NORTH ROLLING PIN
IN-SITU URANIUM MINING TEST
GROUNDWATER RESTORATION REPORT

Submitted to:

U.S. Nuclear Regulatory Commission
Source Material License No. SUA-1199
Docket No. 40-8200
and
Land Quality Division
Wyoming Department of Environmental Quality

April 29, 1981

LICENSEE
THE CLEVELAND-CLIFFS IRON COMPANY
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PROJECT MANAGER FOR THE

THUNDERBIRD JOINT VENTURE
GETTY OIL
TEXAS EASTERN NUCLEAR, INC.
PIONEER NUCLEAR, INC.
I.C.G. VISTA PETROLEUMS
THE CLEVELAND-CLIFFS IRON COMPANY

40-8200
w/ltr 4/29/81

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INTRODUCTION and SUMMARY

The purpose of this document is to demonstrate to the U.S. Nuclear Regulatory Commission (NRC) and to the Wyoming Department of Environmental Quality (WDEQ) that the groundwater at the North Rolling Pin In Situ Uranium Mining Test Site has been adequately restored.

In April 1973, a joint venture of five equal participants was formed to conduct in situ uranium mining research. The Wyoming Mineral Corporation was the managing partner of the joint venture and was subsequently the operator of the research programs. The Thunderbird Joint Venture, managed by The Cleveland-Cliffs Iron Company (Cleveland-Cliffs), was also a joint venture participant and rented the North Rolling Pin Uranium Deposit to the joint venture as a test site for the in situ mining research.

In May 1974, Cleveland-Cliffs, on behalf of the Thunderbird Joint Venture, received the NRC, Source Material License No. SUA-1199 for the in situ mining of the North Rolling Pin Project.

The Wyoming Mineral Corporation began the uranium solution mining research project at North Rolling Pin on June 19, 1974. The in situ testing was conducted in a four-well pattern with an ammonium bicarbonate lixiviant. During testing, the ore-bearing zone lacked sufficient natural groundwater for sustained pumping and circulation of mining chemicals. Also, injectivity and fluid movement were limited by the tight sandstone. The Wyoming Mineral Corporation terminated the project on November 1, 1974 and abandoned the site without completing groundwater restoration.

Groundwater samples collected from the mine zone at the North Rolling Pin Site in 1975, indicated that high concentrations of contaminants from the solution mining project remained in the mine zone. Even though Cleveland-Cliffs and the Thunderbird Joint Venture had not operated an in situ uranium mining test at North Rolling Pin, as Licensee of NRC, Source Material License No. SUA-1199, they have been required to complete groundwater restoration.

During the summer and fall of 1978, Cleveland-Cliffs conducted the first major groundwater restoration program at North Rolling Pin. This program involved the water flushing of the mine zone to stabilize and remove the remaining mining solutions and the groundwater contaminants. As a result of this restoration, the ammonia and uranium concentrations in the groundwater were reduced to less than 2 mg per liter. However, the radium concentrations were thought to be high by the regulatory agencies, which resulted in additional restoration during the summer and fall of 1980.

In the spring of 1980, a plan to perform final restoration and reclamation of the North Rolling Pin Site was proposed to the NRC and the WDEQ. With minor modifications this plan was accepted, and immediately thereafter, the second major groundwater restoration program was begun. Water was injected into the mine zone to raise the water table; to develop additional ion exchange sites; to flush the mine zone; and to create sufficient water head and volume to extract the more concentrated contaminants by pumping. Contaminated water was then pumped from the mine zone. To finally stabilize residual dissolved radium in the groundwater, a dilute barium chloride solution was injected into the wells and then over 100,000 gallons of water were added to flush the barium chloride solution into the mine zone and to stabilize and dilute any residual barium chloride. The 1980 restoration program was terminated in October and the site remained undisturbed for fourteen days to allow the groundwater to reach equilibrium prior to sampling.

The first post-restoration groundwater sampling was conducted on November 4, 1980, and to confirm groundwater quality and stability, a second sampling of the groundwater was conducted on December 9, 1980; forty-nine days after cessation of activities. On each date, water was sampled from the same six wells. Ammonia was not detectable in nine of the twelve samples and was 1.25 mg per liter in the most concentrated sample. Uranium concentrations were below 1.0 mg per liter in all samples except one, which was less than 2.0 mg per liter. Radium concentrations ranged from 0.6 to 12.8 pCi per liter and averaged 3.4 pCi per liter. The average baseline concentration of radium in the ore zone at a nearby solution mine is in excess of 12.8 pCi per liter. Barium was not detectable in any of the samples.

DEMONSTRATION of RESTORATION

The groundwater quality at North Rolling Pin was not adequately defined prior to mining. During the 1980 restoration program, Cleveland-Cliffs has attempted to restore the groundwater quality to approximate premining baseline condition. The groundwater restoration program has restored the groundwater at North Rolling Pin to the original use prior to mining.

As with other uranium ore bodies in the Powder River Basin, it is very doubtful if the baseline water in the ore zone at North Rolling Pin was ever of drinking water quality. The radium concentrations in uranium bearing aquifers are naturally in excess of the 5 pCi per liter drinking water standard in much of Wyoming.

The F Sand in the North Rolling Pin region is not a potential water supply. During water sampling, there was insufficient water to collect by pumping, therefore, the samples were collected by bailing. The lack of water and the limited transfer of water in the ore zone contributed to the unsuccessful nature of the mining project and its ultimate termination. There are adequate sources of high quality water in the aquifers below the F Sand, and it is believed that anyone drilling a successful water well would need to tap these deeper sources of water.

NRC Source Material License No. SUA-1199 did not contain criteria or standards to demonstrate water quality restoration. The LQD, WDEQ did not have rules and regulations defining restoration at the time Wyoming Mineral Corporation conducted the in situ mining test in 1974. Solution mining did not have the environmental controls that are in effect today. Therefore, review of the restoration achieved at North Rolling Pin should take into consideration the environmental requirements that were applicable at the time of NRC licensing.

Based on the above discussions demonstrating groundwater restoration at North Rolling Pin, Cleveland-Cliffs as Manager of the Thunderbird Joint Venture requests that the NRC and the WDEQ approve the groundwater as being restored at the North Rolling Pin Site.

The degree of restoration achieved at North Rolling Pin should not be indicative of restoration capabilities at other in situ uranium mining operations. The geology and hydrology of the F Sand at North Rolling Pin are atypical of the ore bodies being mined by in situ methods. Restoration results achieved at other solution mines in the Powder River Basin would be more typical of the current state of solution mining technology. It is believed that any additional expenditures of any magnitude will not significantly improve the water quality or the potential use of the water at North Rolling Pin.

NORTH ROLLING PIN ENVIRONMENT

Location

The North Rolling Pin Site, shown on the Vicinity Map, Figure 1, is located in southwest Campbell County, Wyoming, approximately 45 miles southwest of Gillette. The sparsely populated area is in the central portion of the Powder River Basin. The site is specifically located in the northwest quarter of Section 14, Township 43 North, Range 76 West, and, areally, the wells utilized in the in situ mine comprise less than one acre.

Geology

The Powder River Basin is a topographic, as well as a structural, basin covering a large part of northeastern Wyoming and extending into southern Montana. The basin is bounded by the Big Horn Mountains on the west, the Laramie Range on the south, the Hartville Uplift on the southeast, and the Black Hills on the northeast. Exposed at the surface in the central part of the basin are rocks of Paleocene and Eocene Age. The Fort Union Formation (Paleocene Age) and the Wasatch Formation (early Eocene Age) are the primary formations exposed at the surface in the centr[illegible] of the Powder River Basin and cover many thousands of square miles.

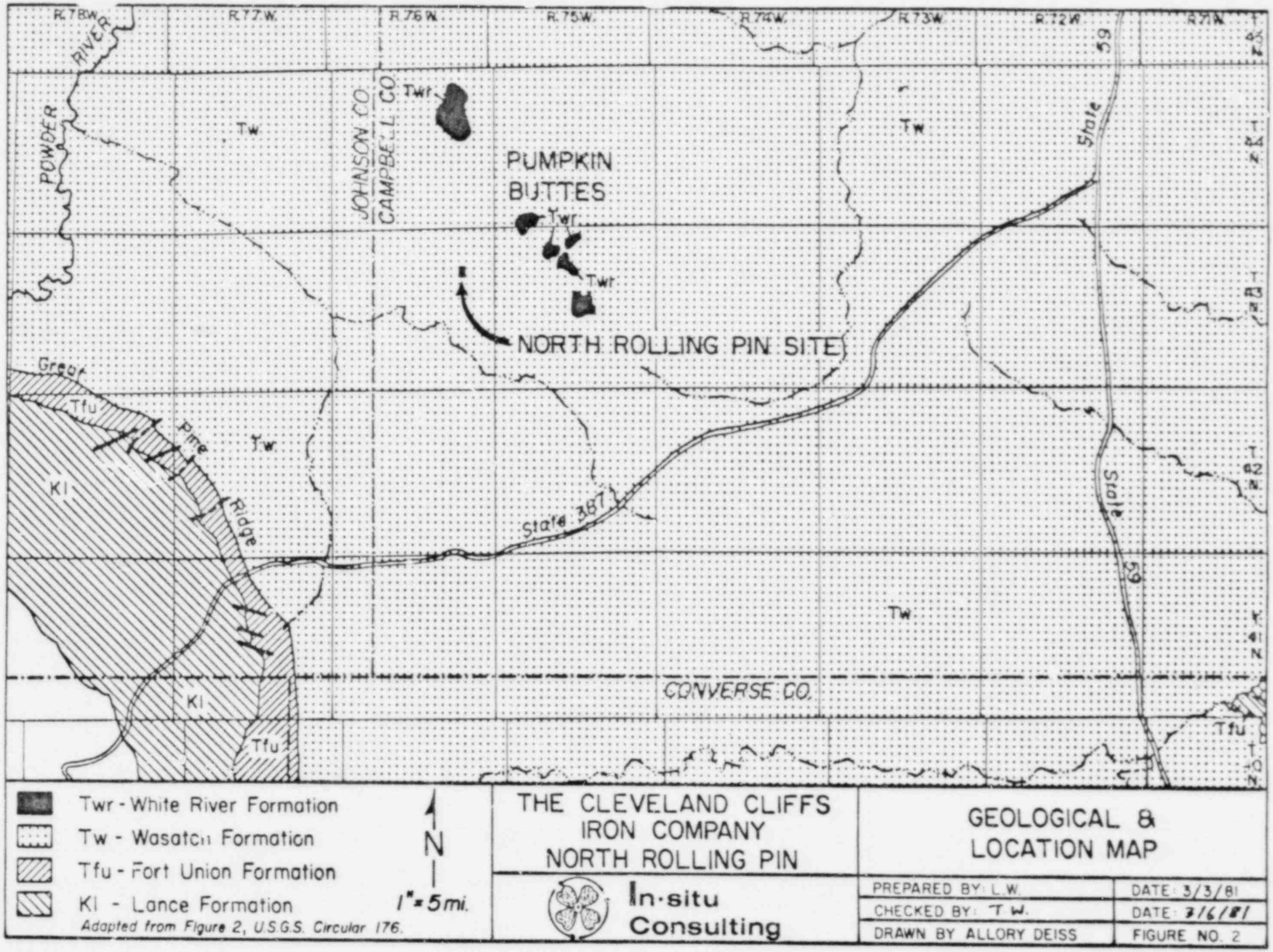
The Wasatch Formation is exposed on the surface at the North Rolling Pin Site and consists of variegated claystones and siltstones, both lenticular and relatively continuous sandstones, and thin coal and carbonaceous siltstone beds (refer to Figure 2). The thickness of the Wasatch Formation is not known, but Love (1952) estimates its thickness to be in excess of 2,000 feet in some parts of the Powder River Basin. The regional dip of the coal beds in the Wasatch Formation is about 30 feet per mile to the north-northwest.

The portion of the Wasatch Formation penetrated by drilling at the North Rolling Pin Site consists of a series of siltstone and sandstone units. Some of these units are continuous in the area; whereas, others are more lenticular in nature. The following sections taken from Well 95, located approximately 350 feet north of mining operation, show the stratigraphy in the vicinity.

REFERENCE:

Official Highway Map of Wyoming
Wyoming State Highway Commission
Dated 1978, SCALE: 1" = Approximately 18 Miles

THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	VICINITY MAP	
In-situ Consulting	PREPARED BY: L.W.	DATE: 3/3/81
	CHECKED BY: T.W	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 1


R.78W.
R.77W.
R.76W.
R.75W.
R.74W.
R.73W.
R.72W.
R.71W.
POWDER RIVER
JOHNSON CO.
CAMPBELL CO.
Twr
Tw
PUMPKIN BUTTES
NORTH ROLLING PIN SITE
State 59
State 387
Great Pine Ridge
Tfu
Kl
CONVERSE CO.
T 43 N
T 42 N
T 41 N
T 40 N
Twr - White River Formation
Tw - Wasatch Formation
Tfu - Fort Union Formation
Kl - Lance Formation
Adapted from Figure 2, U.S.G.S. Circular 176.
N
1" = 5 mi.
THE CLEVELAND CLIFFS IRON COMPANY
NORTH ROLLING PIN
In-situ Consulting
GEOLOGICAL & LOCATION MAP
PREPARED BY: L.W.
DATE: 3/3/81
CHECKED BY: T.W.
DATE: 3/6/81
DRAWN BY ALLORY DEISS
FIGURE NO. 2

Depth	Description
Surface to 95 Feet	Siltstone with lenses of sandy siltstone, silty sandstone, and thick discontinuous lenses of sandstone near the surface.
95 Feet to 137 Feet	Sandstone (F Sand).
137 Feet to 285 Feet	Siltstone with discontinuous sandstone lenses 5 to 10 feet thick in the upper 30 feet of the unit.
285 Feet to 305 Feet	Sandstone.
305 Feet to 343 Feet	Siltstone.
343 Feet to 487 Feet	Sandstone.
487 Feet to 500 Feet	Siltstone.

As shown on the North-South Cross Section, Appendix A, the sandstone zone 95 to 137 feet deep, the F Sand, is the mineralized unit at North Rolling Pin and is approximately 25 to 30 feet thick in the area of mining activity (refer to Figure 3). The North Rolling Pin Uranium Deposit is in the F Sand approximately 120 to 130 feet below the land surface. The F Sand is composed of a fine to medium grained, occasionally coarse grained, arkosic sandstone with five to ten percent clay, two to three percent calcite, and about one percent pyrite. Figure 4 shows the structural contours of the base of the F Sand.

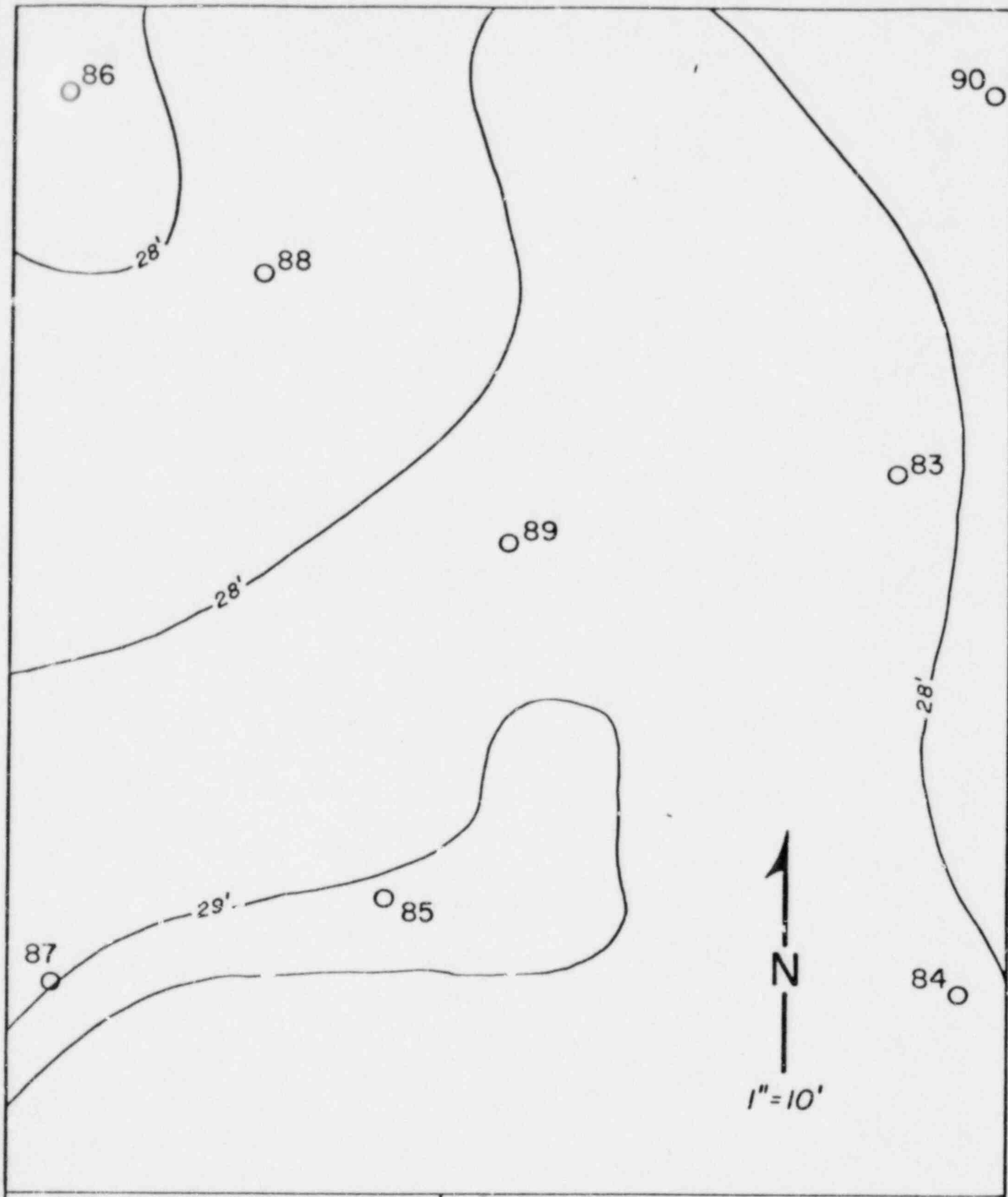
Drill holes for the mining operation showed the F Sand sandstone to be consistently underlain by the siltstone layer (137 feet to 285 feet at Well 95) throughout the area.

