PDR 70-1257

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RECEIVED APR 27 1981 U.S. NUCLEAR REGULATORY COMMISSION

January 30, 1981

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Uranium Process Licensing Section
Uranium Fuel Licensing Branch
Division of Fuel Cycle and
Material Safety
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

DOCKETED USNRC FEB 05 1981 NMSS MAIL SECTION DOCKET CLERK

Gentlemen:

Reference: Your letter of October 3, 1980
My letters of January 9 & 21, 1981

Enclosed are two copies of Exxon Nuclear's responses to comments and questions of section 6 of the enclosure to your October 3, 1980 letter. This completes our responses to your environmental comments and questions on our license renewal application.

If you have any questions or comments, please call me at (509) 375-8537.

Sincerely,

H. Paul Estey

H. Paul Estey, Manager
Licensing & Compliance,
Operating Facilities

HPE/clc

cc: Dr. F. Wimpey
1710 Goodridge Drive
P.O. Box 1303
McLean, VA 22102
(with 3 copies of the Enclosure)

Approved: ____________________
R. Nilson, Manager
Corporate Licensing & Compliance

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6. *Lagoon*

6.1 *Comment*

What has been the annual discharge of uranium to the lagoons? Please compare your best estimate of the uranium discharge to the estimated discharge in the uranium oxide EIS and the various Environmental Reports (Addenda 1-5) submitted for license modification or renewal.

Response

The annual discharges of uranium to the lagoon system are provided below. The basis for these data is Exxon Nuclear's special nuclear material safeguards measurement program, in which the total measured balance as of 3/29/80, plus 100 kg for the non-measured period of October, 1979, was pro-rated by the amount of UF_6 throughput per year. Since October, 1979, actual SNM safeguards measurement data have been used.

Year	Uranium Discharged To Lagoons (kg)
1971	3.4
1972	203.2
1973	204.4
1974	347.4
1975	549.1
1976	682.6
1977	770.4
1978	1093.3
1979	1481.1
1980	1358.6

The amounts of uranium previously estimated (i.e., in the Uranium Oxide Fuel Plant EIS, and Exxon Nuclear's Supplemental Environmental Reports JN-14, Add-1 and JN-14, Add-3) to be discharged to the lagoon system were on the order of 0.5 pounds per day or 180 kg/year. The data presented in the above table were generated in 1980 and represent Exxon Nuclear's official uranium inventory in the lagoon system. Due to the pro-rating of the measured uranium balance in 1980, the official uranium values do not compare favorably with previously estimated values.

6.2 Comment

What is the monthly average and range of concentration (in ppm) of the chemicals NH_3, NO_3, (or total N), F, Na, SO_4 (or S) Al, Zr and U in the lagoon liquid for the last 12 to 18 months?

Response

Over the years, Exxon Nuclear has taken and analyzed lagoon samples for two main purposes; (1) to provide uranium inventory estimates and (2) to provide source term information for lagoon leak investigations. Na, Al and Zr have not been analyzed for in lagoon samples, nor does Exxon Nuclear conduct an on-going routine lagoon sampling program (other than for SNM inventory purposes). However, lagoon sample data that are available are summarized in the following sections.

6.2.1 Lagoon Liquid Samples on 9/29/80

A single sample was taken from each lagoon and analyzed for fluoride, nitrate, ammonia and sulfate content; the analytical results of these samples are summarized below.

	High (ppm)	Low (ppm)	Ave. (ppm)
F	25,000	9,000	15,500
NH_3 + NO_3 (as N)	103,300	6,150	42,700
SO_4	62,250	1,050	30,100

6.2.2 Uranium Content of Lagoon Liquid Samples for Period of January, 1979 Through May, 1980

Weekly samples were collected from each lagoon during this period and analyzed for uranium content; the analytical results of these samples are summarized below.

		Monthly Average Uranium Concentrations (ppm)		
Year	Month	High	Low	Ave.
1979	January	145	12	30
	February	134	66	91
	March	193	37	113
	April	197	57	120
	May	216	90	143
	June	243	175	212
	July	225	214	220
	August	293	181	253

Year	Month	Monthly Average Uranium Concentrations (ppm) High	Low	Ave.
1979	September	285	229	256
	October	307	231	269
	November	228	179	204
	December	272	117	185
1980	January	244	130	187
	February	194	36	121
	March	257	55	163
	April	343	59	221
	May	273	38	183

6.2.3 Chemical Characteristics of Lagoon Liquid for Period of February through October, 1978

Weekly samples were collected from each lagoon during this period and analyzed for uranium, fluoride, nitrate, ammonia and sulfate content; the analytical results of these samples are summarized below.

a) Uranium

Month	Monthly Average Uranium Concentrations (ppm) High	Low	Ave.
February	160	150	155
March	148	5	82
April	116	107	112
May	122	7	80
June	163	97	122
July	206	115	151
August	379	194	277
September	351	175	265
October	314	101	208

b) Fluoride

Month	Monthly Average Fluoride Concentrations (ppm)		
	High	Low	Ave.
February	14,000	9,600	11,800
March	12,350	1,790	7,880
April	12,330	11,070	11,700
May	23,330	1,080	14,430
June	22,400	14,870	18,380
July	11,010	5,550	8,760
August	34,540	17,810	24,380
September	25,900	19,200	22,050
October	35,400	14,880	25,660

c) Nitrate + Ammonia

Month	Monthly Average $NH_3 + NO_3$ (as N) Concentrations (ppm)		
	High	Low	Ave.
February	31,980	12,270	22,125
March	14,550	1,580	9,000
April	16,840	12,820	14,330
May	23,360	2,440	13,550
June	27,330	14,920	21,190
July	28,470	17,350	21,520
August	41,860	30,520	36,110
September	41,330	24,310	30,130
October	23,190	14,670	23,210

d) Sulfate

Month	Monthly Average Sulfate Concentrations (ppm)		
	High	Low	Ave.
February	11,930	1,180	6,560
March	12,390	800	5,180
April	9,300	6,740	8,020
May	9,660	1,130	5,330
June	15,200	890	8,900
July	15,030	1,230	8,170
August	13,940	3,240	10,030
September	29,380	16,220	21,300
October	17,130	4,020	10,720

6.3 Comment

Would the quantities of chemicals, listed in question 6.2 discharged be in the same proportion relative to uranium as the estimated discharge given in your environmental reports (for example Table 3.5 of JN-14 Addendum 3)?

Response

Uranium-to-chemical ratios have been calculated from data contained in Table 3.5 of JN-14, Add-3 and from those presented in the response to question 6.2 (see section 6.2.3, above). These ratios are presented in Table 6.3 (attached). From these data it is seen that the average uranium-to-chemical ratios for the period of February through October, 1978 have exceeded those based on Table 3.5 of JN-14, Add-3 by factors of >26, >25 and >89 for fluoride, nitrate + ammonia (as N), and sulfate, respectively. However, from experience with the recently installed ion-exchange system in one of the UF_6-UO_2 conversion lines, it is anticipated that the uranium-to-chemical ratios of liquids discharged to the lagoon system in the future will be more in the range of those based on Table 3.5 of JN-14, Add-3.

6.4 Comment

To your knowledge, have soil column studies been performed on soil characteristics of those underlying the ENC site? If so, please describe the rate of travel of the various chemicals contained in the lagoon if a leak were to occur.

Response

We are not aware of any such soil column studies. The most appropriate discussion of the sorption characteristics of the soil for these chemicals, along with the rate of travel in the groundwater, is contained in Document No. BNW/JN-68, "Environmental Aspects of the Waste Storage Lagoon" (copy attached).

6.5 Comment

What is the location (distance and direction from the lagoons) of the nearest well that is used for drinking water?

Response

The nearest well that is used for drinking water is located 2.14 miles west (7°30' south of west) from the lagoon system.

6.6 <u>Comment</u>

Describe the causes of leaks from the lagoons to date. Briefly summarize the actions taken to prevent reoccurrences.

<u>Response</u>

The history of known lagoon leaks and associated corrective actions is summarized in Table 6.6 (attached).

6.7 <u>Comment</u>

Please furnish dimensions of the floors of each lagoon.

<u>Response</u>

The dimensions of the lagoon floors are provided below.

Lagoon ID	Length (north-south)(ft.)	Width (east-west)(ft.)
No. 1	201	228
No. 2	101	235
No. 3	346	208
No. 4	244	202
Sandpit	276	14.5

6.8 <u>Comment</u>

Assuming the isopiestic lines on the accompanying sketch are reasonably accurate and the flow of the unconfined aquifer is normal to these lines, a more northwesterly flow component seems indicated in the lagoon area than has been mentioned previously. Readings taken at test wells 1, 8, and to a lesser degree, test well 11 seem to lend verification to the presence of this northwesterly flow. The question then is, what contaminants in what quantities could be migrating northwestward between test wells 1 and 11?

<u>Response</u>

The sketch referred to above was not attached to the questions. However, it is assumed that it is one that was prepared by a consultant following a brief study of the ENC test well system in September and October of 1977 and January, 1978, and which is shown in Figure 7.2-2.

Supplemental water elevation information is presented below for the respective test wells.

Test Well No.	Water Elevation MSL (ft)*	Test Well No.	Water Elevation MSL (ft)*
1	353.36	9	353.29
2	353.33	10	353.35
3	353.39	11	353.50
4	353.39	12	353.45
5	353.45	13	353.48
6	353.46	14	353.06
7	353.42	15	353.06
8	353.56		

(*) Average of 10 measurements each for test wells 1 through 13 between March 3, 1980 and January 21, 1981; average of 5 measurements each for test wells 14 and 15 between September 15, 1980 and January 21, 1981.

These data show that the groundwater elevation at test well no. 8 is higher than that at any of the other test wells, thus supporting the concept of generally easterly flow; also, the groundwater elevations at the test wells west of the lagoon system are higher than those at test wells east of the lagoons. Further, these data support the concept of localized northwardly flow of the groundwater in the vicinity of the lagoon system.

It is also to be noted that chemical characteristics of water in the test wells indicate a flow direction which parallels lines between test wells 1 to 14 and 2 to 15, respectively (see Table 7.3-6).

Further, historical data and information concerning test well sample results and observed defects in lagoon liners support the data presented above. For example, in 1973, analytical results of test well samples indicated that there was a leak from the north lagoon (at that time, only lagoons 1 and 2, and test wells 1, 2, 3, 4 and 8 existed). The north lagoon was emptied, cleaned and the Petromat liner inspected. Figure 6.8-1 (attached) is a copy of a diagram from the subsequent investigation report, which shows the locations ("x" marks) of observed defects in the lagoon liner. Figures 6.8-2 through 6.8-13 show the historical chemical characteristics of groundwater samples collected from test wells 1, 2, 3 and 4.

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[illegible] Comment

Test wells 2 and 3 have shown the presence of fluoride, nitrate and sulfur. Test wells 10, 4, [illegible], and [illegible] have indicated the presence of nitrate and well 7 the presence of sulfur. The proximity of these wells to the toe of the dikes (except number 10) and the distance separating them poses the possibility of narrow contaminant plumes (narrow due to the short distances from possible release points) migrating, undetected, between the test wells along the eastern side of the lagoons. Can you describe the likelihood or probability of the well system detecting leaks assuming the upgrade between lines system does not work?

Response

First, the "between-liners leak monitoring system" does work; a defect in the upper Hypalon liner of lagoon no. 2 was detected by the respective leak monitoring system.

Second, since the fluoride, nitrate and sulfate are intimately mixed in the lagoon system, the detection of one of these chemical characteristics in the groundwater should be accompanied with detection of the other chemical characteristics if the source of contamination is of lagoon origin. This has been shown to be the

At least quarterly, a vacuum is drawn on each sampling head. If liquid is obtained from a sampling head, it is analyzed for fluoride content. The following investigative action would be initiated in the event that a significant quantity of liquid with a fluoride concentration of more than 3 mg/ℓ should be pumped from any between-liner sampling head.

> Determine the lower Hypalon liner integrity by: activation of the sampling heads located between the lower Hypalon liner and the original Petromat liner of lagoons 1 and 3 (4 sampling heads for each of these two lagoons); sampling the 3 dry wells associated with the "French Drains" located under the lower Hypalon liner of lagoon 4; maximum utilization of the lagoon test well system.

If a significant leak is detected in the upper liner of a lagoon, it will be scheduled for repair, expeditiously. Liquid waste from the leaking lagoon would be pumped into the other lagoons. Our normal practice is to maintain the liquid level in each lagoon at (or below) the "safe operating level". In this manner, there is normally ~2 feet of unused storage capacity in each lagoon which would be available in the event (as has been experienced) that a lagoon had to be removed from service, emptied, cleaned and repaired.

6.11 Comment

What remedial action will be taken to clean up contaminants in groundwater due to lagoon leakage in the past?

Response

None. With the groundwater flow being to the north and then east where similar chemical contamination currently exists from other sources, and where there are no drinking water wells, we feel that no remedial action beyond that which has already taken in providing better lagoon liner and leak monitoring systems is warranted.

6.12 Comment

Describe the proposed additional monitor wells to be installed and the adequacy of the overall monitoring well system to define the contaminant plume in groundwater systems.

