T. Nicholson

From: "Larry Rosenmann" <larosenm@gw.dec.state.ny.us>
To: <tjn@nrc.gov>
Date: 06/01/2006 10:45:56 AM
Subject: Concealed

Subject: Regional and site specific Geologic Information

Tom

I am re-sending the two reports that I sent you earlier this month. They should be very helpful to you regarding regional geology and groundwater flow.

The Whitman report was prepared in 1994 as an evaluation of groundwater migration on the site. It focuses the regional information to conditions at the site. It even contains several strike and dip measurements taken on-site in locations that may not be accessable today.

The Whitman Report also lists several site specific reports that should be extremely valuable to us all. Two them were included in the Indian Point 2 Final Facility Description and Safety Analysis Report (FSAR). Another was in the PSAR for proposed Units No. 4 and 5.
If you can find them in the NRC records , I would love copies.

Also, in case you have not already received it, I have attached a spreadsheet that compiles a lot of useful well information from the start of this month. It should provide you a great start on answering your site specific questions. In fact, if you look in the far right of . the spreadsheet, you will find hydraulic conductivity data on some of the more important wells.

Please let me know if there is any other information I may be able to provide.

Thanks

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H-8

GENERAL INFORMATION FOR THE GENERAL MANHATTAN SCHIST

The geological history of Manhattan includes the Precambrian to the Holocene. The Precambrian to Cambro-Ordovician rocks of New York City are divided into two major units separated by Cameron's thrust fault, a regional NE-SW trending structural feature which dips due southeast. The thrust fault extends from Connecticut through the Bronx and through Staten Island and further south into central and southern New Jersey. This regional feature has been classified as a suture of the proto-American plate. In Manhattan the New York City Group or Manhattan Formation are found west of this major thrust fault and the rocks to the east of this fault are known as the Hartland Formation (Hutchinson River Group). The Cameron thrust fault has affected both these units and imparted various structural features such as faults, shears and joint systems. The position of this major suture and so the correct formation name is not know definitively, although the published map [8] shows the thrust line passes through the east side of the East River between Roosevelt Island and Queens.

The project area mainly consists of the Manhattan schist, calcareous rocks of the Inwood Marble and Fordham Gneiss. The Fordham Gneiss has yet to be definitively identified by the exploration program. Manhattan schists are typically crystalline variations of essentially quartz and mica composition with quartz and feldspar rich zones, garnetiferous biotite and muscovite mica schist, quartz-hornblende-mica-garnet schists, and chlorite schists. Intrusion and in-place formation of pegmatite has occurred within the metamorphic rocks typically along and occasionally across the foliation and along other fractures. This activity is highly noticeable in the midtown area of Manhattan Island where these intrusions have locally elevated the metamorphic grade of the schists and modified their textures and structures to resemble almost aplitic gneissic to granitic rocks [9]. The Inwood calcareous rocks vary in composition from calcareous schists to dolomitic marbles and are intercalated with schist in northern Manhattan and the low-lying areas adjacent to the Harlem River in the east.

The axial plane of prominent regional folding aligns close to the axis of Manhattan Island and plunges to the southwest at about 10° to 15°. Other major fold axes plunge at low angles to the southwest [10]. However, the asymmetrical folding of rocks in the Manhattan Prong indicates several intense deformational events occurring over time. These multiple phases of deformation of the Manhattan rocks have produced crenulate, convoluted and parasitic folding of schistosity that leads to considerable local variations in fold geometry and definition.

Most of the fault types in Manhattan have been observed as normal, reverse, strike-slip or oblique, and range between clay gouge filled to healed. Fault gouge, fault breccia, and shear zones encountered in Manhattan range in thickness between a few inches to several tens of feet thick. Flexural slip along foliation occurs due to folding and dislocation and brecciated mylonitic cataclasites occur due to faults, shears and thrusts. The most prominent regional fault in New York City is the 125th Street or Manhattanville Fault that is accompanied by en-echelon faults with parallel WNW-ESE strike. This fault is expected to cross the project alignment in the area of 90th and 96th Street.

The Pleistocene and Holocene erosion and deposition has accumulated glacial till, modified glacial drift, sand and gravel and glacio-lacustrine silt, clay and marshland.

The bedrock surface is undulating, reflecting the geological and geomorphological past of the area. The depressions in the top of rock are typically valley forms and many correspond to structurally controlled stream channels or inlets that have since been covered. Erosional processes have exploited the bedrock that has been weakened by faulting, shearing, and hydrothermal alteration to form many of the valleys in this region.

The bedrock surface was planed by the Pleistocene glaciers removing most of the decomposed to weathered rock, leaving behind a thin mantle of dense till and remnants of decomposed to weathered rock at some locations. Above the basal till lies a mixture of glacial, interglacial and postglacial materials. The glacial deposits can generally be divided into three groups, glacial till, outwash/reworked till deposits and lake deposits of silt and fine sand. However, the stratification is complex and significant variations in the thickness and location of the individual units are common. Boundaries between strata are not clearly defined in many cases and considerable interlayering of the glacial materials is observed. This heterogeneity is typical of glacial depositional environments found at the rear of a terminal moraine. In these environments, different processes of deposition occur during cyclical periods of advance and recession of the ice front because prior deposits are reworked and new materials are deposited.

Overlying much of the glacial deposits is a layer of man-made fill material. There are local deposits of peat and organic silt that were formed by postglacial streams and creeks in marshy or swampy lowland areas. These features were later filled in and the land was reclaimed for development.

The rock mass is characterized by three fundamental joint sets, Set 1 corresponding to the foliation, Set 2 representing a typically steep joint set and Set 3 conjugate to the foliation. The interrelationship between these joint sets is fairly consistent but the dip and dip direction of the joints is highly variable vertically and laterally and sub-sets are common. This report presents the attitude descriptions and ranges that characterize the rock mass.

The faults and shears have been interpreted as planes but it is likely that they are curved. The fault orientation data indicate two families of faults with sub-sets. The F1 family trends NW-SE and includes four sub-sets. F1a faults dip to the northeast at moderate angles, they are typically thin to moderately thick and comprise rough, very close to close, iron stained joints, slightly to moderately weathered and slightly altered. F1b faults dip sub-horizontally to the northeast, they are typically thin to moderately thick and comprise rough, very close to closely spaced, strongly iron stained, slightly clay coated and kaolinized joints and slightly weathered. The F1c faults dip sub-vertically to the southwest, they are typically thin and comprise smooth to rough, very closely spaced joints, slightly weathered and slightly altered. The F1d faults dip sub-horizontally to moderately to the west and occur in the area of 85th Street.

The F2 family trends ENE-WSW and includes two sub-sets. The F2a faults dip moderately to the south, they are typically moderately thick to thick and comprise smooth to rough, irregular, very close to closely spaced kaolinized, mineralized joints and are moderately to completely weathered with very thin clayey silt gouge. The F2b faults dip moderately to the north and are typically thin, comprising smooth to rough, very close to closely spaced, iron stained joints with mineralization including calcite, chlorite and moderately to severely weathered.

BEDROCK CONDITIONS IN THE INWOOD MARBLE AND INTERFACE WITH THE MANHATTAN SCHIST

The rock mass is a complex repetitive intercalation of quartz-mica-garnet schist (Qmgs) and calcareous dolomitic siliceous marble. The intercalation of the sequence is attributed to a major thrust contact producing overturning and metamorphism. The Qmgs constitutes approximately 70 percent of the prevailing rock types but there are significant thicknesses of marble.

The Marble is hard, slightly weathered, fine to coarse-grained marble with faint foliation in places. The joints are typically rough to smooth, irregular, moderately closely to widely spaced, sub-horizontal to sub-vertical, slightly weathered with slight iron staining. There is chlorite, limonite, calcite and quartz mineralization on some joints. Although the dominant mineralogy is calcium and magnesium carbonate, there are mica rich zones with foliation and disseminated Actinolite.

The Qmgs is typically hard to very hard, slightly weathered to fresh, fine-to coarse-grained and foliated. The foliation is thin, convoluted, crenulated but generally sub-horizontal to sub-vertical. The joints are rough, irregular, moderately to very widely spaced, horizontal to vertical slightly weathered, slightly clay coated and iron stained.

There are fracture zones probably associated with faulting but the orientation of the structures has not been defined. The zones are 0.5 to 2 feet thick of rough to smooth, horizontal to vertical dipping joints, clay gouge, calcite and chlorite mineralization with slickensides on foliation and cross-foliation joints.

The upper 10 feet of rock is slightly poorer quality with RQD values between 65 percent and 75 percent and the typical RQD value below this zone is 85 percent to 95 percent and 65 percent to 75 percent in areas affected by the fracture zones.

Joint Attitude

In the schistose rocks the most common fractures fall into three joint sets - along the foliation (Set 1), conjugate to the foliation (Set 3) and steeply dipping (Set 2). The latter two are referred to as **cross-foliation fractures**. The foliation fractures generally occur in two sub-sets with complementary conjugate joints and the steep Set 2 joints overturn. This indicates that the joint system is possibly imposed on a folded schistosity. However, the folding has not been defined in this area.

The attitude of the foliation joints varies from sub-horizontal to sub-vertical due to folding and faulting, but the dominant attitude is moderate dipping to sub-vertical.

The conjugate joints are typically sub-horizontal to moderately dipping but steepen to moderately to sub-vertical close to the faults. The steep Set 2 joints are typically moderately dipping to sub-vertical.

The joint sets in the **foliated marble** are the same as for the schistose rocks. Joints in the **non-foliated marble** are relatively scarce, and where present, there is penetrative weathering of the joint surfaces and a clear plane cannot be seen. However, the ATV data indicate conjugate joint sets with sub-horizontal to sub-vertical dips.

Joint Spacing

The foliation and cross-foliation joints outside fracture zones and faults can widely to very widely spaced or closely to widely spaced. However, a characteristic of the rock mass is that the various joint sets coalesce to form clusters except in fault zones where the spacing is more regular.

Joint Set Orientation

There is a dominant NE-SW trend to the joints, with conjugate dip direction although dip to the NW occurs more frequently.

Faults, Shears and Fracture Zones

The fault orientation data indicate that the general trend of the faults is NE-SW to NEE-SWW. The faults and shears have been interpreted as planes but it is likely that they are curved. It is likely that there are more faults, shears and fracture zones in the rock mass than identified by the borings.

Discontinuities

The rock mass in the upper 10 feet to 30 feet of sound rock tends to be slightly poorer quality in places with a RQD of 65 percent to 90 percent but this is not a persistent feature and typical RQD values are 85 percent to 100 percent. The joints are typically smooth to rough, very closely to closely spaced sub-horizontal to moderately dipping, moderately weathered with chloritic surfaces.

In places the rock is more intercalated and the calcareous rocks have more distinct schistosity and associated foliation joints. The foliation fractures are smooth to rough, wide to very widely spaced, horizontal to moderately dipping, slightly weathered. The **cross-foliation** joints are rough, moderately to very widely spaced, sub-horizontal to horizontal, slightly weathered, healed and mineralized with calcium carbonate in places. The joints occur in clusters typically 1 foot to 2 feet thick with 1 to 2 per foot. The clusters are generally 3 feet to 6 feet apart but up to 5 feet to 15 feet in places.

