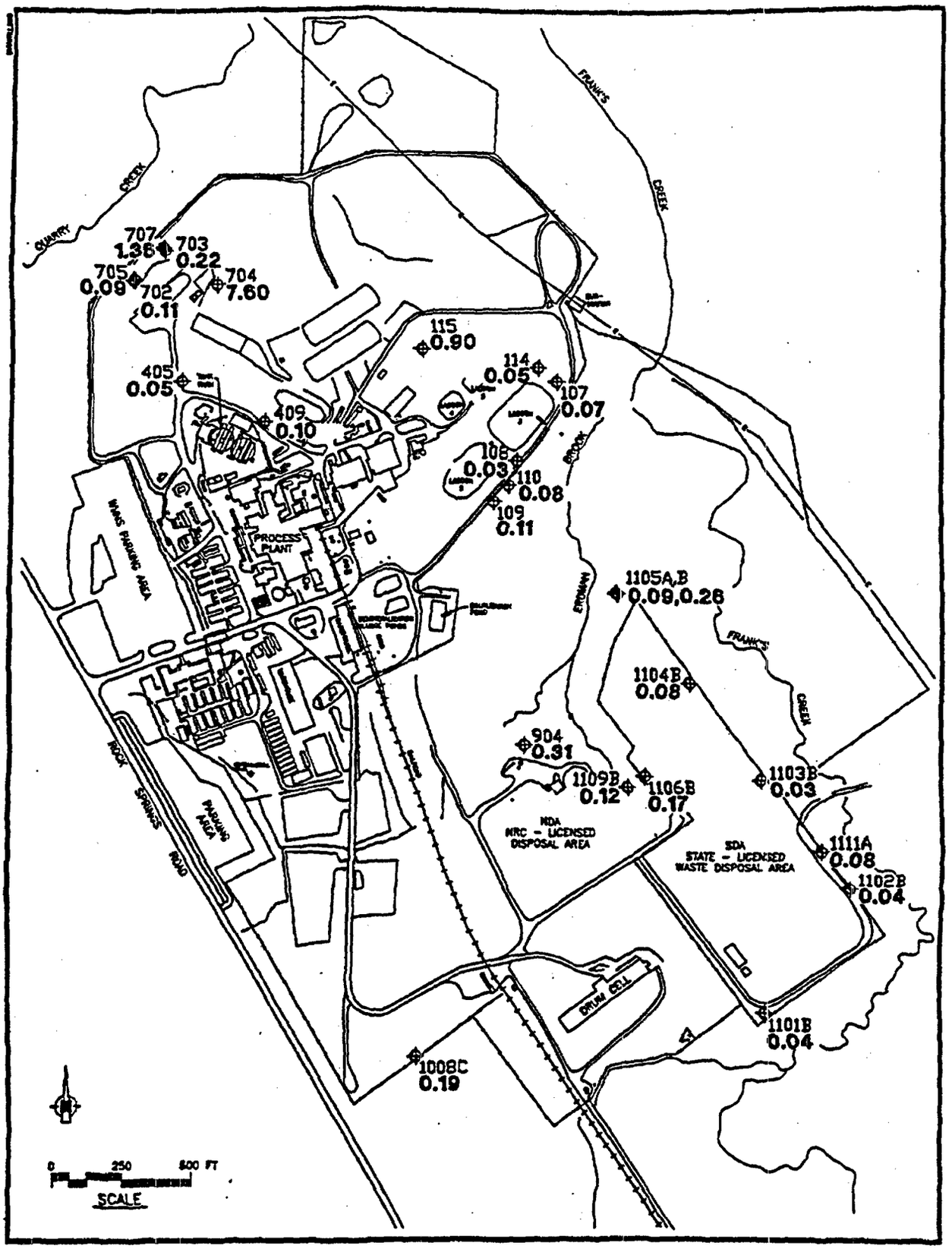


Figure 4-154 Unweathered Lavery Till Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Manganese Concentrations (mg/l).

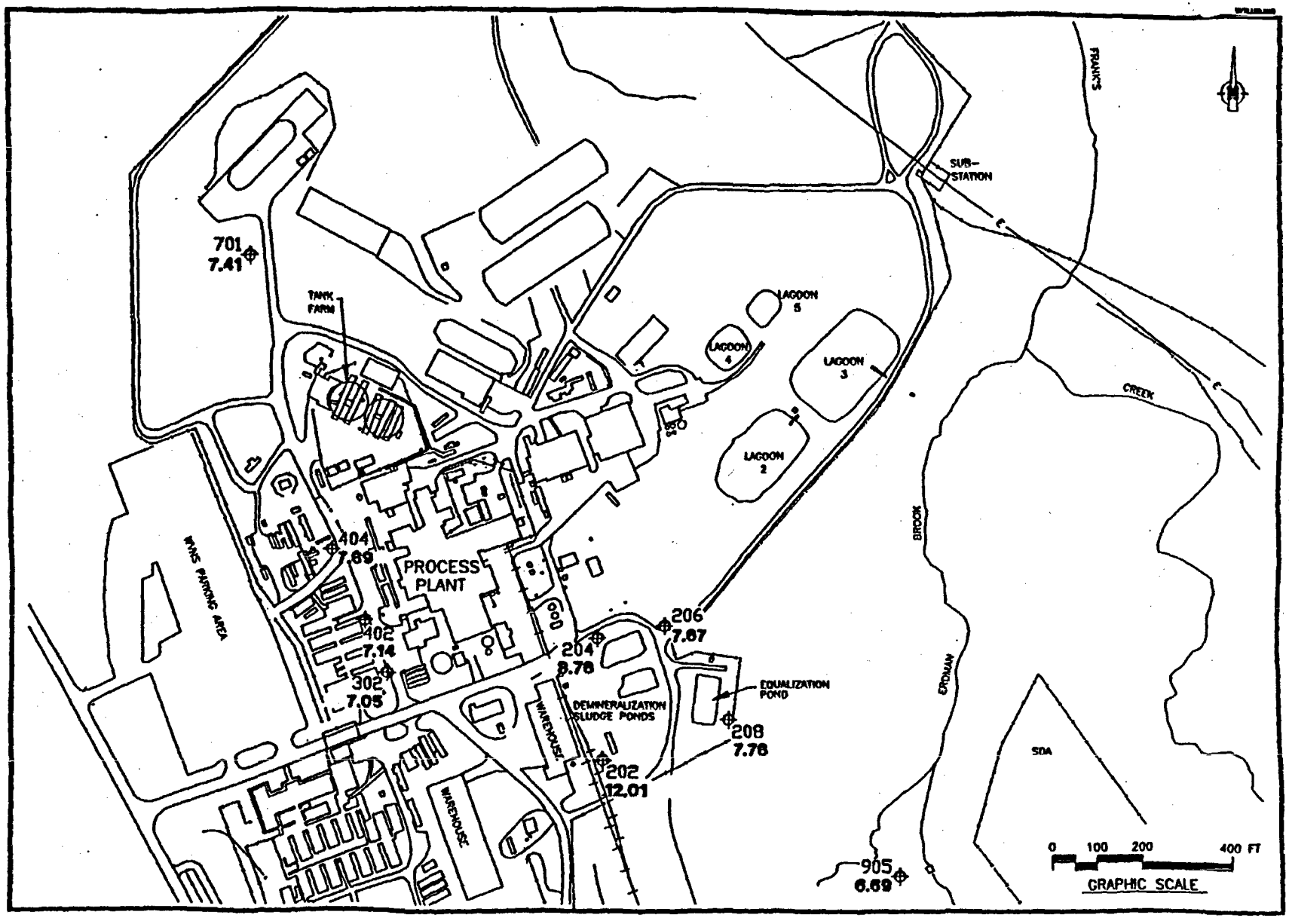


Figure 4-155 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean pH Levels.

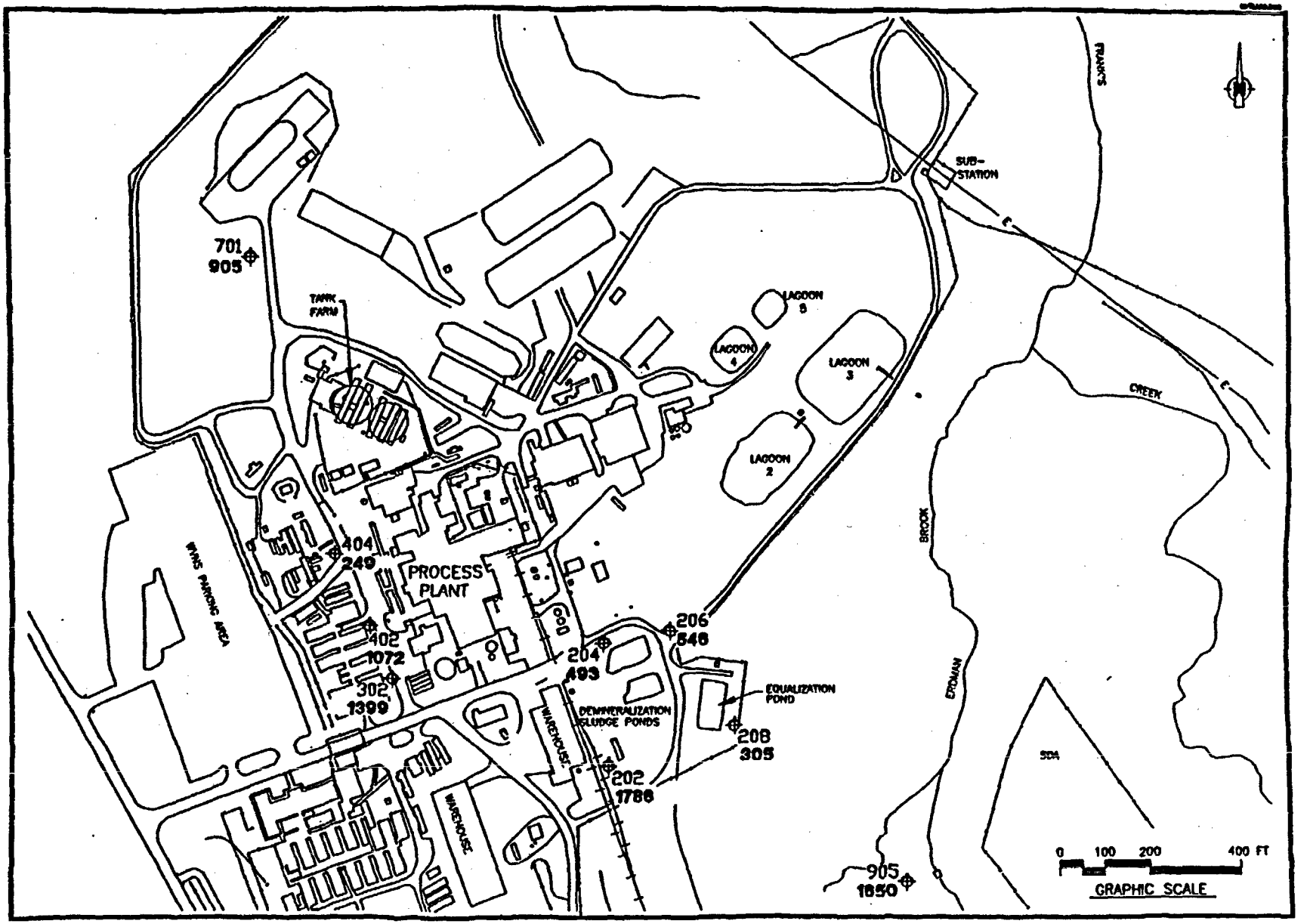


Figure 4-156 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Specific Conductivity (umhos/cm @ 25°C).

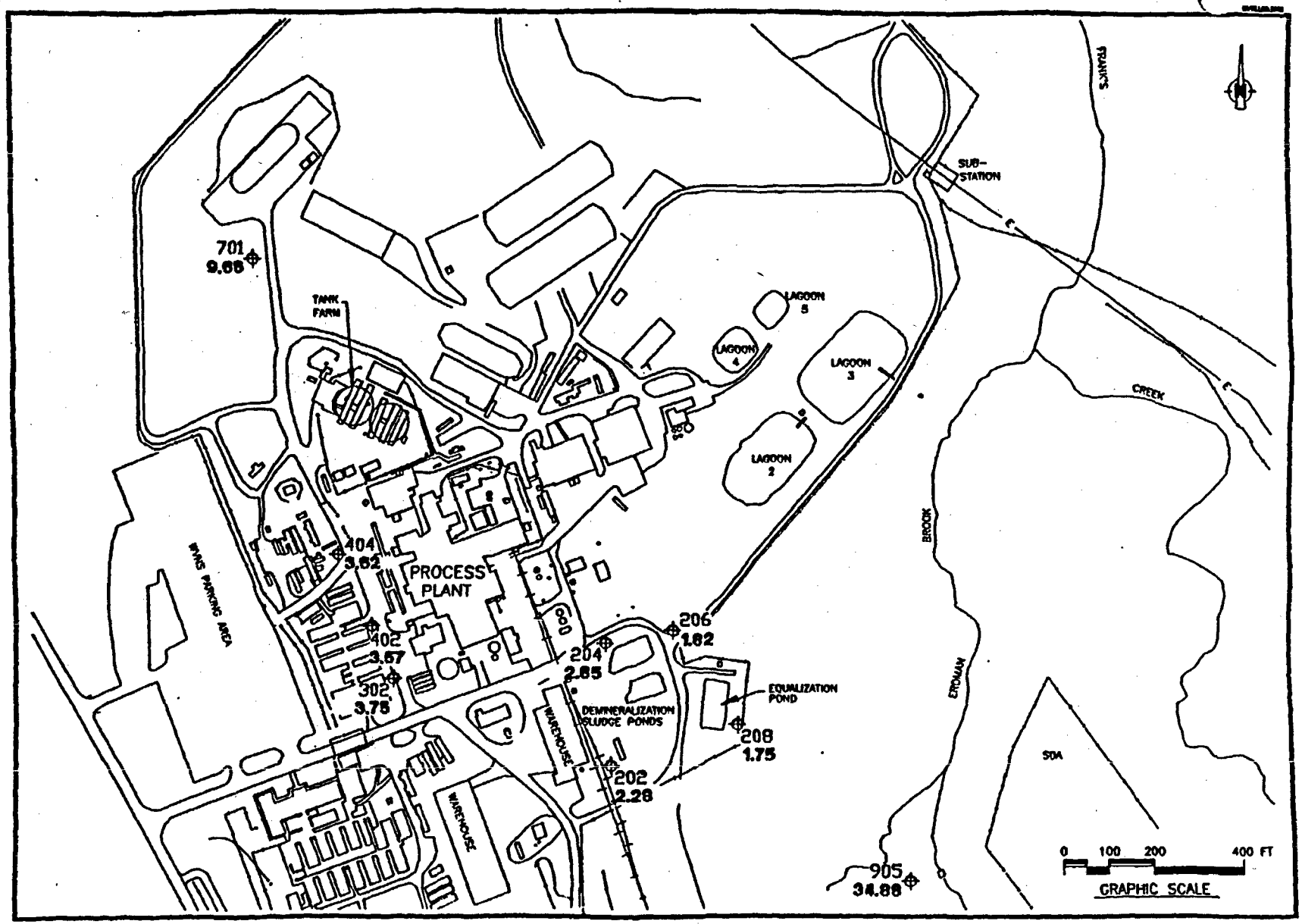


Figure 4-157 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Carbon (TOC) Concentrations (mg/l).