Response

Figure 6.12 (attached) shows the additional test wells (nos. 1 and 15), as well as the other 13 test wells, in relation to the lagoon system. This figure is drawn to scale, and pertinent distances are shown in this figure. (The test well locations shown in Figure

7.2-2 are not to scale.) These two additional test wells were installed in September, 1980, and have been sampled weekly since then.

As discussed in our response to question 6.8, extensive groundwater elevation measurements at the 15 test wells show that the general direction of groundwater flow in the vicinity of the ENC plant is to the east. Similarly, the direction of groundwater flow in the immediate vicinity of the lagoon system is to the north. As such, the current system of test wells is considered adequate to detect leaks from the lagoons, and to track resulting contamination plumes to the southern edge of the DOE property, as discussed in our response to question 6.11.

As discussed in our response to question 6.8, supported by data presented in Table 7.3-6, test wells 1 and 14 appear to be in the western edge of the existing contamination plume, whereas test wells 2, 9 and 15 appear to be representative of the maximum contamination in the groundwater.

TABLE 6.3 Uranium-To-Chemical Ratios

Uranium/Chemical Ratios $\left(\frac{\text{Pounds/day}}{\text{Pounds/day}}\right)$ From Table 3.5 of CN-14, Add-3

U/F	$U/NH_3 + NO_3$ (as N)	U/SO_4
$< 0.4 \times 10^{-3}$	$< 0.3 \times 10^{-3}$	$< 0.2 \times 10^{-3}$

Uranium/Chemical Ratios $\left(\frac{\text{Monthly Ave. ppm}}{\text{Monthly Ave. ppm}}\right)$ From Response to Question 6.2 (section 6.2.3)

Month	U/F $(x10^{-3})$	$U/NH_3 - NO_3$ (as N) $(x10^{-3})$	U/SO_4 $(x10^{-3})$
February	13.1	7.0	23.6
March	10.4	9.1	15.8
April	9.6	7.8	14.0
May	5.5	5.9	15.0
June	6.6	5.8	13.7
July	17.2	7.0	18.5
August	11.4	7.7	27.6
September	12.0	8.8	12.4
October	8.1	9.0	19.4
Ave.	10	7.6	17.8

TABLE 6.6 Summary of Lagoon Leaks & Associated Corrective Actions

Time Period	Causes	Corrective Actions
Pre-1974	Holes in Petromat liner.	Removed an original survey stake and rocks that had worked up to the surface of the underlying soil; patched the holes; several other apparently weak sections of the liner were reinforced; the entire Petromat liner was then resurfaced.
1974-1977	Separation of seams in Petromat liners.	Repaired and reinforced separated seams; reinforced several apparently weak sections of the liners; resurfaced the entire Petromat liners of lagoons nos. 1 & 2; installed a single Hypalon liner on top of the resurfaced Petromat liner of lagoon no. 2.
Post-1977	Separation of seams in Petromat liners.	Repaired and reinforced separated seams in Petromat liners; resurfaced Petromat liners of lagoons nos. 1 & 3; installed double-Hypalon liner systems with intermediate sand layers and leak monitoring systems in all lagoons.

ENVIRONMENTAL ASPECTS OF THE WASTE STORAGE LAGOON

To

JERSEY NUCLEAR COMPANY
BELLEVUE, WASHINGTON

Compiled By

R. H. Purcell

October 1971

BATTELLE MEMORIAL INSTITUTE
PACIFIC NORTHWEST LABORATORIES
RICHLAND, WASHINGTON 99352

ENVIRONMENTAL ASPECTS OF THE WASTE STORAGE LAGOON

INTRODUCTION

The Jersey Nuclear Company has constructed a sealed waste storage lagoon to store its liquid chemical process wastes while a final waste treatment facility is developed. At that time, the lagoon will become an accumulator receptacle at the head end of the process.

The purpose of this report is to examine the effects of the lagoon on the terrestrial and aquatic ecology of the region. The information contained in the report is based upon contributions by:

C. E. Cushing - Ecosystems Department
R. T. Jaske - Water and Land Resources Department
T. P. O'Farrell - Ecosystems Department
A. E. Reisenauer - Water and Land Resources Department
W. H. Rickard, Jr. - Ecosystems Department
R. C. Routson - Water and Land Resources Department

SUMMARY

It is unlikely that the lagoon will have any effect upon the resident birds and small animals of the area as they normally obtain their moisture through their food and other sources as dew on grasses and plants. Game birds are expected on occasion to attempt to use the lagoon as a source of drinking water and migrating waterfowl will probably be attracted to the lagoon as a resting place, particularly if the lagoon offers a refuge from hunters. However, the chemical concentration in the lagoon is expected to deter the use of the lagoon as a source of drinking water and as a resting place. The perimeter fence will prevent the use of the lagoon by deer and wandering cattle.

Ammonium sulfate will build up in the lagoon to a concentration of about 650 grams/liter after one year's operation. No toxicity data on birds was located for this compound. As the high chemical concentration in the lagoon is expected to deter the use of the lagoon to birds, any toxic affects are expected to be negligible. It is recommended that the lagoon be monitored on a regular basis and if adverse effects are discovered that corrective action, such as fencing over the lagoon, be begun.

As the ground water flow from the Jersey Nuclear site is to the Columbia River, the effects of the highly unlikely event of seepage from the lagoon due to an imperfection in the lining was evaluated. Based upon experience of Jersey Nuclear personnel, a one aquare foot imperfection was selected as conservatively exceeding the largest leak which would be undetected by such means as sludge flow patterns. Sorption of the chemicals in the calcareous soil

of the area and dilution by the groundwater reduces the chemical concentration entering the Columbia River to less than maximum permissible concentrations for surface waters. Dilution by the Columbia River reduces the concentrations further and the contribution of these chemicals would be insignificant with regard to potentially significant pollution.

DISCUSSION

Description and Operation of Process Waste Lagoon

According to the design criteria, the lagoon is sized for one year's waste volume. It covers a minimum area of 60,000 square feet and is four feet deep. A dike is provided to divide the lagoon into a working area of 20,000 square feet and a surge area comprising the remainder of the lagoon. The water level in the enclosed 20,000 square feet will be maintained at a one foot minimum depth to prevent drying of the salts in the enclosed area and subsequent blowing of the chemicals out of the lagoon.

The lagoon is sealed on the bottom and all sides with an impervious material (Phillips synthetic non-woven fabric "Petromat" coated with hydraulic sealant and asbestos fibers) to prevent seepage to the ground water. Four test holes have been drilled into the water table, one on each corner, for sampling of the groundwater. The lagoon and the wells will be sampled on a regular basis.

The lagoon is enclosed within the Jersey Nuclear plant perimeter fence (six foot minimum), thereby preventing wild life and non-Jersey Nuclear personnel from access to the lagoon.

An expected maximum of 7300 gallons/day of liquid chemical process waste will be discharged to the lagoon. The separate flows from the various portions of the fuels plants will be collected by a chemical process sewer

system, neutralized with sulfuric acid to minimize the evolution of ammonia fumes from the lagoon surface and discharged through a common outlet into the lagoon. The combined flow is expected to contain the amounts of chemicals listed in Table I.

TABLE I

AMOUNT OF CHEMICALS ENTERING THE LAGOON

Chemicals	Pounds/Day
NH_3	1100
F	530
NO_3	400
Na	30
SO_4	1610
Al	10
Zr	10
U	0.5
Pu	0

Expected Chemical Concentrations After One Year of Operation

The final waste treatment plant is expected to be in operation in late 1972; therefore, the chemical concentrations in the lagoon were calculated assuming 365 days of operation and one foot of water in the 20,000 square foot section of the lagoon (566,000 liters). Examination of solubility data in the Handbook of Chemistry and Physics[1,2] revealed that only the double salt sodium zirconium fluoride ($5\ NaF \cdot 2\ ZrF_4$) would exceed its solubility limit (3.87 grams/liter). The chemical concentrations were corrected for this precipitation and are given in Table II.

TABLE II

LAGOON CHEMICAL CONCENTRATION AFTER ONE YEAR'S OPERATION

Chemical	Total Grams Into Lagoon (Millions)	Grams Precipitated (Millions)	Net Grams in Lagoon (Millions)	Lagoon Concentration (g/l)
NH_3	182	-	182	322
F	87.8	1.2	86.6	153
NO_3	66.3	-	66.3	117
Na	5.0	0.6	4.4	8
SO_4	267	-	267	472
Al	1.7	-	1.7	3
Zr	1.7	0.9	0.8	1.4
U	0.08	-	0.08	0.1

Terrestrial Ecology

1. Biotic Site Description

The Jersey Nuclear Plant is located in an ecological habitat that represents a highly disturbed vegetation that under pristine conditions was dominated by bitterbrush and sagebrush with a sparse herbaceous understory dominated by sandberg bluegrass. Following years of disturbance by fire, grazing and in some instances cultivation the area presently is comprised mostly of alien weeds especially cheatgrass brome and native species of rabbitbrush.

Relatively few bird species tolerate this kind of vegetation. The meadowlark is the most abundant bird. The horned lark and loggerhead shrike are also resident birds. Sometimes the long-billed curlew nests in the vicinity. The upland game birds that occasionally use the area are the mourning dove, California quail and the Chinese ring-necked pheasant.

It is unlikely that the creation of the lagoon will have any effect upon these kinds of birds as they normally obtain their moisture through insects and other types of food. It can be expected that the game birds will on occasion attempt to use the lagoon as a source of drinking water. The high chemical content will deter such use on a regular basis.

The lagoon will probably attract migrating waterfowl as a resting place, especially ducks, coots and grebes, particularly if the lagoon offers a refuge from harrassment by hunters. Ducks attempting to use the lagoon will be mostly spring and winter migrants and will not be present during most of the year. Again the high chemical concentration will deter the use of the lagoon as a source of drinking water and will also serve as a detriment to use as a resting place.

The most abundant small mammals in the area, i.e., pocket mice, deermice, ground squirrels and jackrabbits, will probably not be attracted. to the lagoon at all. These animals normally obtain their moisture from their food and from such sources as dew on grass and plants. The fence will be effective in keeping deer and wandering cattle from attempting to use the lagoon as a source of drinking water.

2. Toxic Effects of Ammonium Sulfate on Biota

Ammonium sulfate will be the compound with the highest concentration in the lagoon. Based upon the sulfate concentration of 472 grams per liter after one year's operation, the ammonium sulfate concentration will be 649 grams/liter.

The compound is a rather innocuous substance; so much so that no work has been attempted to establish LD_{50}'s for organisms other than the laboratory rate. The LD_{50} oral dose to rats is 820 mg/kg.[3] There are apparently no studies of the toxic effects of the compound on birds.

Ammonium persulfate is used at 100 ppm in wheat flour. When heated, it decomposes to ammonium sulfate, which persists and is considered harmless.[4,5] The residual ammonium sulfate concentration is 58 ppm. Amounts 15 times higher (1500 ppm as the persulfate yielding a residual of 870 ppm as the sulfate) have been used in baking practices without adverse effects. At a starting concentration of 10,000 ppm as the persulfate (yielding a residual of 5800 ppm as the sulfate) growth and reproduction was impaired in rats.

The ammonium sulfate concentration increases rapidly in the lagoon (1.8 grams/liter/day), exceeding the concentrations discussed above in less than a week of operation. The lack of studies on birds prevents a direct assessment of any toxic effects on birds. As mentioned previously, the high chemical concentration is expected to deter the use of the lagoon as a source of drinking water and as a resting place. Any toxic effects should be negligible. It is recommended that the lagoon be checked on a regular basis during the coming migratory season to determine if waterfowl are attempting to use the lagoon and if so whether there are any adverse effects on these birds. If there are adverse effects, corrective action (such as fencing over the lagoon) should be begun.

Aquatic Ecology

The lagoon is sealed on the bottom and sides and seepage to the groundwater is highly unlikely. However, as the flow of groundwater from the Jersey Nuclear site is to the Columbia River, the effect of a leak on the aquatic biota was evaluated. Based upon experience of Jersey Nuclear personnel with sealed lagoons, a one square foot imperfection in the Petromat liner was selected as conservatively exceeding the largest leak which would be undetected by such means as sludge flow patterns.

The infiltration rate of the ground in the region is 10 to 15 gallons/day/square foot.(6) The selected leak rate from the lagoon is therefore 15 gallons/day.

The factors to be evaluated are: (1) How much of the chemicals will be held up in the soils? (2) Where will the chemicals reach the river? (3) How much dilution will occur before the chemicals reach the river? (4) What will be the concentrations of the chemicals in the Columbia River? (5) What will be the effects of these concentrations in the river? Each of these factors is discussed separately.

1. Holdup of Chemicals in the Soil

The soils and sediments of the Hanford Project are generally calcareous and react with aqueous solutions to buffer these solutions at pHs greater than 7.0. In addition, these soils tend to raise the solution calcium concentration to 20 ppm or greater. These soils have adequate cation exchange capacities to effect solute sorption, but very low anion exchange capacities; consequently, anions tend to move uninhibited with the aqueous solution.