The rock mass is characterized by intersecting faults and zones of decomposed rock. The foliation joints in the schist and foliated marble are rough to smooth, closely to widely spaced, sub-horizontal to sub-vertical, slightly weathered and occasionally slickensided.

The cross-foliation joints are smooth to rough, moderately to very widely spaced, slightly weathered, altered and healed. Clusters are not as common and there is a significant proportion of the rock mass without joints. The clusters are typically 1 foot thick with 1 to 2 fractures per foot at 5 feet to 15 feet spacing.

The dominant joint set orientation is southwest. The foliation joints, where present, dip to the northwest with a sub-set to the southeast. The Set 3 cross-foliation joints show a similar sub-set conjugate to the Set 1. The Set 2 joints are highly variable with no discernible trend, although this may be due to the small population of Set 2 joints. The recommended design joint set properties for schist and marble are shown in Table 15.

Fractures Zones, Faults and Shears

The faults and shears have been interpreted as planes but it is likely that they are curved. The fault orientation data indicate that the general trend of the faults is NE-SW to NEE-SWW. The dip of the faults ranges between 30° and 60° but typically 50° to 60°. The NEE-SWW family of faults appears to have a conjugate set with dips to the northwest and to the southeast.

The structures range from individual faults less than 1 foot thick to zones of faulting and shearing up to 7 feet thick. The zones comprise groups of faults and shear planes. The structures are typically moderately hard to hard, very closely to closely spaced, smooth to rough, sub-horizontal to vertical, moderately to severely weathered with iron-oxide stained, clay coated and slickensided joint surfaces. Clay gouge is rare but where present is less than 2 inches thick.

Bedrock Hydraulic Conductivity – manhattan schist

In 144 tests (approximately 51 %) no measurable inflow occurred. Based on a review of equipment and procedures this indicates that the effective hydraulic conductivity in these zones was, on average, less than 5×10^{-7} cm/sec.

Where packer test inflows were measured, the calculation of effective hydraulic conductivity is based on procedures outlined in the United States Bureau of Reclamation (U.S.B.R.) Earth Manual. Average values for effective hydraulic conductivity calculated for individual test zones range from 5 **$\times 10^{-7}$ to 10^{-2} cm/sec.**

The lower of these values is at the lower limit that can be reliably obtained from packer testing (i.e. the lower quantitation limit). On Figure 7 these tests are grouped with tests from zones that exhibited effective hydraulic conductivities of less than 10^{-6} cm/sec. Such zones are unlikely to yield significant water during construction.

There is an upper limit to reliable hydraulic conductivity, which depends on test flow rates and the length of the packer string (i.e. the upper quantitation limit). If this is exceeded then results may be a function of resistance to flow in the equipment rather than in the rock. Analysis suggests that some results at or above 2×10^{-3} cm/s exceed the upper quantitation limit and that effective hydraulic conductivity in these cases may be higher than stated.

Variation with Depth

Histogram plots of effective hydraulic conductivity of bedrock, at various depth intervals below top of rock, indicate that with greater depth below top of rock there was an increase in the proportion of tests recording no inflow, and effective hydraulic conductivities were generally lower with depth. This is consistent with observations from rock coring, which showed increased fracturing in the top 5 to 10 feet of rock. Review of boring logs also indicates a decreasing incidence of iron oxide staining with depth. Iron oxide is an indicator of oxidizing conditions that may be caused by oxygen rich groundwater flow.

Variation at Fracture Zones

The subsurface exploration program identified fracture zones, faults and shears at a number of locations where packer tests were conducted. Depending on degree of fracturing, fracture aperture, infilling and continuity these features may be transmitting more groundwater flow than average.

Domain 1

Only at three locations did higher packer test flows clearly coincide with logged fracture zones. The fracture zones at these locations are interpreted as parts of major faults or shears. Elsewhere in Domain 1 packer tests at fracture zones did not result in higher than average flows. This may indicate that permeability of faulted/sheared rock is restricted by factors such as alteration or clay infilling.

Several packer tests in Domain 1 recorded higher than average packer test flows that do not appear to coincide with shear/fracture zones. Some of the discrete fractures that caused these flows have associated packer test hydraulic conductivities of greater than 10^{-4} cm/s. However, since they do not appear to be part of major structural features, sustained inflows may be less than suggested by the test results.

Domain 2

In Domain 2 there are a number of locations where greater packer test flows coincide with logged fracture zones.

every boring where a packer test was conducted included test intervals where higher than average effective hydraulic conductivities coincide with fracture zones some of which are part of interpreted fault or shear planes. Packer test hydraulic conductivities exceeding 10^{-3} cm/s were recorded.

There are further locations within Domain 2 where higher than average packer test inflows were recorded at fracture zones that have not been interpreted as faults/shears, and at discrete fractures that are not part of fracture zones. Such features are likely to occur at regular intervals along the alignment. Some of the features that caused higher packer flows have associated hydraulic conductivities of greater than 10^{-3} cm/s. However, since they do not appear to be part of major structural features, sustained inflows may be less than suggested by the test results.

Statistical Review

In approximately 51 % (144 in total) of tests no inflow was measured. These data indicate that the average effective hydraulic conductivity at these zones is less than 5×10^{-7} cm/s. Statistical review of the remaining tests indicates effective hydraulic conductivity data has a log-normal distribution with mean -4.3 (i.e. the geometric mean hydraulic conductivity is 5×10^{-5} cm/s) and standard deviation 0.9.

Of tests conducted in the upper 10 feet of rock (42 tests) approximately 31 % resulted in no inflow and the hydraulic conductivity of the remaining tests had a geometric mean of 7×10^{-5} cm/s.

BEDROCK HYDRAULIC CONDUCTIVITY FOR THE MARBLE

Average values for effective hydraulic conductivity range between 3×10^{-7} and 9×10^{-4} cm/sec.

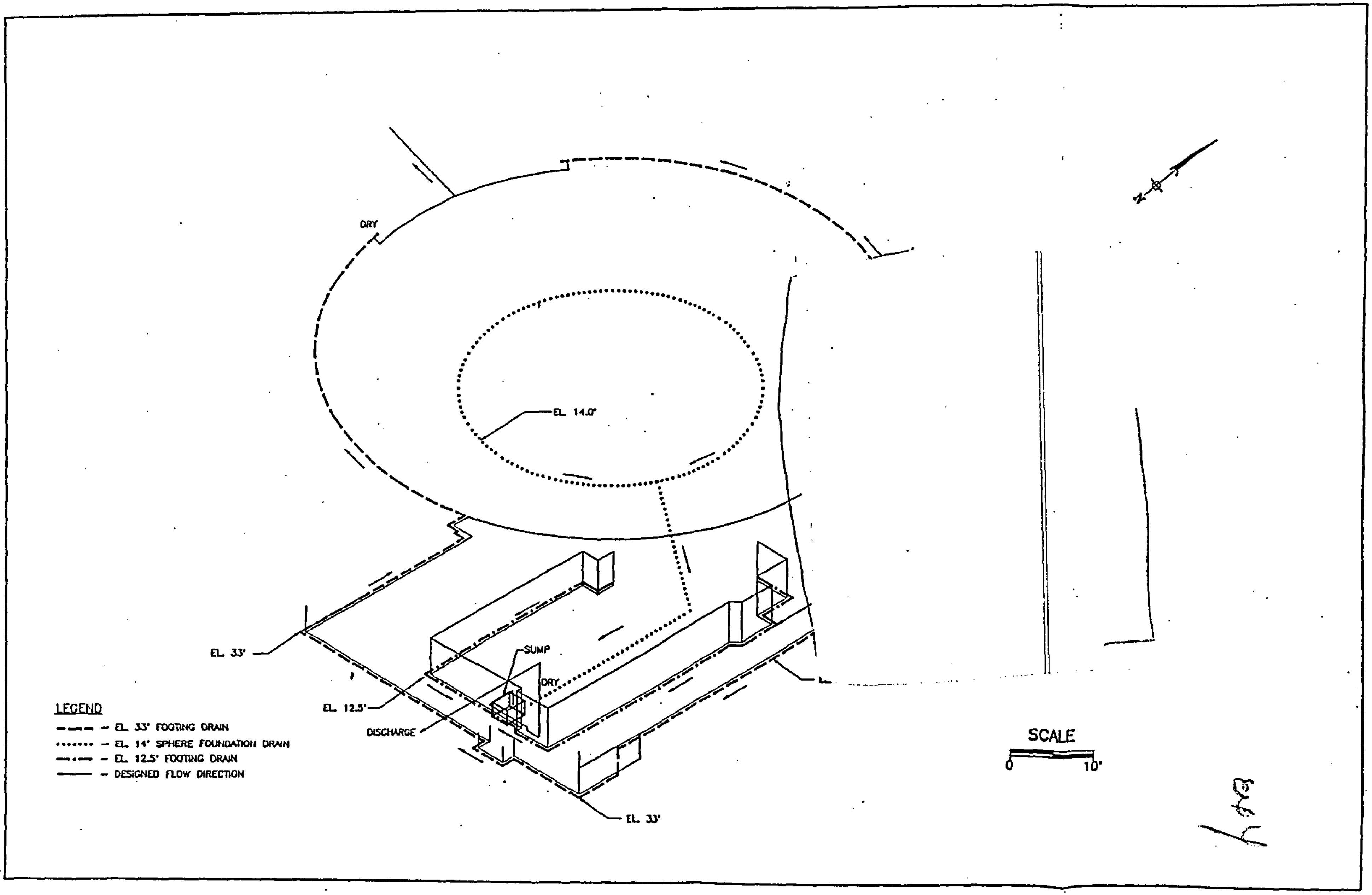
In approximately 70 percent of tests in the area of 125th Street Station (64 percent in Area 4) no measurable inflow occurred. Based on a review of equipment and procedures this indicates that the effective hydraulic conductivity in these zones was, on average, less than 5 x 10^{-7} cm/sec.