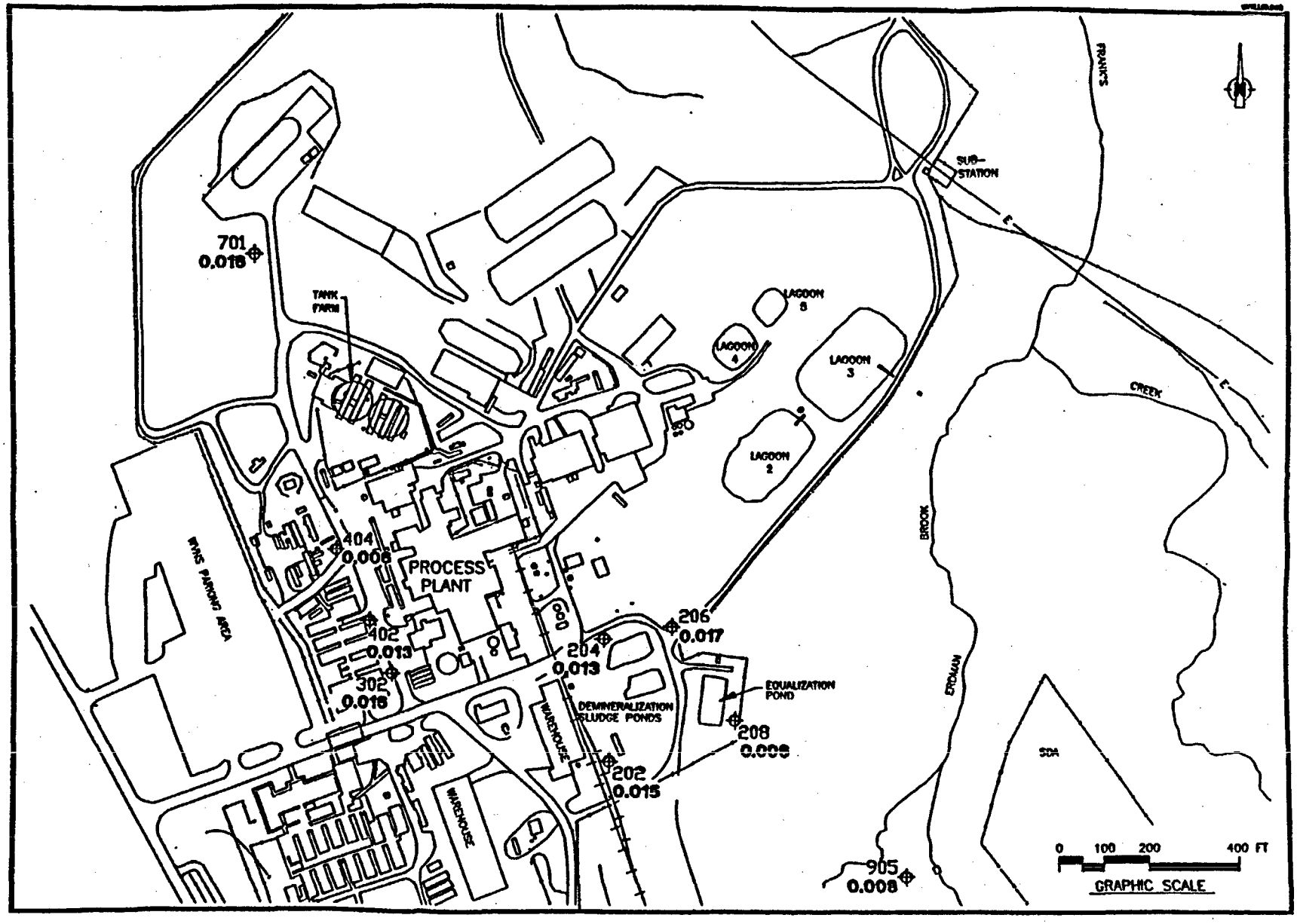


Figure 4-158 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Halogen (TOX) Concentrations (mg/l).

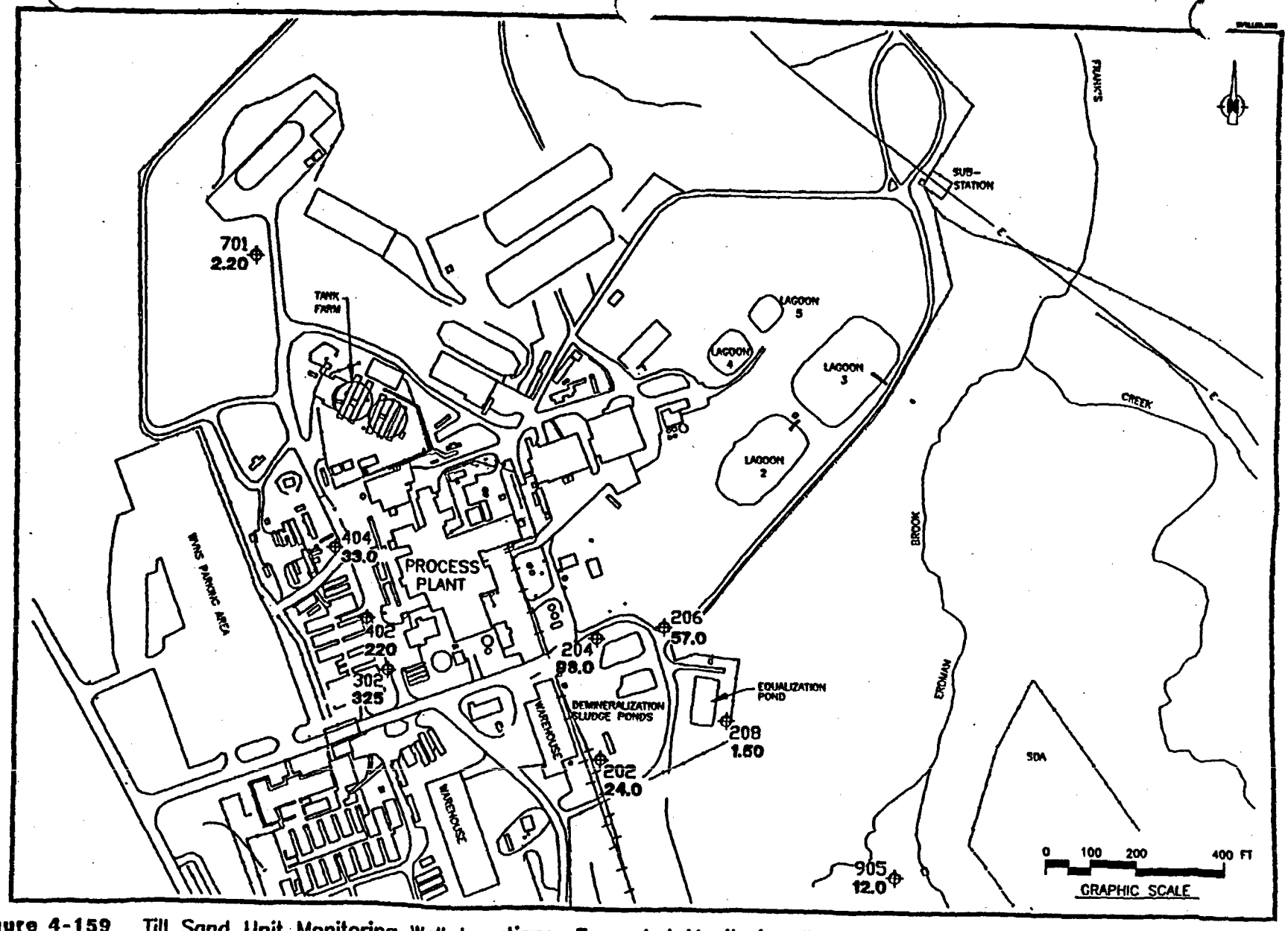


Figure 4-159 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Chloride Concentrations (mg/l).

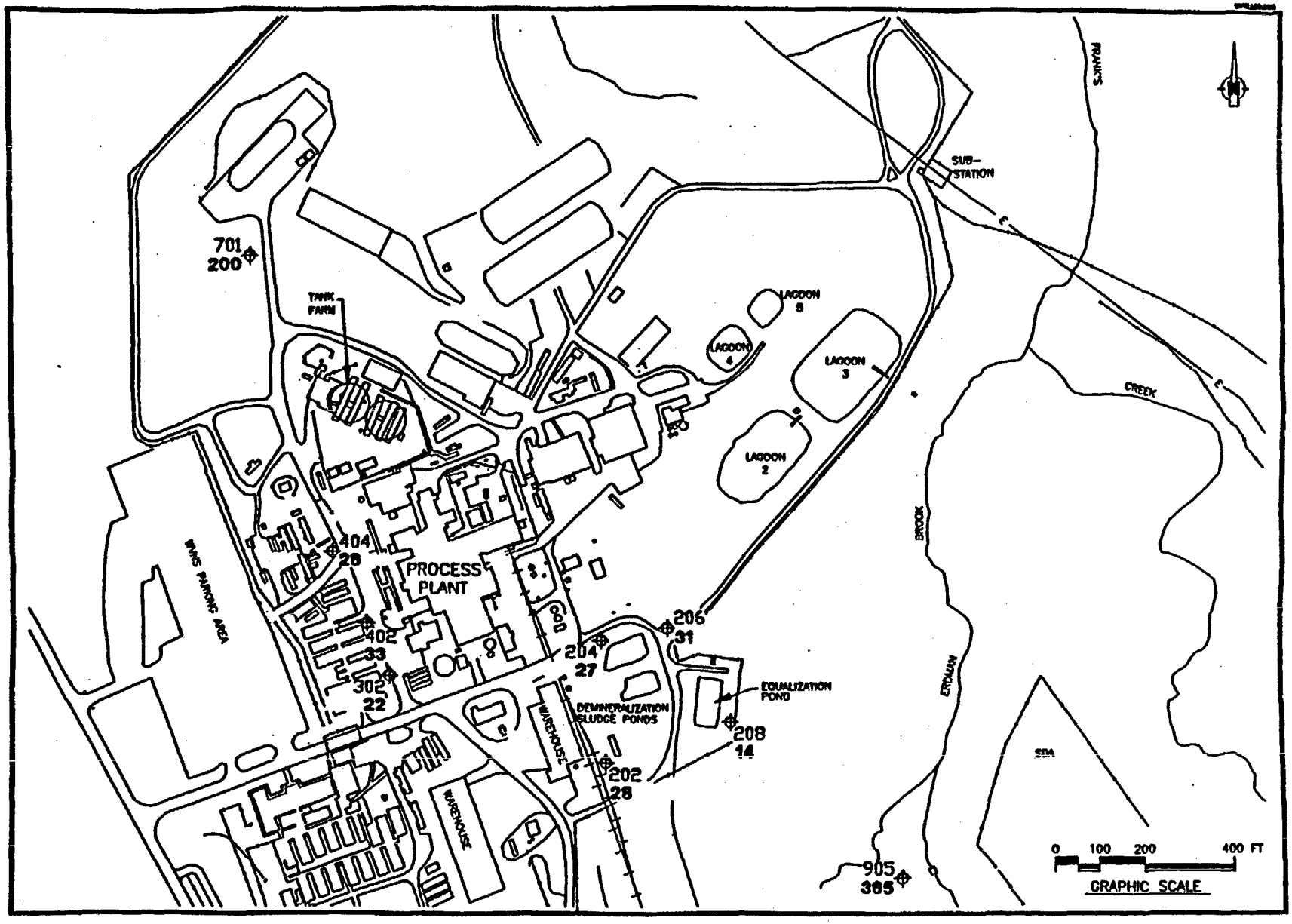


Figure 4-160 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sulfate Concentrations (mg/l).

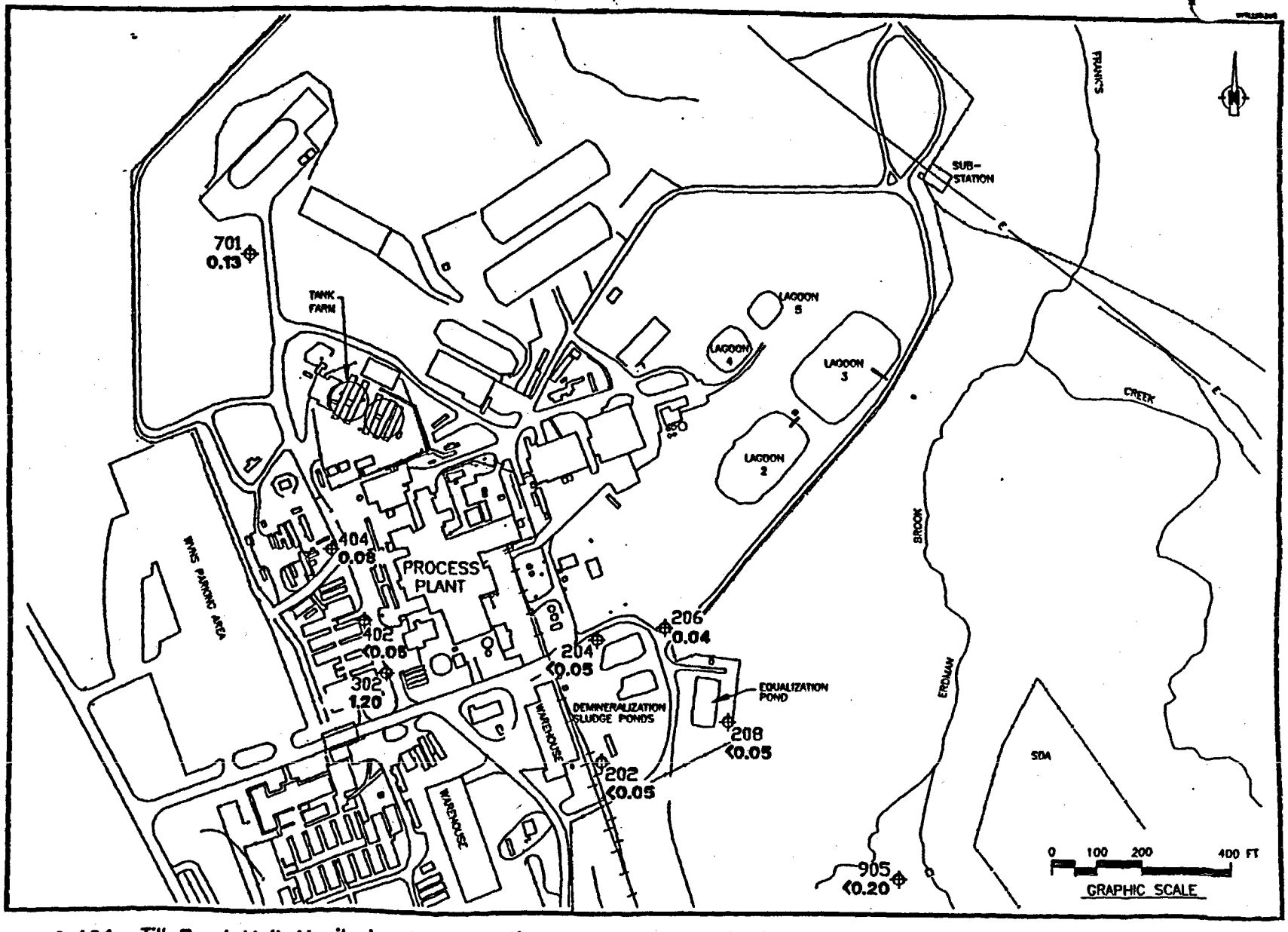


Figure 4-161 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Nitrate + Nitrite – N Concentrations (mg/l).