Zr, U, and Al will hydrolyze and tend to form insoluble hydroxides or hydrous oxides at pH 7.0 or greater and will be filtered from the solution phase by the soil. Equilibrium concentrations in the solution will be 10^{-7} ppm, 10^{-3} ppm, and 10^{-13} ppm for Zr, U, and Al, respectively.(7)

Fluoride will be sorbed due to the replacement of $CaCO_3$ by CaF_2. This reaction can be expected to reduce the fluoride concentration to about 4 ppm.(8) Additional sorption of fluoride is not expected due to its anionic nature.

While ion exchange will sorb some of the sodium, the final concentration cannot be accurately predicted. To be conservative, no sodium removal will be assumed.

Sulfate is an anion and essentially no sorption will occur for this component.

Ammonia will be present in water largely as NH_4^+ (>99%) which would be strongly sorbed on soils by ion exchange; however, NH_4^+ is readily converted to NO_3^- by soil organisms. Generally, the rate of conversion is rapid and the only safe approach is to consider all soluble nitrogen to be in the nitrate form, which will not be sorbed because of its anionic character.

Chemical concentrations after soil sorption are given in Table III.

TABLE III

CHEMICAL CONCENTRATIONS AFTER SOIL SORPTION

Chemical	Lagoon Concentration g/l	Concentration After Soil Sorption g/l
NH_3	322	1291 (292 as N)
NO_3	117	
F	153	0.004
Na	8	8
SO_4	472	472
Al	3	1×10^{-16}
Zr	1.4	1×10^{-10}
U	0.1	1×10^{-6}

2. Direction of Groundwater Flow

The Hanford groundwater system is shown in Figure 1. The contours were drawn from interpretation of water levels in the monitoring wells and river stage measurements. A stream tube from the Jersey Nuclear site has been drawn on the map which shows that the groundwater flow is predominantly east to the Columbia River. Groundwater passing beneath the site would be expected to enter the river near the Port of Benton Pumping Station.

Spreading will occur due to the flow geometry as the waste moves from the lagoon to the water table. However, lateral spreading in the water table due to flow geometry (diverging flow paths) is minimal as shown on the attached figure. A small amount of spreading will occur due to hydrodynamic dispersion. It appears that the lateral spread will not exceed 1/4 mile by the time the waste reaches the river bank.

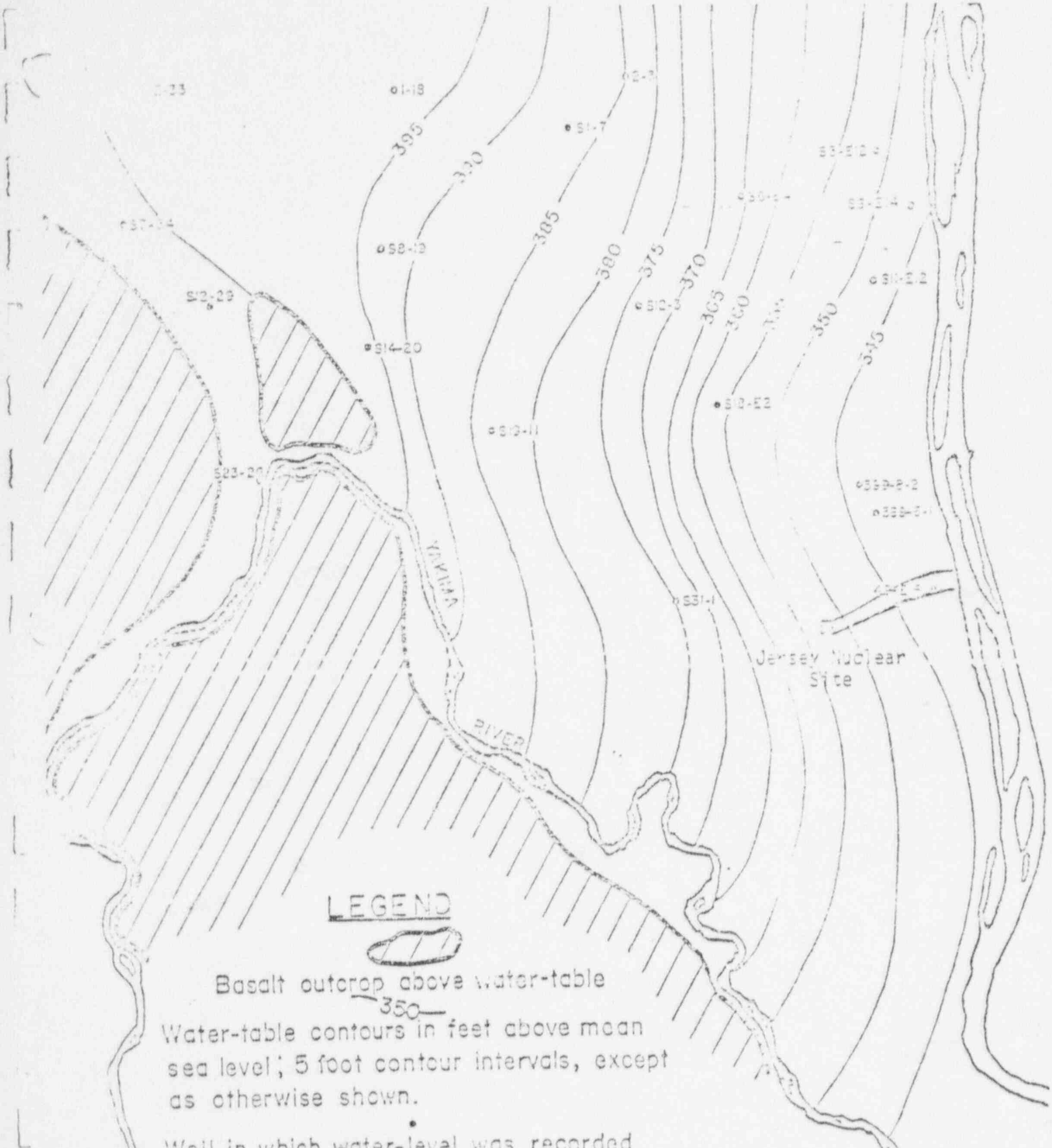

Figure 1

Direction of Groundwater Flow

3. Dilution of Chemicals in Groundwater

The amount of dilution of the chemicals in the groundwater may be calculated from the volume of groundwater being discharged into the river from 1/4 mile of river bank. The normal groundwater flow velocity towards the Columbia River is 15 feet per day.(6) The height of the Pasco gravels were checked in both Geologic Cross Sections "L-L"(9) and "B-B" to determine the height of the gravel layer below the groundwater elevation along the Columbia River bank. Based on the known depth of the Pasco gravels of 20 feet at the Jersey Nuclear Site,(10) a conservative estimate four feet at the river bank was obtained.

The dilution flow of groundwater is conservatively estimated as:

$$\frac{5280 \text{ ft.}}{4} \times 15 \frac{\text{feet}}{\text{day}} \times 4 \text{ feet} \times 7.48 \frac{\text{gallons}}{\text{cu. ft.}}$$

or 592,000 gallons/day. With 15 gallons per day seepage, the groundwater dilution factor is 39,450. The chemical concentrations entering the Columbia River are given in Table IV.

TABLE IV

CHEMICAL CONCENTRATIONS ENTERING COLUMBIA RIVER

Chemical	Concentration After Soil Sorption g/l	Concentration Entering the River g/l
NO_3	1291 (292 as N)	0.033 (0.0074 as N)
F	0.004	1×10^{-7}
Na	8	2×10^{-4}
SO_4	472	0.012
Al	1×10^{-16}	2.5×10^{-21}
Zr	1×10^{-10}	2.5×10^{-15}
U	1×10^{-6}	2.5×10^{-11}

4. Chemical Concentrations in the Columbia River

The chemical concentrations will be further diluted by the volume of the Columbia River. Two aspects of this dilution must be considered; the amount by the time that the chemicals reach the Richland Water Plant intake (three miles downstream) and the point where dilution by the full river volume will occur.

Based upon mean diffusion coefficients for rivers of equivalent velocity to the Columbia River, a dilution factor of 10 was obtained between the point where the chemical waste enters the Columbia River and the Richland Water Plant intake. Dilution by the full river flow (36,000 cubic feet/second minimum) will occur slightly beyond the junction of the Yakima and Columbia Rivers.

The diluted chemical concentrations and the Maximum Permissible Concentrations in surface water[11] are given in Table V.

TABLE V

CHEMICAL CONCENTRATIONS IN COLUMBIA RIVER

Chemical	Concentration Entering River $\times 10^{-3}$g/l	Concentration At Richland Water Plant Intake $\times 10^{-3}$ g/l	Concentration Below Junction w/Yakima River $\times 10^{-3}$ g/l	Maximum Permissible Concentration in Surface Waters $\times10^{-3}$g/l
NO_3	33 (7.4 as N)	3.3 (0.74 as N)	8×10^{-4} (2×10^{-4} as N)	10 (as N)
F	0.0001	0.00001	2.5×10^{-9}	1.5
Na	0.2	0.02	5.1×10^{-6}	-
SO_4	12	1.2	3.1×10^{-4}	250
Al	2.5×10^{-18}	2.5×10^{-19}	6.4×10^{-23}	-
Zr	2.5×10^{-12}	2.5×10^{-13}	6.4×10^{-17}	-
U	2.5×10^{-8}	2.5×10^{-9}	6.4×10^{-13}	5 (Uranyl Ion)

5. Effects of Chemical Concentrations in the Columbia River

The chemical concentrations of the lagoon seepage are less than the maximum permissible concentrations even at the point where the seepage enters the river. Contributions of these chemicals in the Columbia River would be insignificant with regard to potentially significant pollution.

REFERENCES

1. Charles D. Hodgman, Handbook of Chemistry and Physics, 28th Edition, Chemical Rubber Publishing, 1944.

2. Robert C. Weast, Handbook of Chemistry and Physics, 52nd Edition, Chemical Rubber Publishing, 1971.

3. N. I. Sax, Dangerous Properties of Industrial Materials, Rheinhold, 1963, p. 435.

4. T. Sollman. Manual Pharmacol, Saunders, 1957, p. 181.

5. A. Arnold and F. C. Gable, "Observations on the Prolonged Feeding To Rats of the Flour Maturing Agent, Ammonium Persulfate," J. Nutrition 41: 459, 1950.

6. Jersey Nuclear Company, "Application For Special Nuclear Material License, Docket Number 70-1257," 1970, p. II-1.7.

7. M. Pourbaix, Atlas of Electrochemical Equilibria in Aqueous Solution, Pergamon Press, 1966, pp. 170, 204, and 225.

8. L. L. Ames, Anion Replacement Reactions for the Removal of Strontium From Aqueous Solutions, USAEC Report HW-66383, 1960.

9. R. E. Brown, The Geologic and Seismologic Characteristics of the Jersey Nuclear Fuels Site, Research Report to the Jersey Nuclear Company, Battelle-Northwest, November 1970.

10. Geological and Seismology Studies, Proposed Mixed Oxide Fabrication Facility, Report to Jersey Nuclear Company, Dames and Moore, San Francisco, California, 1970, p. 14.

11. Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Agency, 1968, pp. 20 and 23.

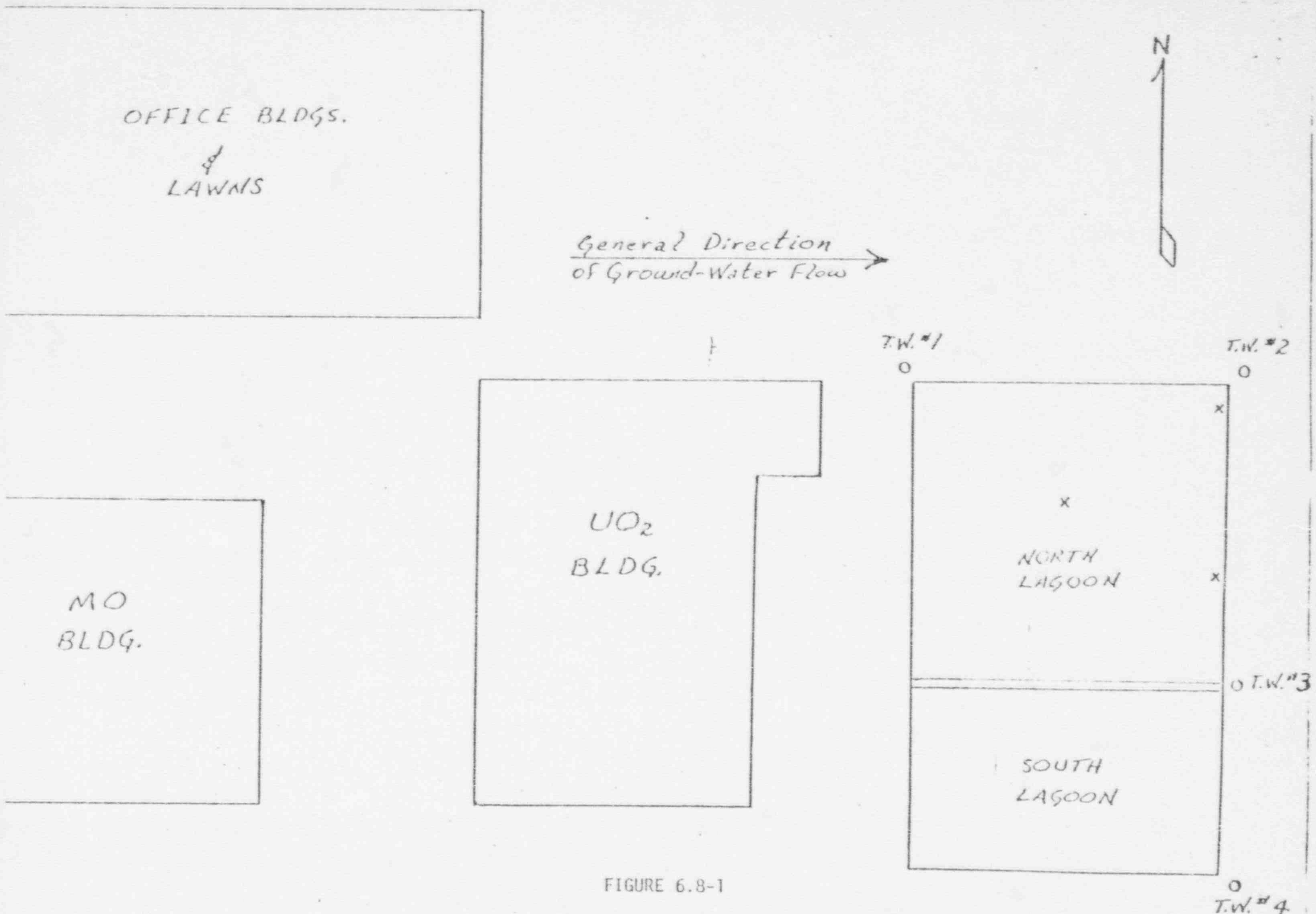

FIGURE 6.8-1

Defects ("X") In North Lagoon (1973 Investigation Report)