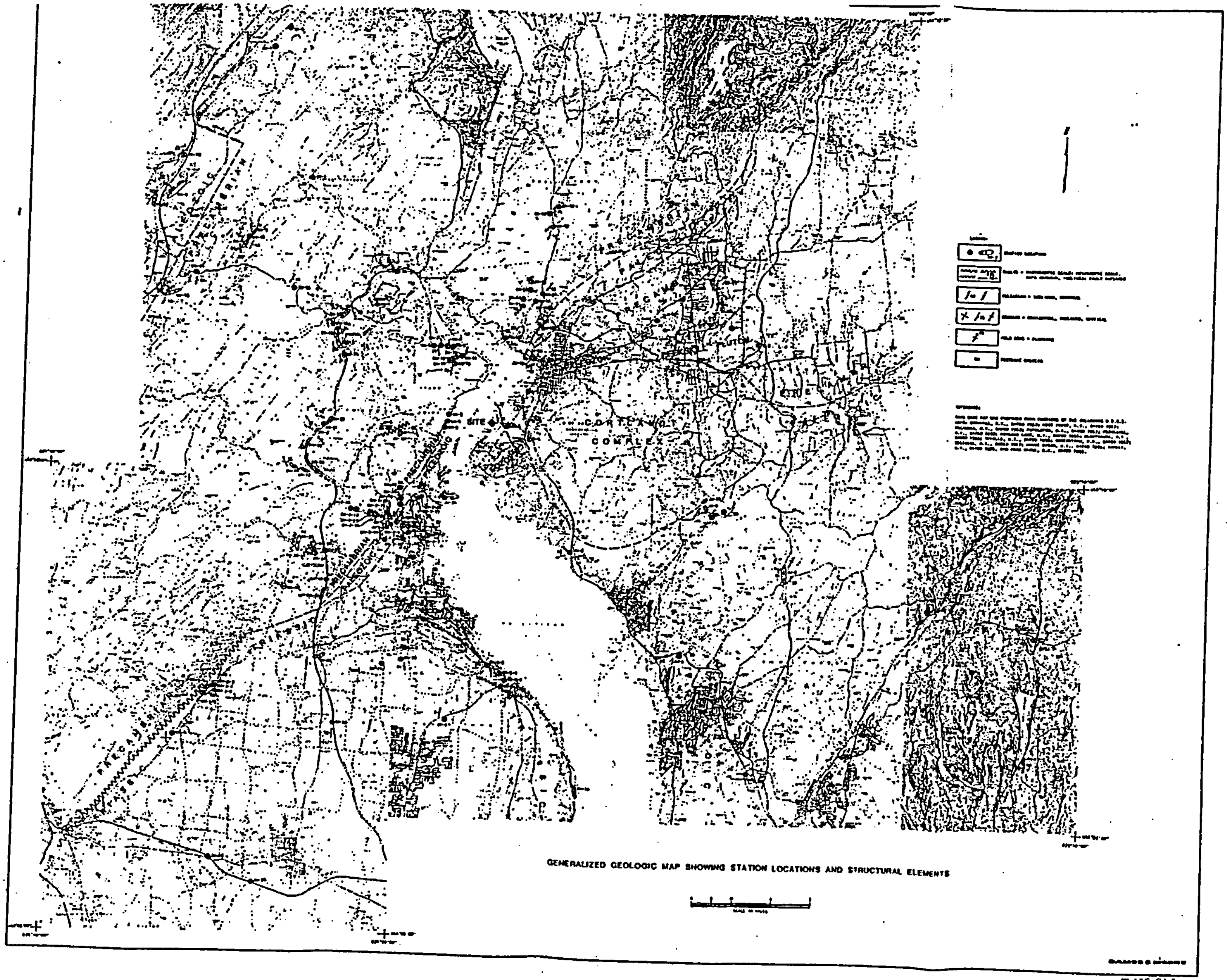
The data indicate a smaller proportion of tests with no inflow in the top 10 feet of rock. This is consistent with observations from rock coring, which show increased fracturing in the top 5 to 10 feet of rock.

The highest effective conductivities typically coincide with fracture zones or zones containing one or more open fracture. It is likely that other zones exist within weathered rock that exhibit hydraulic conductivities of the order of 10^{-3} cm/s.

The majority of the rock mass is anticipated to exhibit effective hydraulic conductivities of 10^{-5} cm/sec or less. In shear/fracture zones rock may exhibit effective hydraulic conductivities of the order of 10^{-3} cm/sec.

ATTACHMENT 7





GENERALIZED GEOLOGIC MAP SHOWING STATION LOCATIONS AND STRUCTURAL ELEMENTS

PLATE C1-2

ATTACHMENT

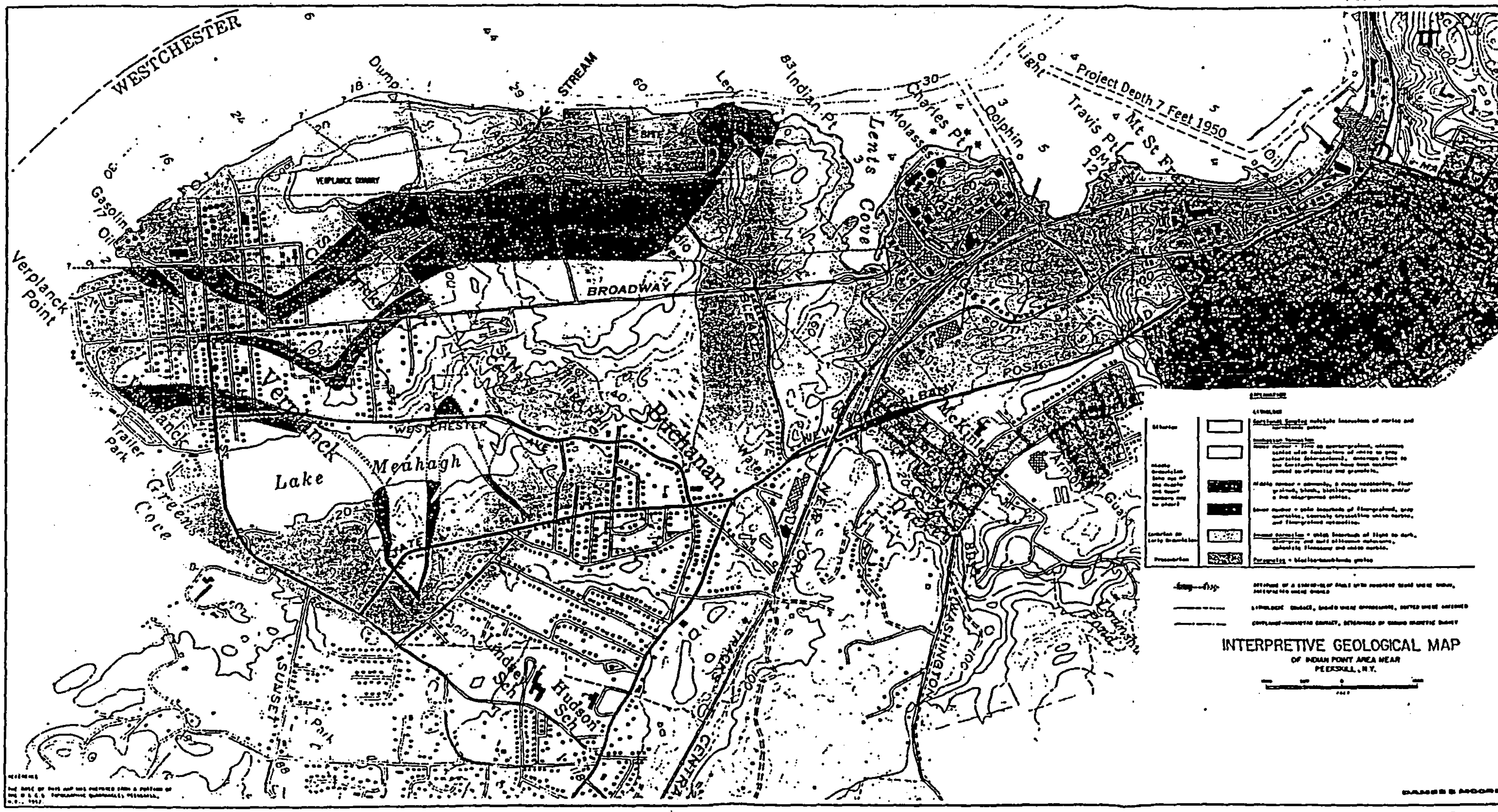


PLATE B3-4

Last updated 5/2/06
Scheduled future update 5/17/06

MONITORING WELL PARAMETERS/DATA

GZA

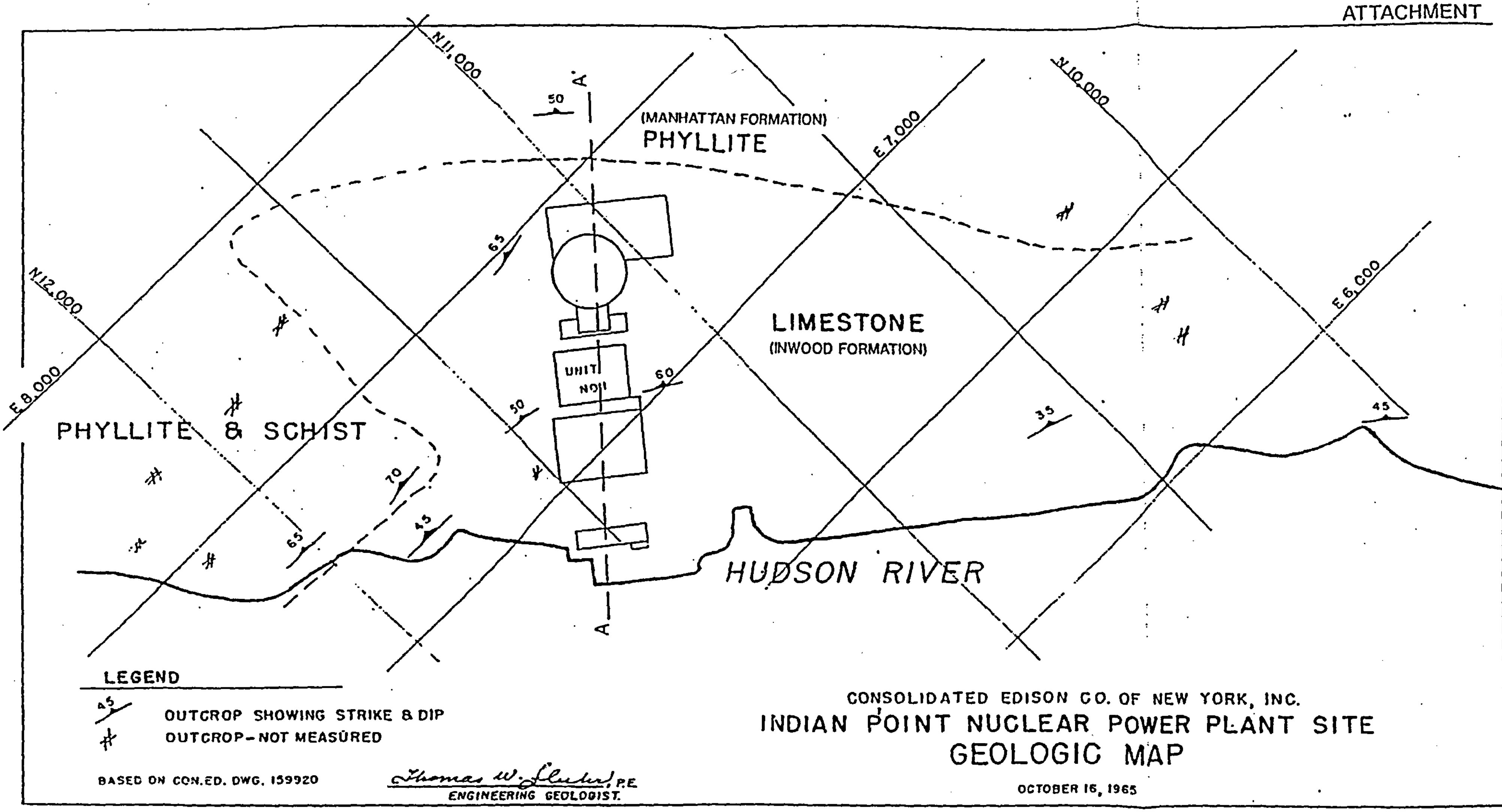
Well	Depths, ft: screen top	screen bottom	sand pack top	sand pack bottom	top of rock	end boring	Elevations, ft: Ground El	top of rock	end boring	screen top	screen bottom	sand pack top	sand pack center	sand pack bottom
MW-30					51	92	82	0	-10					
MW-31					6	90	80	74	-10					
MW-32					6	198	78	78	-120					
MW-33					7	29	19	12	-10					
MW-34					4	29	19	15	-10					
MW-35					7	29	19	12	-10					
MW-36-26	11	26	8	27	27	54	12	-15	-42	1	-14	4	-6	-15
36-41	36	41	32	42						-24	-29	-20	-25	-30
36-53	48	53	47	54						-36	-41	-35	-39	-42
MW-37-22	12	22	8	22	23	57	15	-8	-42	3	-7	7	0	-7
37-32	28	32	27	33						-13	-17	-12	-15	-18
37-40	39	40	38	41						-24	-25	-23	-24	-26
37-57	52	57	50	57						-37	-42	-35	-38	-42
MW-38	5	40	3	40		40	14		-26			-3	-14	-26
MW-39					80	200	83	23	-117					
MW-40					8	200	75	67	-125					
MW-41-15	5	15	2	15	15	95	85	40	-10	80	40	83	47	40
41-42	22	42	22	45						33	13	33	22	10
41-64	59	64	65	64						-4	-9	0	-5	-9
MW-42-51	31	51	29	50	25	80	70	45	-10	39	19	41	31	20
42-79	69	79	68	80						1	-9	2	-4	-10
MW-43-28	8	28	6	30	33	65	49	16	-16	41	21	43	31	19
43-82	42	82	40	82						7	-13	9	-2	-13
MW-44-67	52	67	50	68	31	105	90	59	-15	38	23	40	31	22
44-104	79	104	77	105						11	-14	13	-1	-15
MW-45-43	28	43	26	44	14	65	45	31	-20	18	3	20	11	2
45-62	52	62	61	65						-7	-17	-6	-13	-20
MW-46					0	30	53	53	23					
MW-47-56	36	56	30	57	61	141	72	11	-69	36	16	42	29	15
47-80	70	80	68	80						2	-8	4	-2	-8
MW-48-23	8	23	6	25	25	40	15	-10	-25	7	-8	9	0	-10
48-38	33	38	32	40						-18	-23	-17	-21	-25
MW-49-25	15	25	13	25	30	65	15	-15	-50	0	-10	2	-4	-10
49-42	32	42	31	45						-17	-27	-16	-23	-30
49-65	60	65	55	65						-45	-50	-40	-45	-50
MW-50-42	27	42	21	42	23	67	15	-8	-52	-7	-27	-6	-17	-27
50-67	62	67	60	67						-47	-52	-45	-49	-52
MW-51					16	200	95	79	-105					
MW-52					12	200	17	5	-183					
MW-52-12	2	12	1	12						15	5	17	10	22
MW-101	5	15	4	15		15	134		119	129	119	130	124	119
MW-103	11	26	10	28		26	143	7	117	133	117	133	125	117
MW-104	10	30	9	30	6	30	141	138	110	137	111	132	121	111
MW-105	5	20	4	20		20	136		116	132	116	132	124	116
MW-107	15	35	14	35		35	140		105	126	105	126	116	105
MW-108	3	13	3	13		13	15		2	12	2	12	7	2
MW-109	3	13	3	13		13	15		2	12	2	12	7	2
MW-110	15	30	14	29	8	30	135	127	105	121	105	121	113	105
MW-111	15	19	14	18	18	19	19	1	0	5	0	5	2	0
MW-112	9	24	8	24	10	24	137	127	113	129	113	129	121	113
U3-1	8	18	8	19		19	14		-5	6	-4	6	1	-5
U3-2	5	15	4	18		15	14		-1			10	5	-1
U3-3	5	15	4	15		15	15		0	11	6	11	6	0
U3-4D	25	34	25	34	18	34	14	-5	-20	-11	-20	-11	-15	-20
U3-4S	8	18	7	18	17	18	14	-3	-4			7	2	-4
U3-T1						2	3		2					
U3-T2						1	3		2					
I2	29	39	28	40	82	47	82		40	53	42	53	47	42
River														