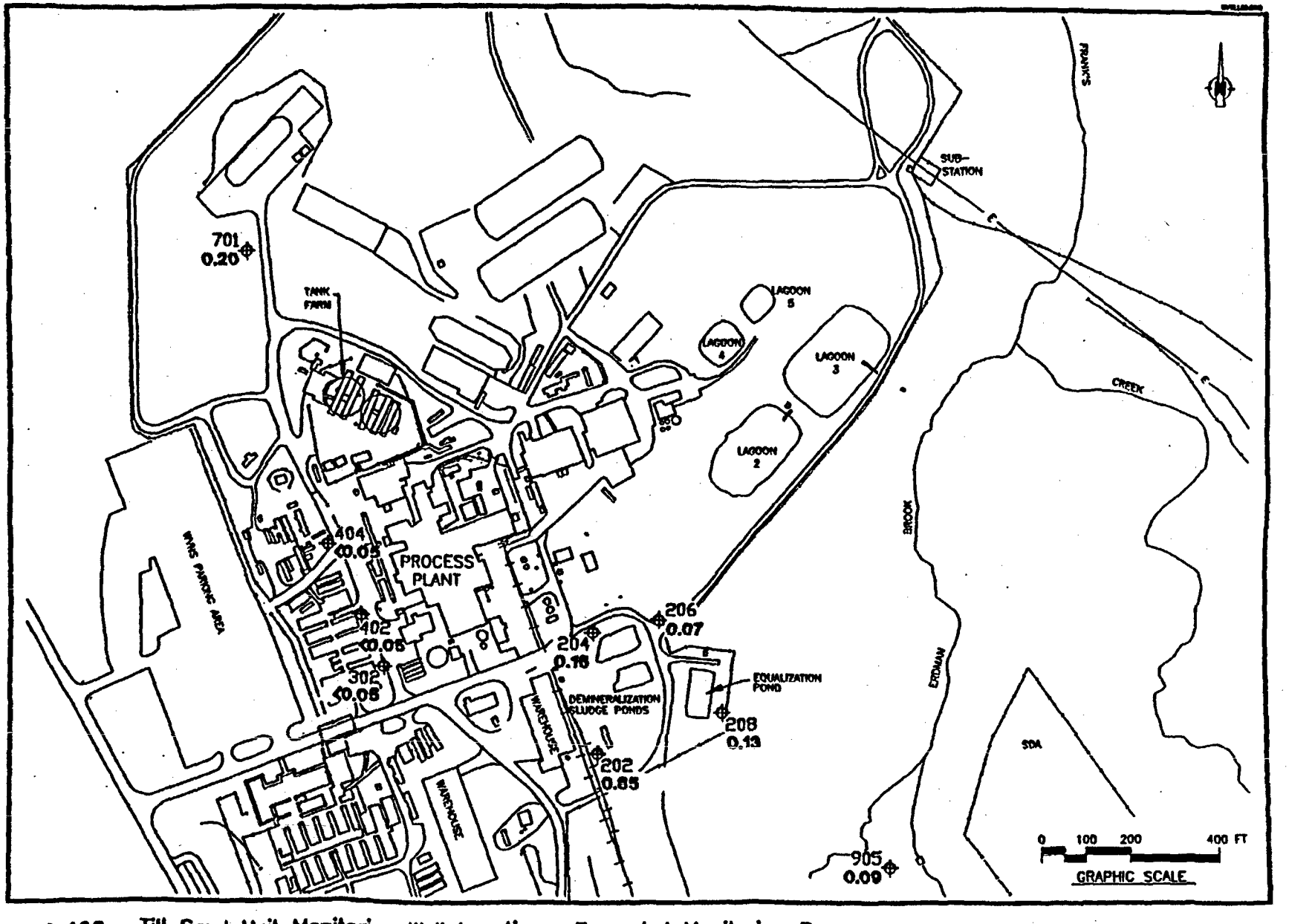


Figure 4-162 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Ammonia Concentrations (mg/l).

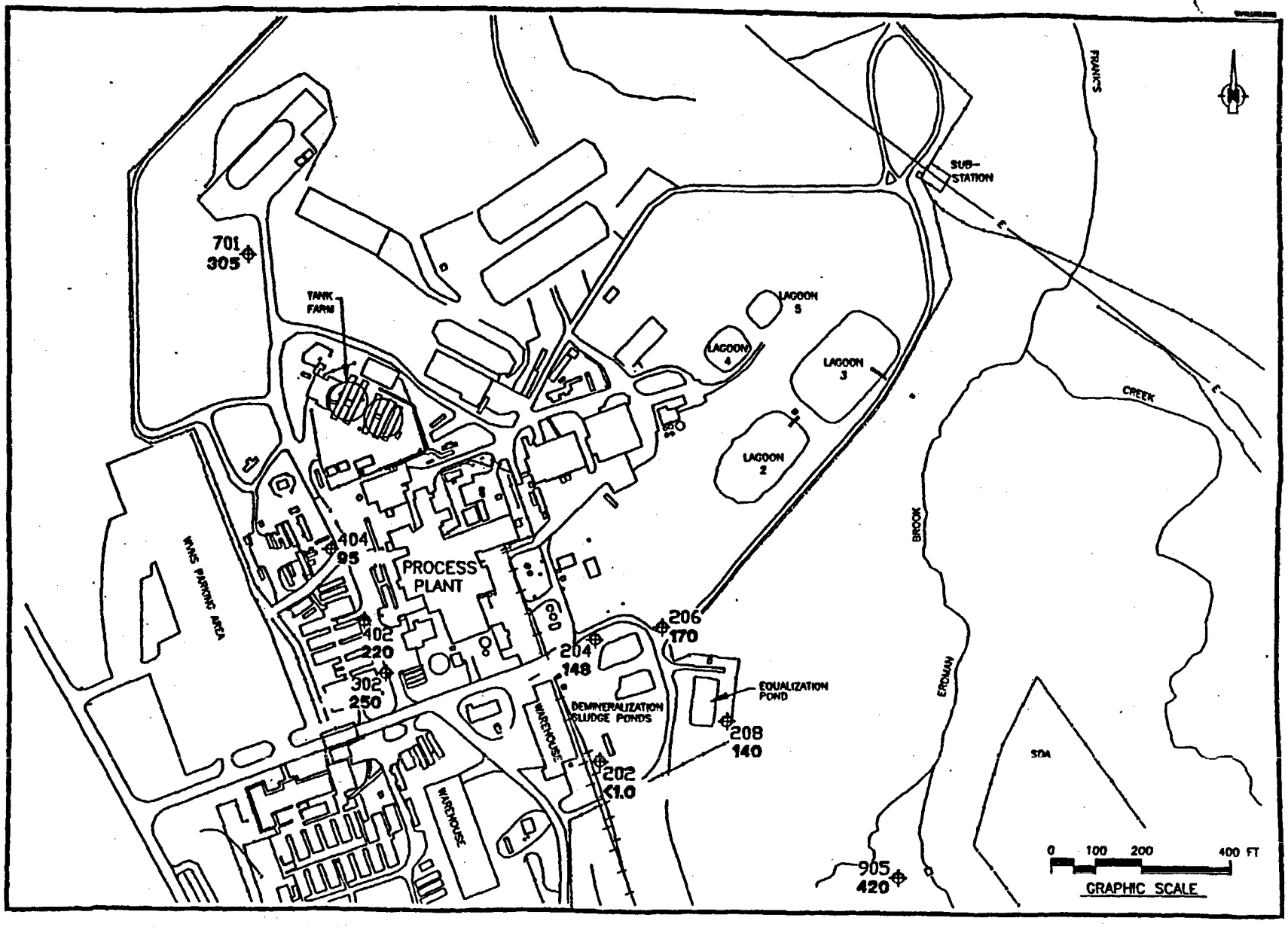


Figure 4-163 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Bicarbonate Alkalinity Levels (mg/l).

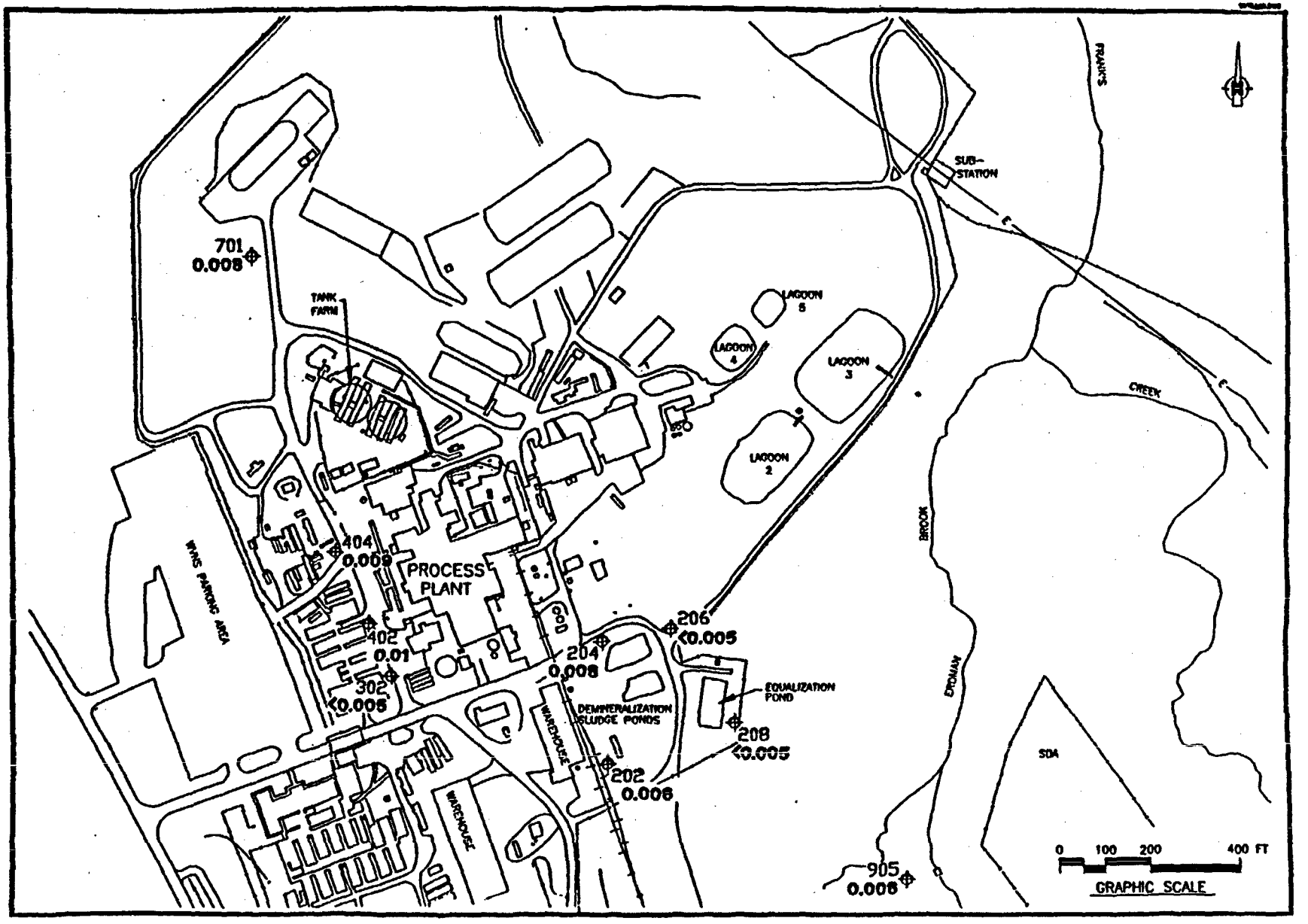


Figure 4-164 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Phenol Concentrations (mg/l).

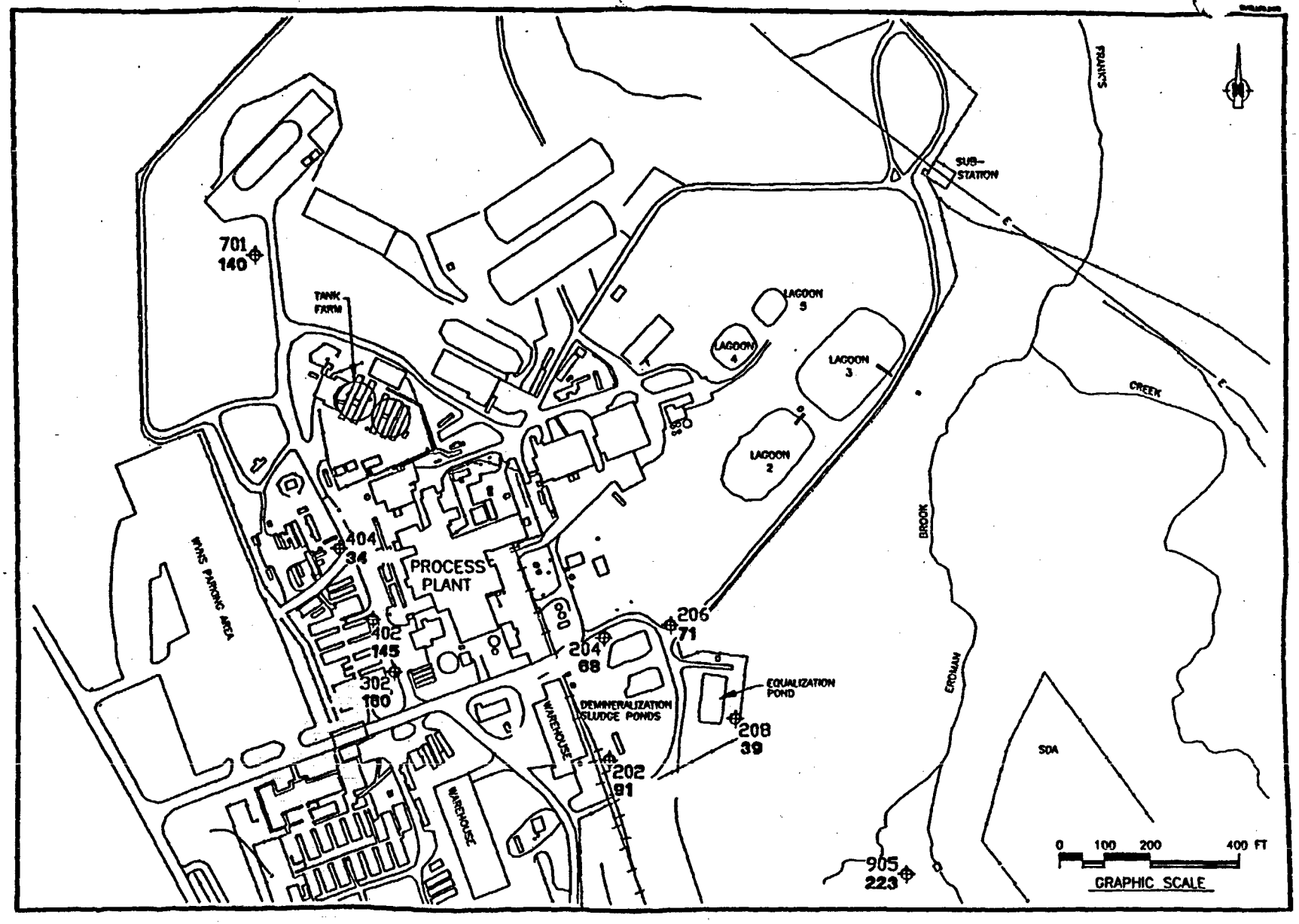


Figure 4-165 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Calcium Concentrations (mg/l).