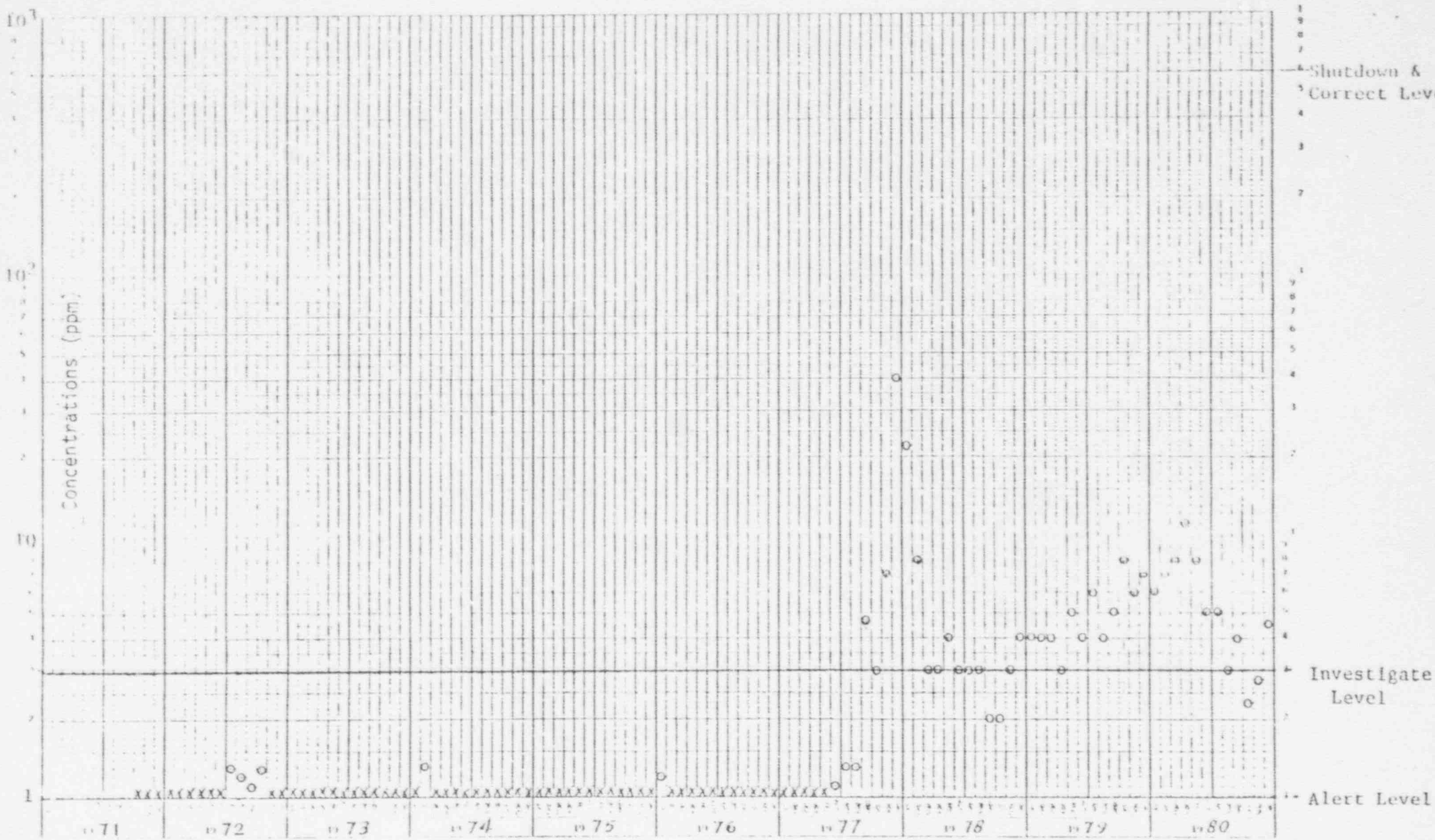

FIGURE 6.8-2 Average Monthly Flouride Concentrations (PPM) In Test Well No. 1.

Note: "X" signifies concentration below "Alert Level".

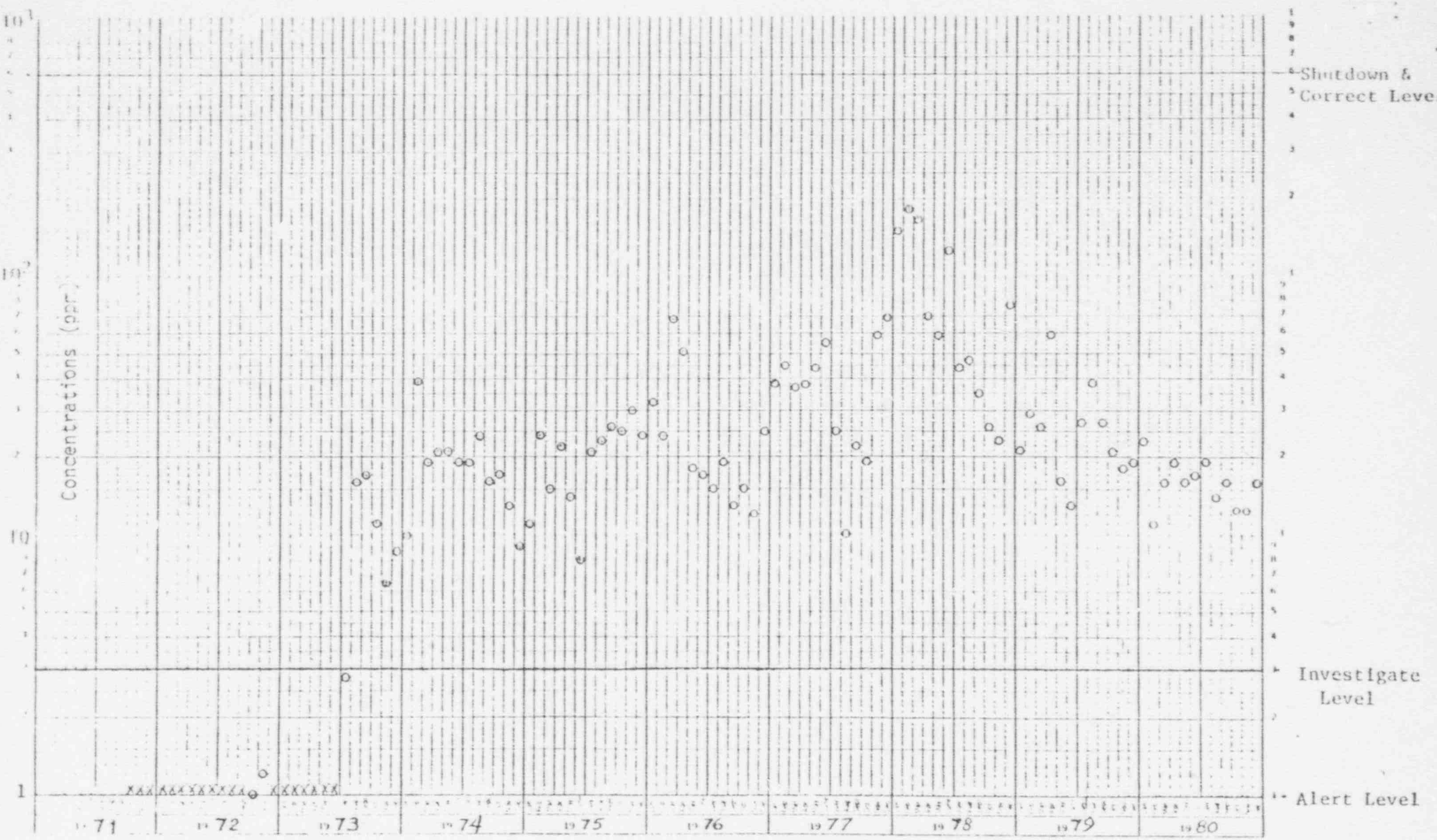

FIGURE 6.8-3 Average Monthly Flouride Concentrations (PPM) In Test Well No. 2.

Note: "X" signifies concentration below "Alert Level".

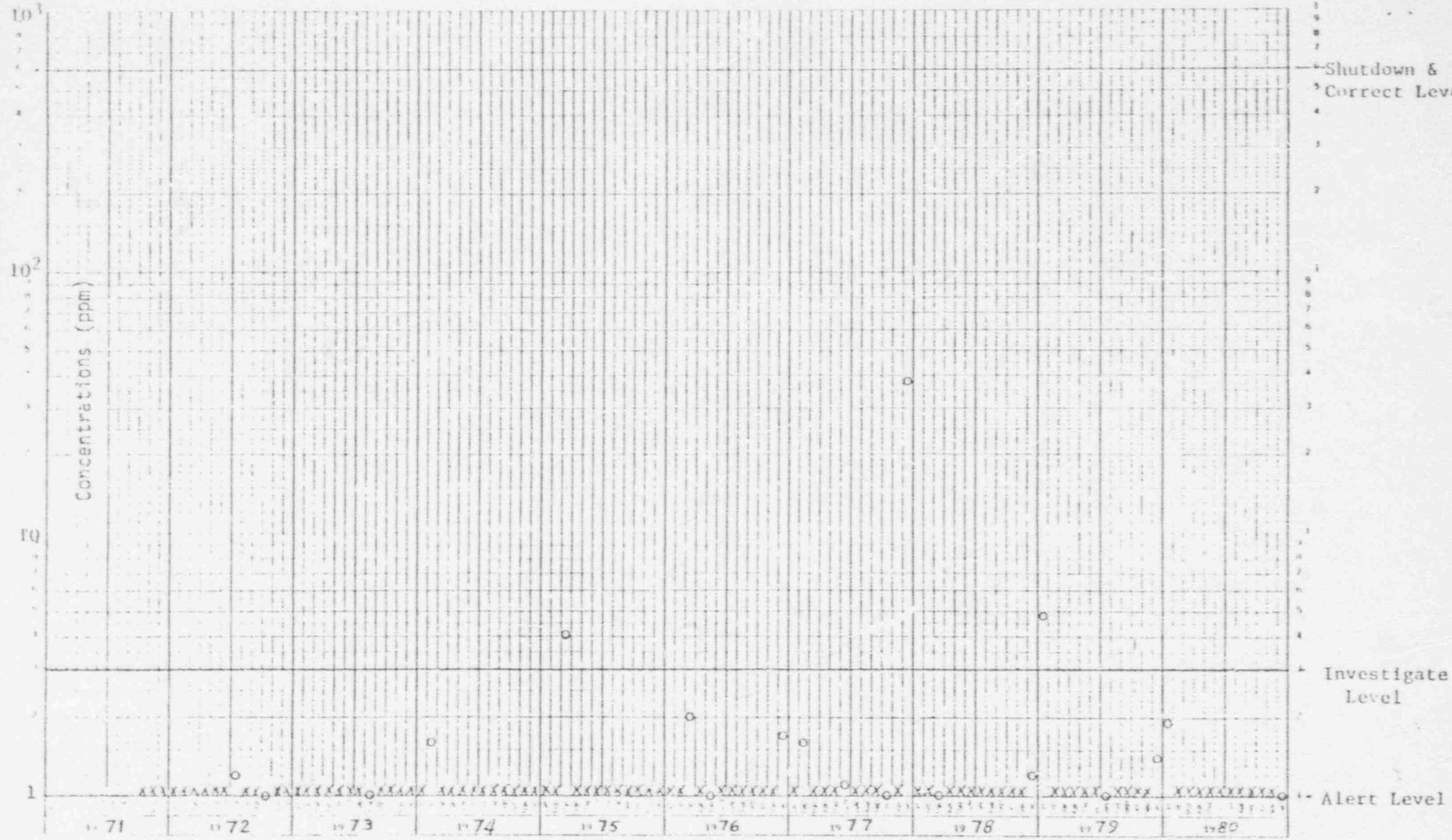

FIGURE 6.8-4 Average Monthly Flouride Concentrations (PPM) In Test Well No. 3.