Well	Avg GW	Max GW		Min GW		H3, pCi/L: Current H3		Max H3		Min H3	
MW-30	18.9	15	1/18/06	12	12/16/05	178,000	3/13/06	978,000	3/16/06	177,000	11/16/05
MW-31	47.7	49	1/6/06	45	2/21/06	18,800	4/25/06	33,100	2/7/06	848	1/16/06
MW-32	37.3					8,000	3/29/06	17,700	3/7/06	3,720	1/12/06
MW-33	18.4	13	1/18/06	10	2/27/06	221,000	4/7/06	253,000	3/3/06	142,000	12/13/05
MW-34	18.7	13	1/3/06	16	2/27/06	276,000	4/7/06	278,000	4/7/06	63,900	12/13/05
MW-35	18.4	12	1/3/06	10	2/27/06	54,200	4/7/06	119,000	3/13/06	38,700	1/27/06
MW-36-26	6.9					34,200	3/23/06	34,200	3/23/06	30,400	2/27/06
36-41	6.8					28,700	3/24/06	47,600	2/13/06	28,700	3/24/06
36-53	6.1					56,100	3/23/06	56,100	3/23/06	22,400	2/13/06
MW-37-22	4.5					34,100	3/27/06	34,100	3/27/06	14,800	2/25/06
37-32	4.6					30,100	3/27/06	30,100	3/27/06	20,300	3/10/06
37-40	5.5					28,300	3/27/06	28,300	3/27/06	14,700	2/26/06
37-57	5.9					30,050	3/27/06	30,050	3/27/06	15,900	2/25/06
MW-38	1.4	8	12/16/05	1	12/18/05	ND	3/13/06	2,630	3/3/06	ND	11/29/05-12/5/05
MW-39	31.0					ND	3/10/06	789	3/2/06		
MW-40	61.2					ND	2/9/06				
MW-41-15	29.5					1,031	3/16/06				
41-42											
41-64	25.8										
MW-42-51	34.5					261,000	3/23/06				
42-79	30.6					6,550	3/24/06				
MW-43-28	35.8					ND	3/16/06				
43-82											
MW-44-67	34.5					ND	3/20/06				
44-104											
MW-45-43	16.2					1,060	4/4/06				
45-62	17.2					298	4/4/06				
MW-46	44.2					1,430	3/1/06				
MW-47-56	25.8					ND	3/16/06				
47-80											
MW-48-23	1.1					ND	3/16/06				
48-38	0.9										
MW-49-25	0.8					15,400	3/22/06				
49-42	1.1					10,100	3/22/06				
49-65	1.0					8,620	3/22/06				
MW-50-42	4.6					8,750	3/22/06				
50-67	2.7					10,700	3/22/06				
MW-51	87.5					ND	4/4/06				
MW-52	18.1					ND	4/4/06				
MW-52-12	7.2										
MW-101	125.4										
MW-103	124.5										
MW-104	121.3										
MW-105	123.7										
MW-107	120.8	126	10/16/05	117	8/22/05	ND	9/28/05				
MW-108	8.1	10		6		ND	11/3/05				
MW-109	8.7	10	10/25/05	5	2/27/06	ND	11/4/05				
MW-110		122		112							
MW-111	9.8	11		8		145,000	4/7/06	296,000	12/13/05	6,320	10/14/2005
MW-112		128									
U3-1	4.5	6	1/4/06	4	10/24/05	887	3/16/06	744	1/12/06	ND	10/21/05-12/15/05
U3-2	4.6	7	10/6/05	4	11/16/05	ND	3/16/06	860	10/6/05	ND	10/28/05-3/16/06
U3-3	5.9	9	10/24/05	5	11/16/05	ND	3/16/06	471	11/10/05	ND	11/18/05-3/16/06
U3-4D	3.8	5	1/5/06	3	2/16/06	1,260	3/16/06	1,260	3/16/06	ND	2/15/06
U3-4S	3.0					ND	12/2/05				
U3-T1						782	3/16/06	835	2/15/06	ND	12/15/05
U3-T2	8.2	9.6				1,540	3/16/06	2,417	1/6/06	1,130	11/16/05
I2	52.6										
River	-1.0	3		-1							

Well	Date	H3
MW-30	11/16/05	296,000
	11/22/05	800,000
	1/30/06	318,000
	2/7/06	811,000
	3/13/06	179,000
MW-33	12/13/05	142,000
	12/19/05	199,000
	1/6/06	188,000
	1/13/06	232,000
	1/27/06	242,000
	3/3/06	253,000
	4/7/06	221,000
MW-34	12/13/05	63,900
	12/19/05	121,000
	1/6/06	158,000
	1/13/06	131,000
	1/20/06	211,000
	1/27/06	212,000
	3/3/06	230,000
	4/7/06	276,000
MW-35	12/13/05	42,300
	12/19/05	78,000
	12/30/05	88,800
	1/6/06	95,400
	1/6/06	96,400
	1/13/06	97,800
	1/20/06	104,000
	1/27/06	38,700
	3/3/06	119,000
	4/7/06	552,000
MW-111	9/29/05	212,000
	10/5/05	168,000
	10/7/05	144,000
	10/14/05	6,320
	10/21/05	284,000
	10/21/05	267,300
	10/28/05	218,000
	11/4/05	302,000
	11/10/05	246,000
	11/16/05	171,000
	11/22/05	180,000
	12/6/05	270,000
	12/13/05	296,000
	12/19/05	192,000
	12/30/05	212,000
	1/6/06	113,000
	1/13/06	199,000
	1/20/06	119,000
	3/3/06	236,000
	04/07/2006	145,000

Hydraulic conductivity, ft/day: Well	depth, ft		elevation, ft		K
MW-30	42	46	10	5	2.10
	45	50	7	2	2.85
	46	53	3	-1	8.87
	82	82	-1	-10	6.61
MW-31	35	41	45	37	0.06
	43	52	35	27	4.90
	51	60	29	20	0.25
	59	67	21	13	0.24
	66	74	14	6	0.24
	74	82	6	-3	0.27
	80	80	0	-11	0.17
MW-32	70	80	8	-2	0.81
	80	90	-2	-12	0.86
	117	127	-39	-49	0.94
	131	141	-53	-63	2.86
	148	158	-70	-80	1.34
	170	180	-92	-102	4.81
	175	185	-97	-107	2.81
	185	195	-107	-117	1.20
MW-33	7	29	12	-10	0.36
MW-34	4	29	15	-10	0.26
MW-35	7	29	12	-10	0.31
MW-111	18	19	1	0	0.45
MW-39	84	84	24	14	12.6
	70	80	14	4	1.90
	80	90	4	-7	0.44
	89	99	-6	-16	1.20
	119	129	-36	-46	0.78
	129	139	-46	-56	0.61
	139	149	-56	-66	0.19
	152	162	-69	-79	0.67
	165	175	-82	-92	0.81
	175	185	-92	-102	1.83
	185	195	-107	-112	1.97

well screen in unconsolidated deposit (soil backfill/natural soil)
well screen in consolidated (bedrock)



A-A' LINE OF HYDROGEOLOGIC CROSS-SECTION SHOWN ON ATTACHMENT 4

ASSESSMENT OF GROUND-WATER MIGRATION PATHWAYS

FROM UNIT 1 SPENT FUEL POOLS

AT INDIAN POINT NUCLEAR POWER PLANT
BUCHANAN, NY

PREPARED FOR

CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.