Hydrology

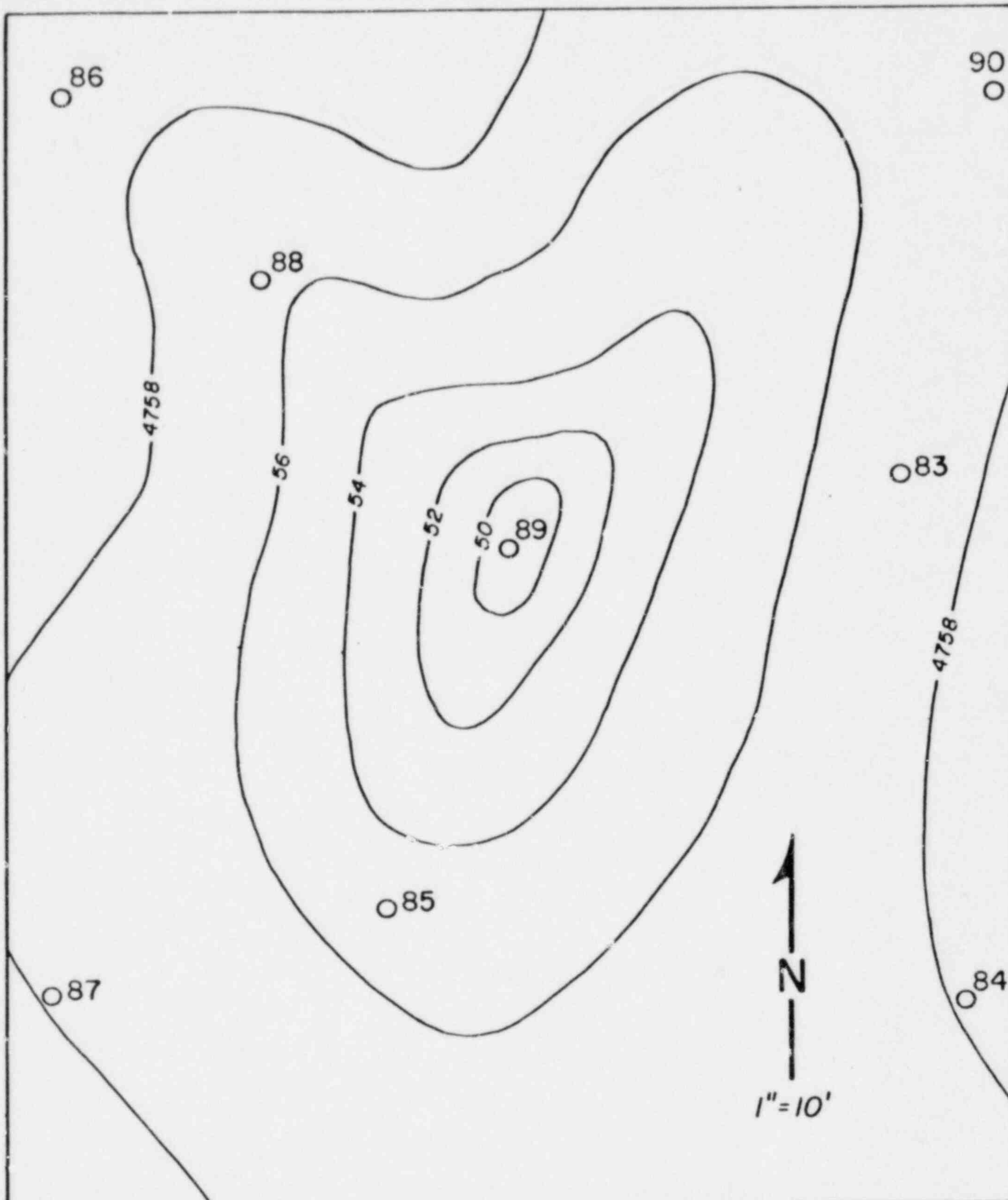
It is believed that no hydrologic tests or groundwater flow estimates were made by the Wyoming Mineral Corporation. The hydrologic evaluation of the ore zone at North Rolling Pin was conducted during the 1980 restoration program.

One multi-well injection test (Injection Well 89, Observation Wells 89 and 85) and three single-well injection tests (Wells 83, 85, and 88) were performed at North Rolling Pin to determine the hydrologic properties of the F Sand. The well locations are shown in Figure 5.

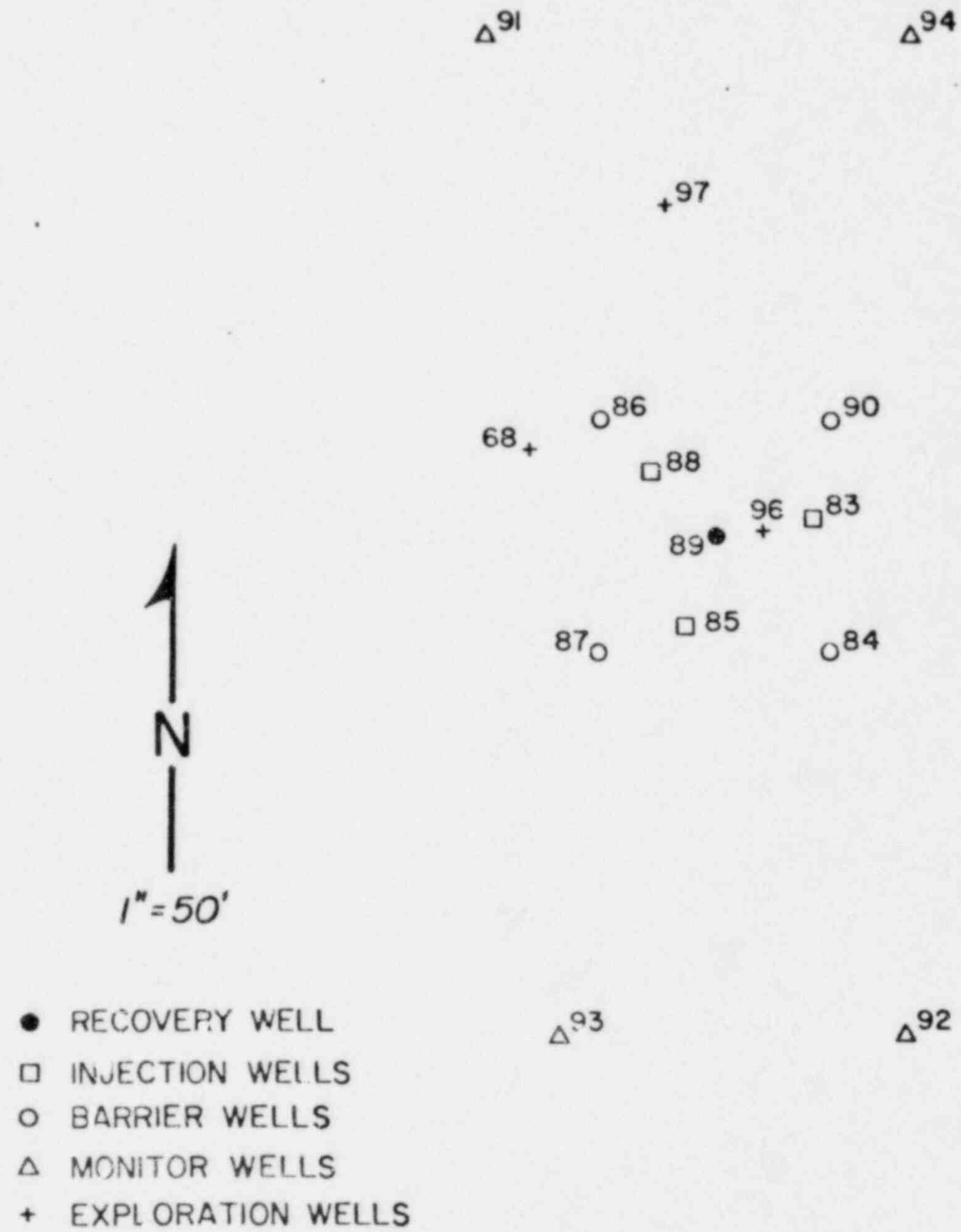
Boulton's (1954, 1963) delayed yield type curve was selected to analyze water level buildup data in observation wells. Boulton's technique was later elaborated by Prickett (1965), who used type curves based on Boulton's formulas and verified their application to aquifer test data. An enlarged version of Boulton's type curves, suitable for matching aquifer test data is given in Lohman (1972) and was used in the present data. One of the assumptions used in the derivation of Boulton's equation is that the formation is a water table



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	'F' SAND ISOPACH	
In-situ Consulting	PREPARED BY: L.W.	DATE: 3/3/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 3



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	STRUCTURE CONTOURS BASE OF 'F' SAND	
In·situ Consulting	PREPARED BY: L.W.	DATE: 3/3/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 4



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	WELL LOCATION MAP	
In-situ Consulting	PREPARED BY: L.W.	DATE: 3/3/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 5

aquifer. To verify this assumption, the water levels were measured and confirmed by correlating with geologic cross sections that water levels rise to approximately 20 feet above the bottom of the F Sand. The upper 10 feet are presumably at or near residual saturation in the vadose zone. The top of the F Sand and water level are respectively about 130 feet and 140 feet below ground level. The F Sand porosity is estimated to be approximately 30%.

The storage coefficient of 0.02, calculated from the aquifer test, indicated the F Sand behaves as a water table or phreatic aquifer, and not as a confined aquifer under greater than atmospheric pressure.

The straight line method (Earlougher, 1977) was used to analyze the water level buildup data in injection wells since the method considers the effect of skin (well loss).

Figures 6 to 8 show the aquifer test analyses on the multiwell injection test. Figures 9 to 11 show the analyses on the single-well injections tests on Wells 83, 85, and 88. The average values of transmissivity and storage coefficient were calculated to be 336 gpd/ft. (0.6 darcy) and 0.024, respectively. Table 1 summarizes the test results.

TABLE 1 - SUMMARY of AQUIFER TEST RESULTS

Date	Test	Well No.	Transmissivity (gpd/ft)	Storage Coefficient
7/30/80	Multi-well Injection Test on 89	89	314	--
		85	622	0.022
		83	518	0.025
7/31/80	Single-Well Injection Test	88	237	--
8/01/80	Single-Well Injection Test	85	543	--
8/01/80	Single-Well Injection Test	83	179	--

The water level was measured six times from July 7 to December 9, 1980. The water levels along with the well collar elevations provided the piezometric surfaces (Figures 12 to 17, Table 2). The water levels measured on July 7 were considered to be the static water levels since the measurements were done prior to the 1980 restoration program.