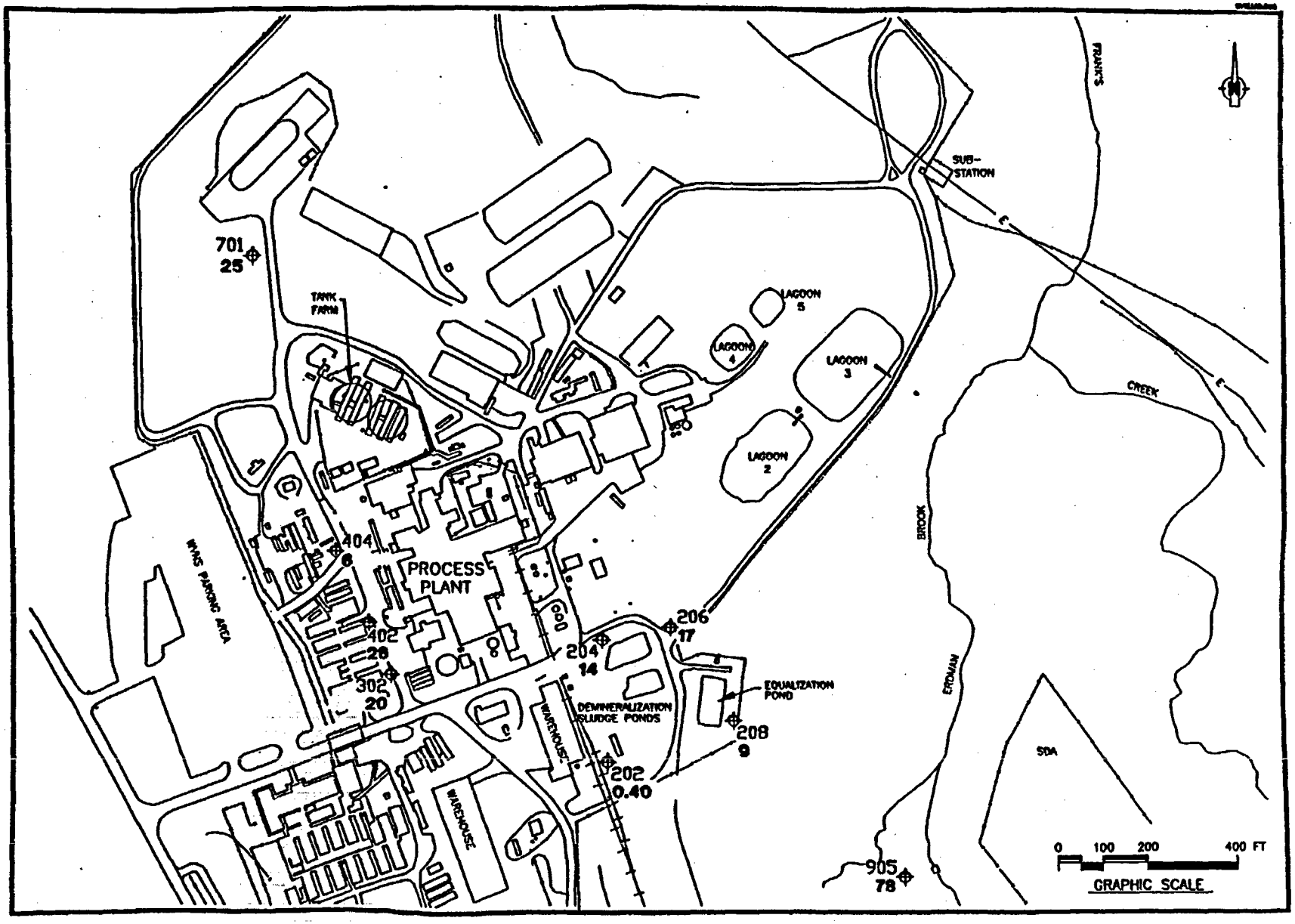


Figure 4-166 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Magnesium Concentrations (mg/l).

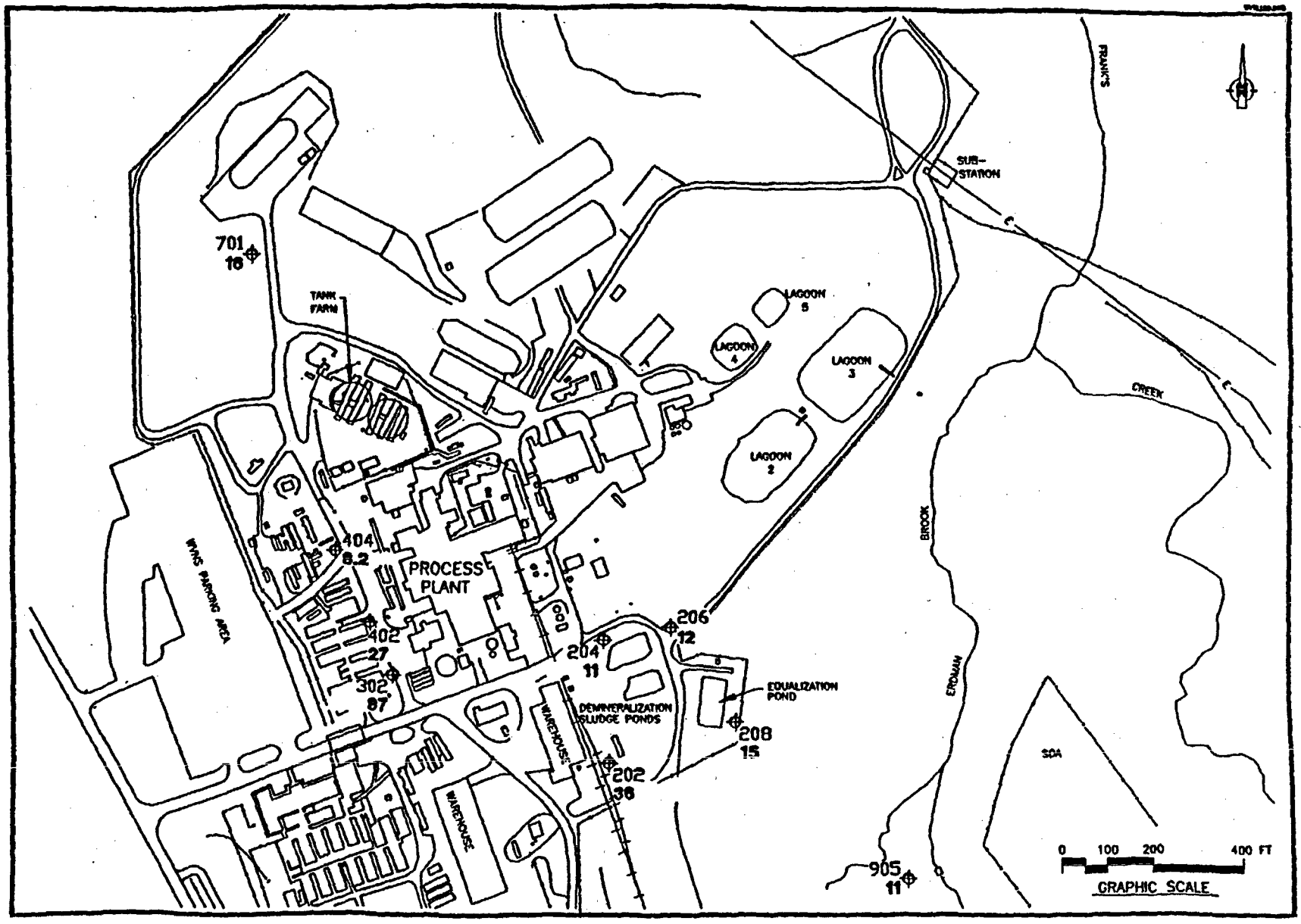


Figure 4-167 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sodium Concentrations (mg/l).

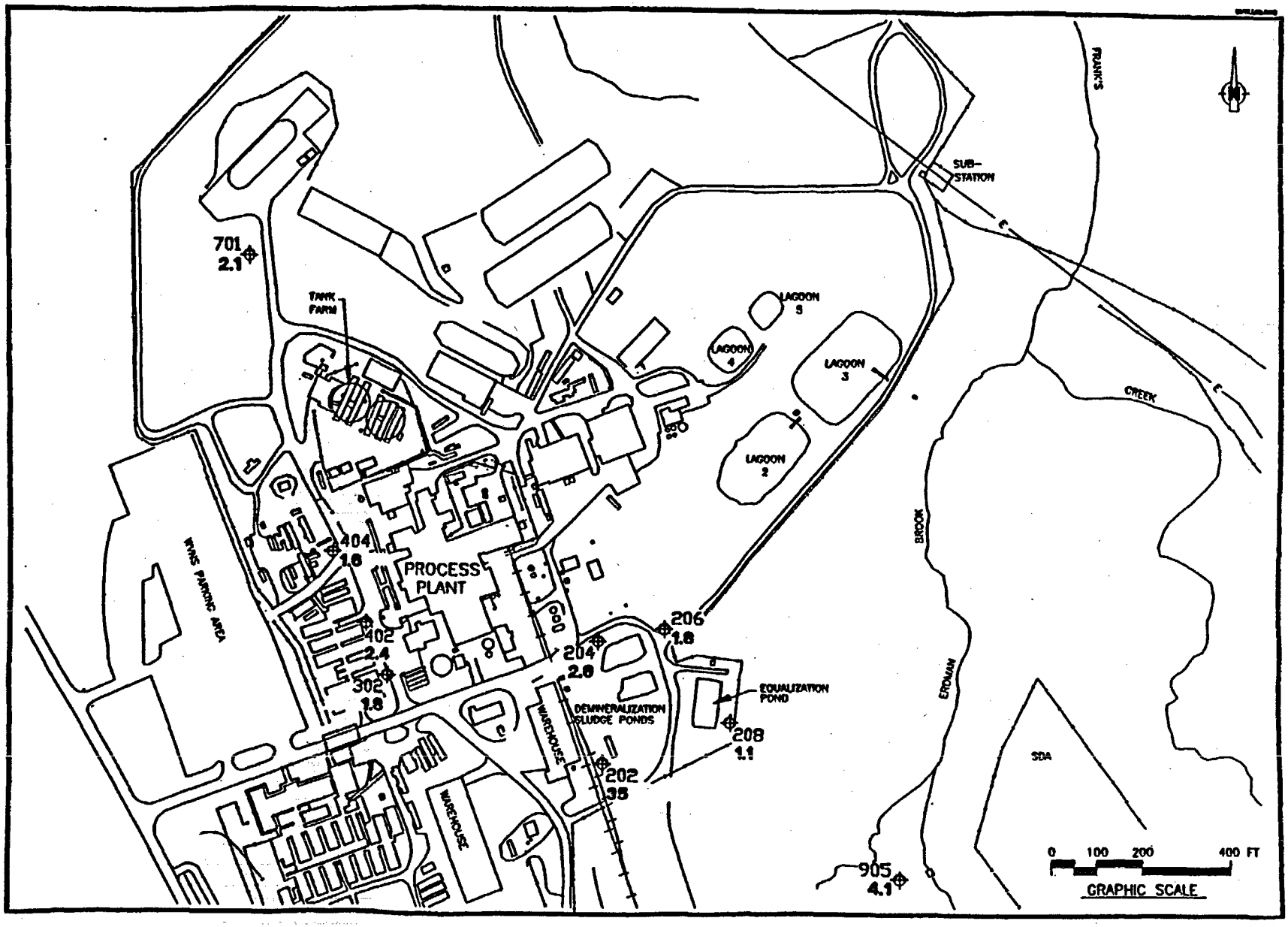


Figure 4-168 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Potassium Concentrations (mg/l).

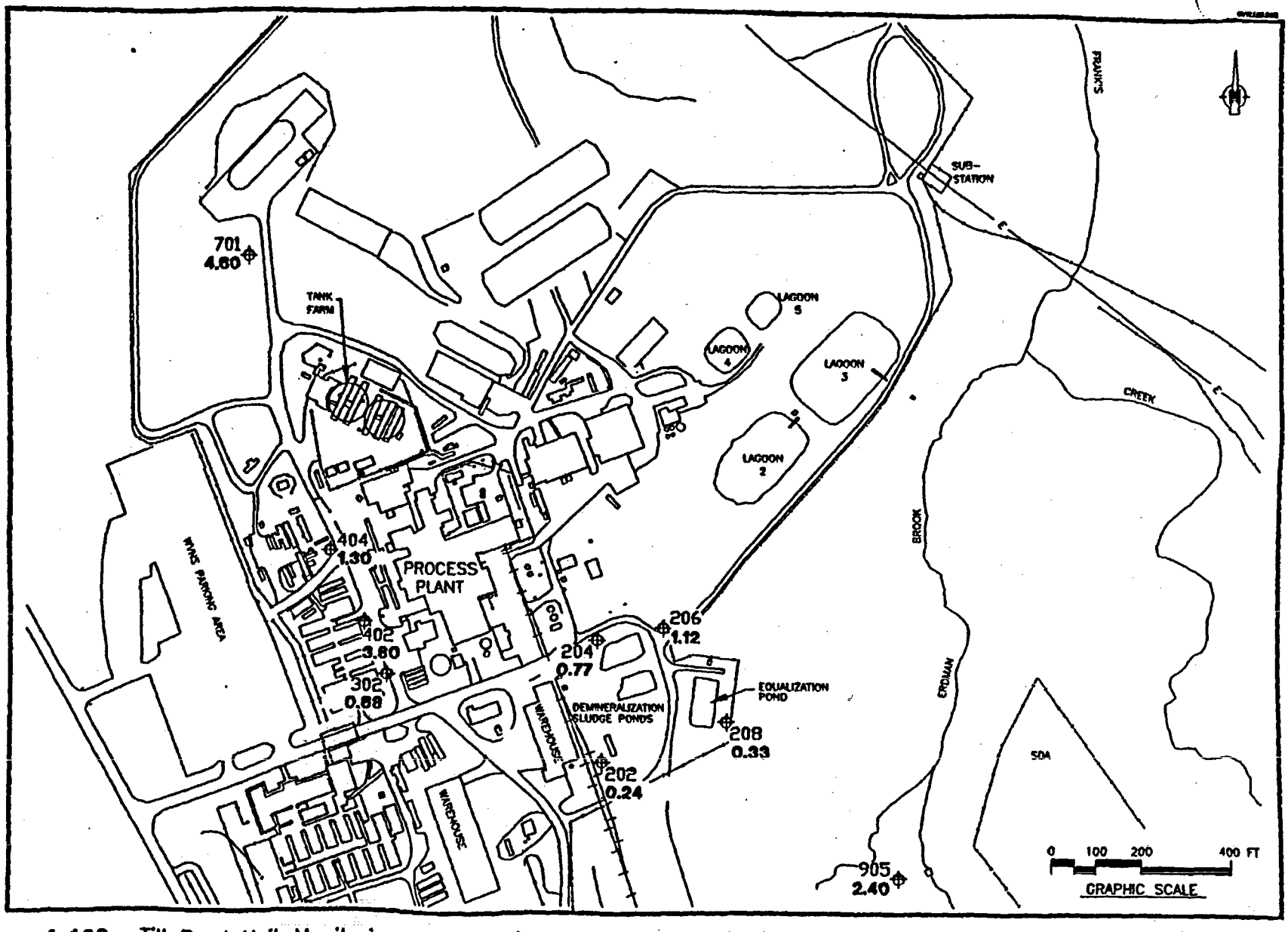


Figure 4-169 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Iron Concentrations (mg/l).

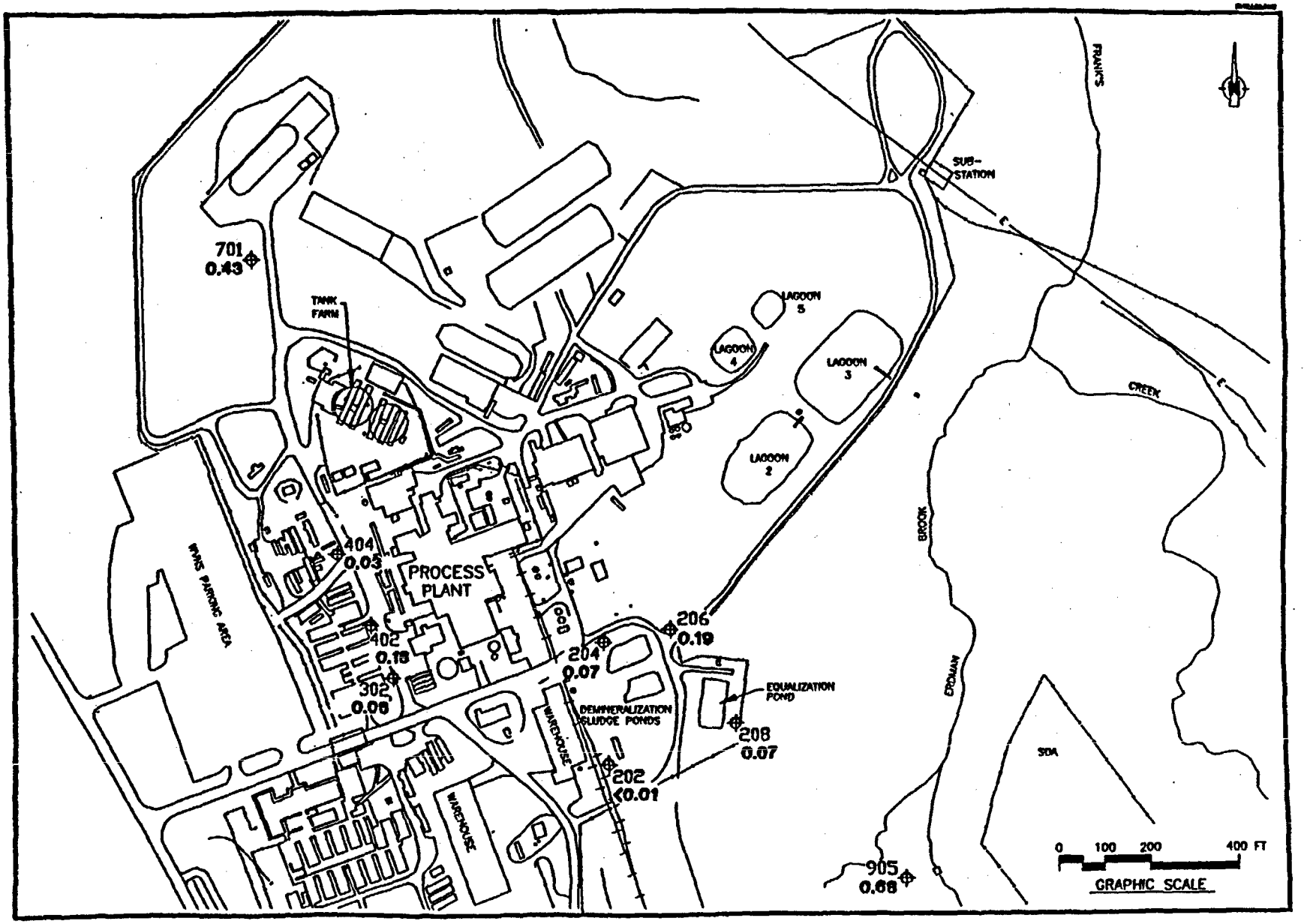


Figure 4-170 Till Sand Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Manganese Concentrations (mg/l).