Note: "X" signifies concentration below "Alert Level".

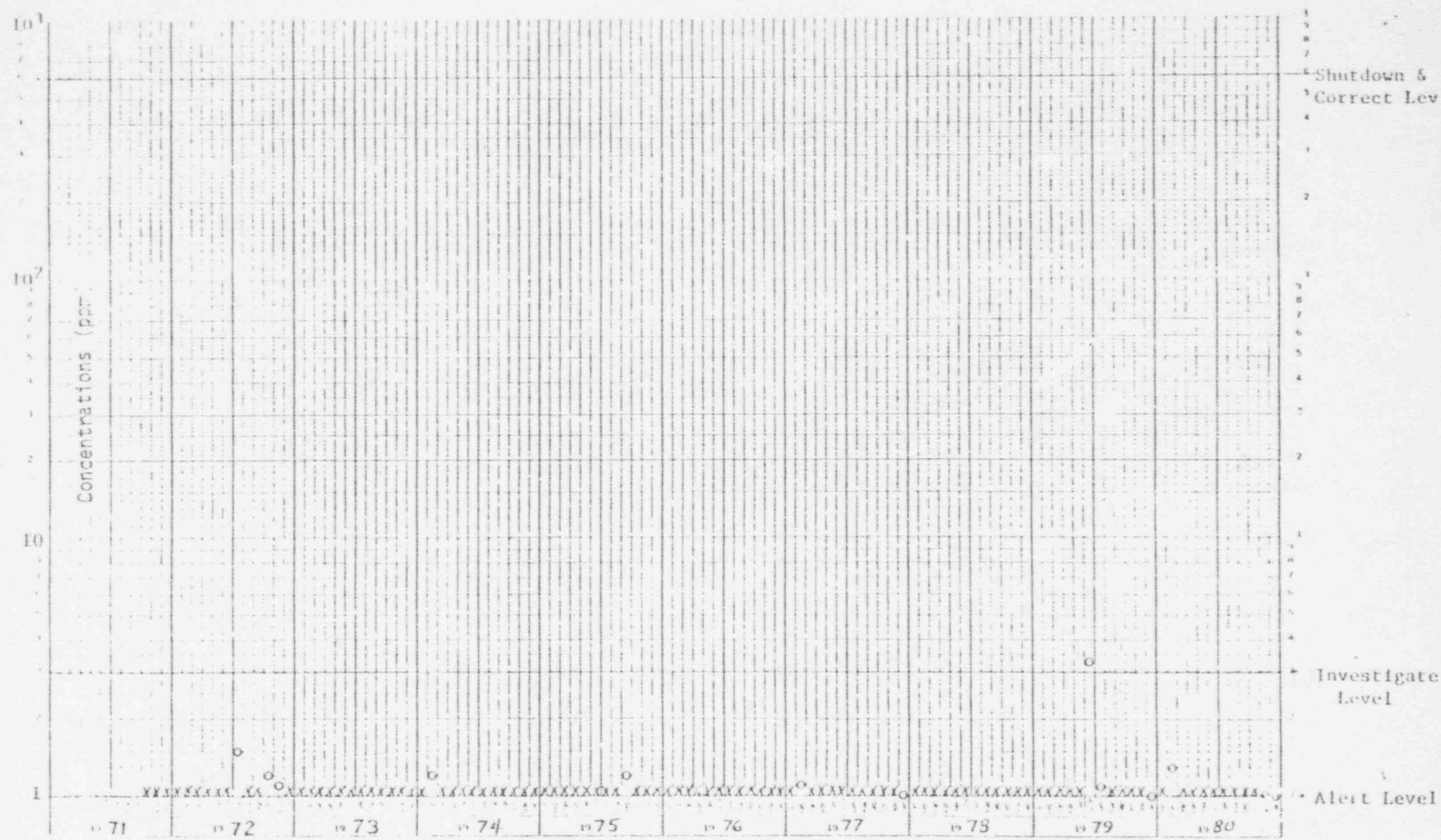

FIGURE 6.8-5 Average Monthly Flouride Concentrations (PPM) In Test Well No. 4.

Note: "X" signifies concentration below "Alert Level".

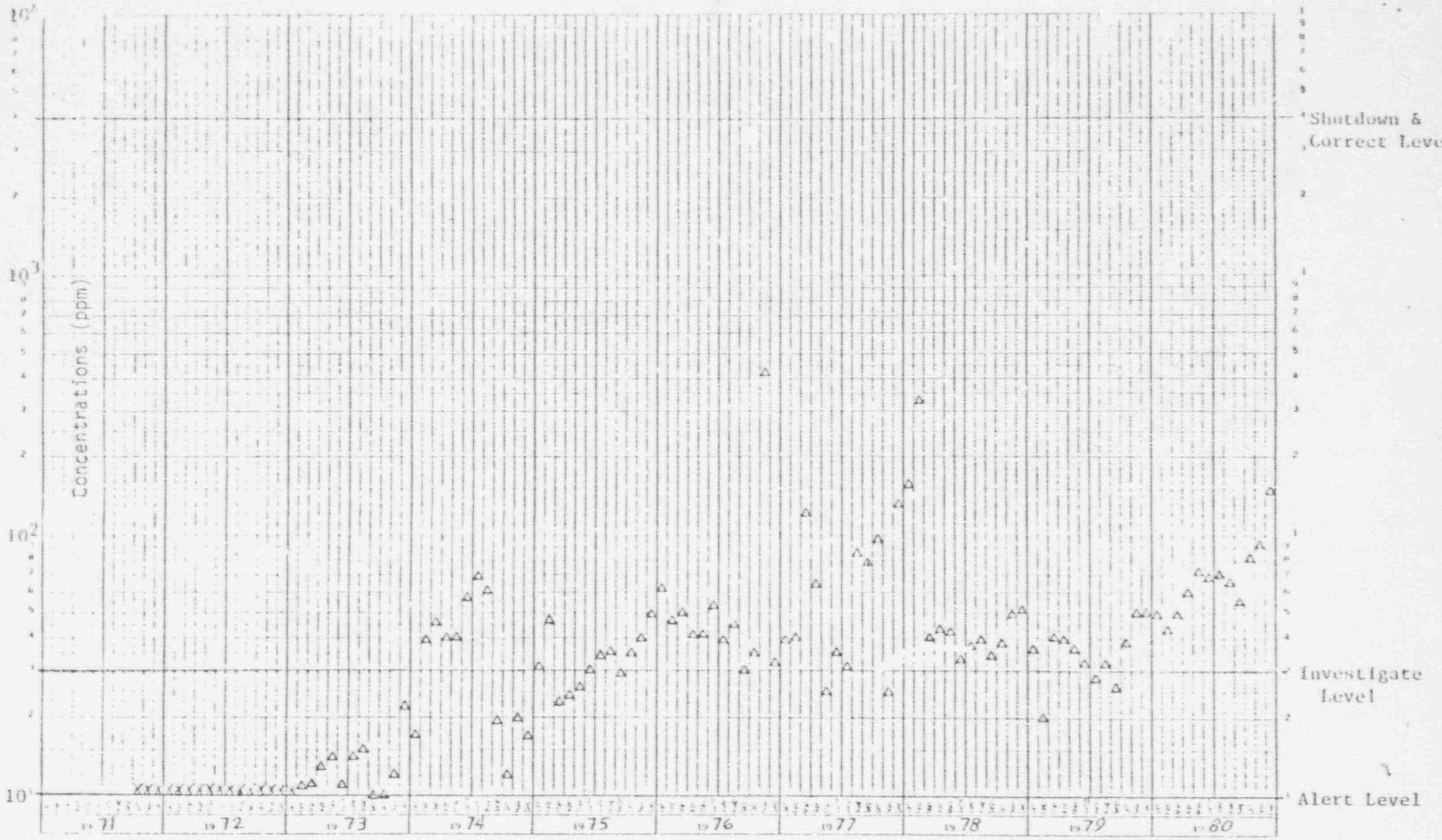

FIGURE 6.3-6 Average Monthly NO_3 + NH_3 (as N) Concentrations (PPM) In Test Well No. 1.

Note: "X" signifies concentration below "Alert Level".

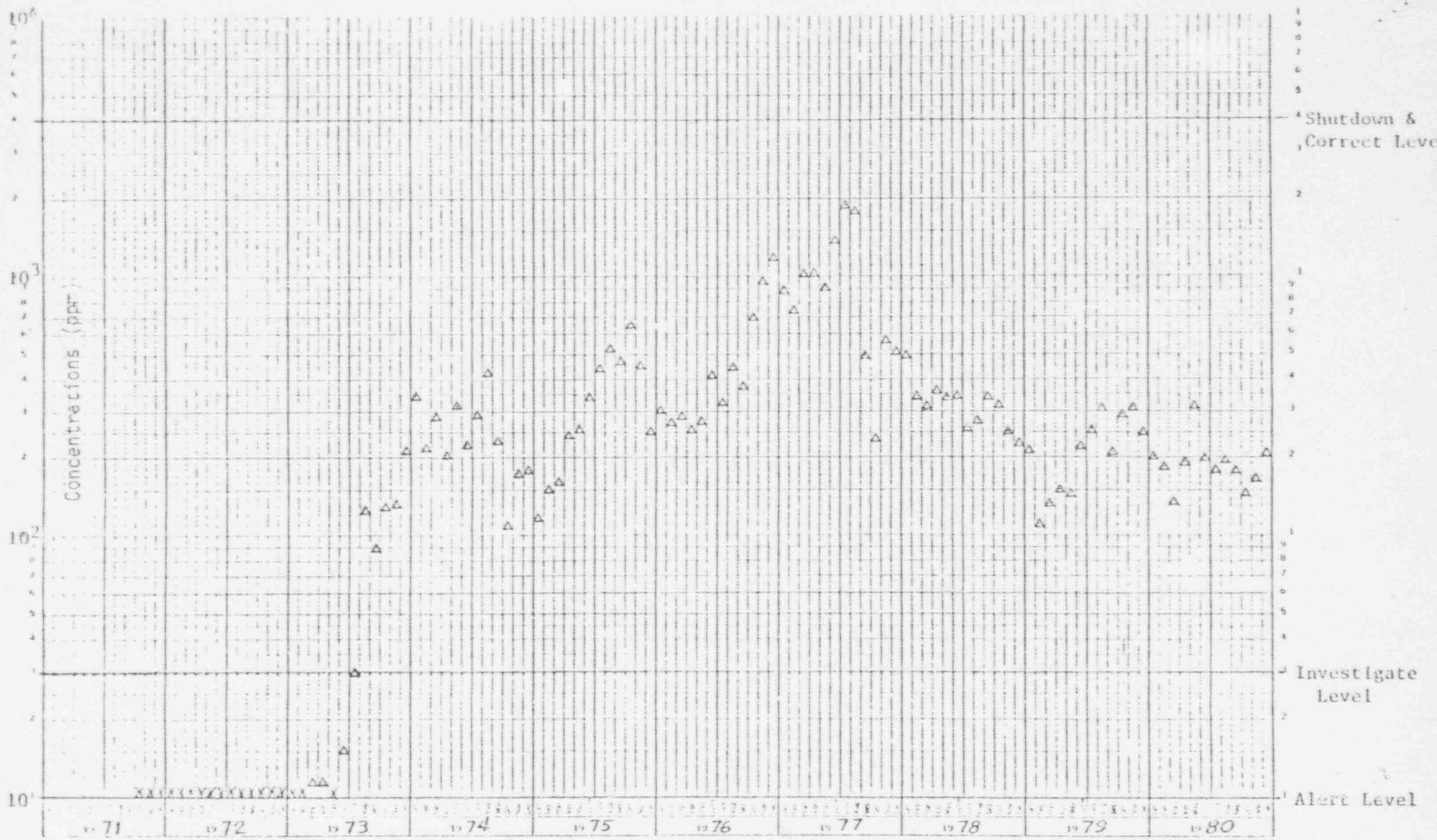

FIGURE 6.8-7 Average Monthly NO_3 + NH_3 (as N) Concentrations (PPM) In Test Well No. 2.

Note: "X" signifies concentration below "Alert Level".