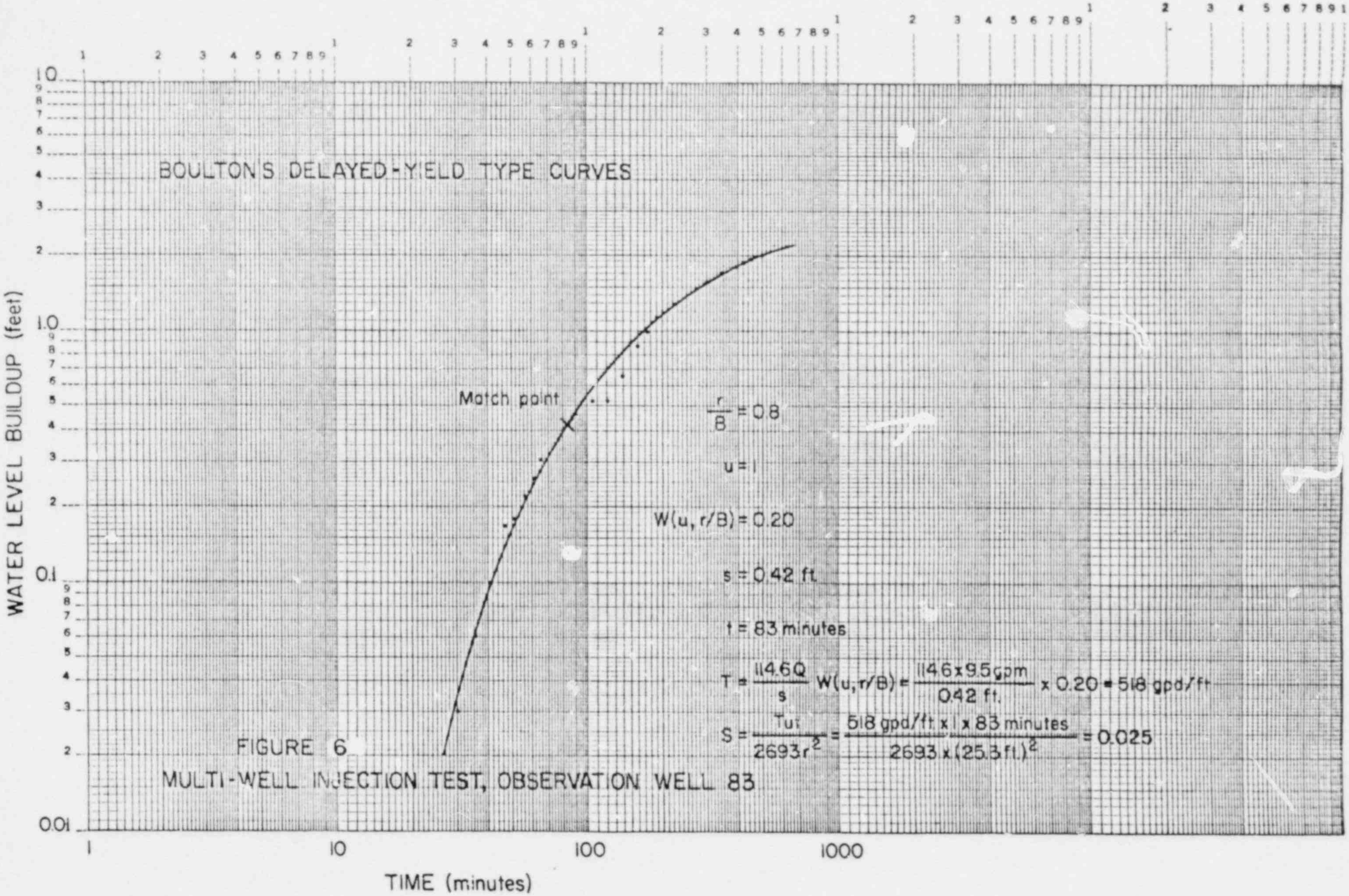


FIGURE 6

MULTI-WELL INJECTION TEST, OBSERVATION WELL 83

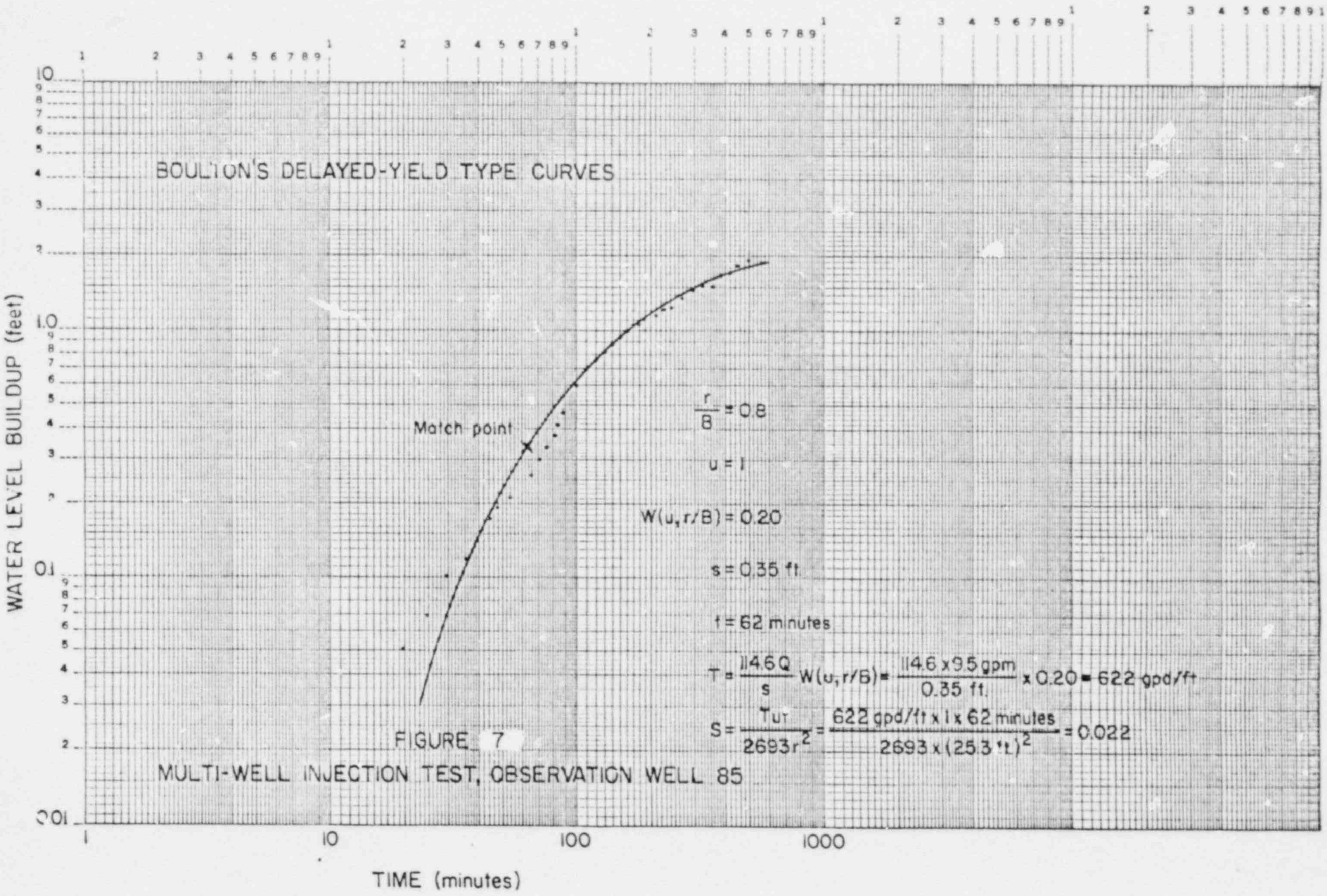


FIGURE 7

MULTI-WELL INJECTION TEST, OBSERVATION WELL 85

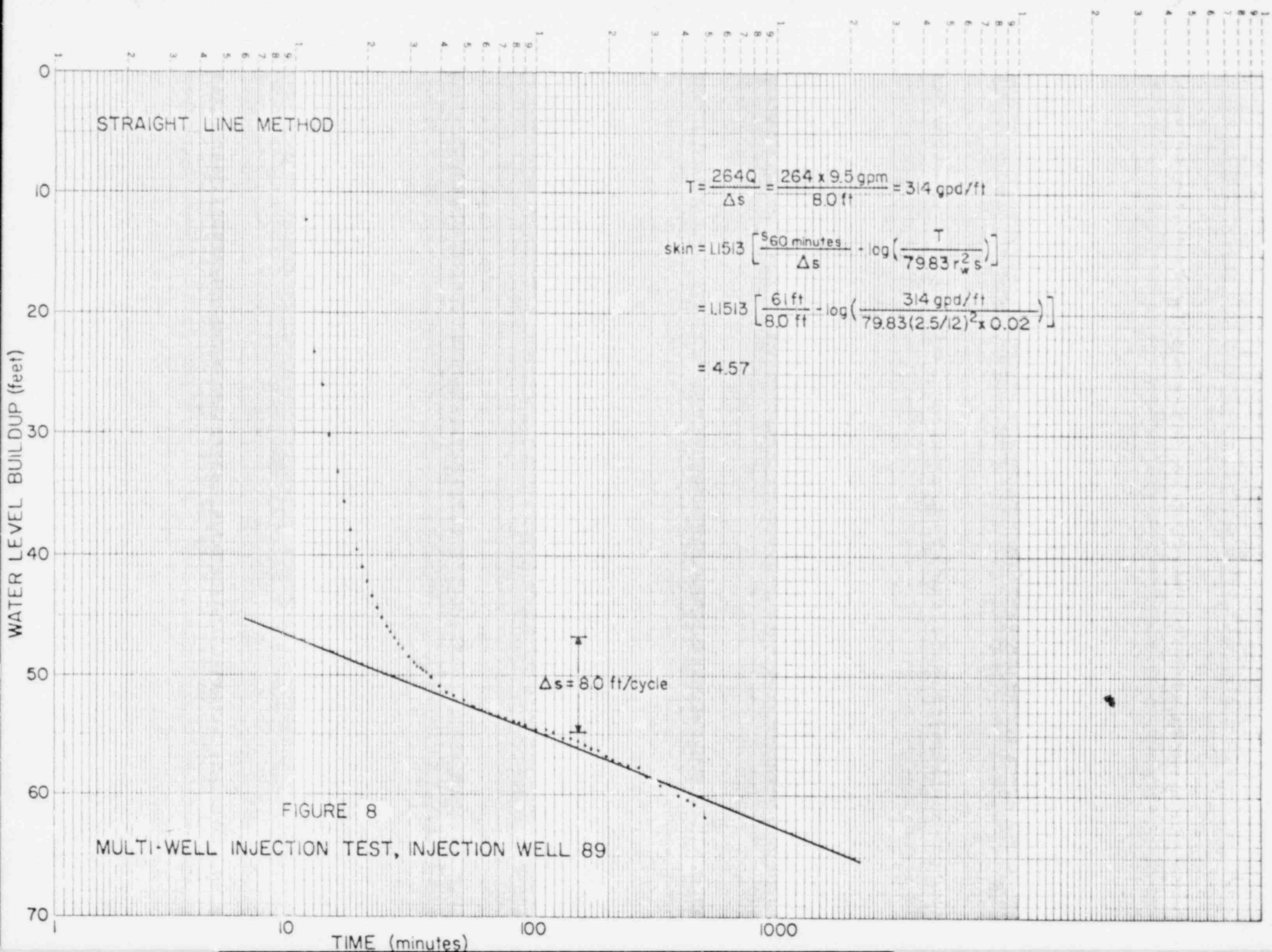


FIGURE 8

MULTI-WELL INJECTION TEST, INJECTION WELL 89

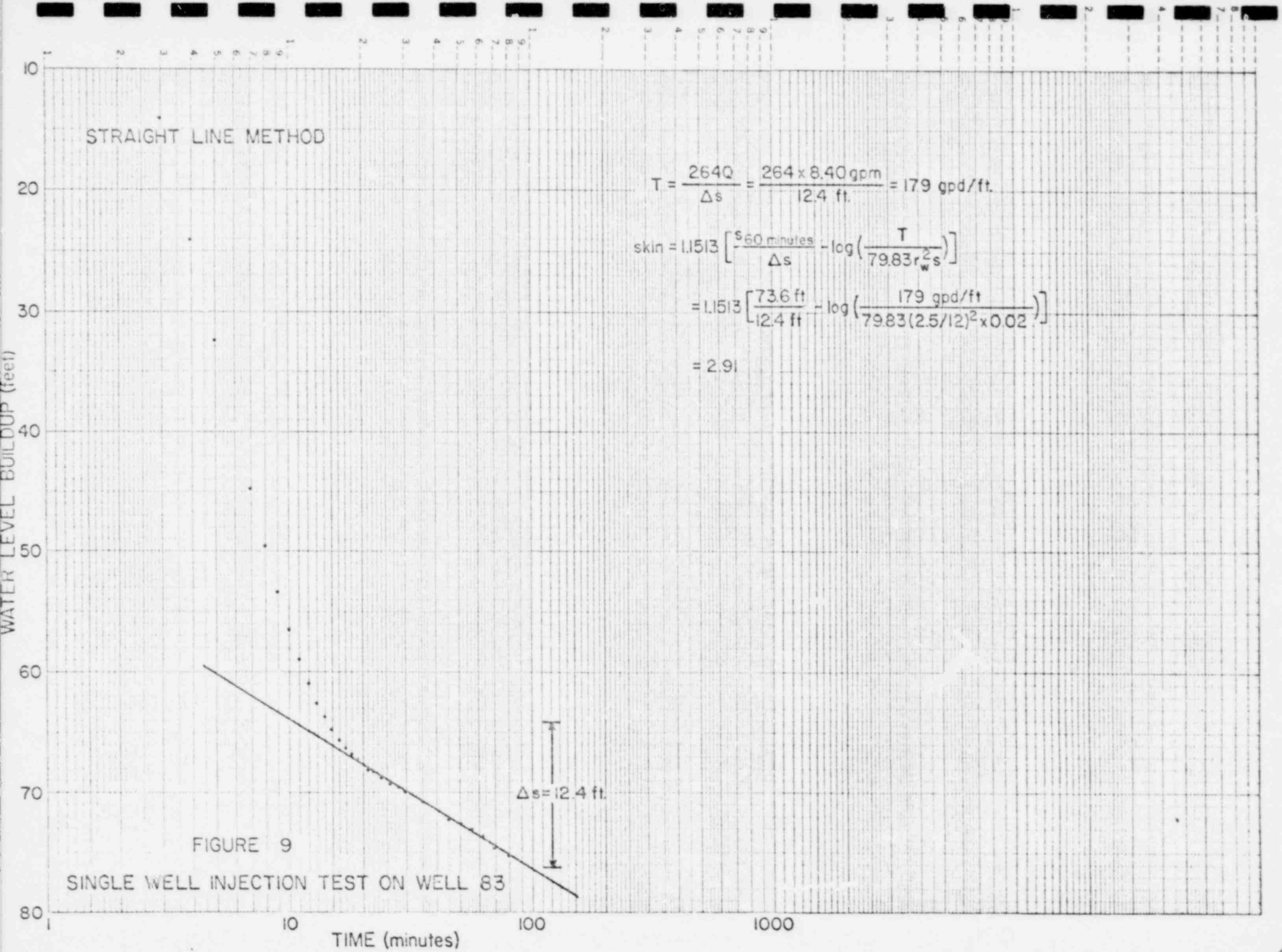


FIGURE 9

SINGLE WELL INJECTION TEST ON WELL 83

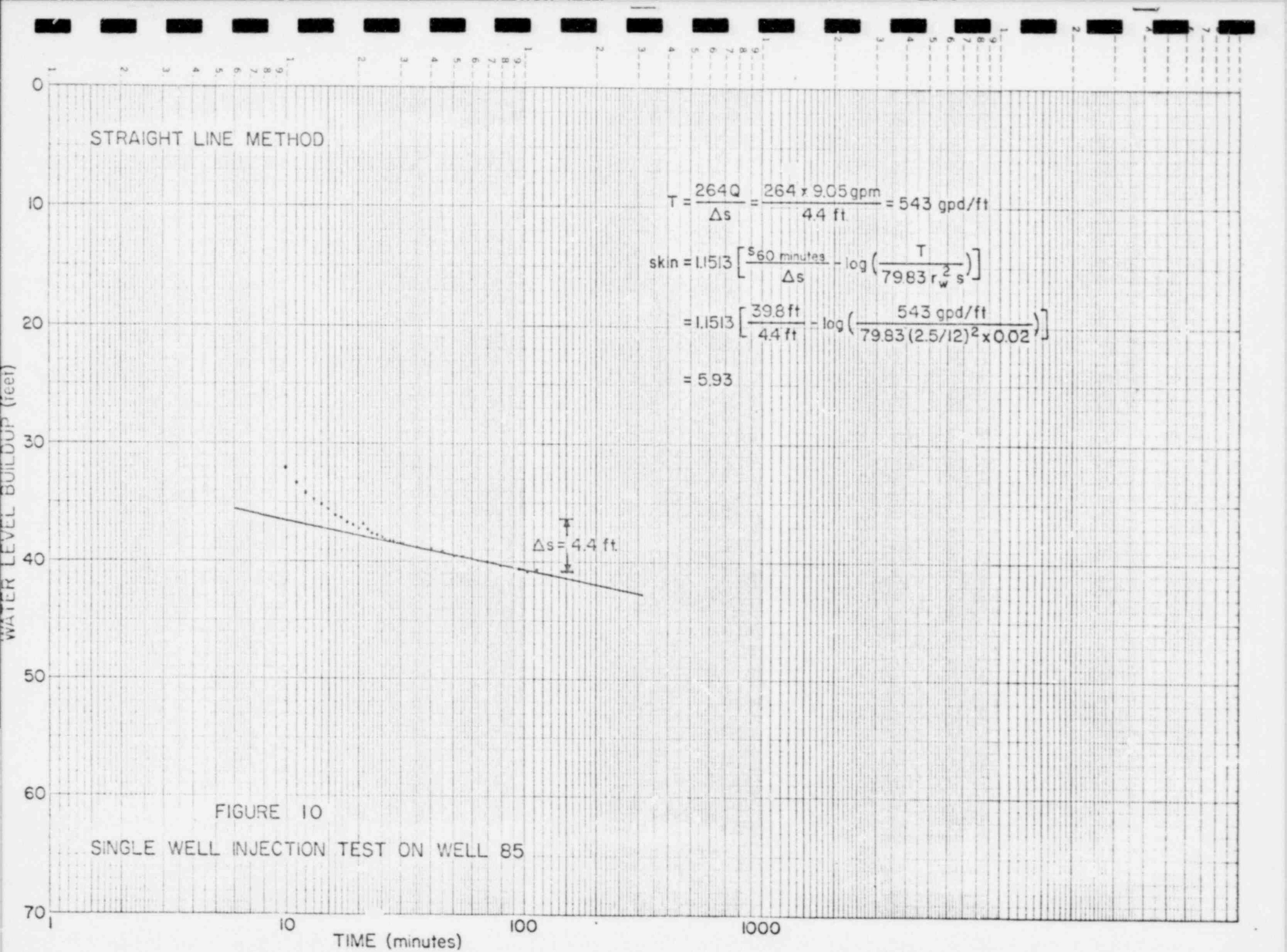