PREPARED BY

THE WHITMAN COMPANIES, INC.
EAST BRUNSWICK, NEW JERSEY

PROJECT # 940510

JULY 1994

44 West Ferris Street, East Brunswick. New Jersey 08816

THE
WHITMAN
Companies
INC.

44 West Ferris Street
East Brunswick, N.J. 08816
(908) 390-5858
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July 5, 1994

Mr. Eustratios Comninellis
Consulting Engineer
Civil Engineering Department
Consolidated Edison Co. of New York, Inc.
4 Irving Place
New York, NY 10003

RE: Assessment of Ground Water Migration Pathways
From Unit No. 1 Indian Point Nuclear Power Plant

Dear Mr. Comninellis:

At your request, The Whitman Companies, Inc. has prepared the attached report assessing migration pathways and environmental impacts in the case potentially contaminated water from spent fuel pools at Unit 1 leaked into ground water.

It is our finding that a site-specific combination of hydrogeologic and design features of Unit 1 is favorable for minimizing environmental impacts of any subsurface leaks. Most of the water that might leak from the spent fuel pools would be intercepted and recovered by a subsurface drainage system operated at the Chemical Systems Building. This system was installed at the time Unit 1 was constructed to combat high ground water levels. An upward hydraulic gradient and upward flow resulting from location of the Station in a regional ground water discharge zone (the Hudson River valley) will prevent any downward migration of water from the leak. If any portion of the leak were not intercepted by the subsurface drain system, it would likely follow a shallow ground water flow pathway into a small stream discharging into the Hudson River some 1,700 feet southwest of Unit 1. Ground water in the area is not used for drinking water supply.

If you have any questions regarding this letter, or if we can be of any further assistance, please contact us at (908) 390-5858.

Very truly yours,

Andrew Michalski (SD)

Andrew Michalski, Ph.D., CGWP
Director of Hydrogeology

AM/ld

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TABLE OF CONTENTS

ATTACHMENTS

ASSESSMENT OF GROUND-WATER MIGRATION PATHWAYS
FROM UNIT 1 SPENT FUEL POOLS
AT INDIAN POINT NUCLEAR POWER PLANT
BUCHANAN, NY

1.0 INTRODUCTION

This report provides an assessment of migration pathways in the event potentially contaminated water from spent fuel storage pools at Unit 1 of the Indian Point Nuclear Power Plant leaked into ground water. Our evaluation is based upon review of various reports listed below, interpretation of geologic and hydrogeologic data contained in these reports, geologic and hydrogeologic reconnaissance of the Station and its vicinity, as well as a review of design drawings for Unit 1 subsurface drainage systems and photographs taken during the construction of Unit 1.

Major reports reviewed included: "A Geologic Report on the Indian Point Power House Site" by Sidney Paige, Consulting Geologist (1955); "Memorandum on Geologic Features of Indian Point Nuclear Power Plant Site" by Thomas W. Fluhr, P.E., Engineering Geologist (1965). These two reports were found in Section 2.7 of the Indian Point 2 Final Facility Description and Safety Analysis Report (FSAR). Other documents reviewed include: "Supplemental Geological Investigation of the Indian Point Generation Station" by Dames & Moore (1975); portions of PSAR for proposed Units No. 4 and No. 5, and a report on "Hydrogeologic Investigation of The Verplanck Quarry" (1981) by Dames & Moore.

During a site visit on June 3, 1994, Dr. Andrew Michalski of The Whitman Companies, Inc. examined rock outcrops exposed at the Station along the eastern bank of the Hudson River and at the Verplanck Quarry. He also surveyed the river bank for manifestations of fresh water discharges into the river at low tide. In addition, construction drawings for drainage systems associated with Unit 1 and adjacent buildings containing fuel pools and chemical systems were examined and detailed photographs depicting excavation and foundation works at Unit 1 were reviewed. Discussions were held with site personnel on engineering and hydrogeologic features of Unit 1.

2.0 SITE GEOLOGY

The Indian Point station is located upon the Paleozoic (Cambro-Ordovicism) bedrock of the Inwood Formation (Attachment 1). This Formation, which is the older unit of the Manhattan Prong, consists of dolostone and marbles. These rocks are exposed on site, along the Hudson River and in the Verplanck Quarry located approximately 3,000 feet south-southwest of the site (Attachment 2). In general, the outcrop area of the Inwood Formation in the site vicinity is confined to a topographically low area between Broadway and the Hudson River (Attachment 2).

The dark schists of the Manhattan Formation lie unconformably above and to the east of the Inwood Formation (Attachments 2 and 3). Both of these formations were regionally metamorphosed to medium grade prior to the intrusion of the Cortlandt Complex east of the site (Attachment 1). The intrusion has produced an aureole of contact metamorphism in the adjacent Manhattan Prong, and further complicated an already complex tectonic history of the metamorphosed, folded and faulted metasediments in the area.

A maximum apparent thickness of the Inwood Formation of 2,000 feet is reported in the White Plains area. As indicated by results of an extensive geologic investigation by Dames & Moore, the Inwood Formation at the Indian Point site is composed of three interbedded lithologies: a blue-gray to light-gray dolostone, a limestone similar in appearance to the dolostone, and several thick beds of white marble. A weak foliation in these rocks is underlined by light-colored micas. Minor layers of cherts and phyllites, usually folded and boudined, are present within the lithologies.

The Inwood Formation exhibits a well-defined layered structure which generally strikes north-south to north-east and dip easterly at 50 to 70 degrees to the east and southeast. The bedrock is reportedly intensely, though not uniformly, jointed. Several major groups of fractures were distinguished. One of these major sets measured in the Inwood Formation strikes NNE, which is nearly parallel to the principal structural grain of the region.

Originally, the alluvial and glacial overburden at the site of Unit No. 1 was shallow. The overburden was completely removed prior to the construction of Unit 1. At the eastern portion of the site, the bedrock was excavated to an approximate elevation of +70 feet msl. The elevation at the south side drops abruptly to +15 feet at the intake structure on the Hudson River. Unit 2, located immediately north of Unit 1, was constructed at a lower elevation than Unit 1.

3.0 GROUND WATER

3.1 Regional Setting

The occurrence and flow of ground water beneath the Station is controlled primarily by the following three factors related to the regional hydrogeologic framework of the site:

1. The location of the station adjacent to the Hudson River is of greatest significance. The river serves as a major regional sink collecting ground water flows from the adjacent upland areas. The storage pools at Unit No. 1 are located only 700 feet from the eastern bank of the river (Attachment 4). Generally, the ground water discharge areas near major rivers exhibit a horizontal ground water flow component directed toward the river and an upward vertical flow component increasing with depth.

2. The permeability contrast between the relatively permeable metamorphosed limestone and dolostones of the Inwood Formation and the low-permeability schists of the Manhattan Formation, together with a limited extent of the Inwood Formation, are important factors modifying ground water flow in the area in relation to a reference case of a site with uniform permeability adjacent to a major river valley. The permeable character of jointed limestone and dolostone beds of the Inwood Formation is indicated by an observation of no return of drill water when test borings were made into the Inwood Formation (Fluhr, 1965). On the other hand, schists of the Manhattan Formation are known to exhibit low permeability. Conceivably, the band of the relatively permeably Inwood Formation, cropping out between Broadway and the Hudson River and dipping steeply eastward under the schists of the Manhattan Formation (Attachment 4), will act as an underdrain collecting ground water flows from fractures in the schist from the upland area and transmitting the flows updip and laterally toward the Hudson River and in the direction of the Verplanck Quarry.

3. The steeply-dipping, layered (foliated) structure of the Inwood Formation tends to produce hydraulically anisotropic behavior of this formation as a whole. The greatest permeability axis lies within the bedding (foliation and shear) fractures (Attachment 4). Such permeability anisotropy tends to promote horizontal ground water flow in the direction of the principal structural grain (which is subparallel to the river), rather than directly to the river. In reality, the permeability of the Inwood Formation is likely to be controlled by the presence of more transmissive bedding plane separations which acts as discrete aquifer units. The presence of

numerous joints (majority of which do not extend beyond individual beds) and other fracture results tend to produce complex, leaky relations between such discrete units. The different hydraulic role of bedding plane and joints in the Inwood Formation is suggested by an examination of a large on-site outcrop located between Unit 1 and the river in the GT-1 gas turbine alleyway.

It should be stated that no significant dissolution features or indications of a solution-type permeability were observed in the Inwood Formation during the earlier site investigations (Paige, 1955; Fluhr, 1965; Dames & Moore, 1975 and 1981). The lack of any significant karstic features is also evident at outcrops of the Inwood Formation exposed at the Station and along the Hudson River bank.

3.2 Site Hydrogeology

Site-specific measurements of ground water elevations in the vicinity of Unit No. 1 were obtained in several open coreholes drilled into the Inwood Formation during early site investigation (Paige, 1955). Relevant data for the four coreholes are compiled in Table 1 below. The total depth of these coreholes ranged from 93.7 feet to 100.0 feet, with the bottom of the holes approximately 16 feet to 53 feet below an average water level in the adjacent Hudson River. The reported ground-water level elevations ranged from 55 feet above msl in hole G-6 to 38 feet above msl for hole G-10 (Table 1).

When the measured ground water level elevations are contoured and plotted on a site plan (Attachment 5), an apparent ground water flow in the southerly direction is obtained, as indicated by an arrow on Attachment 5. This apparent flow direction is parallel to the N-S direction of strike of beds measured by Fluhr (1965) for the area north of Unit 1 (Attachment 3), and is consistent with the ground water flow direction postulated under items (2) and (3) above. South of Unit 1, the strike of the Inwood bed's shifts westward towards the river (Attachment 3) and the Verplanck Quarry. The ground water flow direction is likely to follow that shift.

Although the apparent flow direction indicated by the ground water levels measured in open coreholes is generally consistent with the flow direction postulated earlier based upon hydrogeologic analysis, the use of a term "apparent flow direction" is preferred for the following reasons: 1) The ground water level measured in a long open hole might represent a composite of water levels of several water-bearing units (discrete fracture units) penetrated by the hole, but individual holes might not penetrate the same suit of the discrete units, and 2) The water levels measured in the open hole likely include a significant vertical component of hydraulic head, which is directed upward in a ground water discharge area.

TABLE 1

Ground-Water Elevation Data
Reported For Several Open Core-Holes

Boring No.	G-6	G-8	G-10	H-8
Surface Elevation (feet msl)	78.9	78.0	41.0	64.9
Bottom Elevation (feet msl)	-21.1	-16.5	-54.0	-28.8
Total depth, feet	100.0	94.5	95.0	93.7
Ground Water Elevation (feet msl)*	55	47	38	49

* As reported on page W-26 of a "Geologic Report" By Sidney Paige, 1955 (Section 2.7-1). All other data taken from Figure 2.7-3 of the "Indian Point Generating Unit No. 2 Final Facility Description and Safety Analysis Report."