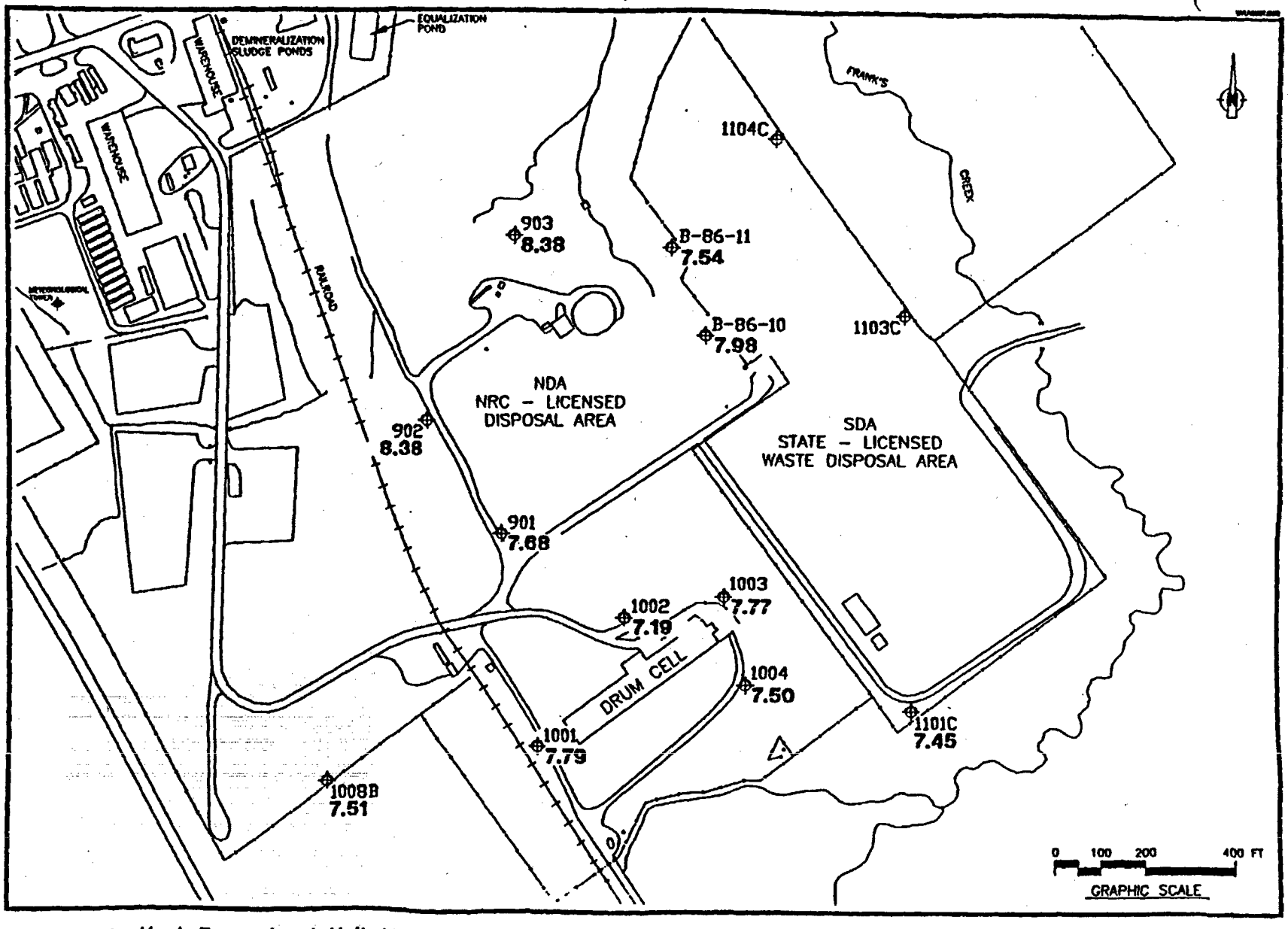


Figure 4-171 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean pH Levels.

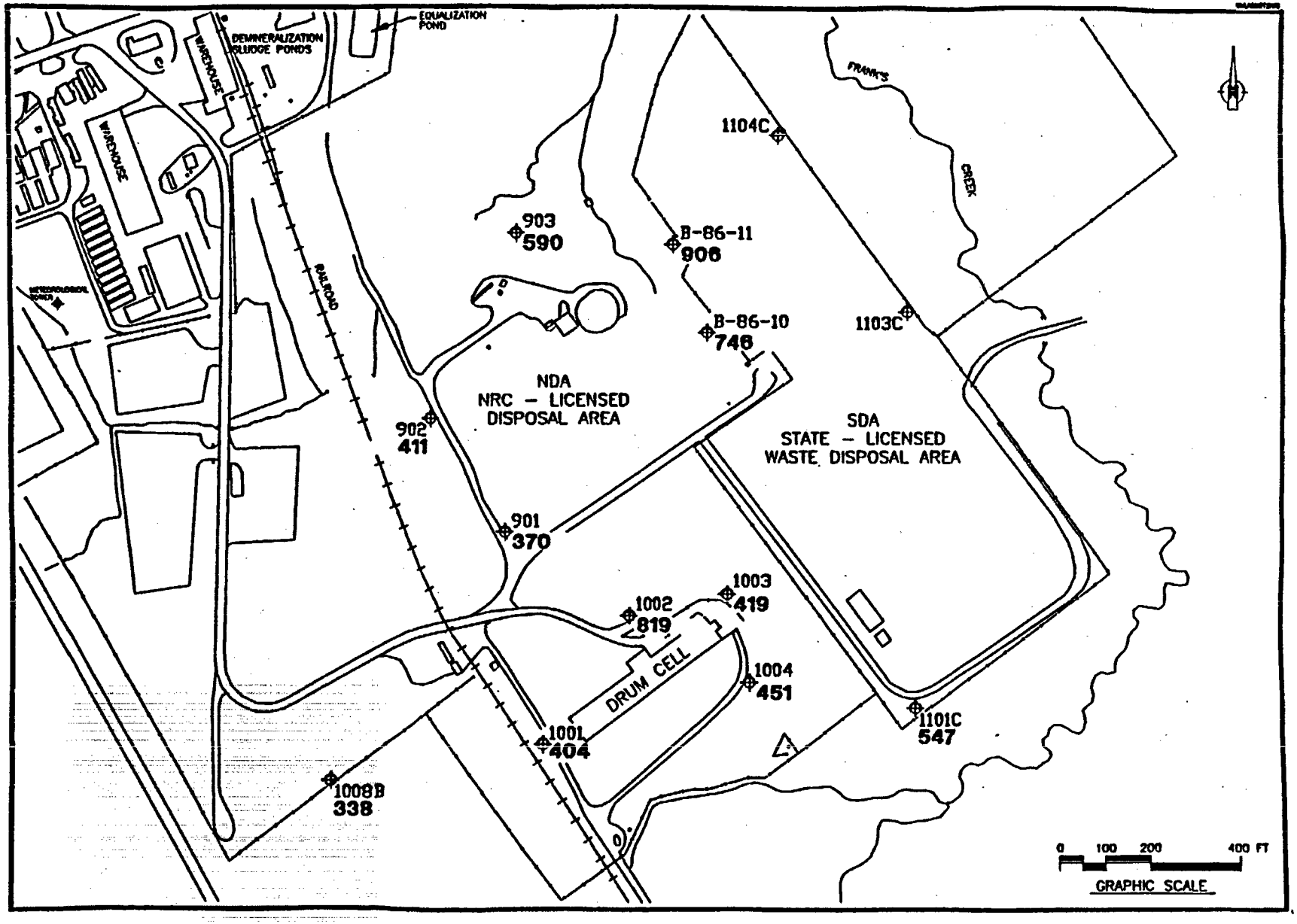


Figure 4-172 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Specific Conductivity (umhos/cm @ 25°C).

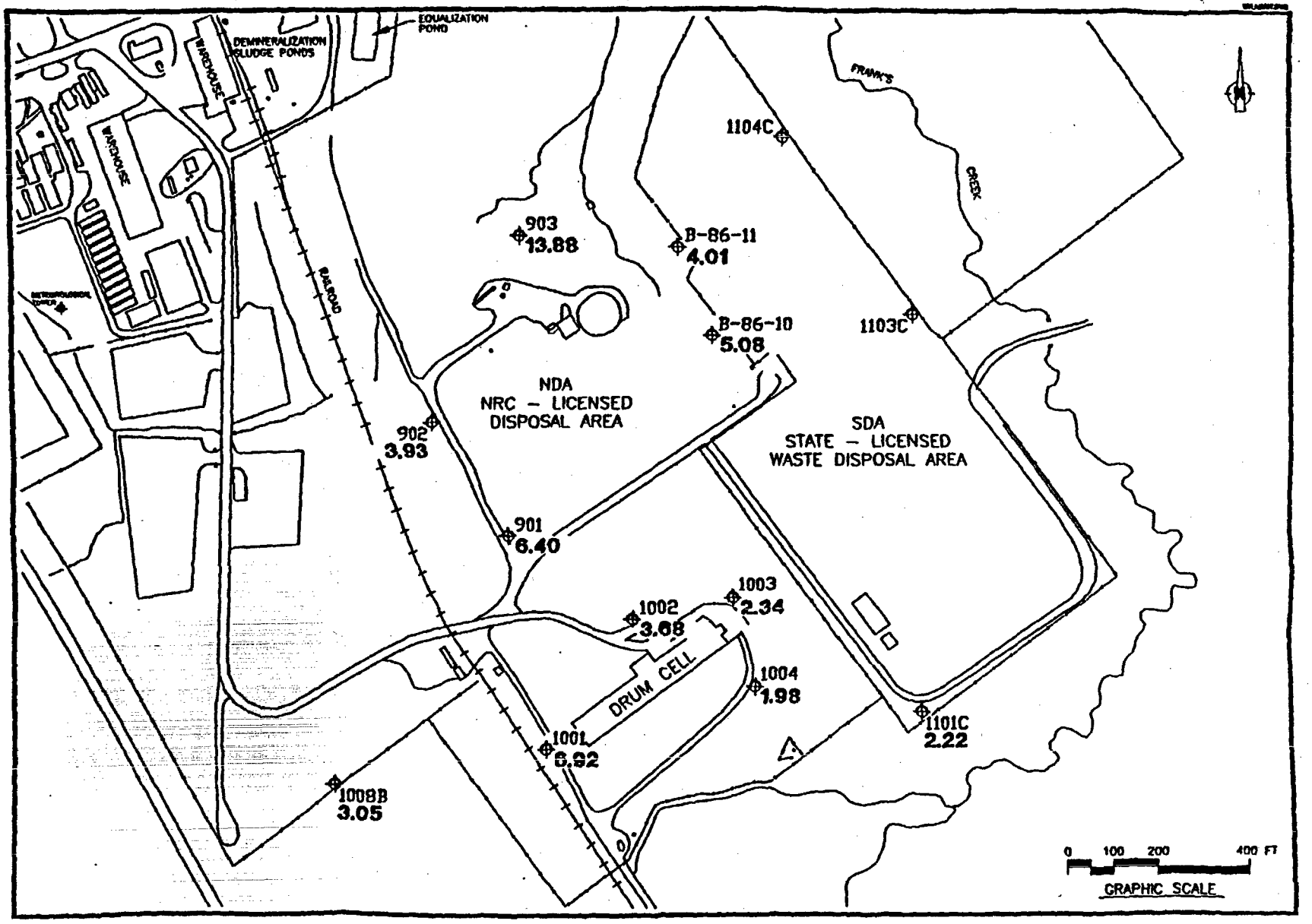


Figure 4-173 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Carbon (TOC) Concentrations (mg/l).

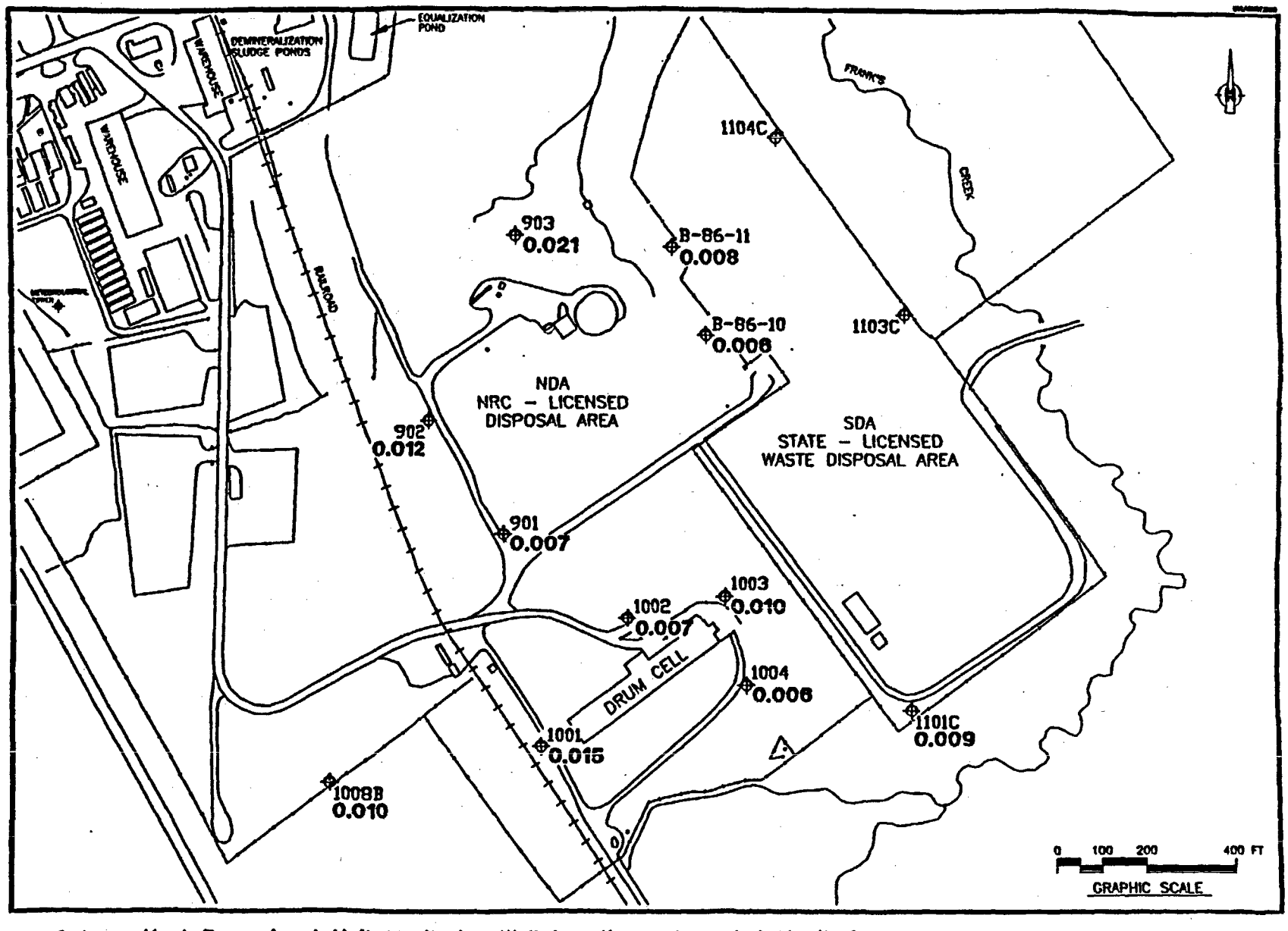


Figure 4-174 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Total Organic Halogen (TOX) Concentrations (mg/l).