FIGURE 10

SINGLE WELL INJECTION TEST ON WELL 85

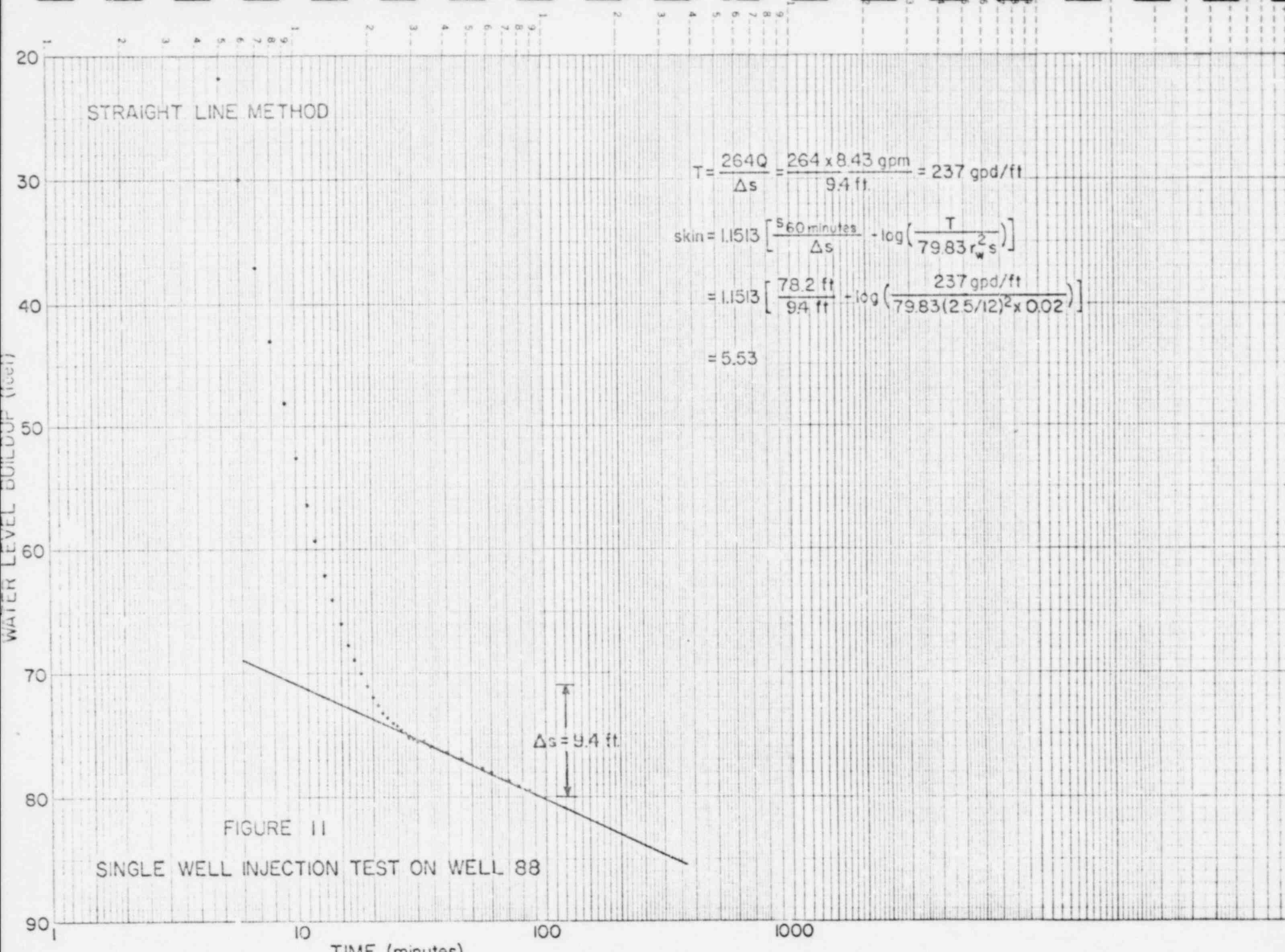
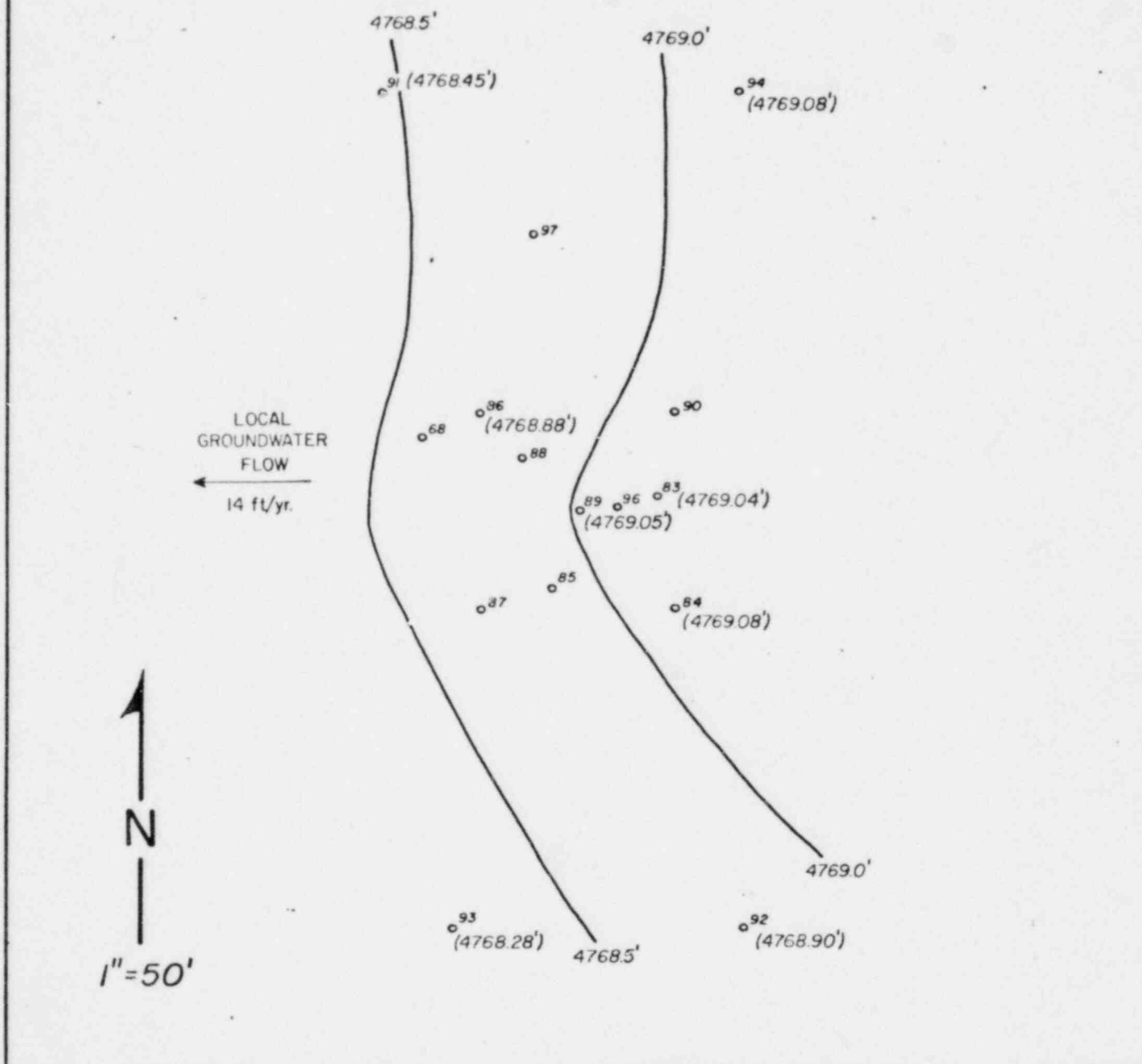


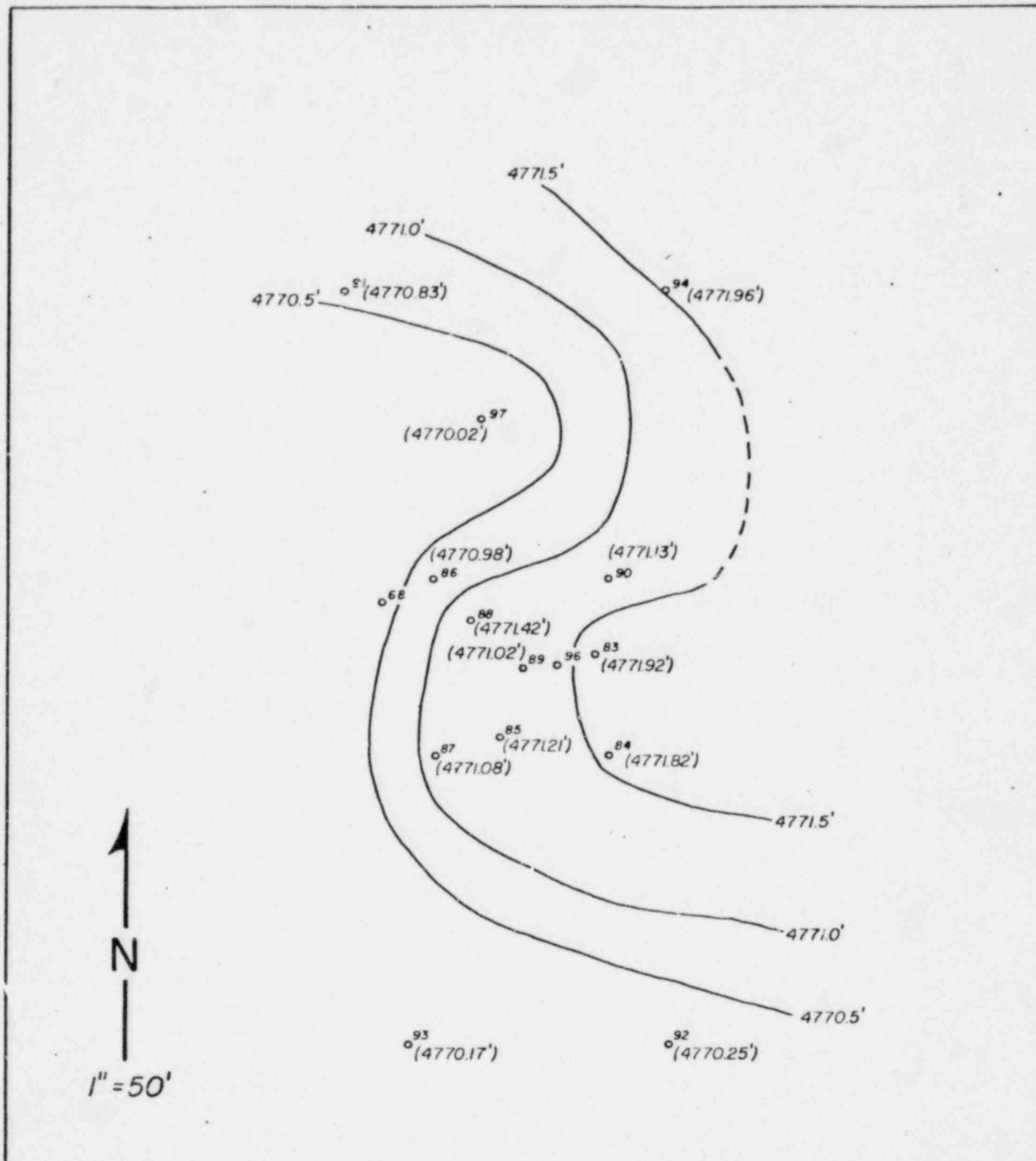
FIGURE 11

SINGLE WELL INJECTION TEST ON WELL 88



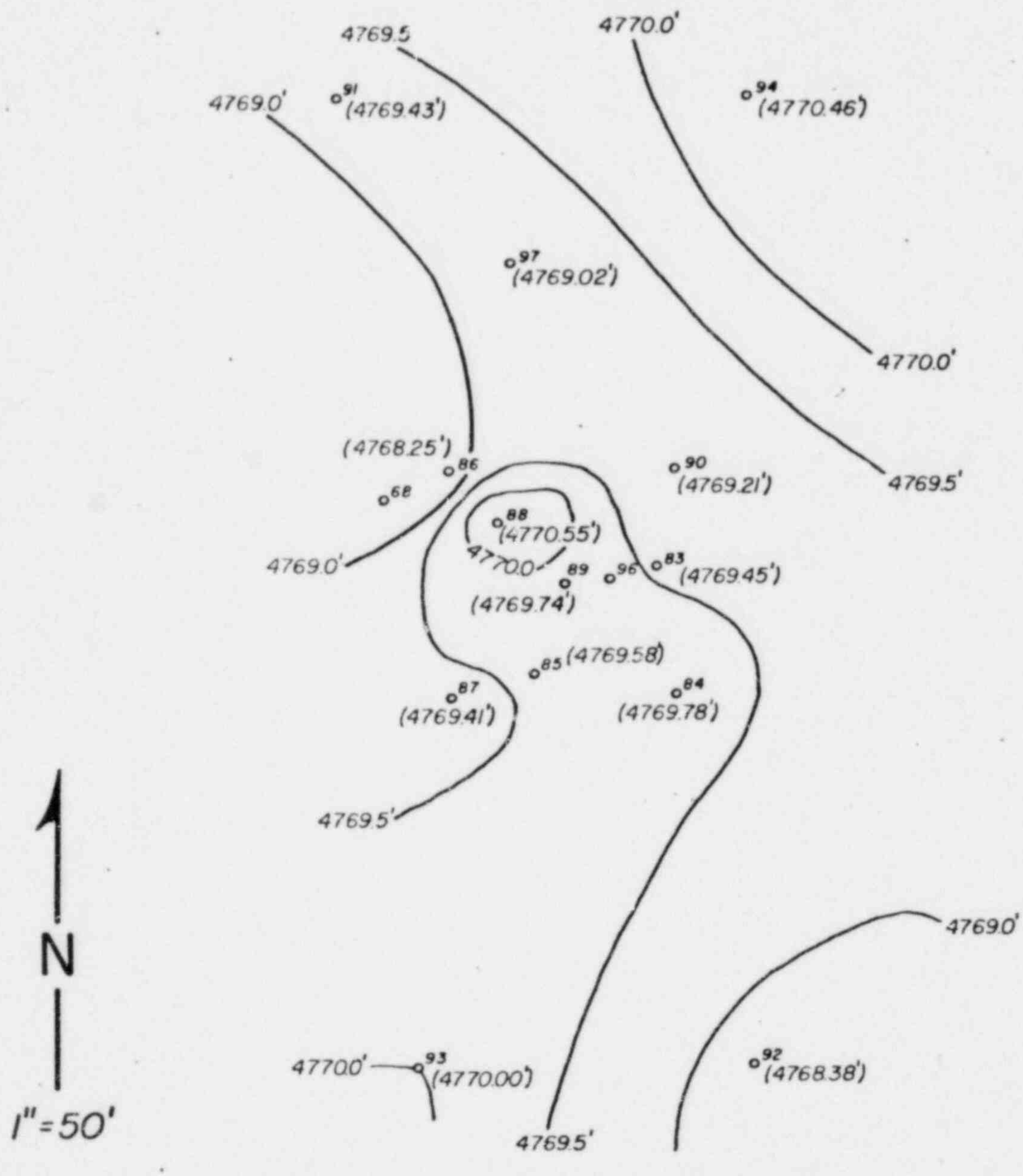
THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, JULY 7, 1980

In·situ Consulting	PREPARED BY: T.W.	DATE: 3/6/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 12