In our opinion, the relatively high water level elevations (38 to 55 feet above msl) measured in deep open holes drilled in a close proximity to the river (Attachment 5) was largely due to the presence of an upward hydraulic gradient and an upward ground water flow beneath the area of Unit 1. The occurrence of the pre-construction potentiometric level at such a relatively high elevation is confirmed by examination of old photographs taken during early stages of construction of Unit 1. One of such photographs (Attachment 6), taken during normally dry-weather period in the Fall of 1959, shows (ground) water pumped from a temporary sump located adjacent to the Unit 1 structures under construction. A darker contact apparent on the steep excavation wall is indicative of the position of the water table. The water table elevation apparent on the wall on the photograph is similar to the water level elevations measured in on-site coreholes. Still another indication of the upward hydraulic gradient is provided by a relatively high water level elevation measured in the Verplanck Quarry (approximately 20 feet above msl) whereas the level of the river is approximately mean sea level. The water level in the quarry, which was excavated to the maximum elevation of 160 feet at a sump area, has remained fairly constant for "quite a few years" (Dames & Moore, 1981). Quarrying operations were abandoned in 1942. Dames & Moore (1981) estimated the ground water inflow to the quarry at 26 gpm at the time of their investigation.

The occurrence of an upward flow component in the area adjacent to the river has a significant implication on the migration pathways of potential contamination released into ground water at Unit 1. The presence of an upward vertical gradient would create an hydraulic barrier preventing migration of the contamination into a deeper ground water system, thus effectively limiting the migration of any potentially contaminated water released at Unit 1 to a shallow ground water system.

3.3 Effects of Plant Construction on Ground Water Flow

The construction of Unit 1 involved making large excavation into bedrock of the Inwood Formation and, in a limited way, into the low-permeability Manhattan Schist (Attachments 4 and 5). The final ground elevation at the eastern portion of the plant is approximately +70 feet msl; the elevation of the southern portion of the plant drops abruptly to +15; in the western side of the plant towards the intake structure on the Hudson River, the surface elevation is also +15. Unit 2, located immediately north of Unit 1, was built on excavated Inwood Formation at a lower elevation than Unit 1. Finally, Unit 3 was constructed on the Inwood Formation south of Unit 1. West of the three units, along the riverside, the surface elevation is +15 feet msl.

The bottom of construction excavation for Unit 1 reached an elevation which was approximately 25-40 feet below the pre-construction potentiometric level measured in the coreholes (Section 3.2). This relatively deep penetration into the saturated zone during Unit 1 construction required interception and pumping of ground water to keep the potentiometric surface in a depressed position at the foundation level. Detailed construction photographs taken in the Fall of 1959 show ground water pumping from temporary sumps located adjacent to the Unit 1 structures under construction (Attachment 6). As part of foundation works at Unit 1, three independent drain systems were constructed to intercept ground water and direct it to a sump from which the water could be pumped out. A more detailed description of these drains is provided in Section 3.4. The pumping of ground water collected by the drains has created a "cone of depression" typically associated with ground water pumping. Along with ground water removal, the drains provide a primary receptor of any water leaked from the fuel storage pools.

Any water leaked from the pools that might not be intercepted by the drains would follow the pathway of the shallow ground water. For the shallow ground flow system beneath the site, the Hudson River provides the ultimate discharge zone and receptor of any water released at the Station. Because of the anisotropic permeability of the Inwood Formation, horizontal flow direction subparallel to the river may be preferred over a flowpath directly from Unit 1 to the river. For the preferential flow of shallow ground water and potential contaminant migration southward subparallel to the river, a small stream flowing northwest through an adjacent property to the southwest (labelled "Stream" on Attachment 2) appears to provide a secondary receptor of any contaminated water that may migrate along the shallow ground water pathway. During the hydrogeologic reconnaissance of June 3, 1994, the flow in the stream was estimated at several gallons per minute (gpm) at its confluence with the Hudson River. Approximately 500 feet in the upstream direction, below a location where the stream emerges from a culvert under a main parking lot of the Georgia Pacific Corporation, seeps of shallow ground water were evident on the eastern slope of the stream swale. (Unit 1 is located approximately 1,700 feet east of the seeps.)

The Verplanck Quarry, located approximately 3,000 feet southwest of Unit 1, may provide a tertiary discharge zone for shallow ground water from the Unit 1 area. Although it is likely that nearly all water which may leak from the Unit 1 spent fuel pools will be collected by the Unit 1 drain systems and any remainder would discharge to the stream, to be conservative, an area potentially affected by a release of contamination at Unit 1 would be limited to the area in-between the river and Broadway (Attachment 2).

3.4 Subsurface Drains As Primary Interceptors of Potential Releases From Unit 1 Spent Fuel Pools

Since ground water levels encountered during the pre-construction site investigation and during construction activities were 25-40 feet above the foundation footings, subsurface drain systems were constructed at two different levels of the footings for the Unit 1 structures. The first system at an elevation +12.5 feet msl drains to a sump, equipped with pumps and automatic water level controls to maintain the water table in a depressed position. The total flow rate from the lower subsurface drain is approximately 14 gpm. Because the pools with spent fuel are located within the cone of depression created by the system drainage, there is a reasonable expectation that any leak from the pools would be intercepted by the drain system.

Examination of design drawings of the second subsurface drain system indicates that the Fuel Storage Building (which contains the pools) is served primarily by a perimeter footing drain installed at an elevation of +33 feet (Attachment 7). This system, made up of a 12-inch perforated pipe, serves the eastern side of foundation for the fuel storage pools and then runs along the northern side of the building toward a drain header located on the western side of the Containment Structure. This system is known to carry an estimated base flow of 0.06 to 0.6 gpm. This drain system connects to the building internal drainage system which discharges into the Unit 1 discharge canal. The drain system at +33 feet does not constitute the lowest-elevation drain present in the vicinity of the fuel storage pools (Attachment 7).

The permeable infilling placed between foundation for the spent fuel pools and bedrock along the foundation walls creates a hydraulic connection between the pools and the subsurface footing drain sump located under the Chemical System Building (Attachment 7). This drainage system at +12.5 feet is expected to collect any leak from the pools developed below an elevation of +33 feet, as this system at +12.5 feet drains to a sump being the low point of the "cone of depression." Ground water enters this sump at a typical rate of 14 gpm. A radiation monitor is installed in the discharge line from the sump.

The results of radiation monitoring by Station personnel have confirmed the presence of the hydraulic connection between the fuel storage pools and sump in the Chemical System Building. Furthermore, mass balance computations performed by Station personnel indicate that virtually all tracer mass released from the pools was recovered via the sump at +12 feet. The results of these tracer studies demonstrate that the subsurface drain system with sump at +12 feet is capable to recovering all or nearly all contamination that might leak from the Unit 1 spent fuel pools. The need for operating a ground water pumping system at Unit 1 structures, necessitated by an upward gradient and flow of ground water, has produced a very effective hydraulic containment and recovery system for any leaks of water from the spent fuel pools.

A third subsurface drain system encircles the Containment Structure at an elevation of +14 feet (Attachment 7). The third system, which is connected to a sump located under the Chemical Systems Building, carries no flow. The lack of flow in this drain system is likely due to its more distant location from the principal bedrock cuts than the other two systems and the placement of the drains in a grout envelope.

4.0 IMPACT ON POTENTIAL RECEPTORS

4.1 Ground Water Use

No usable aquifers occur beneath the facility or in its immediate vicinity. Unconsolidated aquifers are absent in the area, and wells installed in bedrock formations generally can yield only small quantities of water, particularly if installed in the low-permeability Manhattan Schist. The local population is served primarily by municipal water derived from surface reservoirs upstream of the site.

A search of potable wells was performed in 1969 as part of preparation of PSAR for then-proposed Units 4 and 5. Results of this search, including a well location map, are presented in Attachment 8. Only three (3) domestic supply wells were identified within a 2-3 mile radius of the site east of the Hudson River. The bottom elevation of the nearest domestic well identified through the search was approximately 20 feet above the river's level, thus several feet above the water level elevation of +12 feet in the Unit 1 sump. The Westchester County Department of Health has advised that there have been no requests for any supply wells since 1969.

The only municipal supply wells utilizing ground water within a five-mile radius is at Stony Point, located on the western side of the Hudson River. The supply wells, apparently completed in unconsolidated deposits, are relatively shallow. The deepest well reaches only 35 feet. The well system reportedly yields 550 gpm (PSAR, Units No.4 and No. 5).

The nearest drinking water intake on the Hudson River is for the Castle Point Veteran's Hospital located approximately 21.3 miles upriver from the Station.

4.2 Potential Impacts

The site-specific hydrogeologic conditions and design features of Unit 1 have created three levels of containment or barriers which tend to minimize environmental impacts in the case of a leak occurring at the spent fuel pools. The first level of containment is provided by the ground water pumping from the Unit 1 subsurface drain systems. As demonstrated by the results of tracer studies, this drainage system is capable of removing nearly all contamination that might leak from the fuel storage ponds located in an adjacent building. The second level of containment is furnished by the upward flow of ground water in a regional discharge zone, forcing any flow not intercepted by the on-site drainage to migrate laterally along a shallow ground water path toward the nearest stream. The third level of containment is provided by the differences in hydraulic properties between the Inwood

Formation and the Manhattan Schists. The differences preclude any potential migration pathways beyond an area located west of Broadway and east of the Hudson River.

As indicated by the well search results (Section 4.1), no water supply wells are present within the potentially impacted area in-between the Hudson River, Broadway and the Verplanck Quarry. Since the well water supply system at Stony Point and other domestic supply wells listed in Attachment 8 are located well outside the conservatively defined potential impact area, it is highly unlikely that a leak from the Unit 1 storage pools could impact water quality in those wells.

5.0 SUGGESTED GROUND-WATER MONITORING

In our opinion, a ground-water monitoring system relying upon sampling at ground water discharge point from the sump pump at the Chemical Systems Building and sampling of water quality in the stream located 1,700 feet southwest of Unit 1 (the nearest secondary discharge point) would be capable of an early detection of a water leak from the storage pools. Such a system has an advantage of early warning over systems relying upon the use of ground water monitoring wells. The complexity of fracture flow in the Inwood Formation undermines the reliability of well-based monitoring. In addition, the proposed system can also be used to monitor the effectiveness of a corrective action which may be undertaken should a confirmed leak occur.

6.0 CONCLUSIONS

Based upon our evaluation of available reports, design data, and a site reconnaissance, the following conclusions are offered regarding migration pathways and potential impacts should a release of water from spent fuel pool at Unit No. 1 occur:

1. There is little potential for any water released from Unit 1 to enter deeper ground water flow systems. The site is located in a regional ground water discharge zone. An upward gradient typical of such zone provides a hydraulic barrier, limiting the potential spread of contamination to shallow flow system only.

2. A subsurface drainage system with a sump at the Chemical Systems Building, operated to keep water table depressed below the foundation level in bedrock, is capable of intercepting nearly all leaks that may originate near the bottom of fuel

storage pools. A very high recovery rate for potential leaks was demonstrated by results of tracer studies.