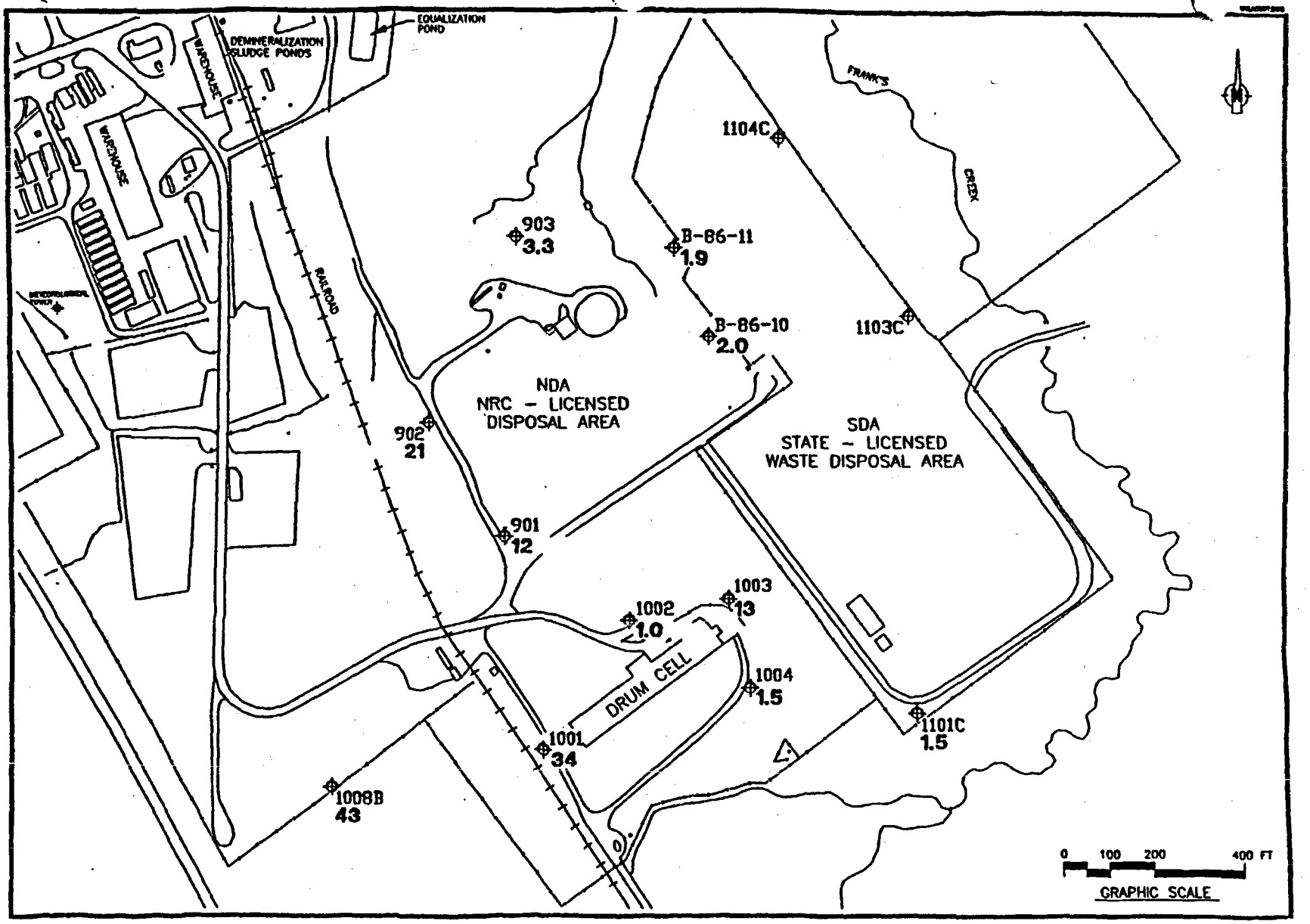


Figure 4-175 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Chloride Concentrations (mg/l).

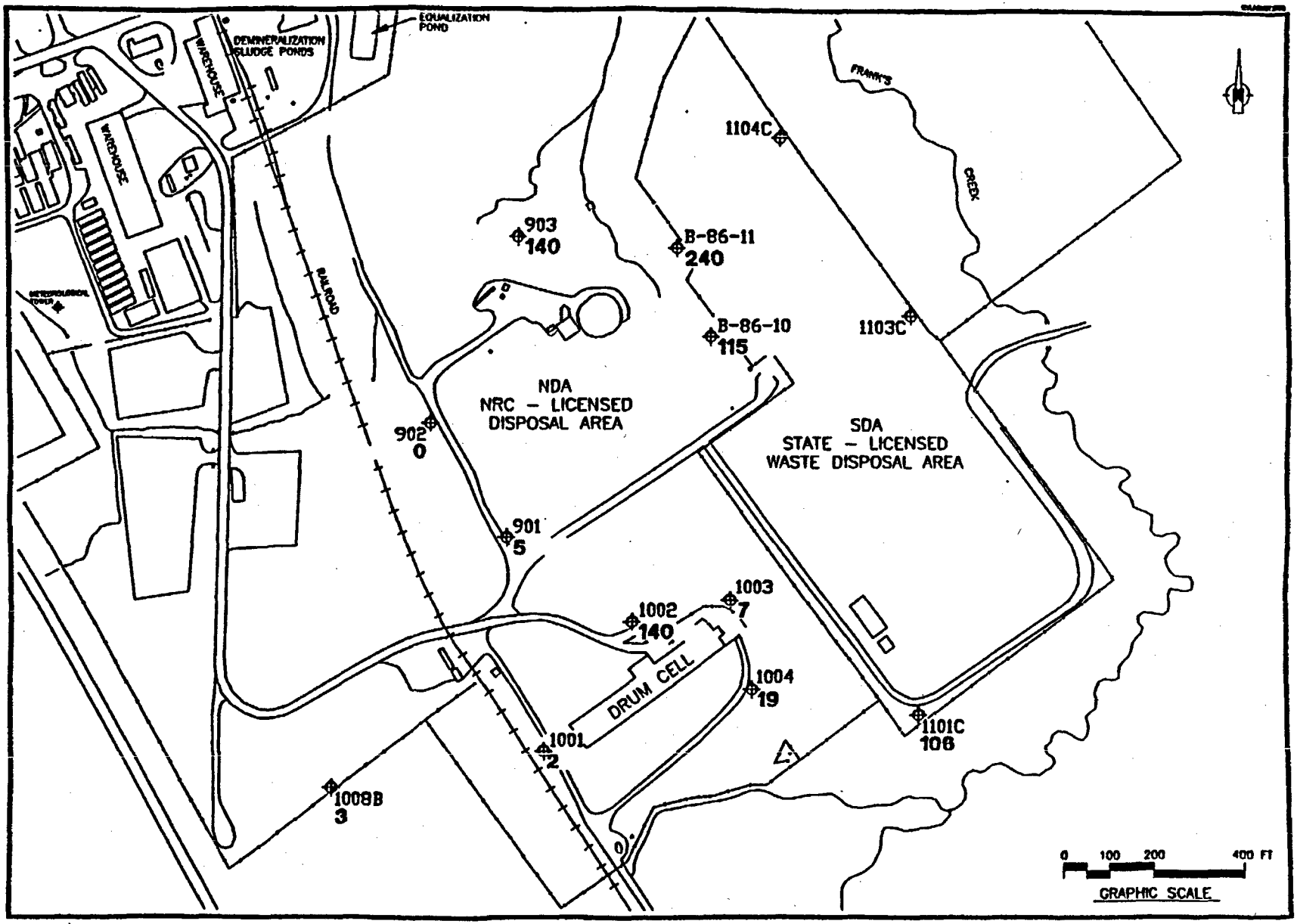


Figure 4-176 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sulfate Concentrations (mg/l).

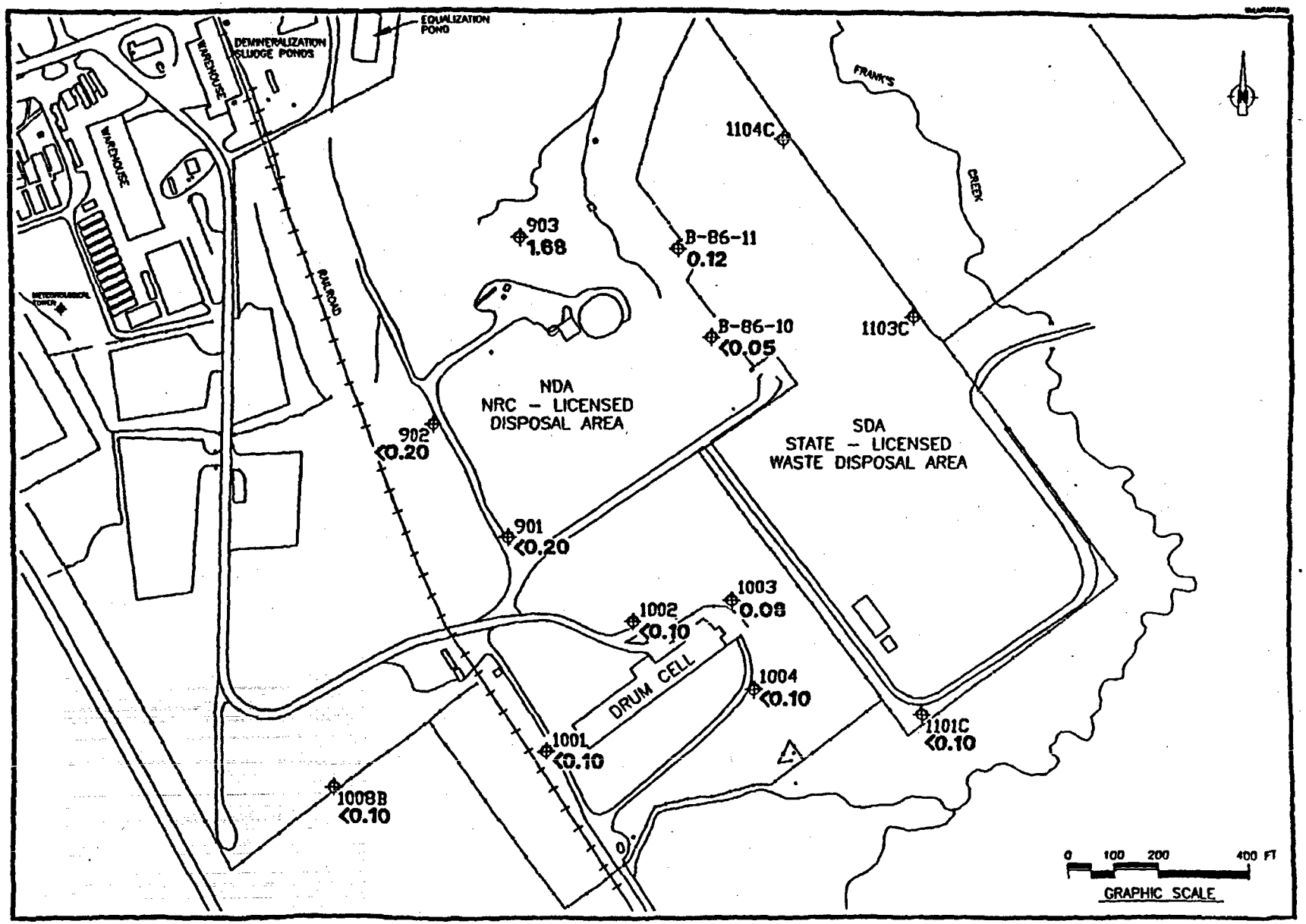


Figure 4-177 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Nitrate + Nitrite – N Concentrations (mg/l).

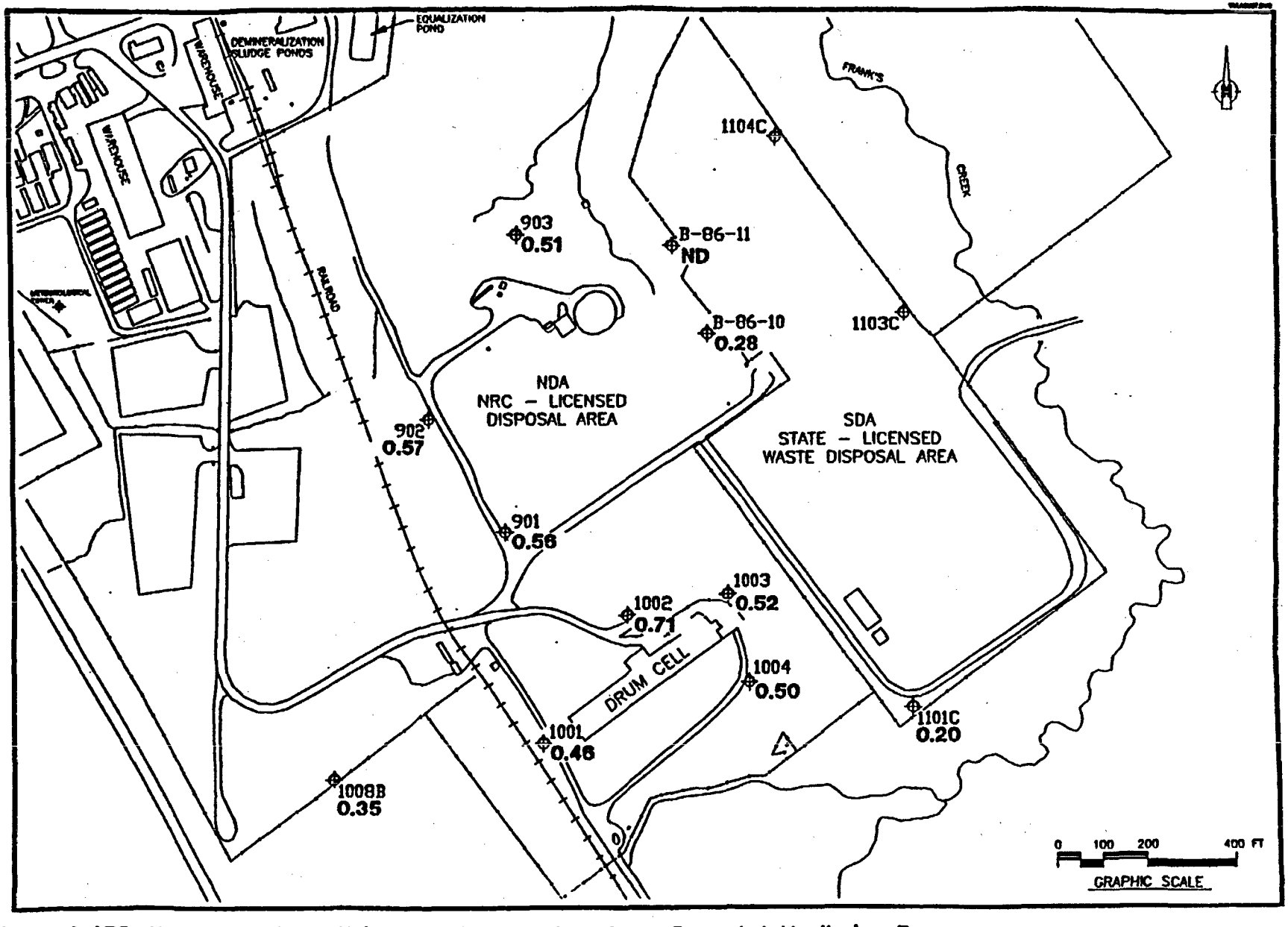


Figure 4-178 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Ammonia Concentrations (mg/l) (ND = Non-Detected).