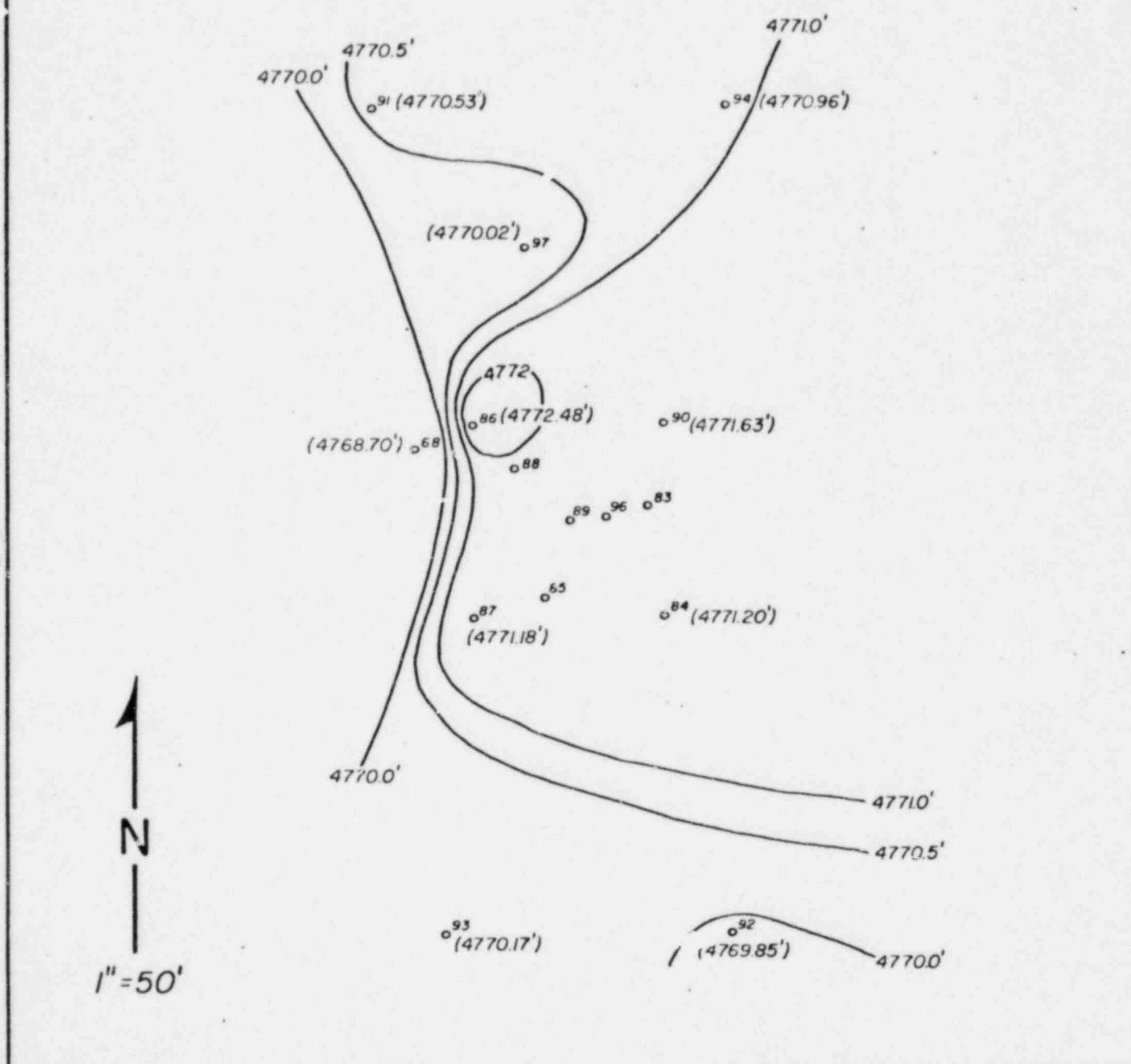


THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, JULY 13, 1980

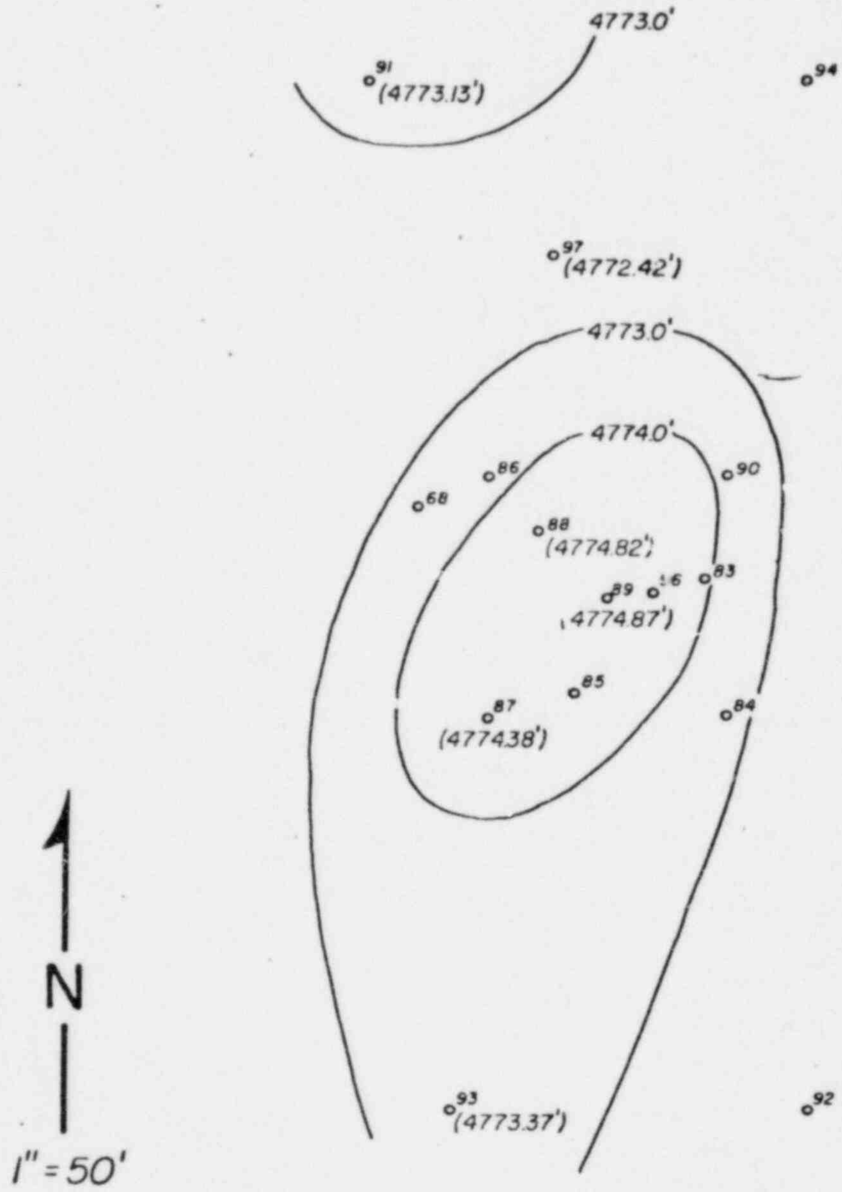
In-situ Consulting	PREPARED BY: T.W.	DATE: 3/6/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 13



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, JULY 24, 1980	
In·situ Consulting	PREPARED BY: T.W.	DATE: 3/6/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 14



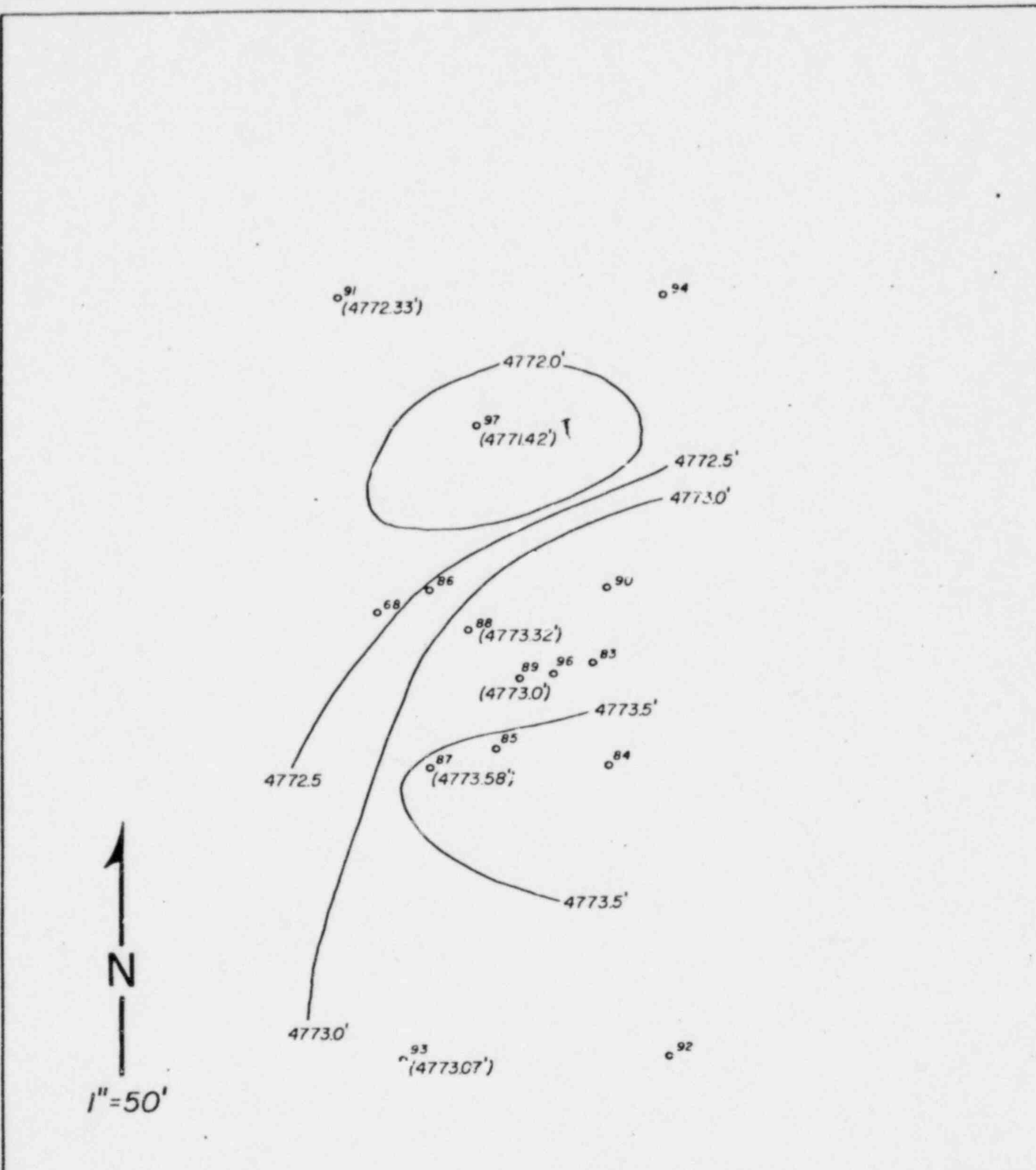
THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, JULY 28, 1980	
In-situ Consulting	PREPARED BY: T.W.	DATE: 3/6/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 15



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, NOV. 4, 1980

In-situ Consulting

PREPARED BY: T.W.	DATE: 3/6/81
CHECKED BY: T.W.	DATE: 3/6/81
DRAWN BY ALLORY DEISS	FIGURE NO. 16



THE CLEVELAND CLIFFS IRON COMPANY NORTH ROLLING PIN	LOCAL PIEZOMETRIC SURFACE MAP, DEC. 9, 1980

In-situ Consulting	PREPARED BY: T. W.	DATE: 3/6/81
	CHECKED BY: T.W.	DATE: 3/6/81
	DRAWN BY ALLORY DEISS	FIGURE NO. 17

TABLE 2 - PIEZOMETRIC SURFACES*

Well No.	7/07/80	7/13/80	7/24/80	7/28/80	11/04/80	12/09/80
83	4769.04	4771.92	4769.45	--	--	--
84	4769.08	4771.50	4789.78	4771.20	--	--
85	--	4771.21	4769.58	--	--	--
86	4768.88	4770.98	4768.25	4772.48	--	--
87	--	4771.08	4769.41	4771.18	4774.38	4773.58
88	--	4771.42	4770.55	--	4774.82	4773.32
89	4769.05	4771.07	4769.74	--	4774.87	4773.07
90	--	4771.13	4769.21	4771.63	--	--
91	4768.45	4770.83	4769.43	4770.53	4773.13	4772.33
92	4768.90	4770.25	4768.35	4769.85	--	--
93	4768.28	4770.17	4770.00	4770.17	4773.57	4773.07
94	4769.08	4771.96	4770.46	4770.96	--	--
97	--	4770.02	4769.02	4770.02	4772.42	4771.42

* Above Mean Sea Level

Based on the hydraulic gradient calculated from the July 7 piezometric contours and the average hydrologic properties observed from the injection tests, a westward groundwater velocity of 14 feet per year was obtained. The magnitude of velocity is fairly consistent with the regional groundwater flow observed at neighboring sites in the region.

With injection test data on transmissivity and storage coefficient, a maximum pumping rate of 1.8 gallons per minute is derived. At the North Rolling Pin Site, however, the pumping ratio actually measured has been only a few tenths of a gallon per minute. The reason is two-fold. The geologic cross sections indicate that the pilot well field is in a depression with at least three partial boundaries limiting the flow. From image well theory, this would reduce the sustained pumping rate by approximately a factor of 3. Furthermore, the saturated thickness is reduced toward these boundaries resulting in an effective reduction in transmissivity. The combined effect of both factors is to limit the practical natural pumping rate (without injection) to only a few tenths of a gallon per minute. Therefore, the water in the F Sand cannot be considered as a viable water source. A water supply well in this area would be drilled deeper into the underlying aquifer which would provide a steady reliable supply of good quality water. This was done prior to the solution mining test to obtain sufficient quantities of water for mining and restoration.

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Lohman, S. W., Groundwater Hydraulics, U.S. Geological Survey Professional Paper 708, 1972.

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IN SITU URANIUM MINING TEST

The in situ solution uranium mining project at the North Rolling Pin Site was begun by Wyoming Mineral Corporation on June 19, 1974.

The in situ mining well field consisted of 12 wells which are shown in Figure 5 and are numbered 83 through 94. The mine pattern consisted of three injection wells (Wells 83, 85, and 88) and one recovery well (Well 89). The injection wells formed an equilateral triangle and each was spaced approximately 23 feet from the central recovery well.

To supply sufficient water for continuous pumping and the circulation of lixiviant in the ore zone, and to create a water barrier for mine solution control, four water injection barrier wells (Wells 84, 86, 87 and 90) were drilled into the mine zone around the mine pattern area at 60-foot spacings. Each barrier well was approximately 45 feet from the center recovery well.

Four monitor wells (Wells 91, 92, 93, and 94) were completed into the F Sand, 100 feet out from the barrier wells to provide for monitoring of possible mining solution excursions.

To supply an adequate quantity of water to the ore zone and the test site, a water supply well (Well 95) was drilled through the F Sand into the A Upper-B Sand to a depth of approximately 500 feet, where sufficient water could be obtained. Well 95 is shown on the Well Field Layout Map, Appendix A.

Wells 68, 96, and 97 have been used for restoration and monitoring at the North Rolling Pin Site.

The recovery, injection and barrier wells were completed from 7½-inch rotary drill holes by inserting and cementing 4½-inch outside diameter preperforated schedule 40 PVC pipe. Perforations were made by cutting horizontal slots 3 inches long and 3 inches apart on two sides of the pipe. The perforations were positioned to admit fluid into and out of only the mineralized portion of the F Sand. Cement was kept above the perforated portion of the pipe by a prepoured cement plug, and it was kept out of the annulus exposed to the perforations by a cementing basket. Holes cut into the pipe above the basket and plug admitted cement into the annulus. The cement plug was drilled out and the well was washed clean after the cement in the annulus had hardened.

The monitor wells were cased and developed as described above for the recovery and injection wells, except the monitor wells were perforated throughout the F Sand.

Only two water wells had been sampled by Wyoming Mineral Corporation to determine baseline groundwater quality prior to in situ testing at the North Rolling Pin Site. In July 1974, single water samples were collected from Well 89, the recovery well at the center of the well field, and a ranch house well at the Franklin Brown Ranch located approximately 1 3/4 miles south-southwest of the North Rolling Pin Site and were analyzed for a complete set of consituents. The results of the baseline analyses for Well 89 are shown in Table 4, Appendix B. The results for the Brown Ranch well sample are not thought to be relevant to this report and therefore have not been included.

There is a possibility that the water sample from Well 89 was collected after the injection of higher quality water from Well 95 and does not represent baseline water quality in the F Sand. The radium concentration appears to be low for groundwater in a uranium bearing sandstone.

It is not known if approved groundwater sampling methods were used to obtain a representative sample from Well 89, if the water sample was properly preserved prior to analysis, or if analytical quality control was practiced during analysis. Therefore, considering that there was only one sample collected from the in situ mine zone prior to the injection of mining solutions, and the integrity of that sample is questionable, the baseline groundwater quality data are not considered to be totally reliable.

The solution mining of uranium at North Rolling Pin was to be preceded by the injection of water from Well 95 into the three injection wells and the four barrier wells, to establish a water flow net toward the recovery well prior to the injection of the ammonium bicarbonate mining solution. Once the flow circuit was established, the mining solution was to be injected, commencing the solution mining test program. By continuing to inject fresh water under pressure through the barrier wells and saturating the ore zone, the mining solution being injected through the three inner injection wells could be confined in the saturated mining area and directed toward the central recovery well. (This confinement and injection principle was later used during site restoration).

However, when it was first attempted to inject water into the ore zone, the injectivity was found to be very low (on the order of a few tenths of a gallon per minute per well). Numerous techniques were employed in an effort to increase the injection rates. The injectivity in the recovery well, the injection wells and the barrier wells was increased to an average of 9 gallons per minute per well.

Although the injectivity of the recovery well (Well 89) had been increased from 0.87 gallons per minute to 15 gallons per minute, the well could not be pumped at a rate of 3 gallons per minute without going dry. Therefore, the three injection wells were converted to recovery wells and the recovery well was converted to an injection well.

The actual operating in situ mining research program, with the injection of ammonium bicarbonate lixiviant began on September 4, 1974 and was operated until October 28, 1974. The concentrations of ammonium bicarbonate and hydrogen peroxide in the injected mining solution were approximately 3 grams per liter each.

GROUNDWATER RESTORATION

Following the in situ test, very limited groundwater restoration work was conducted by Wyoming Mineral Corporation at the North Rolling Pin Site during the fall of 1974.

Water samples from the in situ mine zone were collected and analyzed by Wyoming Mineral Corporation in January and February of 1975 and by Cleveland-Cliffs in October of 1975. The analyses, shown in Appendix B, indicated to Cleveland-Cliffs that the F Sand at North Rolling Pin had not been adequately restored.

In January, 1976, Cleveland-Cliffs notified Wyoming Mineral Corporation that they, as operator of North Rolling Pin, had not fulfilled their restoration obligations, as required by the NRC Source Material License and stated that they must rectify the situation. During subsequent communications, Wyoming Mineral Corporation would not assume responsibility for the condition of the North Rolling Pin Site. It was this liability which Cleveland-Cliffs, as licensee of NRC Source Material License No. SUA-1199, was required to undertake and to complete the groundwater restoration at the North Rolling Pin Site.

From the time Wyoming Mineral Corporation terminated the in situ mining project until July, 1978, the North Rolling Pin Site was maintained in an inactive state, allowing the natural chemical and physical processes in the mine zone to assist in the completion of groundwater restoration. It was thought that naturally occurring ion exchange, clay adsorption, salt precipitation, etc., could be at least partially effective in removing the contaminants from the groundwater.