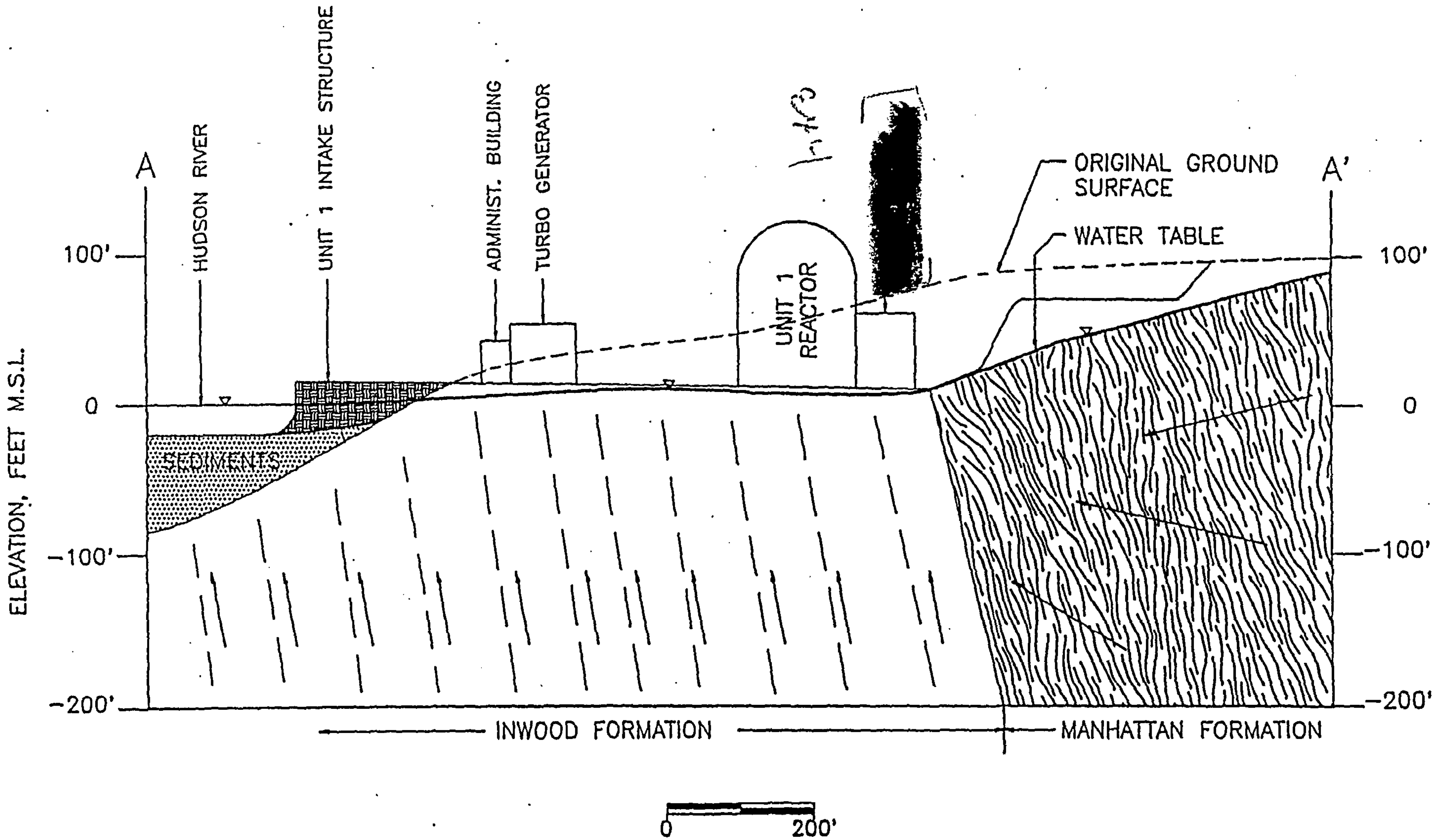
3. Although the Hudson River provides an ultimate receptor of ground water flow from the vicinity of Unit 1, the actual flow pathways for the shallow ground water are likely to be subparallel to the river due to effects of geologic structure. A small stream located on the adjacent property west of the site provides the most likely receptor of shallow ground water flow from the site which might not be intercepted by the subsurface drainage system.

4. In a worst case scenario, the area of potentially impacted ground water is conservatively estimated to be limited to a downgradient (downstream) area between Broadway, the river and the Verplanck Quarry. There is virtually no potential that any contaminated ground water could flow beneath the Hudson River and reach an area on the western side of the river.

5. There are no principal or primary aquifers beneath the facility nor in its immediate vicinity. The local population does not use wells as a source of potable water. The nearest municipal supply wells are located several miles away across the river.

6. A monitoring system relying upon sampling of ground water discharges from the sump at the Chemical System Building and at the nearest stream downgradient of the Station is capable of an early detection of potential leaks from the spent fuel pools.

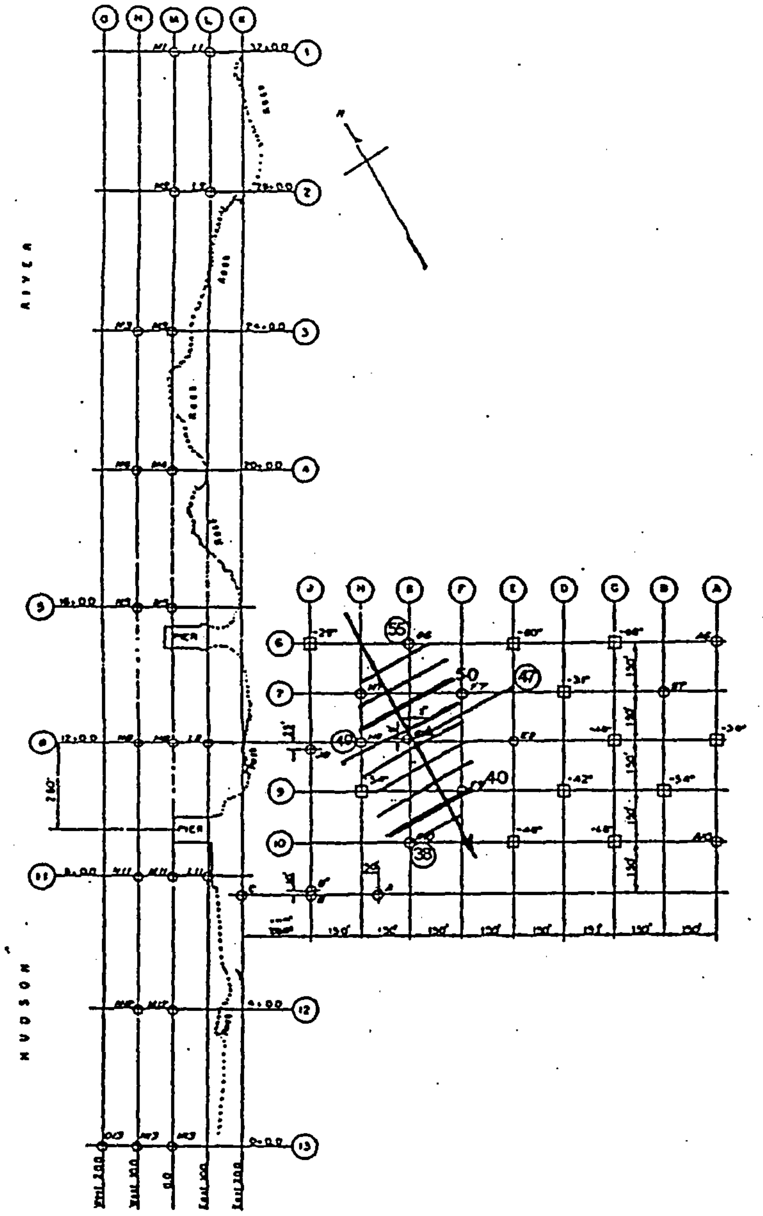
ATTACHMENT 4



APPROX. HORIZONTAL SCALE
VERTICAL EXAGGERATION 2 TIMES

<u>NOTE:</u> ARROWS INDICATE GENERALIZED GROUND WATER FLOW DIRECTIONS IN THE PLANE OF THIS SECTION. HORIZONTAL FLOW COMPONENT IN THE INWOOD FORMATION IS TOWARDS THE VIEWER.

ATTACHMENT 5



P L A N

NOTES

INFORMATION OBTAINED BY CON EDISON CO. SURVEYORS.

Indicates location of rock, below surface as obtained by probing.

For soundings see dwgs 132060, 132061 & 132062.

(49) - WATER LEVEL ELEVATION, FEET MSL

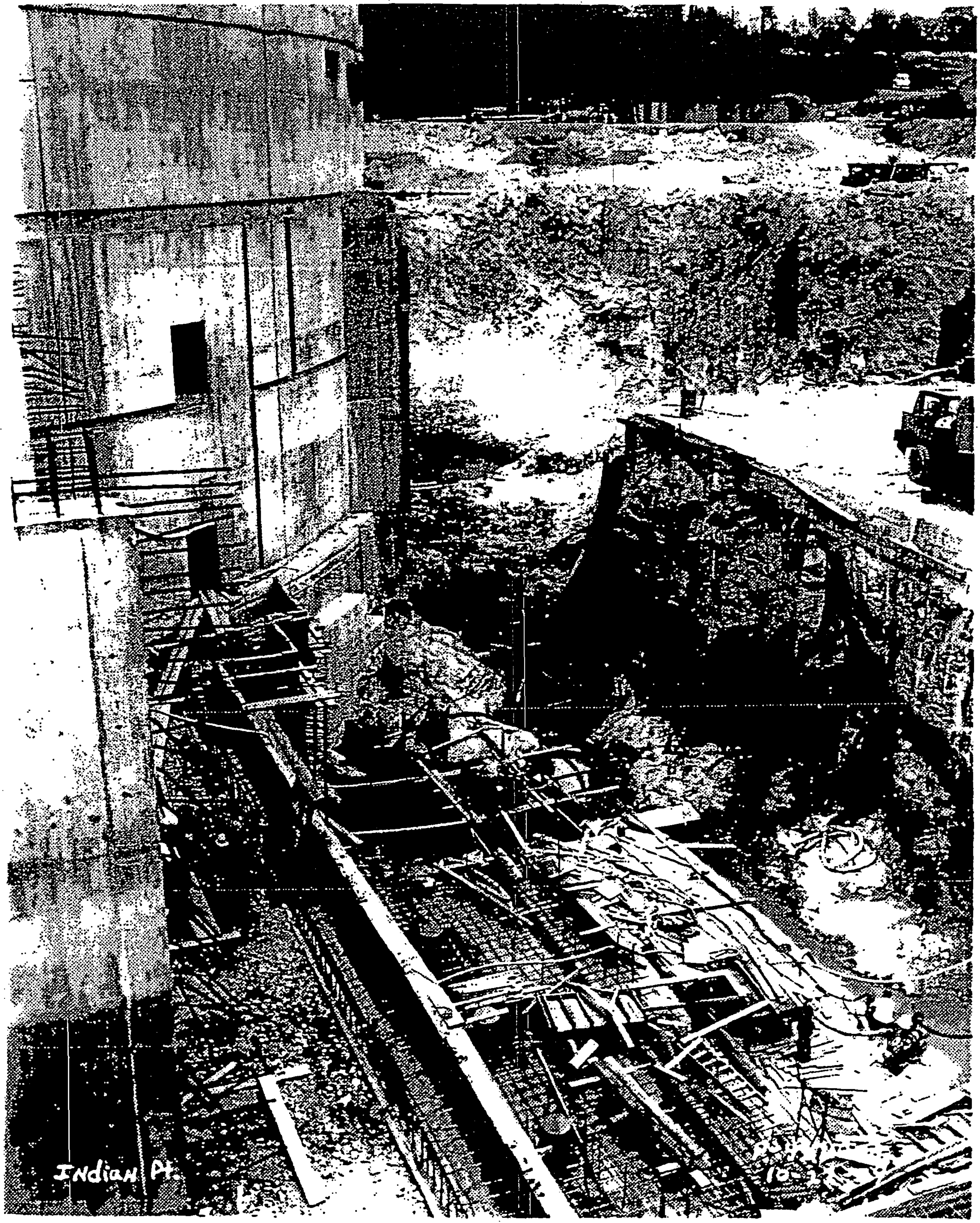
50 ———— - GROUND WATER ELEVATION CONTOUR