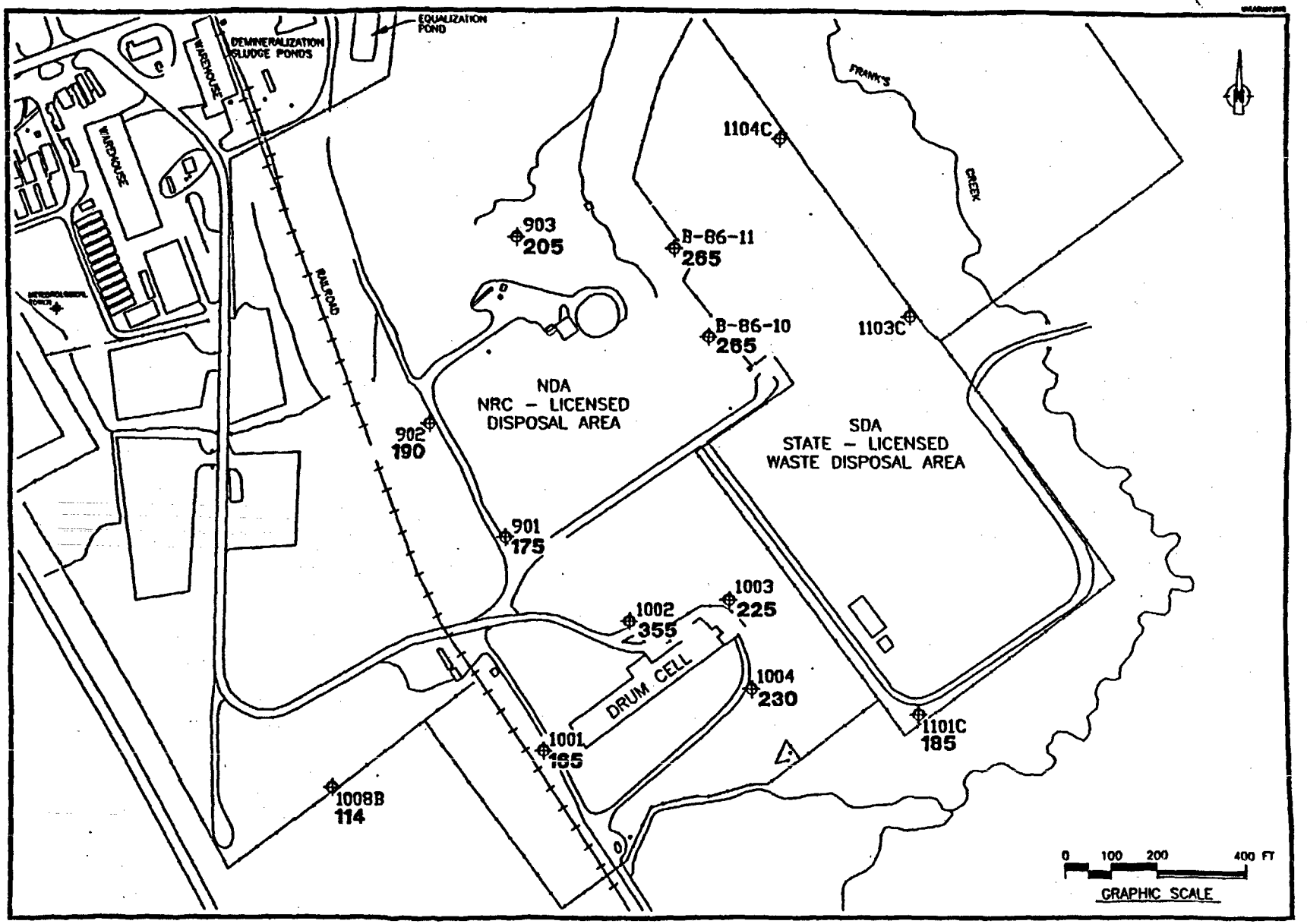


Figure 4-179 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Bicarbonate Alkalinity Levels (mg/l).

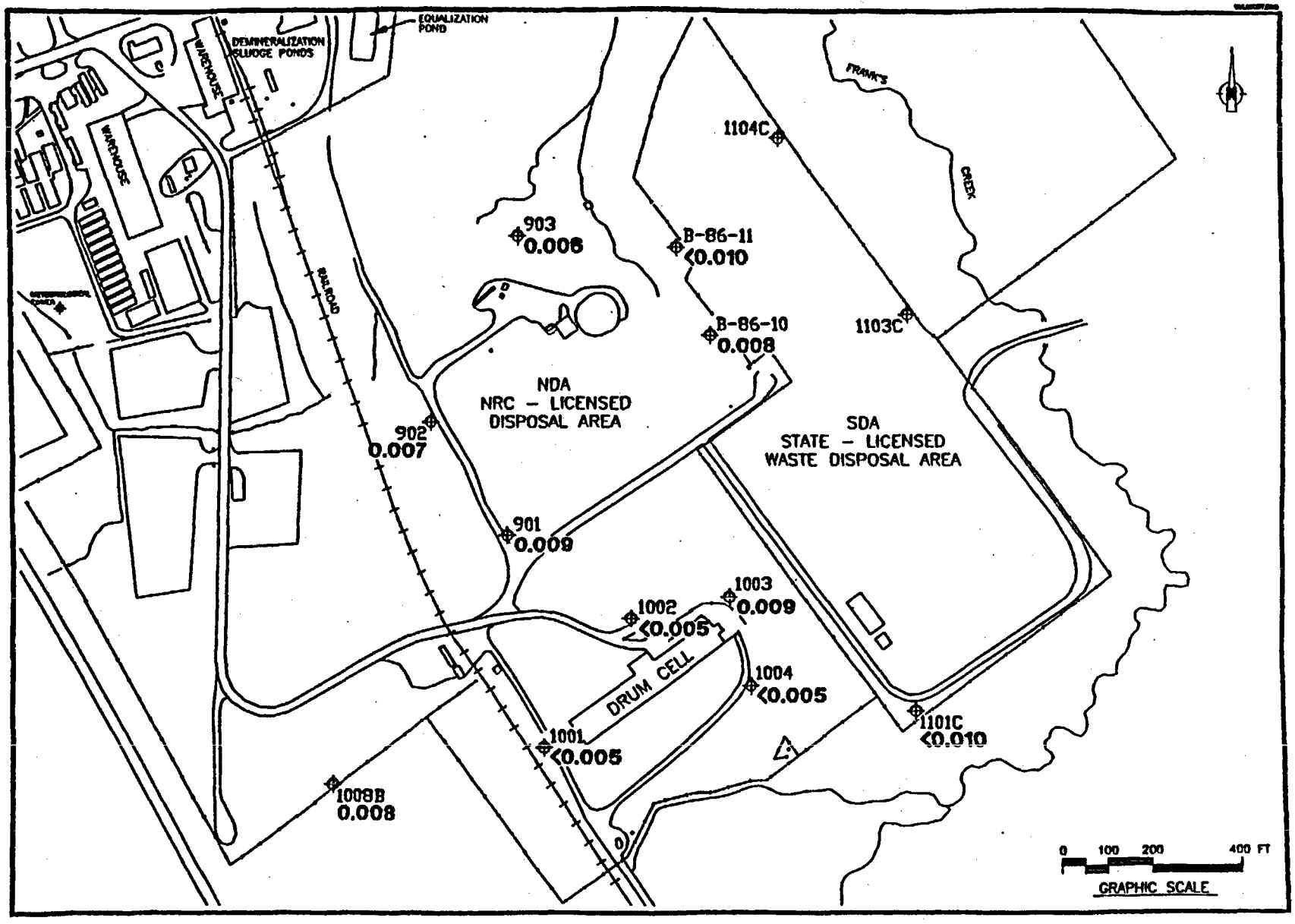


Figure 4-180 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Phenol Concentrations (mg/l).

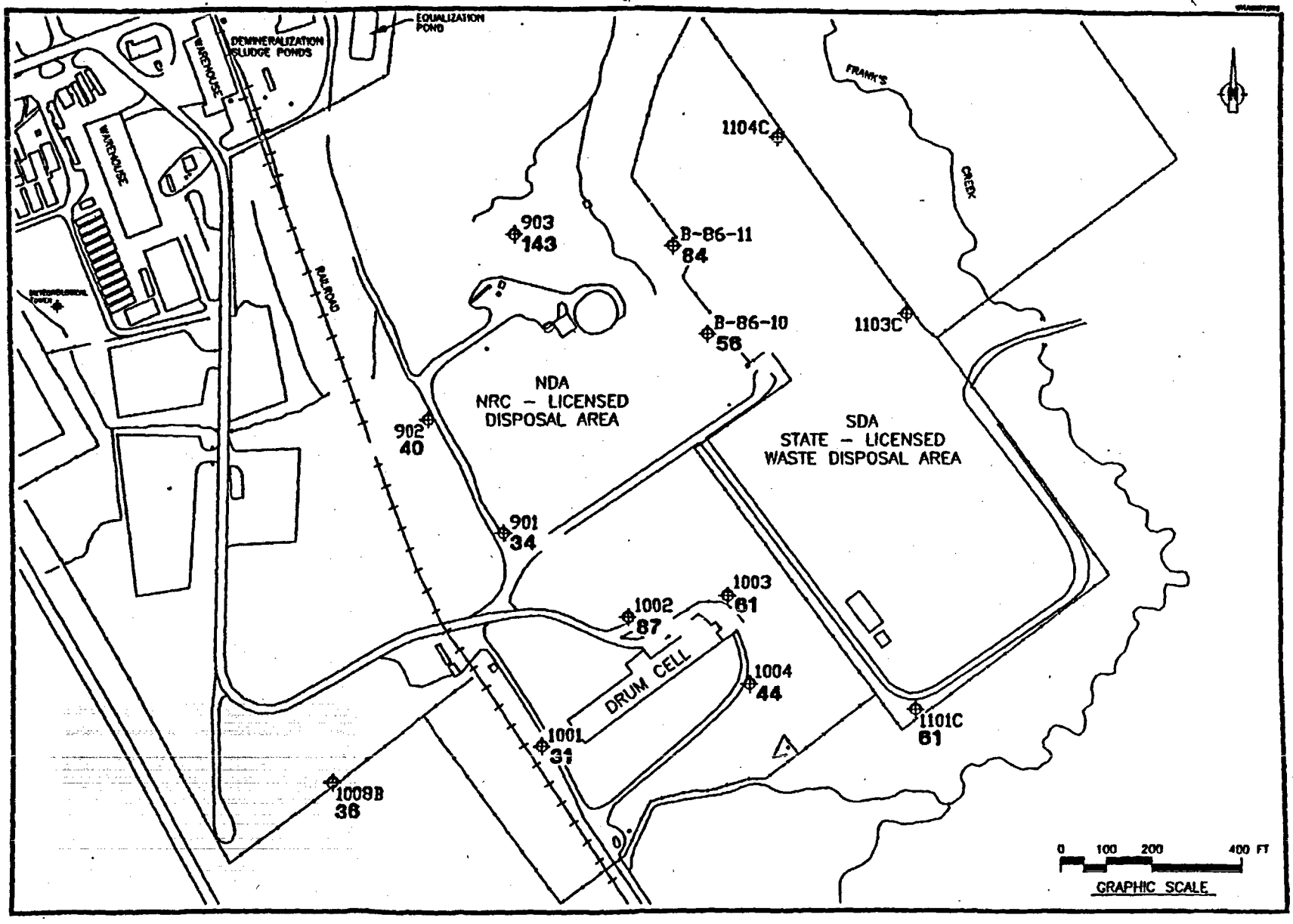


Figure 4-181 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Calcium Concentrations (mg/l).

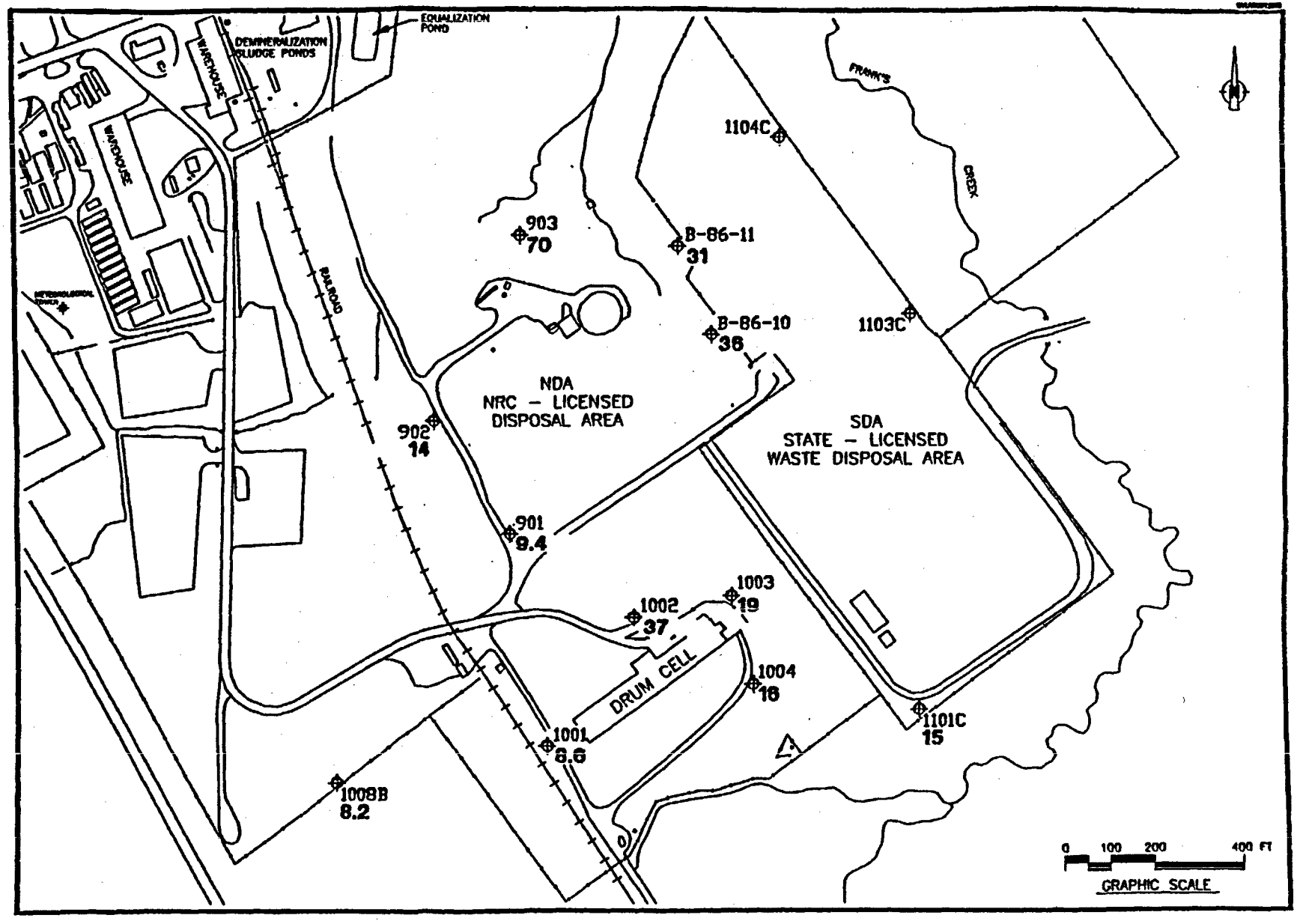


Figure 4-182 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Magnesium Concentrations (mg/l).