In July, 1978, Cleveland-Cliffs took the initiative and began an intensive groundwater restoration program at North Rolling Pin. The monitor and barrier wells were flushed with water from Well 95, in order to improve well efficiency and to remove any residual drilling mud and other residues and contaminants that may have been present in the wells. During restoration, water from Well 95, the water supply well, was injected into the monitor wells and the barrier wells, and pumped from the wells in the interior of the well field. This restoration method was employed in an effort to increase the volume of high quality water in the mine zone, to aid water-mine zone contact in order to resolubilize unstable contaminants, to raise the water table elevation to contact new stable ion exchange sites, to confine the contaminants inside of the monitor wells and to sweep the contaminants toward the center of the well field where the water could be extracted by pumping.

After extracting approximately 14,300 gallons of water from the mine zone, the 1978 restoration activities were terminated on October 21. The North Rolling Pin Site was inactivated for 15 days in order for the restoration-mine zone to reach a steady state equilibrium, thus improving the possibility of collecting representative samples of the groundwater. Groundwater samples were collected on November 6, 1978 to determine the quality of the groundwater and to determine the results of the restoration program. The sample analyses are shown in Tables 4, 5, 6, Appendix B. As can be seen, the ammonia had been reduced by a factor of approximately 100, to below 1 mg per liter and the uranium had been reduced to 1.4 mg per liter (Well 89) or below. However, the radium concentrations did remain elevated in Well 89. Therefore, the regulatory agencies did require that additional groundwater restoration be conducted at the North Rolling Pin Site.

In May, 1980, Cleveland-Cliffs presented a plan to perform the final restoration of the North Rolling Pin Site to the NRC and to the WDEQ. The plan to complete satisfactory restoration would include three phases. The first phase would involve an evaluation of the current condition of the wells at the site including the measurement of the water levels and the sampling of the water that was present. Phase II would include the necessary well improvement and groundwater restoration. And, Phase III would be a resampling of the wells to demonstrate restoration. On July 3, 1980, the WDEQ approved the three-phase, site restoration plan with few minor modifications. The NRC made an amendment to the Source Material License on July 7, 1980, for Cleveland-Cliffs to proceed with the three-phase, site restoration plan as proposed.

Prior to collecting Phase I water samples, it was necessary to have the wells cleaned out with a drill rig. Frequent cleanout was necessary thereafter to maintain reasonable injection and pumping rates.

After the wells were cleaned out, approximately three weeks were allowed for the formation to stabilize in order for representative water samples to be collected. Both the NRC and the WDEQ were notified one week in advance that Cleveland-Cliffs was planning to conduct the Phase I groundwater sampling on July 21, 1980. The groundwater was sampled in six wells on July 21, 1980, and the samples were split with representatives of the WDEQ. Due to minimal water in the wells, the sampling was conducted by bailing the water from the wells. Filtering and sample preservation were performed on site in accordance with LQD, WDEQ Guideline 8. Within 24 hours, the samples were submitted to the laboratory for analysis. The analyses for the July 21, 1980, samples are shown in Appendix B.

The ammonia concentrations were generally below 10 mg per liter. Uranium in the monitor wells was below 1 mg per liter; and in the interior wells it averaged approximately 4.5 mg per liter. Radium concentrations ranged from 1.9 pCi per liter in Monitor Well 93, to 89 pCi per liter in Recovery Well 89.

The planned second phase, restoration of the groundwater, be an immediately after the water sampling. The primary restoration methods employed were similar to the 1978 restoration program. The dry portion of the aquifer was flooded; the contaminants were stabilized on unsaturated adsorption and ion exchange sites; and in the more highly contaminated areas of the mine zone, the contaminants were flushed from the aquifer by pumping.

It was calculated that approximately 160,000 gallons of groundwater were naturally contained inside of the barrier wells (Wells 84, 86, 87, and 90) shown in Figure 5, (water depth of 20 ft. X 60 ft. X 60 ft X 0.3 porosity X 7.48 gal/cu ft.). The interior of the three injection wells, the ·ea used for uranium leaching contained approximately 35,600 gallons (794 sq. ft. X 20 ft. X 0.3 ft. X 7.48 cu ft.). And the ore zone was approximately 8 feet thick at the bottom of the F Sand and contained approximately 14,250 gallons in the higher contaminated area in the triangle formed by the injection wells.

Approximately 200,000 gallons of high quality water from Well 95 were injected into the three injection wells to raise the elevation of the water table. This volume was approximately 5.5 times the estimated aquifer volume contained in side of the injection well pattern. The interior of the mine pattern area was thought to be a stagnation area which effectively contained the bulk of the contaminants while the water table was being elevated.

A total of approximately 364,000 gallons of water were then injected into the four barrier wells. With the previously injected 200,000 gallons, the injected volume of water was approximately 3.5 times the natural water volume contained inside of the square barrier well pattern. The water table was raised, the contaminants were flushed toward the center of the well field, and sufficient volume and head were created to permit the pumping of the contaminants out of Well 89 in the center of the mine zone. Approximately 18,000 gallons, approximately 1.3 ore zone pore volumes were pumped from Well 89 while water was being injected into Wells 83, 85, and 88. To further permanently stabilize the soluble radium that was in the groundwater, by ion exchange and adsorption on the clays in the F Sand, an additional 374,000 gallons of water were injected into the area inside of the monitor wells. Approximately 4,300 gallons of restoration water were then pumped from Well 97 to remove the residual soluble radium that was also more concentrated near this well.

After considerable flushing of the mine zone, groundwater samples were collected and analyzed. Except for radium, the contaminating constituents had been reduced to acceptable levels. To reduce the concentration of soluble radium in the restoration zone, a solution of 20 mg per liter barium chloride was injected into the wells to precipitate and stabilize the radium. The wells with moderate injection rates received 1,000 gallons of the 20 mg per liter solution. The wells with limited injectivity received only 100 gallons of the barium chloride solution. Thereafter, flush water was injected into each well to push the solution out into the mine zone and to dilute any residual barium. The barium chloride solution and flush water injection volumes are shown in Table 3.

TABLE 3

BARIUM CHLORIDE and FLUSH WATER INJECTION VOLUMES

Well No.	Volume of 20 mg/l $BaCl_2$ Injected in Gallons	Volume of Flush Water after $BaCl_2$ Injection in Gallons
68	100	1,000
83	1,000	12,294
84	1,000	4,143
85	1,000	10,558
86	1,000	10,001
87	1,000	10,019
88	1,000	10,705
89	1,000	13,618
90	1,000	15,814
91	100	1,012
92	100	1,012
93	100	1,063
94	100	1,045
97	1,000	12,091
Total	9,500	104,375

After the final flush water additions on October 21, all wells were purged with nitrogen to arrest oxidation and bacterial action in the restoration zone and then the wells were capped. The North Rolling Pin Site was undisturbed for 14 days to allow the groundwater in the restoration zone to stabilize and reach equilibrium prior to sampling.

Wastewater produced during the restoration activities was pumped into an above-ground swimming pool for evaporation. Sprayers directed downward into the pool were used to increase the rate of evaporation. By November 4, 1980, evaporation had reduced the wastewater to approximately 550 gallons. The concentrated wastewater was pumped into eleven 55-gallon steel drums. Solid residue in the pool from well cleanout, from the precipitation of salts, and from pumping, along with the pool liner were placed in a separate 55-gallon drum. The 12 drums of waste were later disposed of in the tailings pond of the Getty-Petrotomics Uranium Mill located in the Shirley Basin of Wyoming.

The first post-restoration groundwater sampling was conducted on November 4, 1980. To confirm restored groundwater quality and stability, a second post restoration sampling of the groundwater was conducted 49 days after cessation of restoration activities on December 9, 1980. On each date, the same six wells were sampled by a bail sampler. After the wells had been sampled, the conductivity and pH were measured in the field, the samples were packed in ice, and were immediately taken to the laboratory for filtration, preservation and analysis. Water quality analyses were conducted pursuant to EPA, Methods for Chemical Analysis of Water and Wastes and other EPA approved standard methods. The results of the water quality analyses are shown in Appendix B. For comfirmation of 1980 post restoration water quality, copies of the "Field Records" and the "Analysis Reports" are attached as Appendix C for the November 4, and the December 9, 1980, samples.

In comparing the 1980 post-restoration groundwater quality to the groundwater quality in 1975 after the termination of mining, and to the groundwater after the 1978 restoration program, it can be demonstrated that significant restoration of the groundwater has been achieved. In the barrier well (Table 2, Appendix B), the uranium was reduced to below 1 mg per liter and the radium was reduced to approximately 2 pCi per liter.

In Injection Well 88 (Table 3, Appendix B), ammonia had been reduced from 59 mg per liter after mining to a nondetectable level. Uranium was reduced from 8 mg per liter post-mining to less than 1 mg per liter in both 1980 post-restoration samples.

The ammonia concentrations in the centrally located recovery well (Well 89, Table 4, Appendix B) were 576 mg per liter and 254 mg per liter in two separate samples analyzed after the mining had terminated. The ammonia concentration was reduced to a nondetectable level and 1.25 mg per liter in the two post-restoration samples. The uranium concentration had been reduced to below 0.2 mg per liter.

The radium concentrations in Wells 88 and 89 had been reduced to an average of 5.3 and 8.7 pCi per liter, respectively. This is less than the average baseline concentration of radium in the ore zone of a nearby solution mine.

Ammonia was not detectable in Monitor Wells 93 and 97, and it was less than 0.5 mg per liter in Well 91, in the post restoration samples. Uranium concentrations were less than 0.025 mg per liter in the four samples from Monitor Wells 91 and 93 and were 0.26 mg per liter and 1.87 mg per liter in the samples from Well 97. Radium was below 2 pCi per liter in all samples except the December 9 sample from Monitor Well 97, which was 2.6 pCi per liter.

It has been thought that the monitor wells may have been used as disposal wells during termination of the mining project. This possibility is indicated by the October 16, 1975, analyses of samples from Wells 91 and 93 for ammonia and radium. However, the water quality around the monitor wells has been restored. Monitor Well 97 was drilled in 1977 prior to the 1978 restoration program and is located closer to the mine zone. Radium was the only constituent that was concentrated in the water during the July, 1980, prerestoration sampling (4.7 pCi per liter) and as discussed was reduced to approximately 2 pCi per liter.

Residual barium from the barium chloride treatment of radium was not detectable in any of the samples.

It is believed that oxygen in the air could be dissolving in the shallow water via the F Sand wells, and the oxygen in combination with the natural bicarbonate in the water, is continuing to naturally leach uranium. With continued sampling and exposure of the wells to atmospheric conditions, uranium, gross alpha and possibly other parameters could be concentrating in the groundwater. It is recommended that Cleveland-Cliffs be provided authorization to cement all of the wells at North Rolling Pin that were drilled and completed into the F Sand. Following cementing of the wells, the well casings would be cut off 2 to 4 feet below ground level. The topsoil would be redistributed as necessary prior to reseeding. The revegetation of the site would conclude Phase III of the plan proposed to the regulatory agencies in May, 1980, and should "close the books" on North Rolling Pin.

TEL:ceg:alm
Casper, Wyoming
April 29, 1981

APPENDIX A

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APPENDIX B

TABLE 1

Barrier Well 84

		10/16/75	07/21/80
pH, Field	Units	--	--
pH, Lab	Units	9.8	7.5
Conductivity, Field	μ mhos/cm @ 25°C	--	--
Conductivity, Lab	μ mhos/cm @ 25°C	--	820
Total Dissolved Solids (TDS)	mg/l	440	854
Sodium (Na)	mg/l	--	78.6
Potassium (K)	mg/l	--	10.8
Calcium (Ca)	mg/l	16	66.7
Magnesium (Mg)	mg/l	--	34.5
Sulfate (SO_4)	mg/l	--	437
Chloride (Cl)	mg/l	32	9.3
Carbonate (CO_3)	mg/l	29	0
Bicarbonate (HCO_3)	mg/l	117	136
Nitrate (NO_3 as N)	mg/l	--	--
Nitrite (NO_2 as N)	mg/l	--	--
Fluoride (F)	mg/l	--	1.2
Total Alkalinity (as $CaCO_3$)	mg/l	--	--
Total Hardness (as $CaCO_3$)	mg/l	--	--
Boron (B)	mg/l	--	<0.2
Aluminum (Al)	mg/l	--	<0.05
Arsenic (As)	mg/l	--	0.016
Barium (Ba)	mg/l	--	0.8
Cadmium (Cd)	mg/l	--	<0.002
Chromium (Cr)	mg/l	--	<0.02
Copper (Cu)	mg/l	--	6.98
Iron (Fe)	mg/l	--	0.36
Lead (Pb)	mg/l	--	0.25
Manganese (Mn)	mg/l	--	0.36
Mercury (Hg)	mg/l	--	<0.05
Nickel (Ni)	mg/l	--	<0.02
Selenium (Se)	mg/l	--	0.006
Zinc (Zn)	mg/l	--	2.04
Molybdenum (Mo)	mg/l	--	0.09
Vanadium (Va)	mg/l	--	<0.1
Ammonia (NH_3+NH_4 as N)	mg/l	0.20	11.0
Uranium (U_3O_8)	mg/l	1.200	7.2
Radium 226 (Ra)	pCi/l	--	12.0±1.9
Gross Alpha	pCi/l	--	667±35
Gross Beta	pCi/l	--	332±19

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/F

TABLE 2

Barrier Well 87

		11/04/80	12/09/80
pH, Field	Units	7.9	7.4
pH, Lab	Units	7.4	7.7
Conductivity, Field	μ mhos/cm @ 25°C	805	891
Conductivity, Lab	μ mhos/cm @ 25°C	756	795
Total Dissolved Solids (TDS)	mg/l	524	468
Sodium (Na)	mg/l	144	131
Potassium (K)	mg/l	4	5
Calcium (Ca)	mg/l	26	23
Magnesium (Mg)	mg/l	2	3
Sulfate (SO_4)	mg/l	260	198
Chloride (Cl)	mg/l	5	6
Carbonate (CO_3)	mg/l	0	0
Bicarbonate (HCO_3)	mg/l	149	171
Nitrate (NO_3 as N)	mg/l	0.06	0.03
Nitrite (NO_2 as N)	mg/l	ND	ND
Fluoride (F)	mg/l	0.36	0.21
Total Alkalinity (as $CaCO_3$)	mg/l	122	140
Total Hardness (as $CaCO_3$)	mg/l	73	70
Boron (B)	mg/l	ND	ND
Aluminum (Al)	mg/l	0.09	ND
Arsenic (As)	mg/l	0.001	0.008
Barium (Ba)	mg/l	ND	ND
Cadmium (Cd)	mg/l	0.008	ND
Chromium (Cr)	mg/l	ND	ND
Copper (Cu)	mg/l	ND	0.01
Iron (Fe)	mg/l	0.08	0.24
Lead (Pb)	mg/l	ND	ND
Manganese (Mn)	mg/l	0.01	ND
Mercury (Hg)	mg/l	ND	ND
Nickel (Ni)	mg/l	ND	ND
Selenium (Se)	mg/l	0.004	0.001
Zinc (Zn)	mg/l	0.035	0.047
Molybdenum (Mo)	mg/l	ND	ND
Vanadium (Va)	mg/l	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	ND	ND
Uranium (U_3O_8)	mg/l	0.24	0.73
Radium 226 (Ra)	pCi/l	2.8±1	1.1±0.5
Gross Alpha	pCi/l	30±2	68±2
Gross Beta	pCi/l	13.4±1.4	88±3

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/G

TABLE 3

Injection Well 88

		02/02/75	07/21/80	11/04/80	12/09/80
pH, Field	Units	--	--	7.7	7.2
pH, Lab	Units	--	7.6	7.4	7.7
Conductivity, Field	μ mhos/cm @ 25°C	--	--	761	822
Conductivity, Lab	μ mhos/cm @ 25°C	--	1,010	721	840
Total Dissolved Solids (TDS)	mg/l	--	1,164	499	541
Sodium (Na)	mg/l	--	178	151	142
Potassium (K)	mg/l	--	8.98	4	6
Calcium (Ca)	mg/l	--	63.0	21	35
Magnesium (Mg)	mg/l	--	26.3	3	3
Sulfate (SO_4)	mg/l	--	610	250	245
Chloride (Cl)	mg/l	--	9.9	4	5
Carbonate (CO_3)	mg/l	--	0	0	0
Bicarbonate (HCO_3)	mg/l	430	145	146	190
Nitrate (NO_3 as N)	mg/l	--	--	0.04	ND
Nitrite (NO_2 as N)	mg/l	--	--	ND	ND
Fluoride (F)	mg/l	--	4.6	0.33	0.40
Total Alkalinity (as $CaCO_3$)	mg/l	--	--	120	156
Total Hardness (as $CaCO_3$)	mg/l	--	--	57	100
Boron (B)	mg/l	--	<0.2	ND	ND
Aluminum (Al)	mg/l	--	<0.5	0.10	ND
Arsenic (As)	mg/l	--	<0.005	0.001	0.006
Barium (Ba)	mg/l	--	<0.01	ND	ND
Cadmium (Cd)	mg/l	--	0.005	0.007	ND
Chromium (Cr)	mg/l	--	<0.02	ND	ND
Copper (Cu)	mg/l	--	<0.02	ND	0.01
Iron (Fe)	mg/l	--	0.06	0.33	0.03
Lead (Pb)	mg/l	--	<0.05	ND	ND
Manganese (Mn)	mg/l	--	0.08	0.02	ND
Mercury (Hg)	mg/l	--	<0.05	ND	ND
Nickel (Ni)	mg/l	--	0.05	ND	ND
Selenium (Se)	mg/l	--	0.008	0.001	0.018
Zinc (Zn)	mg/l	--	0.11	0.012	0.021
Molybdenum (Mo)	mg/l	--	0.05	ND	ND
Vanadium (Va)	mg/l	--	0.3	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	59	7.4	ND	ND
Uranium (U_3O_8)	mg/l	8.22	5.5	0.16	0.65
Radium 226 (Ra)	pCi/l	--	13±2.1	1.1±0.6	9.4±1.6
Gross Alpha	pCi/l	--	557±30	14.9±1.2	123±3
Gross Beta	pCi/l	--	394±22	29±[illegible]	79±3