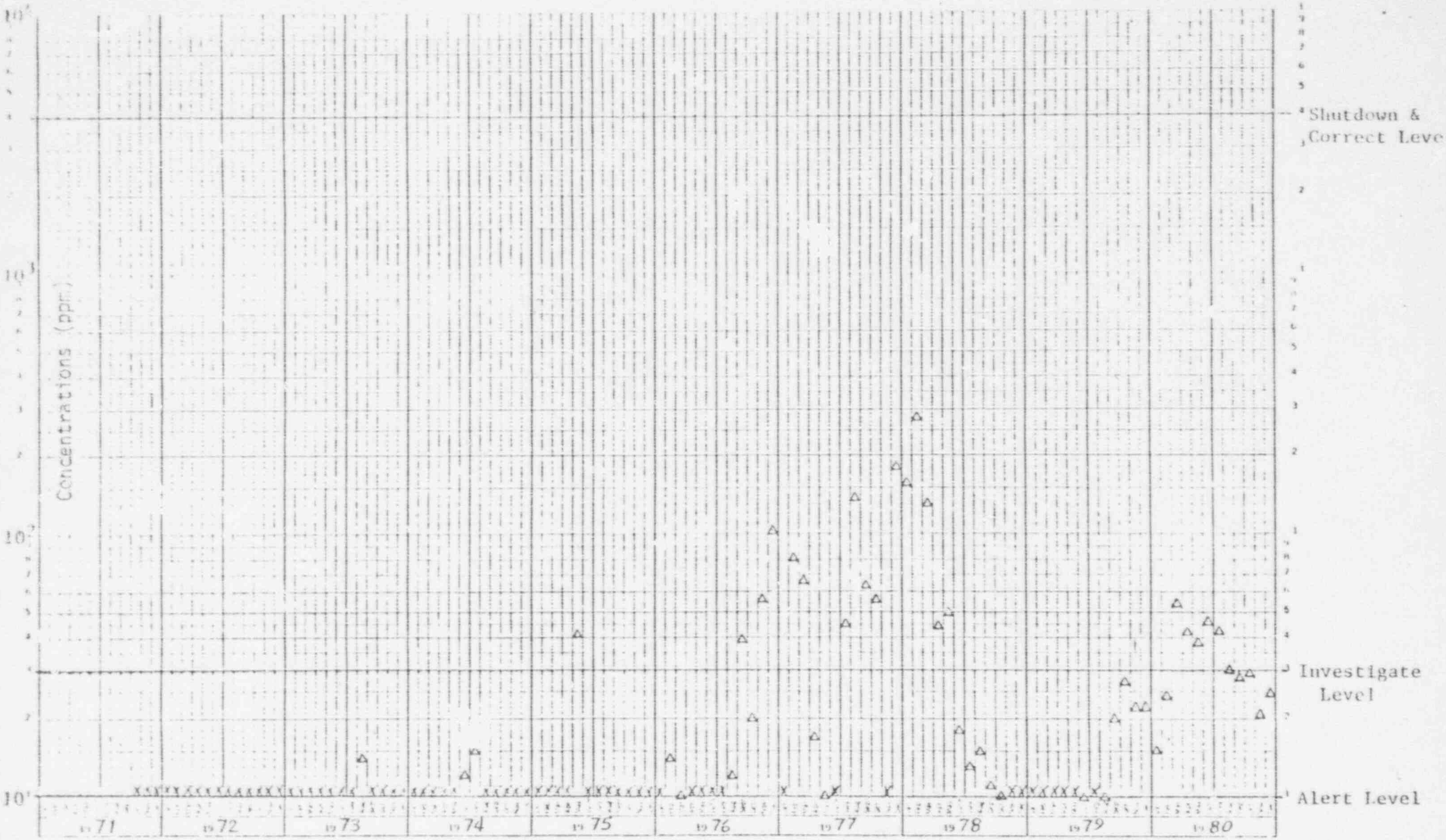

FIGURE 6.8-8 Average Monthly NO_3 + NH_3 (as N) Concentrations (PPM) In Test Well No. 3 .

Note: "λ" signifies concentration below "Alert Level".

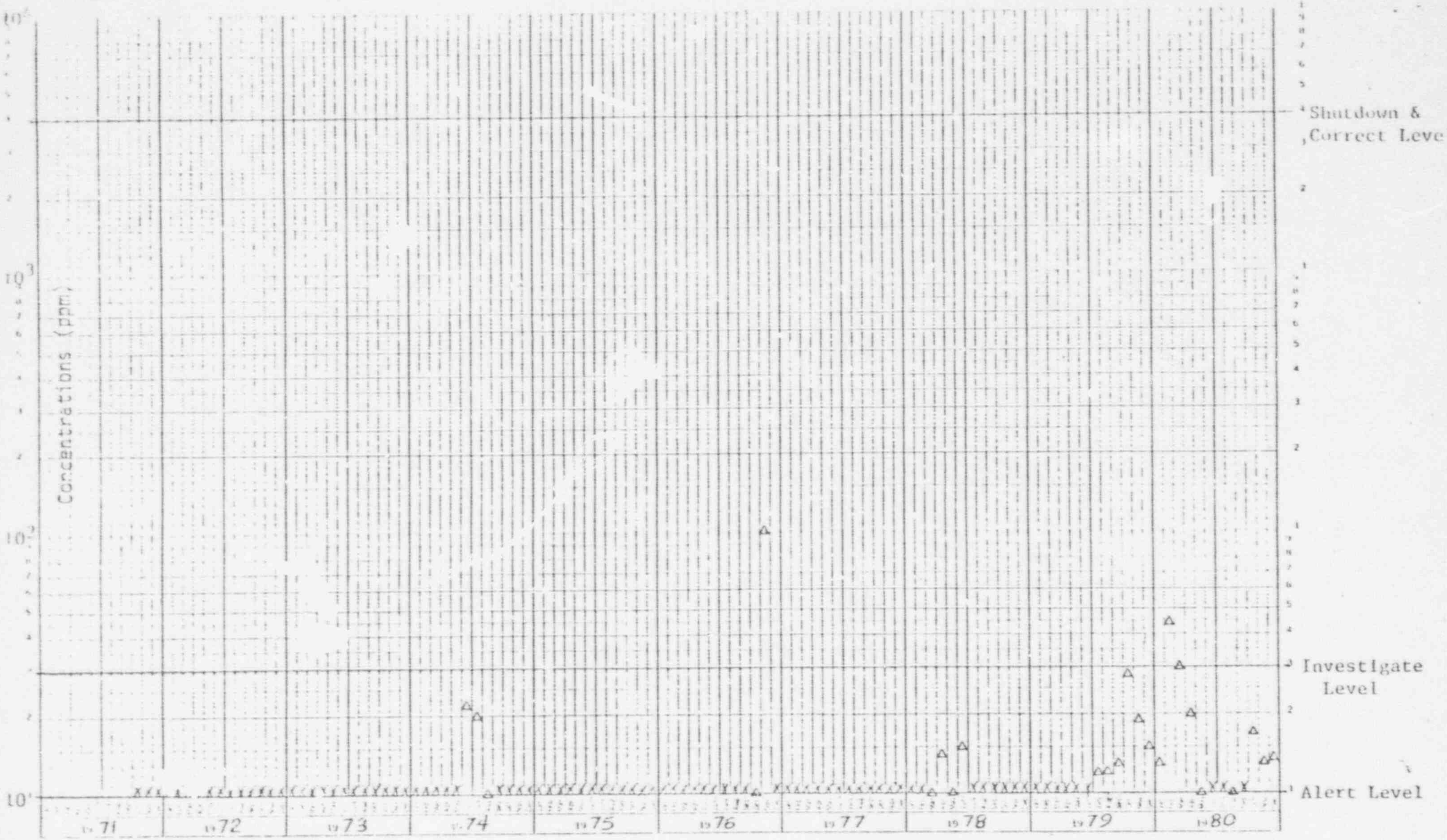

FIGURE 6.8-9 Average Monthly NO_3 + NH_3 (as N) Concentrations (PPM) In Test Well No. 4.

Note: "X" signifies concentration below "Alert Level".

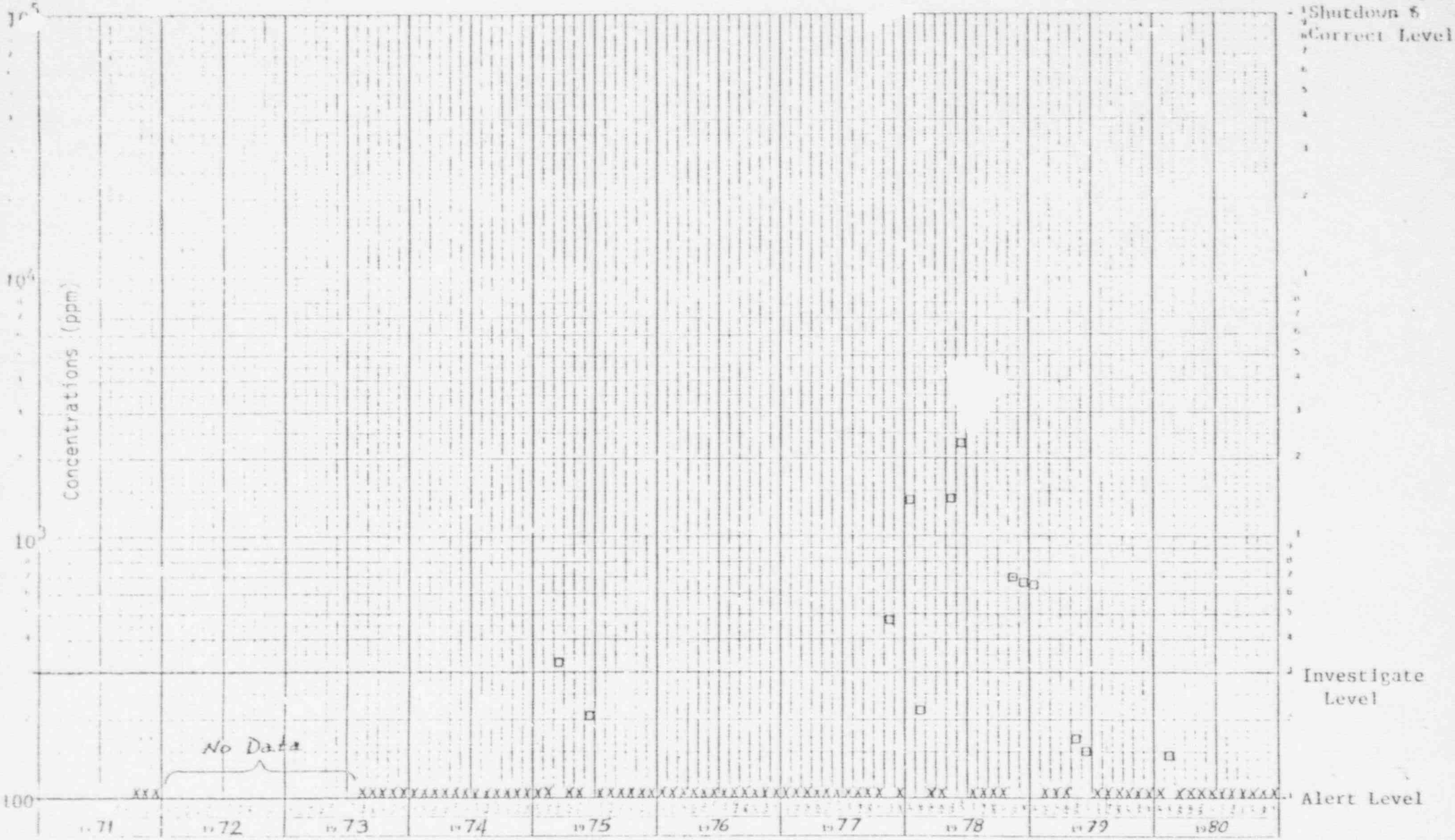

FIGURE 6.8-10 Average Monthly Sulfate Concentration (PPM) in Test Well No. 1.

Note: "X" signifies concentration below "Alert Level".