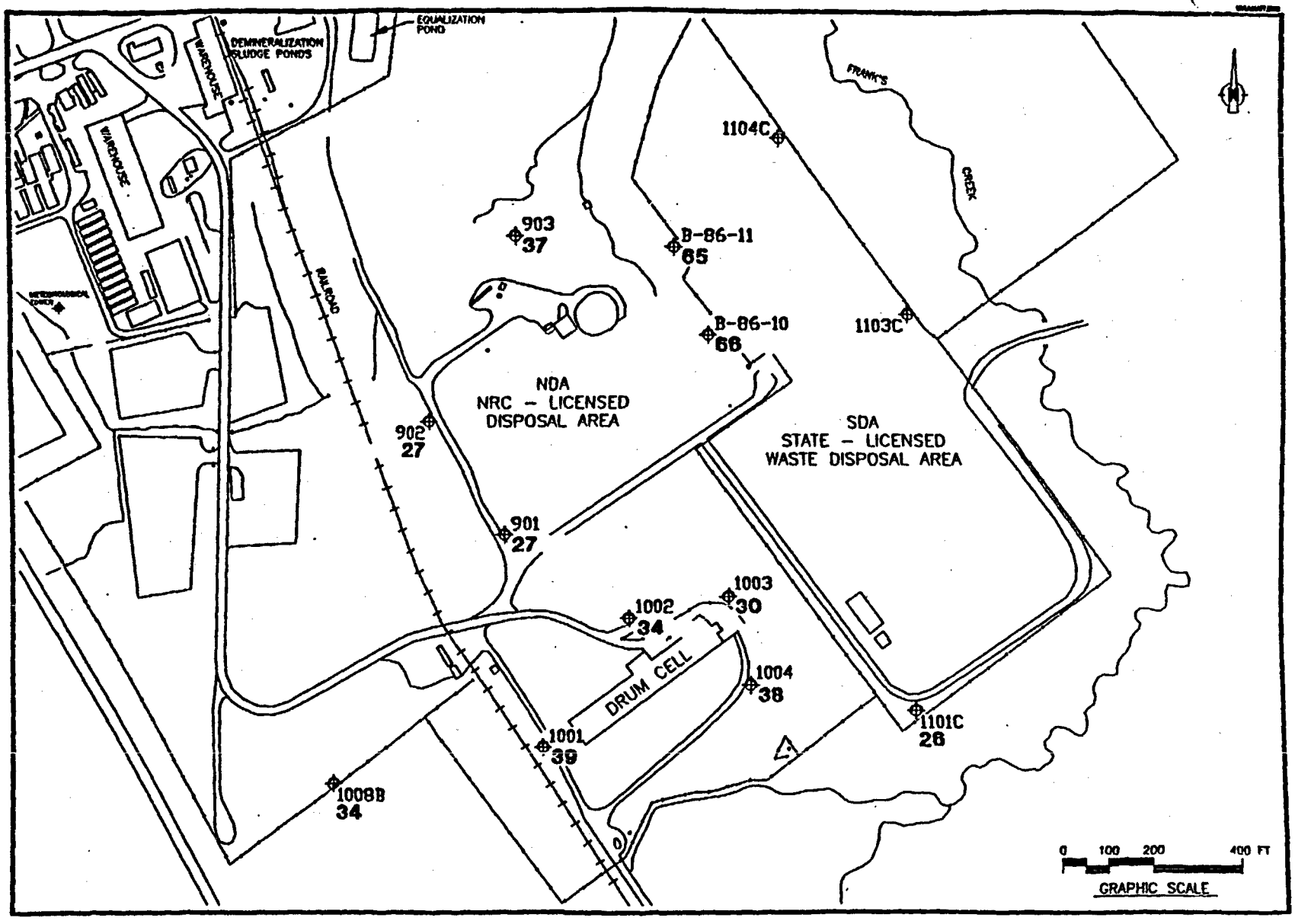


Figure 4-183 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Sodium Concentrations (mg/l).

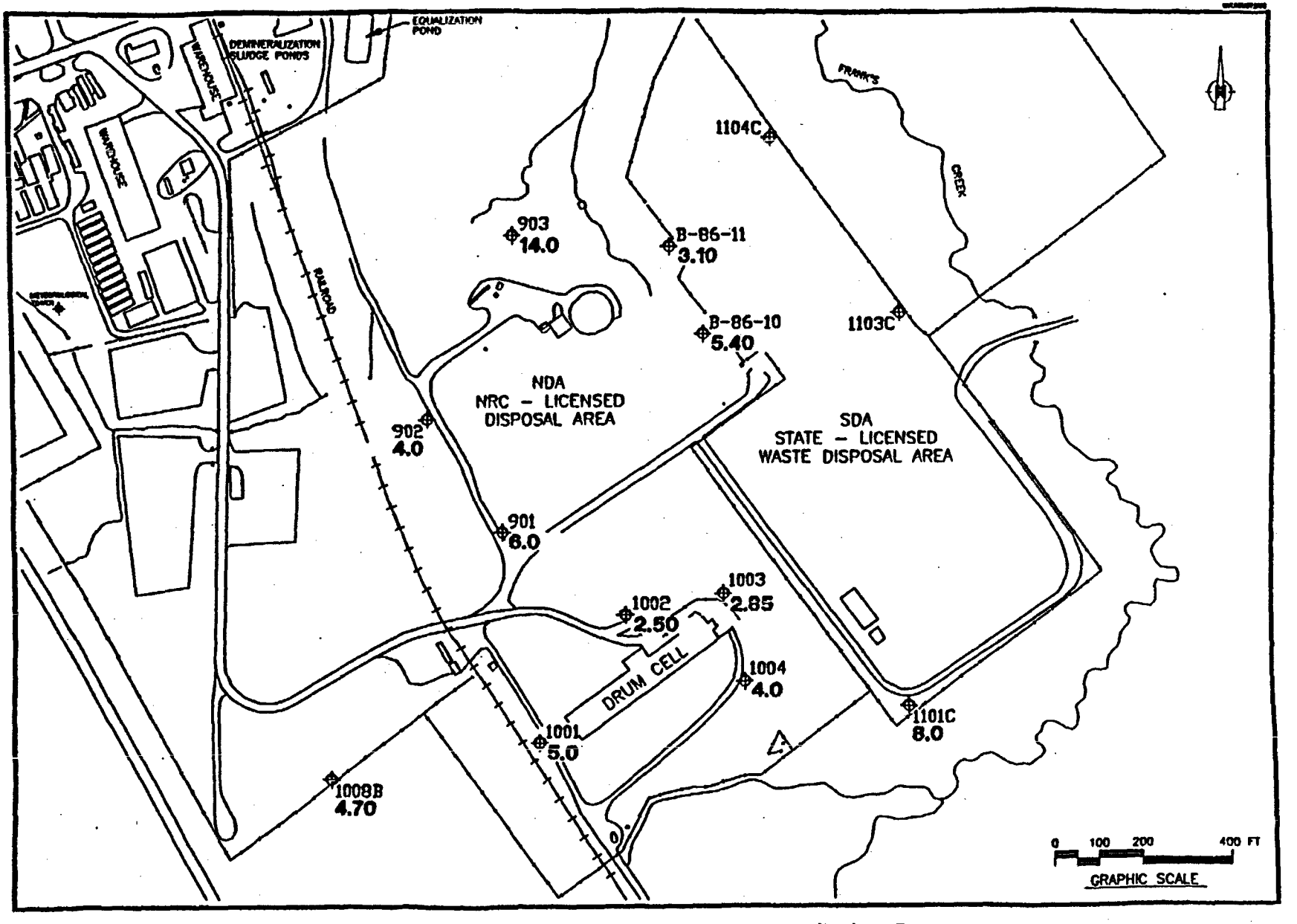


Figure 4-184 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Potassium Concentrations (mg/l).

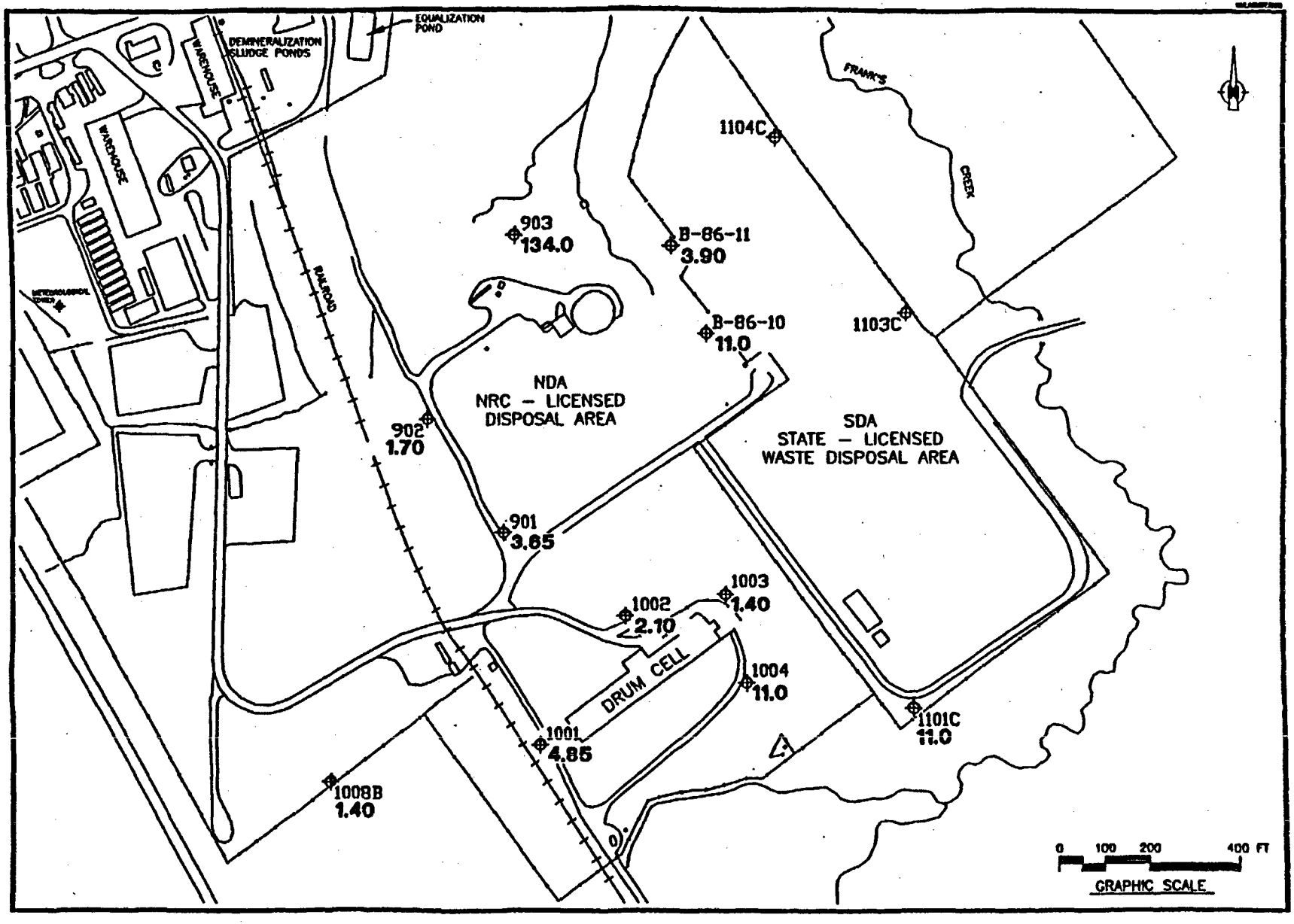


Figure 4-185 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Iron Concentrations (mg/l).

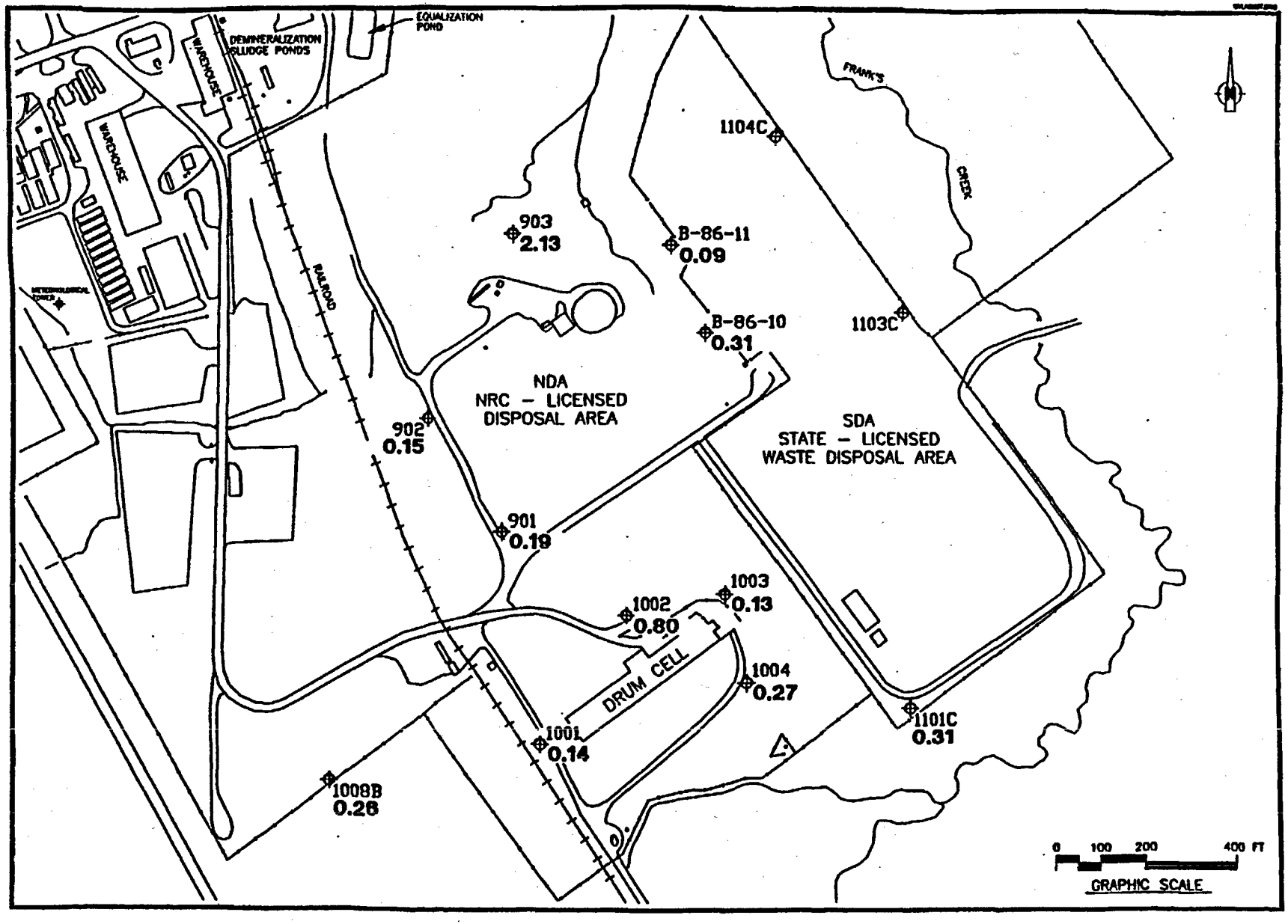


Figure 4-186 Kent Recessional Unit Monitoring Well Locations, Expanded Monitoring Program 1991 Mean Manganese Concentrations (mg/l)