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/D

TABLE 4

Recovery Well 89

		July 1974	01/25/75	10/16/75	11/06/78	07/21/80	11/04/80	12/09/80
pH, Field	Units	--	--	--	--	--	7.9	7.5
pH, Lab	Units	8.2	--	7.3	7.1	7.3	7.5	7.8
Conductivity, Field	μ mhos/cm @ 25°C	--	--	--	--	--	851	1,615
Conductivity, Lab	μ mhos/cm @ 25°C	--	--	--	--	1,360	814	1,681
Total Dissolved Solids (TDS)	mg/l	444	--	1,170	804	1,724	548	1,138
Sodium (Na)	mg/l	180	--	125	--	111	157	255
Potassium (K)	mg/l	3.6	--	5.2	--	10.2	4	9
Calcium (Ca)	mg/l	21	--	94	79	140	31	99
Magnesium (Mg)	mg/l	0.05	--	26	--	122	3	8
Sulfate (SO_4)	mg/l	233	--	907	344	936	282	668
Chloride (Cl^-)	mg/l	6	--	10	14	--	5	12
Carbonate (CO_3)	mg/l	0	--	0	0	0	0	0
Bicarbonate (HCO_3)	mg/l	107	820	306	136	266	159	159
Nitrate (NO_3 as N)	mg/l	<0.02	--	--	--	--	0.05	ND
Nitrite (NO_2 as N)	mg/l	--	--	67.5	--	--	ND	ND
Fluoride (F^-)	mg/l	0.18	--	1.9	--	0.91	0.24	0.28
Total Alkalinity (as $CaCO_3$)	mg/l	107	--	306	--	--	130	130
Total Hardness (as $CaCO_3$)	mg/l	61.9	--	237	--	--	90	280
Boron (B)	mg/l	<0.1	--	--	--	<0.2	ND	ND
Aluminum (Al)	mg/l	<0.2	--	<0.18	--	<0.5	ND	ND
Arsenic (As)	mg/l	<0.5	--	--	--	<0.005	0.001	0.004
Barium (Ba)	mg/l	<0.5	--	< 0.5	--	<0.1	ND	ND
Cadmium (Cd)	mg/l	< 0.005	--	0.02	--	0.008	0.002	ND
Chromium (Cr)	mg/l	0.017	--	0.005	--	<0.02	ND	ND
Copper (Cu)	mg/l	< 0.005	--	0.08	--	7.92	ND	0.01
Iron (Fe)	mg/l	0.05	--	13	--	0.09	0.08	0.02
Lead (Pb)	mg/l	0.02	--	0.07	--	0.44	ND	ND
Manganese (Mn)	mg/l	0.009	--	0.53	--	0.06	0.01	0.05
Mercury (Hg)	mg/l	<0.0001	--	0.0001	--	<0.05	ND	ND
Nickel (Ni)	mg/l	0.01	--	0.07	--	<0.02	ND	ND
Selenium (Se)	mg/l	<0.005	--	0.009	ND	0.009	0.002	0.003
Zinc (Zn)	mg/l	0.03	--	0.18	--	3.69	0.010	0.029
Molybdenum (Mo)	mg/l	<0.04	--	< 0.03	ND	0.01	ND	ND
Vanadium (Va)	mg/l	<0.001	--	< 0.001	ND	<0.1	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	<0.1	576	254	1.9	5.3	ND	1.25
Uranium (U_3O_8)	mg/l	0.031	8.47	2.40	1.4	1.0	0.07	0.18
Radium 226 (Ra)	pCi/l	0.6	--	4,530	50±1.2	89±5	4.5±1.2	12.8±1.8
Gross Alpha	pCi/l	33	--	6,200	--	147±8	9.0±1.0	18±1
Gross Beta	pCi/l	52	--	3,440	--	61±12	9.5±1.3	43±2

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/A

TABLE 5

Monitor Well 91

		01/05/75	01/25/75	02/03/75	10/16/75	11/06/78	07/21/80	11/04/80	12/09/80
pH, Field	Units	--	--	--	--	--	--	7.6	8.0
pH, Lab	Units	--	--	--	7.0	7.6	7.8	7.3	7.1
Conductivity, Field	μ mhos/cm @ 25°C	--	--	--	--	--	--	777	825
Conductivity, Lab	μ mhos/cm @ 25°C	--	--	--	--	--	870	727	778
Total Dissolved Solids (TDS)	mg/l	--	--	--	919	504	914	488	444
Sodium (Na)	mg/l	--	--	--	--	--	179	140	130
Potassium (K)	mg/l	--	--	--	--	--	8.06	4	6
Calcium (Ca)	mg/l	--	--	--	60	22	25.8	23	19
Magnesium (Mg)	mg/l	--	--	--	--	18.1	--	2	7
Sulfate (SO_4)	mg/l	--	--	--	90	216	388	245	133
Chloride (Cl)	mg/l	--	--	--	6	10	53	6	32
Carbonate (CO_3)	mg/l	--	--	--	0	0	0	0	0
Bicarbonate (HCO_3)	mg/l	60	110	420	451	100	131	132	217
Nitrate (NO_3 as N)	mg/l	--	--	--	--	--	--	0.2	0.05
Nitrite (NO_2 as N)	mg/l	--	--	--	--	--	--	0.01	ND
Fluoride (F)	mg/l	--	--	--	--	--	13	1.4	8.07
Total Alkalinity (as $CaCO_3$)	mg/l	--	--	--	--	--	--	108	178
Total Hardness (as $CaCO_3$)	mg/l	--	--	--	--	--	--	66	77
Boron (B)	mg/l	--	--	--	--	--	< 0.2	ND	ND
Aluminum (Al)	mg/l	--	--	--	--	--	< 0.5	0.13	ND
Arsenic (As)	mg/l	--	--	--	--	--	0.010	0.001	0.016
Barium (Ba)	mg/l	--	--	--	--	--	< 0.1	ND	ND
Cadmium (Cd)	mg/l	--	--	--	--	--	< 0.002	0.008	ND
Chromium (Cr)	mg/l	--	--	--	--	--	< 0.02	ND	ND
Copper (Cu)	mg/l	--	--	--	--	--	6.23	ND	0.01
Iron (Fe)	mg/l	--	--	--	--	--	0.08	0.10	0.08
Lead (Pb)	mg/l	--	--	--	--	--	0.29	0.05	ND
Manganese (Mn)	mg/l	--	--	--	--	--	0.02	0.04	ND
Mercury (Hg)	mg/l	--	--	--	--	--	< 0.05	ND	ND
Nickel (Ni)	mg/l	--	--	--	--	--	0.03	ND	ND
Selenium (Se)	mg/l	--	--	--	0.08	ND	0.009	0.001	0.009
Zinc (Zn)	mg/l	--	--	--	--	--	2.99	0.017	0.036
Molybdenum (Mo)	mg/l	--	--	--	0	ND	0.01	ND	ND
Vanadium (Va)	mg/l	--	--	--	0	ND	< 0.1	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	59	144	59	65	0.65	5.0	0.15	0.45
Uranium (U_3O_8)	mg/l	2.97	2.97	9.80	0.05	0.042	0.4	0.024	0.023
Radium 226 (Ra)	pCi/l	--	--	--	50±9	0.7±0.1	3.6±1.0	1.4±0.7	1.4±0.6
Gross Alpha	pCi/l	--	--	--	115±10	--	9±2	9.0±1.0	15±1
Gross Beta	pCi/l	--	--	--	54±12	--	8±3	8.6±1.3	36±2

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/B

TABLE 6

Monitor Well 93

		01/05/75	01/25/75	02/03/75	10/16/75	11/06/78	07/21/80	11/04/80	12/09/80
pH, Field	Units	--	--	--	--	--	--	9.2	8.9
pH, Lab	Units	--	--	--	2.7	7.6	7.1	8.0	7.3
Conductivity, Field	µmhos/cm @ 25°C	--	--	--	--	--	--	731	887
Conductivity, Lab	µmhos/cm @ 25°C	--	--	--	--	--	1,130	472	840
Total Dissolved Solids (TDS)	mg/l	--	--	--	6,558	498	1,026	721	480
Sodium (Na)	mg/l	--	--	--	--	--	188	131	137
Potassium (K)	mg/l	--	--	--	--	--	36.4	5	9
Calcium (Ca)	mg/l	--	--	--	71	19	44.8	22	23
Magnesium (Mg)	mg/l	--	--	--	--	--	17.8	3	2
Sulfate (SO_4)	mg/l	--	--	--	280	216	226	233	230
Chloride (Cl)	mg/l	--	--	--	2,430	10	264	10	27
Carbonate (CO_3)	mg/l	--	--	--	0	0	0	0	0
Bicarbonate (HCO_3)	mg/l	30	440	450	0	108	91.1	120	115
Nitrate (NO_3 as N)	mg/l	--	--	--	--	--	--	ND	ND
Nitrite (NO_2 as N)	mg/l	--	--	--	--	--	--	ND	ND
Fluoride (F)	mg/l	--	--	--	--	--	23	3.3	12.35
Total Alkalinity (as $CaCO_3$)	mg/l	--	--	--	--	--	--	98	95
Total Hardness (as $CaCO_3$)	mg/l	--	--	--	--	--	--	68	65
Boron (B)	mg/l	--	--	--	--	--	< 0.2	0.1	ND
Aluminum (Al)	mg/l	--	--	--	--	--	10.5	0.21	0.12
Arsenic (As)	mg/l	--	--	--	--	--	0.007	0.001	0.006
Barium (Ba)	mg/l	--	--	--	--	--	0.6	ND	ND
Cadmium (Cd)	mg/l	--	--	--	--	--	< 0.002	0.008	ND
Chromium (Cr)	mg/l	--	--	--	--	--	< 0.02	ND	ND
Copper (Cu)	mg/l	--	--	--	--	--	7.65	ND	0.01
Iron (Fe)	mg/l	--	--	--	--	--	0.72	0.17	0.14
Lead (Pb)	mg/l	--	--	--	--	--	0.39	0.02	ND
Manganese (Mn)	mg/l	--	--	--	--	--	0.18	0.03	0.03
Mercury (Hg)	mg/l	--	--	--	--	--	< 0.05	ND	ND
Nickel (Ni)	mg/l	--	--	--	--	--	< 0.02	ND	ND
Selenium (Se)	mg/l	--	--	--	0	ND	0.008	0.001	0.001
Zinc (Zn)	mg/l	--	--	--	--	--	3.69	0.011	0.071
Molybdenum (Mo)	mg/l	--	--	--	0.11	ND	< 0.01	ND	ND
Vanadium (Va)	mg/l	--	--	--	0.36	ND	< 0.1	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	133	41	19	349	0.40	24.7	ND	ND
Uranium (U_3O_8)	mg/l	1.10	2.33	--	0.110	0.042	< 0.1	0.013	0.010
Radium 226 (Ra)	pCi/l	--	--	--	150±15	0.5±0.1	1.9±0.8	0.6±0.4	1.3±0.6
Gross Alpha	pCi/l	--	--	--	410±60	--	8±2	4.0±0.7	16±1
Gross Beta	pCi/l	--	--	--	45±9	--	1±2	1.4±1.0	37±2

ND - Not Detectable

TSL:alm
4/17/81

S6/NRP1/C

TABLE 7

Well 97

		07/21/80	11/05/80	12/09/80
pH, Field	Units	--	7.9	8.3
pH, Lab	Units	7.6	7.6	7.1
Conductivity, Field	µmhos/cm @ 25°C	--	720	301
Conductivity, Lab	µmhos/cm @ 25°C	600	721	534
Total Dissolved Solids (TDS)	mg/l	604	475	329
Sodium (Na)	mg/l	119	138	93
Potassium (K)	mg/l	4.84	4	3
Calcium (Ca)	mg/l	19.7	18	18
Magnesium (Mg)	mg/l	21.2	3	3
Sulfate (SO_4)	mg/l	277	245	142
Chloride (Cl)	mg/l	8.8	6	5
Carbonate (CO_3)	mg/l	0	0	0
Bicarbonate (HCO_3)	mg/l	121	129	132
Nitrate (NO_3 as N)	mg/l	--	0.1	0.1
Nitrite (NO_2 as N)	mg/l	0.80	0.003	ND
Fluoride (F)	mg/l	--	0.30	0.33
Total Alkalinity (as $CaCO_3$)	mg/l	--	106	108
Total Hardness (as $CaCO_3$)	mg/l	--	58	58
Boron (B)	mg/l	<0.2	ND	ND
Aluminum (Al)	mg/l	<0.5	ND	0.37
Arsenic (As)	mg/l	<0.005	0.001	0.008
Barium (Ba)	mg/l	<0.1	ND	ND
Cadmium (Cd)	mg/l	<0.002	ND	ND
Chromium (Cr)	mg/l	<0.02	ND	ND
Copper (Cu)	mg/l	6.76	ND	0.02
Iron (Fe)	mg/l	0.03	0.08	0.21
Lead (Pb)	mg/l	0.22	ND	ND
Manganese (Mn)	mg/l	0.04	ND	0.02
Mercury (Hg)	mg/l	<0.05	ND	ND
Nickel (Ni)	mg/l	<0.02	ND	ND
Selenium (Se)	mg/l	0.005	0.001	ND
Zinc (Zn)	mg/l	2.86	0.163	0.027
Molybdenum (Mo)	mg/l	<0.01	ND	ND
Vanadium (Va)	mg/l	<0.1	ND	ND
Ammonia (NH_3+NH_4 as N)	mg/l	2.0	ND	ND
Uranium (U_3O_8)	mg/l	0.3	0.26	1.87
Radium 226 (Ra)	pCi/l	47.7±4.2	1.9±0.8	2.6±0.8
Gross Alpha	pCi/l	75±5	41±2	287±5
Gross Beta	pCi/l	15±4	31±2	264±5

ND - Not Detectable

TEL:alm
4/17/81

S6/NRP1/E

APPENDIX C

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 87 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No 87

Water Level 126.7 Pumping Time

Discharge or Flow Rate Grab Sample by bail

pH 7.89 pH Calibration

Temperature 18.5 °C Conductivity 700 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity Corrected to 25°C=805 umhos

Date Delivered 11-4-80

Remarks Sample to be filtered by WAMCO 11-4-80.

Operator Louderbach + Henry

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 88 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No. 88

Water Level 134.4 Pumping Time

Discharge or Flow Rate Grab

pH 7.72 pH Calibration

Temperature 15.0 °C Conductivity 610 umhos

Alkalinity by WAMCO ~~Measurement~~ Time

Laboratory WAMCO Conductivity Corrected to 25°C = 761 umhos/cm

Date Delivered 11-4-80

Remarks To be filtered by WAMCO 11-4-80.

Operator Louderbach and Henry

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 89 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No 89

Water Level 135.2 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.86 pH Calibration

Temperature 18.5 °C Conductivity 740 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity Corrected to 25°C = 851 umhos/cm

Date Delivered 11-4-80

Remarks To be filtered by WAMCO 11-4-80

Operator Louderbach and Henry

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 91 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No. 91

Water Level 123.8 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.60 pH Calibration

Temperature 14.1 °C Conductivity 610 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity Corrected to 25°C = 777 umhos/cm

Date Delivered 11-4-80

Remarks To be filtered by WAMCO 11-4-80

Operator Louderbach and Henry

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 93 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No 93

Water Level 132.3 Pumping Time

Discharge or Flow Rate Grab sample

pH 9.24 pH Calibration

Temperature 19.5 °C Conductivity 650 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity Corrected to 25°C = 731 umho/cm

Date Delivered 11-4-80

Remarks To be filtered by WAMCO 11-4-80

Operator Louderbach and Henry.