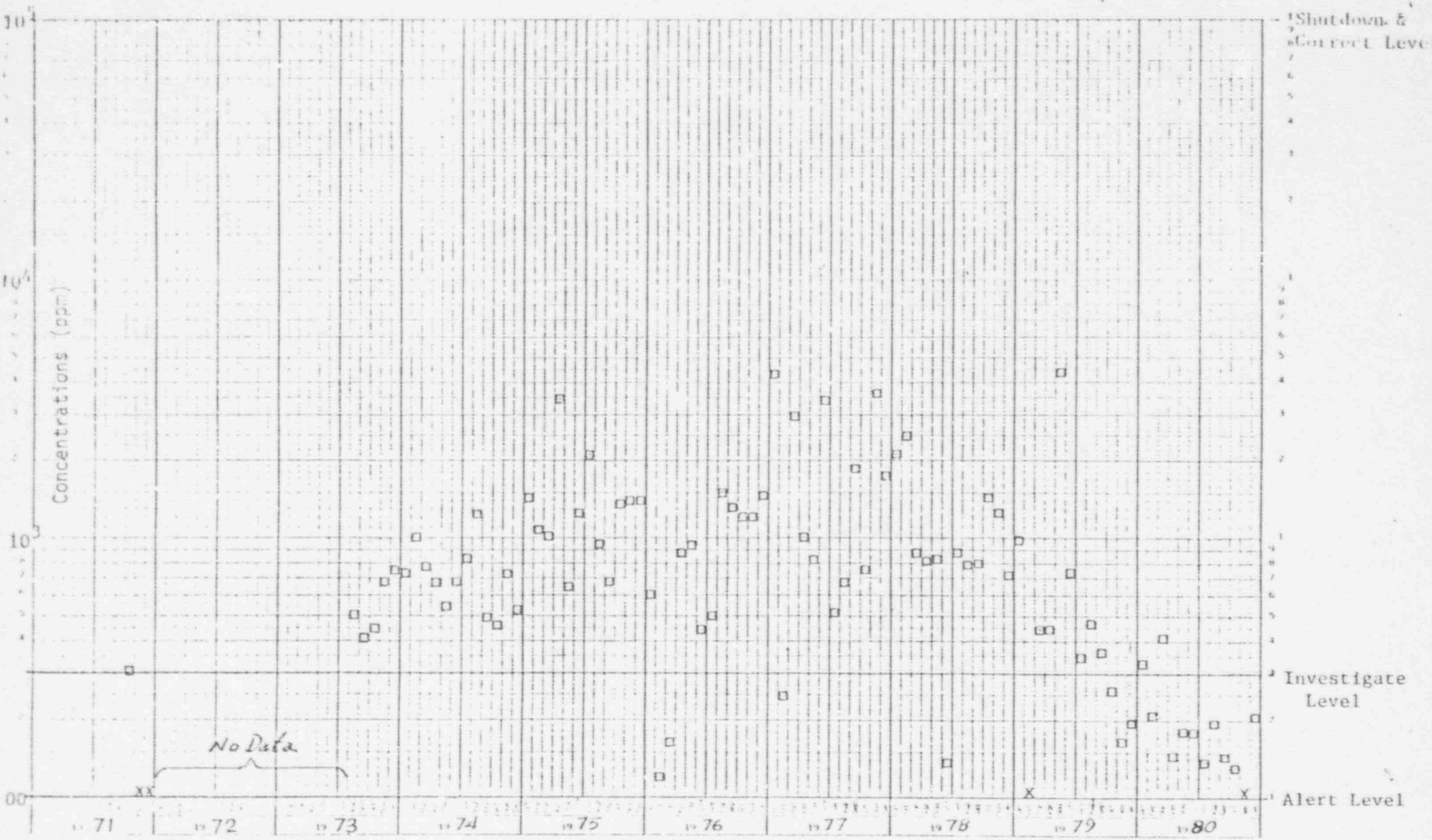

FIGURE 6.3-11 Average Monthly Sulfate Concentration (PPM) in Test Well No. 2.

Note: "X" signifies concentration below "Alert Level".

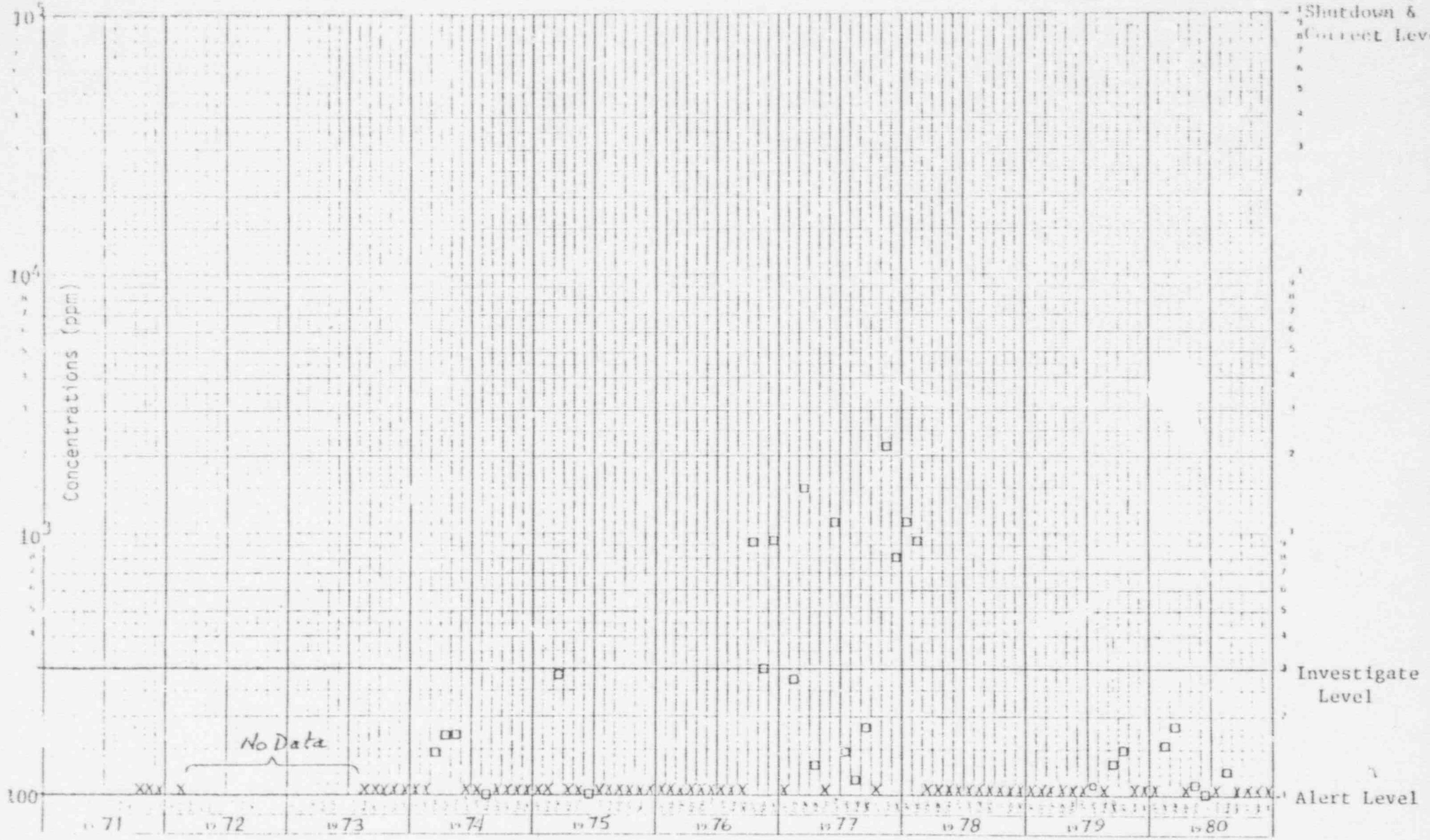

FIGURE 6.8-12 Average Monthly Sulfate Concentration (PPM) in Test Well No. 3.

Note: "X" signifies concentration below "Alert Level".

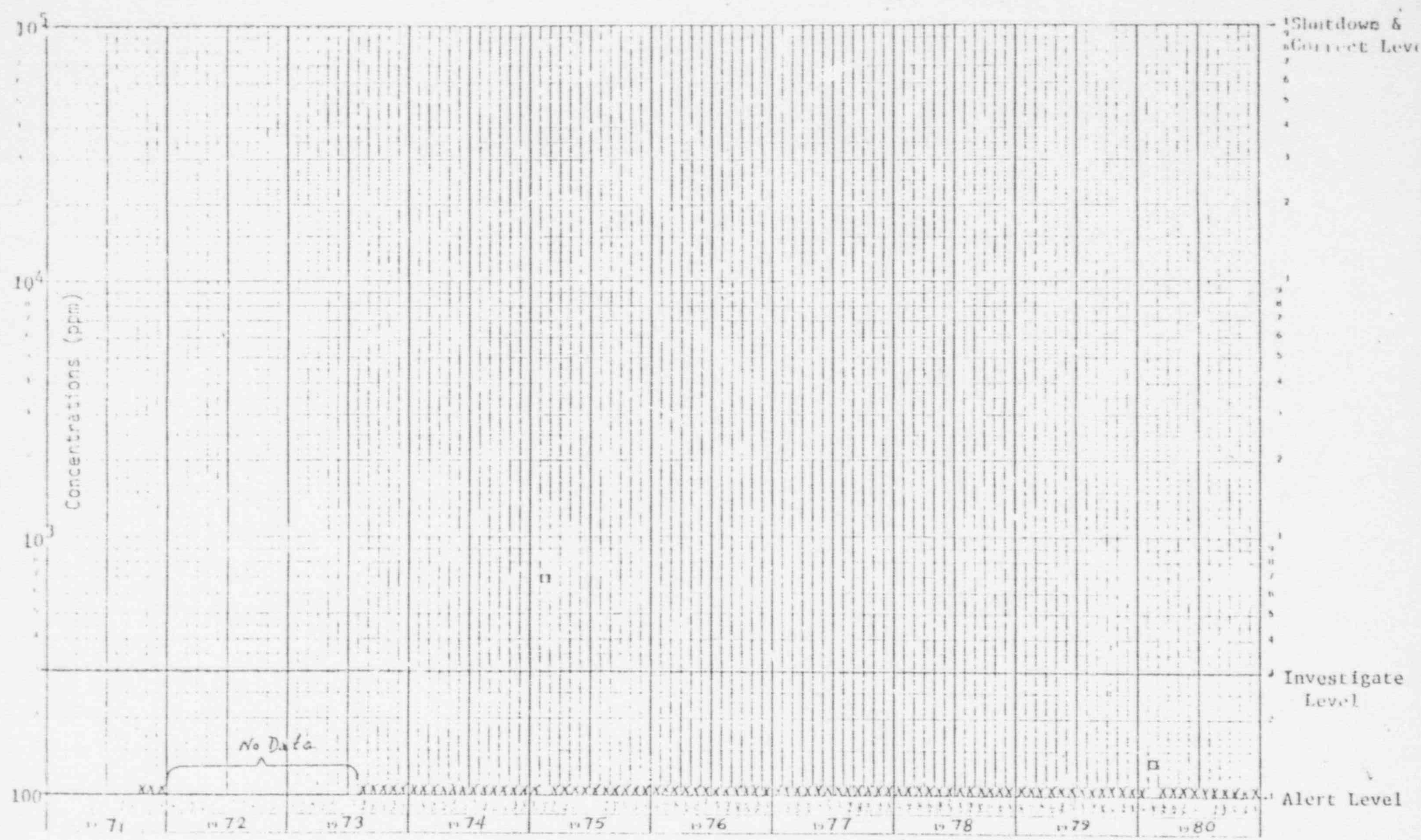

FIGURE 6.8-13 Average Monthly Sulfate Concentration (PPM) in Test Well No. 4 .

Note: "X" signifies concentration below "Alert Level".