GROUND WATER ELEVATIONS AND APPARENT FLOW DIRECTION

SOURCES:

SITE PLAN AND BORING LOCATION FROM FIGURE 2.7-3; GROUND WATER ELEVATIONS FROM TABLE 1

ATTACHMENT 6



ATTACHMENT 8A

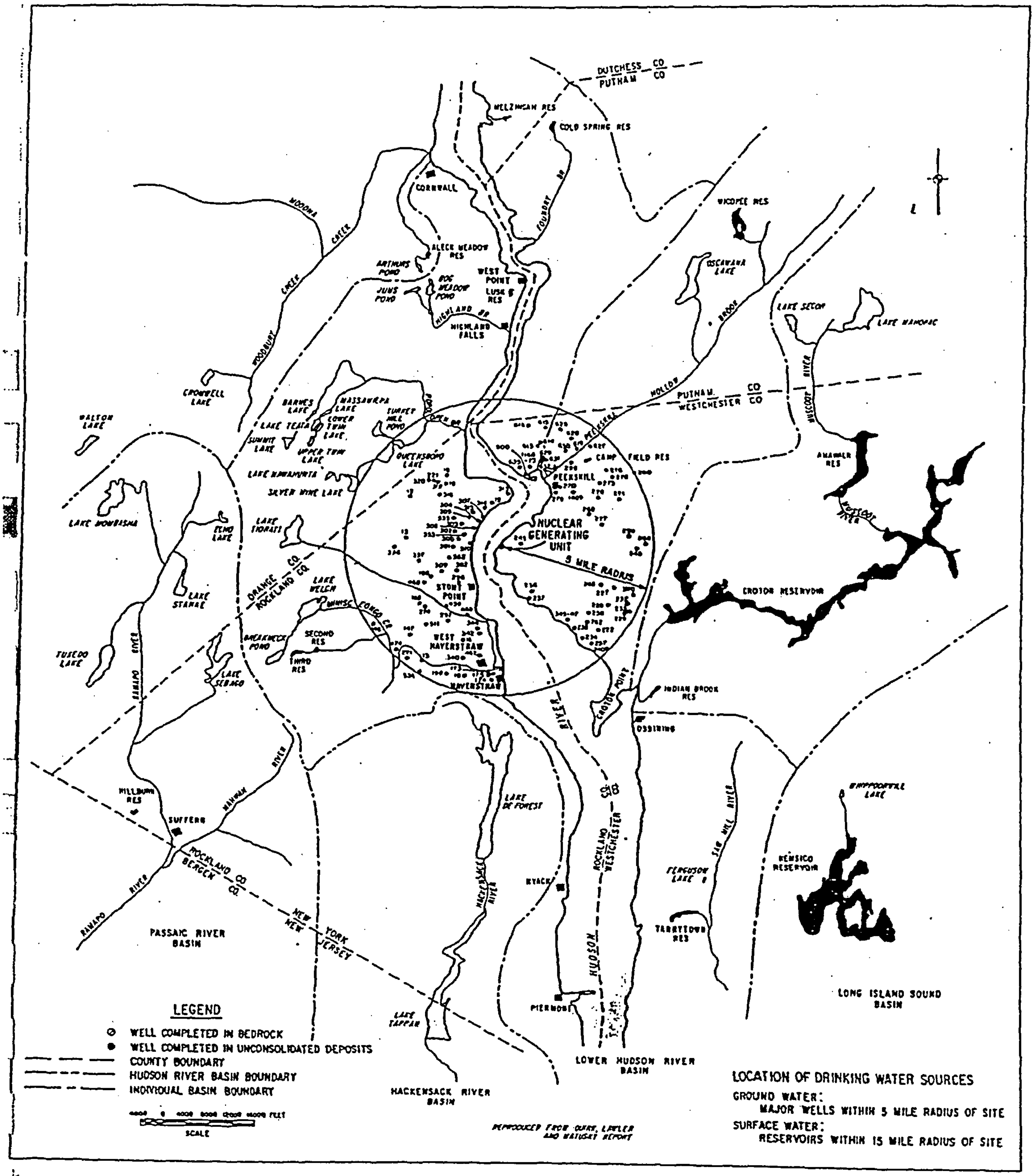


FIGURE 2.6.4-B

CONSOLIDATED EDISON CO. OF N.Y. INC.
NUCLEAR UNIT 4
WATER SUPPLIES IN WATERSHED AREA

ATTACHMENT 8B

Table 1

PRIVATE WATER WELLS IN VICINITY OF NUCLEAR UNIT #4

Westchester County

Code	Owner	Altitude Above Sea Level	Depth (ft.)	Diameter (in.)	Depth to Bedrock	Water Level Below Ground	Yield (gpm)
222	D. Brown	250	79	6	1	--	12
223	L. Seltzar	310	80	8	1	--	--
224	A. Lamm	440	80	6	7	--	10
225	W. Gropper	510	110	6	2	21	20
226	S. Kaplan	320	110	6	--	--	5
227	J. Croman	42o	40	36	--	8	--
228	R. Mertins	180	9	60	--	5	--
229	E. Murphy	270	76	6	5	--	3
230	H. Meyers	320	81	6	1	6	2.5
232	H. Peckerman	220	114	6	2	--	6
233	H. Mertins	280	20	36	--	10	--
234	E. Cavanaugh	140	102	6	10	18	4.5
235	NYC YMCA	20	200	6	--	--	--
240	S. Delar	390	250	6	3	--	7
245	Indian Point Pk.	120	100	6	10	--	4
257	M. Benedict	180	185	6	13	--	10
260	Westchester Co. Park Commission	300	7	24	--	3.3	--
262	J. Keesler	100	15	8	--	1	5
265	W. Freeland	320	101	6	15	25	5
268	H. Baker	210	11	36	--	4	--
273	L. Turner	340	25	60	--	10	--
275	L. McFadden	560	57	6	--	45	2
276	St. Peters School	520	187	10	--	--	12
278	Bird Estate	460	12	36	--	5	--
279	J. Williams	10	6	60	--	4	--
280	G. Bergel	500	184	6	--	65	2
343	W. Borden Co.	300	100	6	16	9	10.5
390	J. Lindeau	300	22	36	--	16	--
600	Esso Bulk Plant	10	78	6	--	3	100
616	G. Kummer	320	75	6	15	15	6
627	J. Mikulak	180	52	6	--	15	3
628	F. Singer	40	15	24	--	12	5
629	J. Goldburg	10	105	6	--	2	--
631	J. Bersani	10	47	6	20	10	25
632	G. Szabo	45	87	6	--	20	25
633	C. Mahl	380	147	6	16	10	3
634	C. Ferrara	360	106	6	12	20	4
635	Oldstone on Hudson	130	200	8	--	20	15
1166-73	NY National	6	48	6	--	--	63
	Guard	6	90	--	--	--	63
1409	Horton Ice Cream	160	16	72	--	4	100

Table 2

PRIVATE WATER WELLS IN VICINITY OF NUCLEAR UNIT #4

Rockland County, N.Y.

Code	Owner	Altitude Above Sea Level	Depth (ft.)	Diameter (in.)	Depth to Bedrock	Water Level Below Ground	Yield (gpm)
10	Garnerville Ice Company	180	468	6	21	17	33
12	NY Telephone Co.	82	217	8	55	45	125
13	Birchwoods	390	400	6	--	--	60
14	Birchwoods	390	460	6	240	--	65
15	Garnerville Holding	150	220	5	30	32	250
16	NYS Rehabilitation Hospital	170	350	10	85	40	200
18	NYS Rehabilitation Hospital	170	400	10	85	--	200
147	L. Ware	340	125	6	57	20	30
148	C. Weniger	490	148	6	4	5	10
167	NYS Rehabilitation Hospital	170	350	10	85	40	200
168	M. Marzocco	200	170	5	--	50	--
173	Simmons Building	25	330	12	90	Flows	--
174	Brookside Farm	100	250	8	45	Flows	80
175	Haverstraw Laundry	30	452	8	125	Flows	90
176	N. Mitchell	20	200	8	--	--	10
188	Camp Bullowa	270	163	10	18	38	14
192	Haverstraw Laundry	30	452	8	215	Flows	55
198	NY Water Service Corp.	305	320	10	12	52	138
210	L. Schultz	600	100	6	16	6	5
239	NYSDPW	532	15	2½	9	5	--
264	I. Rose	220	34	6	--	--	15
271	G. Lips	360	265	6	214	25	--
274	A. Rose	200	212	6	20	28	9
296	L. Manglass	120	100	6	--	10	6
297	A. Kapusinki	110	145	6	90	12	20
300	P. Shed	520	59	6	10	15	--
301	A. Takacs	340	50	6	1	12	--
302	C. Fine	580	190	6	2	30	--
303	Tolake Corp.	440	225	8	18	12	70
304	D. Kelman	280	173	6	16	30	12
305	E. Spillinger	400	96	6	--	--	12
306	Fresh Air Camp Assoc.	200	180	8	2	30	12
307	E. Brissing	100	196	6	18	7	--
309	C. Akins	250	125	6	--	--	9

Table 2
(Continued)

PRIVATE WATER WELLS IN VICINITY OF NUCLEAR UNIT #4

Rockland County, N.Y.

Code	Owner	Altitude Above Sea Level	Depth (ft.)	Diameter (in.)	Depth to Bedrock	Water Level Below Ground	Yield (gpm)
310	NY Trap Rock	100	100	6	15	30	--
311	C. Johnson	130	25	6	6	4	5
312	E. Tenyck	220	81	8	3	22	1½
313	T. Scozzafava	5	30	6	--	5	8
314	P. Schoo	15	110	8	12	5	--
315	S. Schwartz	400	151	6	16	9	8
335	Girl Scout Camp	500	180	6	--	45	20
336	H. Conklin	500	110	6	27	8	17
337	L. Begun	360	110	6	2	15	2
338	J. Fitzgerald	220	100	6	6	8	--
340	J. Shankey	160	183	6	38	--	--
342	Kay Fries Chemical Inc.	135	52	8	47	--	--
344	Kay Fries Chemical Inc.	115	45	2	--	--	75
352	M. Cook	220	92	6	18	15	7
353	N. Hall	540	210	6	2	19	10
382	P. Larkin	150	125	6	22	5	10
456	A. Cooper	650	8	36	--	5	--
459	W. Gannon	140	175	6	45	5	--
460	H. Lewis	270	116	6	13	12	15
462	Lustra Plastics	70	400	8	107	40	28
468	US Gypsum Co.	15	220	8	31	Flows	50
471	R. Lund	440	435	6	325	150	10
472	H. Schuler	190	256	6	81	160	30
473	J. Holt	310	247	6	209	45	10
474	J. Carpenter	310	130	6	30	17	4
511	Tamarac Nurseries	260	133	6	82	30	40
536	A. Levine	400	298	6	184	136	50