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 11-4-80

Sample No. 97 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No. 97

Water Level 124.1 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.90 pH Calibration

Temperature 15.2 °C Conductivity 580 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity corrected to 25°C = 720 umho/cm

Date Delivered 11-4-80

Remarks To be filtered by WAMCO 11-4-80

Operator Lauderbach and Henry

WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY DATE: December 12, 1980

WAMCO NO.	SAMPLE DESCRIPTION						Mg/L
2004	Water	1	2	3	4	5	Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Total Dissolved Solids *	524	499	548	488	472	
	Sodium (Na)	144	151	157	140	131	
	Potassium (K)	4	4	4	4	5	
	Calcium (Ca)	26	21	31	23	22	
	Magnesium (Mg)	2	3	3	2	3	
	Sulfate (SO_4)	260	250	282	245	233	
	Chloride (Cl)	5	4	5	6	10	
	Carbonate (CO_3)	0	0	0	0	0	
	Bicarbonate (HCO_3)	149	146	159	132	120	
	Hydroxide (OH)						
	pH, Units	7.41	7.46	7.52	7.32	7.95	
	Conductivity, Micromhos/cm @ 25° C	756	721	814	727	721	
	Total Milliequiv, Major Cations	7.82	7.81	8.73	7.50	7.18	
	Total Milliequiv, Major Anions	7.99	7.70	8.62	7.43	7.10	
	Absolute Value, Charged Bal.	-1.08	0.71	0.63	0.47	0.56	
	Ammonia (NH_4 as N)	ND	ND	ND	0.15	ND	0.05
	Nitrate (NO_3 as N)	0.06	0.04	0.05	0.2	ND	0.05
	Nitrite (NO_2 as N)	ND	ND	ND	0.01	ND	0.001
	Fluoride (F)	0.36	0.33	0.24	1.4	3.3	0.1
	Total Alkalinity as $CaCO_3$	122	120	13[illegible]	108	98	
	Total Hardness as $CaCO_3$	73	57	90	66	68	
	Boron (B)	ND	ND	ND	ND	0.1	0.01

*Determined by evaporation @ 180° C

REMARKS:

1. NRP 87 11-5-80
2. NRP 88 11-5-80
3. NRP 89 11-5-80
4. NRP 91 11-5-80
5. NRP 93 11-5-80

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WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY   DATE: December 12, 1980

WAMCO NO.	SAMPLE DESCRIPTION						Mg/L Detection Limit
2004	Water	6					
	Analyses reported in Milligrams Per Liter except where noted:						
	Total Dissolved Solids *	475					
	Sodium (Na)	138					
	Potassium (K)	4					
	Calcium (Ca)	18					
	Magnesium (Mg)	3					
	Sulfate (SO_4)	245					
	Chloride (Cl)	6					
	Carbonate (CO_3)	0					
	Bicarbonate (HCO_3)	129					
	Hydroxide (OH)						
	pH, Units	7.61					
	Conductivity, Micromhos/cm @ 25°C	721					
	Total Milliequiv, Major Cations	7.25					
	Total Milliequiv, Major Anions	7.39					
	Absolute Value: Charged Bal.	-.96					
	Ammonia (NH_3 as N)	ND					0.05
	Nitrate (NO_3 as N)	0.1					0.05
	Nitrite (NO_2 as N)	0.003					0.001
	Fluoride (F)	0.30					0.1
	Total Alkalinity as $CaCO_3$	106					
	Total Hardness as $CaCO_3$	58					
	Boron (B)	ND					0.01

*Determined by evaporation @ 180° C

REMARKS:

6. NRP 97 11-5-80

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P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY DATE: December 12, 1980

WAMCO NO.	SAMPLE DESCRIPTION						Mg/L
2004	Water	1	2	3	4	5	Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Aluminum (Al)	.09	.10	ND	.13	.21	0.05
	Arsenic (As)	0.001	0.001	0.001	LT.001	0.001	0.005
	Barium (Ba)	ND	ND	ND	ND	ND	0.03
	Cadmium (Cd)	0.008	0.007	0.002	0.008	0.008	0.002
	Chromium (Cr)	ND	ND	ND	ND	ND	0.01
	Copper (Cu)	ND	ND	ND	ND	ND	0.01
	Iron (Fe)	0.08	0.33	0.08	0.10	0.17	0.01
	Lead (Pb)	ND	ND	ND	0.05	0.02	0.01
	Manangese (Mn)	0.01	0.02	0.01	0.04	0.03	0.01
	Mercury (Hg)	ND	ND	ND	ND	ND	0.0005
	Nickel (Ni)	ND	ND	ND	ND	ND	0.02
	Selenium (Se)	0.004	0.001	0.002	.001	LT.001	0.005
	Zinc (Zn)	0.035	0.012	0.010	0.017	0.011	0.005
	Molybdenum (Mo)	ND	ND	ND	ND	ND	0.05
	Uranium (U_3O_8) PPB	240	160	74	24	13	1 PPB
	Vanadium (V_2O_5)	ND	ND	ND	ND	ND	0.05
	Radium (Ra-226) PiC/L ± Prec.	2.8 ±	1.1 ±	4.5 ±	1.4 ±	0.6 ±	0.5 PiC/L
		1.0	0.6	1.2	0.7	0.4	
	Gross Alpha	30 ± 2	14.9 ±	9.0 ±	9.0 ±	4.0 ±	
			1.2	1.0	1.0	0.7	
	Gross Beta	13.4±	29 ±	9.5 ±	8.6 ±	1.4 ±	
		1.4	2	1.3	1.3	1.0	

REMARKS: Analyses performed according EPA Manual, 1976 and/or Standard Methods for Examination of Water and Wastewater, 14th Edition.

1. NRP 87 11-5-80
2. NRP 88 11-5-80
3. NRP 89 11-5-80
4. NRP 91 11-5-80
5. NRP 93 11-5-80

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WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY   DATE: December 12, 1980

WAMCO NO.	SAMPLE DESCRIPTION						Mg/L
2004	Water	6					Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Aluminum (Al)	ND					0.05
	Arsenic (As)	0.001					0.005
	Barium (Ba)	ND					0.03
	Cadmium (Cd)	ND					0.002
	Chromium (Cr)	ND					0.01
	Copper (Cu)	ND					0.01
	Iron (Fe)	0.08					0.01
	Lead (Pb)	ND					0.01
	Manangese (Mn)	ND					0.01
	Mercury (Hg)	ND					0.0005
	Nickel (Ni)	ND					0.02
	Selenium (Se)	LT.001					0.005
	Zinc (Zn)	0.163					0.005
	Molybdenum (Mo)	ND					0.05
	Uranium (U_3O_8) PPB	260					1 PPB
	Vanadium (V_2O_5)	ND					0.05
	Radium (Ra-226) PiC/L ± Prec.	1.9 ±	0.8				0.5 PiC/L
		41 ±	2				
		31 ±	2				

REMARKS: Analyses performed according EPA Manual, 1976 and/or Standard Methods for Examination of Water and Wastewater, 14th Edition.

6. NRP 97 11-5-80

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CLIFFS
CASPER, WYOMING

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 12-9-80

Sample No. 87 Sample Time

Groundwater X Surface Water

Well No. ~~or Stream and Location~~ 87

Water Level 127.5 Pumping Time

Discharge or Flow Rate Grab sample by bail

pH 7.44 pH Calibration

Temperature 9.3 °C Conductivity 620 umhos

Alkalinity by WAMCO Measurement Time

Laboratory WAMCO Conductivity corrected to 25°C = 891 umho/cm

Date Delivered 12-9-80

Remarks Sample to be filtered by WAMCO 12-9-80

Operator Henry and Ness

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 12-9-80

Sample No. 88 Sample Time

Groundwater X Surface Water

Well No. or Stream and Location Well No. 88

Water Level -135.9 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.21 pH Calibration

Temperature 8.5 °C Conductivity 560 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity corrected to 25°C = 822 umhos/cm

Date Delivered 12-9-80

Remarks To be filtered by WAMCO 12-9-80.

Operator Henry and Ness

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 12-9-80

Sample No. 89 Sample Time

Groundwater X Surface Water

Well No. ~~or Stream and Location~~ 89

Water Level -137.0 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.47 pH Calibration

Temperature 8.5 °C Conductivity 1100 umhos

Alkalinity by WAMCO ~~Measurement~~ Time

Laboratory WAMCO Conductivity Corrected to 25°C= 1615 umho/cm

Date Delivered 12-9-80

Remarks To be filtered by WAMCO

Operator Henry and Ness

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 12-9-80

Sample No. 91 Sample Time

Groundwater X Surface Water

Well No. ~~or Stream and Location~~ 91

Water Level -124.6 Pumping Time

Discharge or Flow Rate Grab sample

pH 7.98 pH Calibration

Temperature 7.2 °C Conductivity 540 umhos

Alkalinity by WAMCO ~~Measurement~~ Time

Laboratory WAMCO Conductivity corrected to 25°C = 825 umho/cm

Date Delivered 12-9-80

Remarks To be filtered by WAMCO 12-9-80

Operator Henry and Ness

Water Quality Sample -- Field Record

Project North Rolling Pin Cleanup Date 12-9-80

Sample No. 93 Sample Time

Groundwater X Surface Water

Well No. ~~or Stream and Location~~ 93

Water Level 132.6 Pumping Time

Discharge or Flow Rate Grab sample

pH 8.92 pH Calibration

Temperature 7.6 °C Conductivity 590 umhos

Alkalinity by WAMCO ~~Measurement Time~~

Laboratory WAMCO Conductivity Corrected to 25°C = 887 umhos/cm

Date Delivered 12-9-80

Remarks To be filtered by WAMCO 12-9-80.

Operator Henry and Ness

Water Quality Sample -- Field Record

Project North Rolling Pin   Date 12-9-80

Sample No. 97   Sample Time

Groundwater X   Surface Water

Well No. ~~or Stream and Location~~ 97

Water Level 125.1   Pumping Time

Discharge or Flow Rate Grab sample

pH 8.36   pH Calibration

Temperature 7.6 °C   Conductivity 200 umhos

Alkalinity by WAMCO   Measurement Time

Laboratory WAMCO   Conductivity Corrected to 25°C = 301 umho/cm

Date Delivered 12-9-80

Remarks To be filtered by WAMCO 12-9-80

Operator Henry and Ness

WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY   DATE: January 13, 1981

WAMCO NO.	SAMPLE DESCRIPTION	1	2	3	4	5	Mg/L Detection Limit
2049	Water						
	Analyses reported in Milligrams Per Liter except where noted:						
	Total Dissolved Solids *	468	541	1138	444	480	
	Sodium (Na)	131	142	255	130	137	
	Potassium (K)	5	6	9	6	9	
	Calcium (Ca)	23	35	99	19	23	
	Magnesium (Mg)	3	3	8	7	2	
	Sulfate (SO_4)	198	245	668	133	230	
	Chloride (Cl)	6	5	12	32	27	
	Carbonate (CO_3)	0	0	0	0	0	
	Bicarbonate (HCO_3)	171	190	159	217	115	
	Hydroxide (OH)						
	pH, Units	7.70	7.77	7.79	7.07	7.32	
	Conductivity, Micromhos/cm @ 25°C	795	840	1681	778	840	
	Total Milliequiv. Major Cations	7.23	8.33	16.92	7.34	7.50	
	Total Milliequiv. Major Anions	7.09	8.36	16.84	7.23	7.43	
	Absolute Value, Charged Bal.	0.98	-0.18	0.24	0.75	0.47	
	Ammonia (NH_4 as N)	ND	ND	1.25	0.45	ND	0.05
	Nitrate (NO_3 as N)	0.03	ND	ND	0.05	ND	0.05
	Nitrite (NO_2 as N)	ND	ND	ND	ND	ND	0.001
	Fluoride (F)	0.21	0.40	0.28	8.07	12.35	0.1
	Total Alkalinity as $CaCO_3$	140	156	130	178	95	
	Total Hardness as $CaCO_3$	70	100	280	77	65	
	Boron (B)	ND	ND	ND	ND	ND	0.01

*Determined by evaporation @ 180° C

REMARKS:

1. North Rolling Pin 87 12-9-80
2. " " " 88 "
3. " " " 89 "
4. " " " 91 "
5. " " " 93 "

WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY DATE: January 13, 1981

WAMCO NO.	SAMPLE DESCRIPTION	6					Mg/L
2049	Water						Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Total Dissolved Solids *	329					
	Sodium (Na)	93					
	Potassium (K)	3					
	Calcium (Ca)	18					
	Magnesium (Mg)	3					
	Sulfate (SO_4)	142					
	Chloride (Cl)	5					
	Carbonate (CO_3)	0					
	Bicarbonate (HCO_3)	132					
	Hydroxide (OH)						
	pH, Units	7.18					
	Conductivity, Micromhos/cm @ 25°C	534					
	Total Milliequiv, Major Cations	5.28					
	Total Milliequiv, Major Anions	5.25					
	Absolute Value, Charged Bal.	0.28					
	Ammonia (NH_4 as N)	ND					0.05
	Nitrate (NO_3 as N)	0.1					0.05
	Nitrite (NO_2 as N)	ND					0.001
	Fluoride (F)	0.33					0.1
	Total Alkalinity as $CaCO_3$	108					
	Total Hardness as $CaCO_3$	58					
	Boron (B)	ND					0.01

*Determined by evaporation @ 180° C

REMARKS:

6. North Rolling Pin 97 12-9-80

WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY DATE: January 13, 1981

WAMCO NO.	SAMPLE DESCRIPTION	1	2	3	4	5	Mg/L
2049	Water						Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Aluminum (Al)	ND	ND	ND	ND	.12	0.05
	Arsenic (As)	.008	.006	.004	.016	.006	0.005
	Barium (Ba)	ND	ND	ND	ND	ND	0.03
	Cadmium (Cd)	ND	ND	ND	ND	ND	0.002
	Chromium (Cr)	ND	ND	ND	ND	ND	0.01
	Copper (Cu)	.01	.01	.01	.01	.01	0.01
	Iron (Fe)	.24	.03	.02	.08	.14	0.01
	Lead (Pb)	ND	ND	ND	ND	ND	0.01
	Manangese (Mn)	ND	ND	.05	ND	.03	0.01
	Mercury (Hg)	ND	ND	ND	ND	ND	0.0005
	Nickel (Ni)	ND	ND	ND	ND	ND	0.02
	Selenium (Se)	LT.001	.018	.003	.009	LT.001	0.005
	Zinc (Zn)	.047	.021	.029	.036	.071	0.005
	Molybdenum (Mo)	ND	ND	ND	ND	ND	0.05
	Uranium (U_3O_8) PPB	725	650	175	23	10	1 PPB
	Vanadium (V_2O_5)	ND	ND	ND	ND	ND	0.05
	Radium (Ra-226) PiC/L ± Prec.	1.1 ±	9.4 ±	12.8 ±	1.4±	1.3±	0.5 PiC/L
		0.5	1.6	1.8	0.6	0.6	
	Gross Alpha	68± 2	123± 3	18 ± 1	15±1	16±1	
	Gross Beta	88 ±3	79± 3	43 ± 2	36±2	37±2	

REMARKS: Analyses performed according EPA Manual, 1976 and/or Standard Methods for Examination of Water and Wastewater, 14th Edition.

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WAMCO LAB

P.O. BOX 3632 • CASPER, WYOMING 82602

ANALYSIS REPORT

COMPANY: CLEVELAND CLIFFS IRON COMPANY DATE: January 13, 1981

WAMCO NO.	SAMPLE DESCRIPTION	6					Mg/L
2049	Water						Detection
	Analyses reported in Milligrams Per Liter except where noted:						Limit
	Aluminum (Al)	.37					0.05
	Arsenic (As)	.008					0.005
	Barium (Ba)	ND					0.03
	Cadmium (Cd)	ND					0.002
	Chromium (Cr)	ND					0.01
	Copper (Cu)	.02					0.01
	Iron (Fe)	.21					0.01
	Lead (Pb)	ND					0.01
	Manangese (Mn)	.02					0.01
	Mercury (Hg)	ND					0.0005
	Nickel (Ni)	ND					0.02
	Selenium (Se)	ND					0.005
	Zinc (Zn)	.027					0.005
	Molybdenum (Mo)	ND					0.05
	Uranium (U_3O_8) PPB	1875					1 PPB
	Vanadium (V_2O_5)	ND					0.05
	Radium (Ra-226) PiC/L ± Prec.	2.6 ±	0.8				0.5 PiC/L
	Gross Alpha	287±5					
	Gross Beta	264±5					

REMARKS: Analyses performed according EPA Manual, 1976 and/or Standard Methods for Examination of Water and Wastewater, 14th Edition.

6. North Rolling Pin 97 12-9-80