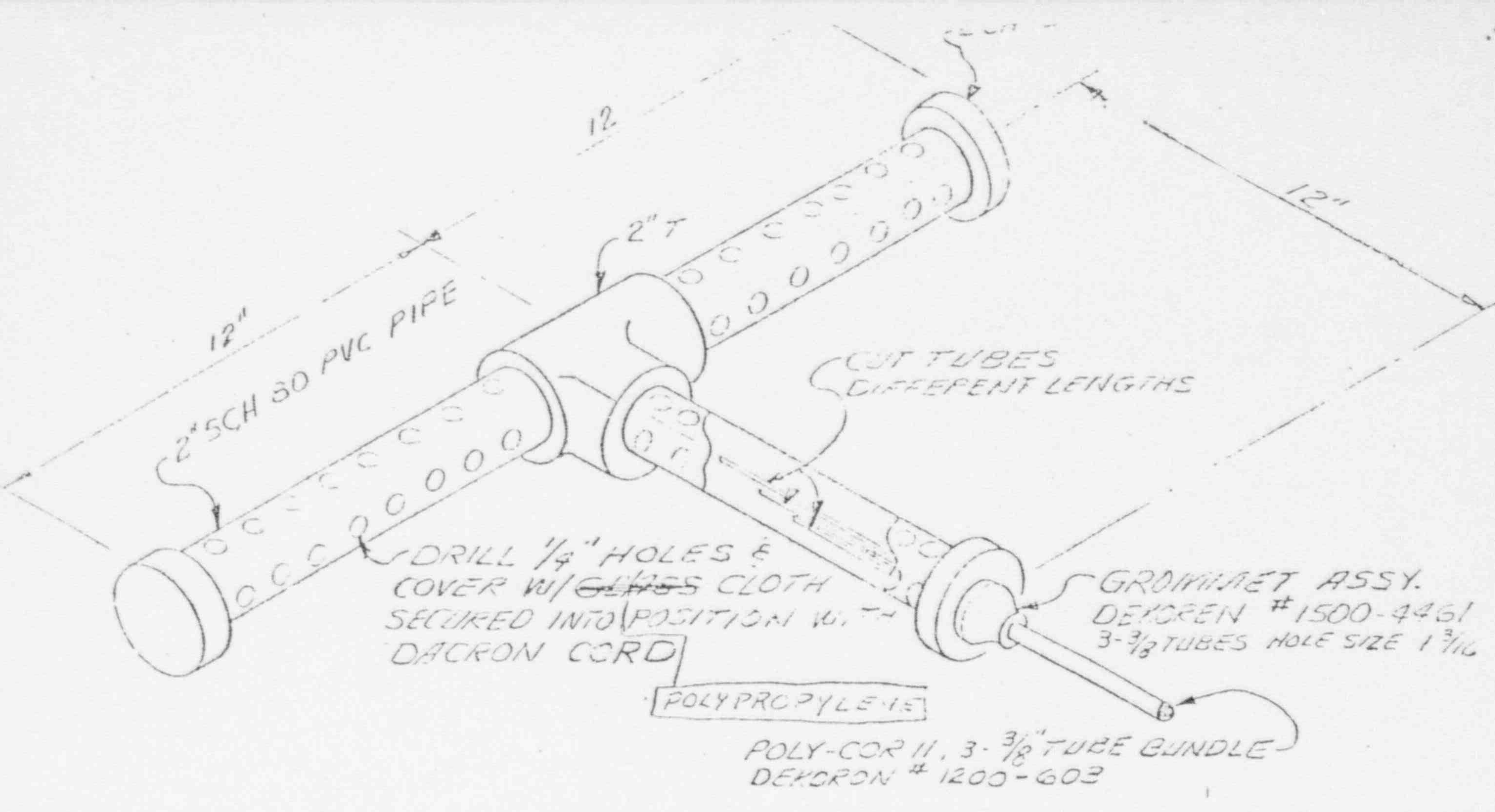

FIGURE 6.10-1

SAMPLING HEAD

LAGOON LEAKAGE MONITOR

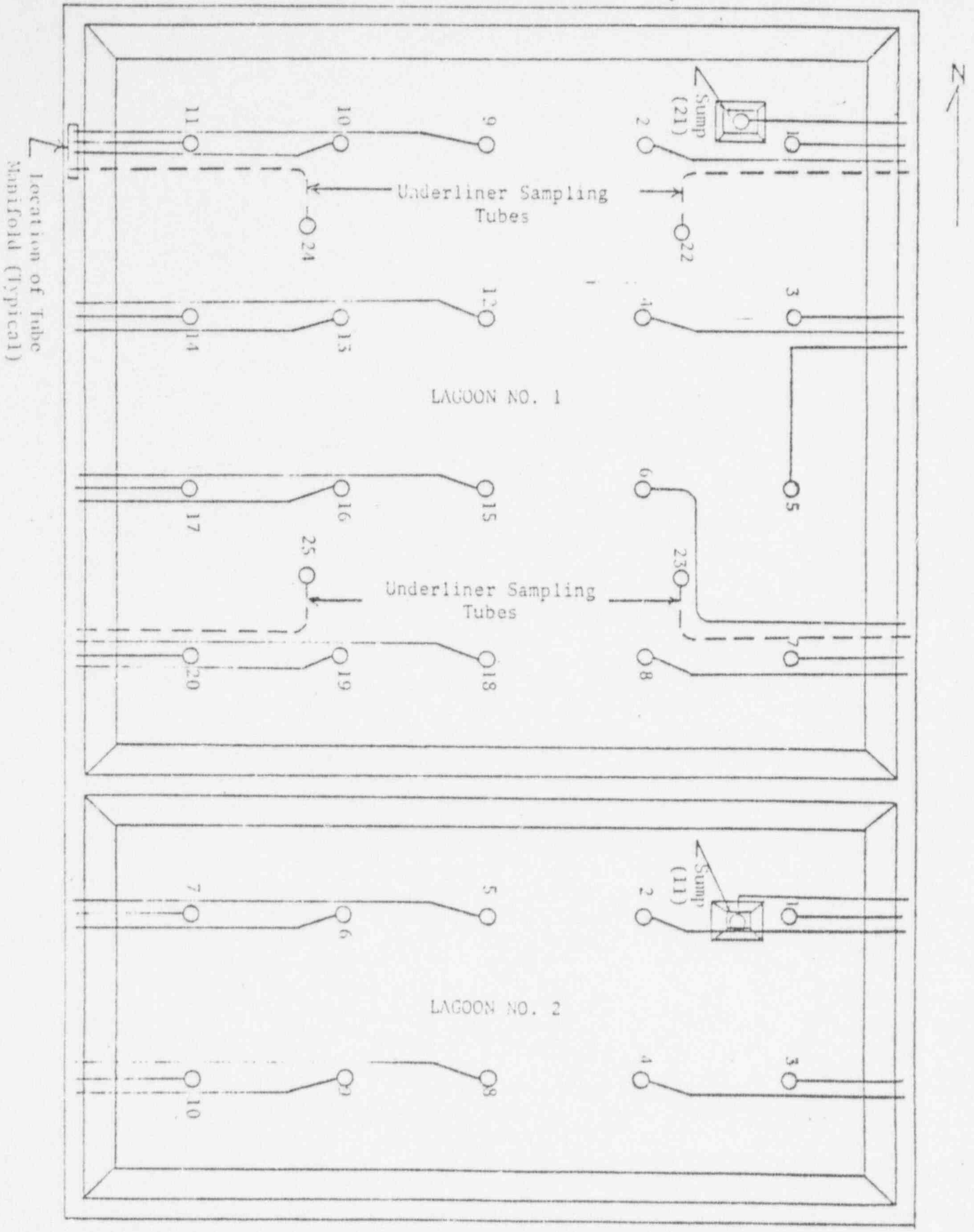

FIGURE 6.10-2

LOCATIONS OF LAGOON LINER INTEGRITY SAMPLING SYSTEM COMPONENTS

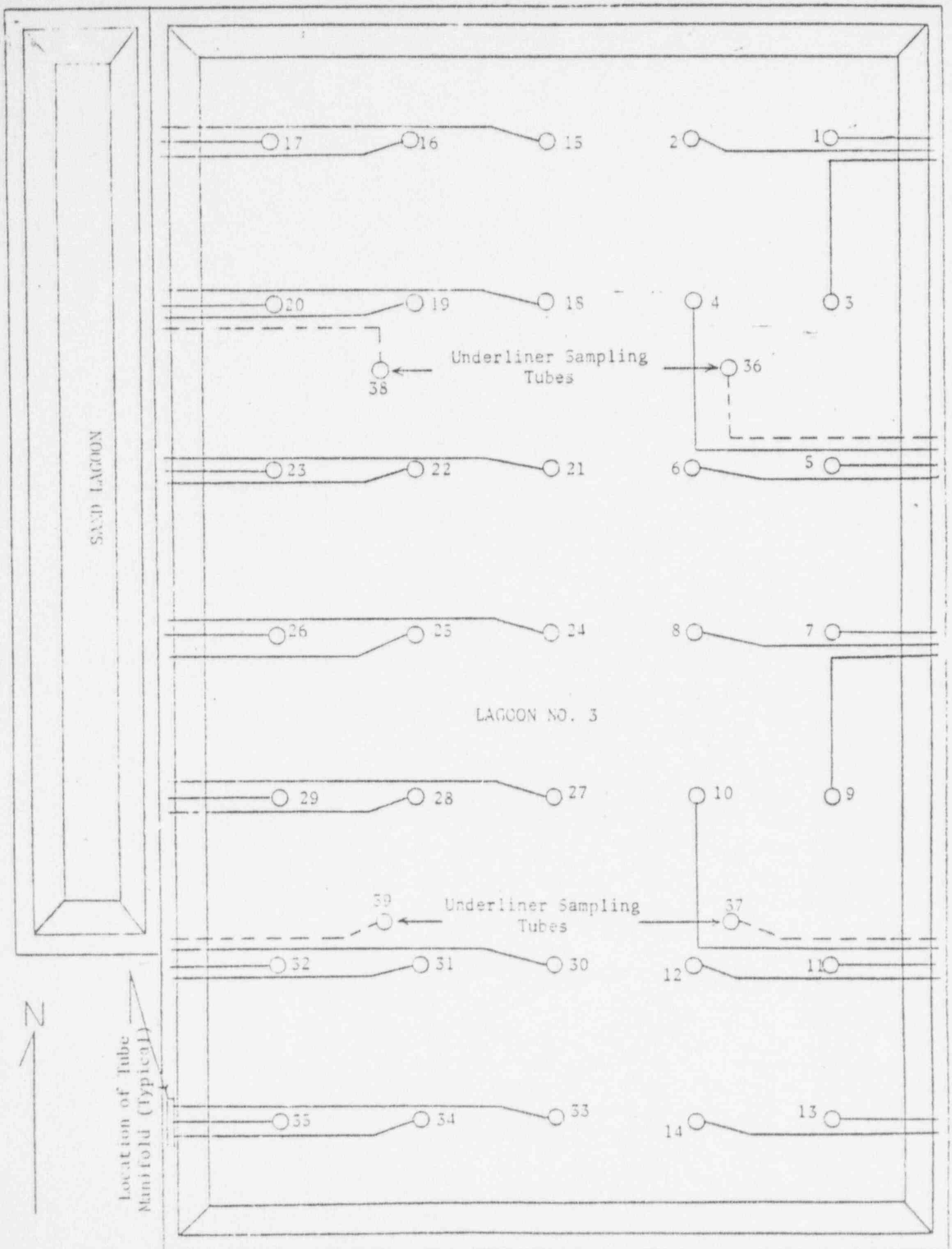

FIGURE 6.10-3 LOCATIONS OF LAGOON LINER INTEGRITY SAMPLING SYSTEM COMPONENTS

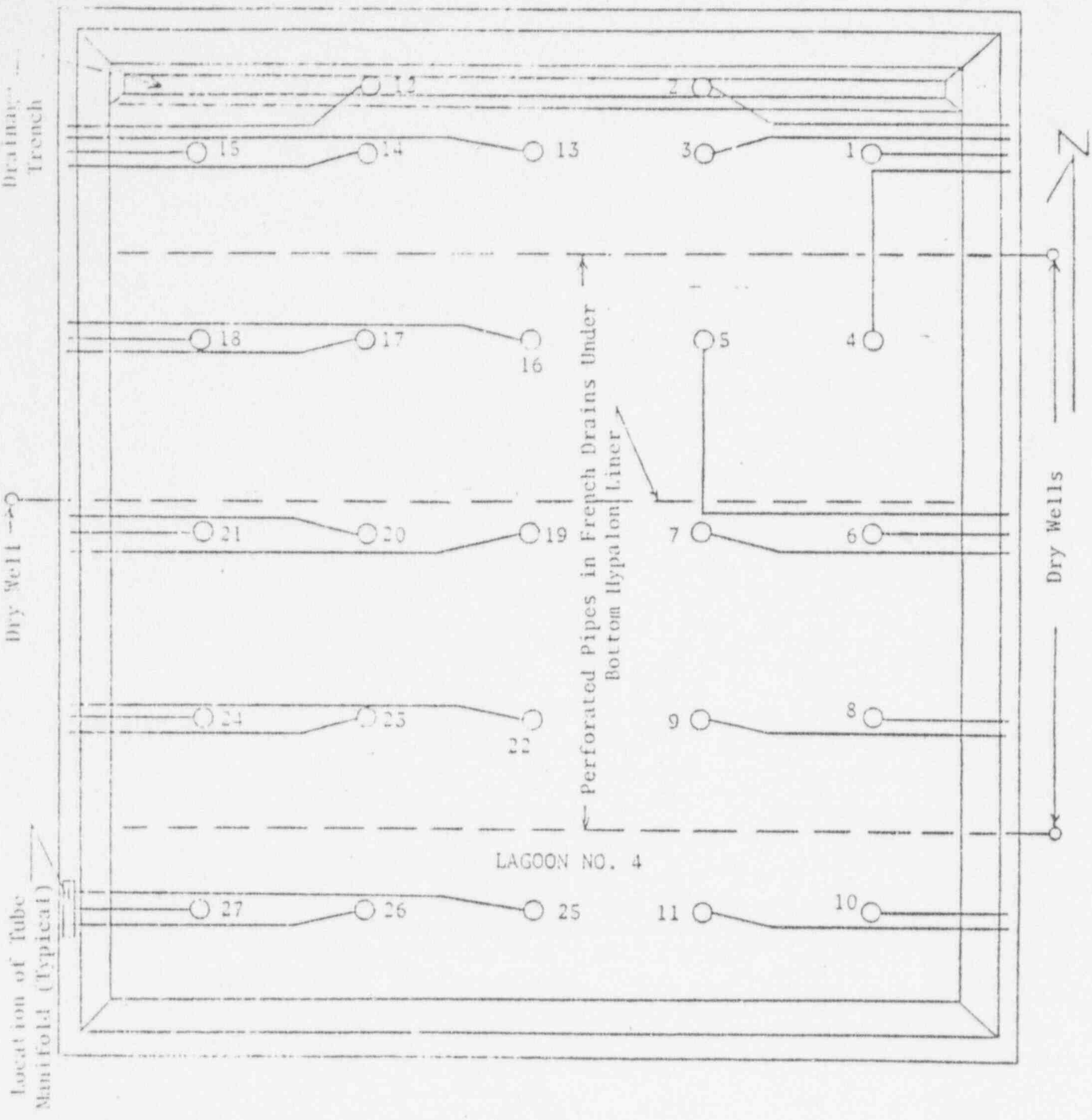

FIGURE 6.10-4

LOCATIONS OF LAGOON LINER INTEGRITY SAMPLING SYSTEM COMPONENTS

FIGURE 6.12

Locations of Test Wells