NIAGARA MOHAWK

NIAGARA MOHAWK POWER CORPORATION/300 ERIE BOULEVARD WEST, SYRACUSE, N.Y. 13202/TELEPHONE (315) 474-1511

July 24, 1980

Office of Inspection and Enforcement
Region I
Attention: Mr. R. T. Carlson, Chief
Reactor Construction and Engineering
Support Branch
U.S. Nuclear Regulatory Commission
631 Park Avenue
King of Prussia, Pennsylvania 19406

Dear Mr. Carlson:

Re: Nine Mile Point Unit 2
Docket No. 50-410

A potential deficiency involving the possible future movement of the Nine Mile Point Unit 2 Radwaste Building geologic feature was initially reported by telephone to Mr. A.C. Cerne of your staff on December 4, 1979. Since the investigation of the Radwaste Building geologic feature has not been completed, this letter serves as an interim report.

Attached is our response to the Nuclear Regulatory Commission's Office of Nuclear Reactor Regulation's geologic information Request Q361.1 for Nine Mile Point Unit 2. This response provides the current status of the investigation of the Radwaste Building geologic feature.

A final report will be submitted by December 31, 1980.

Very truly yours,

NIAGARA MOHAWK POWER CORPORATION

Gerald K. Rhode
Vice President
System Project Management

PEF/kmb
Attachment

8009090 848

Q361.1 Either additional evidence, re-analysis, or discussion is needed to clarify your position that the thrust faults mapped in the heater bay and radwaste buildings and the intake shaft are not capable within the meaning of Appendix A 10 CFR Part 100 and are instead old faults which have had minor postglacial adjustments. The last paragraph on page 3-15 of Volume I describes four lines of evidence from which the age of these structures can be inferred:

a. The presence of glacio-lacustrine clay within one of the low angle thrust faults is used to argue that the fault pre-dates glacial Lake Iroquois. Elsewhere in the report (Executive Summary, page 3-2) it is stated that these clays are contorted, suggesting the possibility of minor adjustments during the latest Pleistocene or Holocene. Another interpretation of equal likelihood is that the deposition of these clays within the fault and their subsequent deformation is related to the soil mechanics as a result of impoundment and rapid drawdown of Lake Iroquois during Late Pleistocene and Early Holocene. Based on your detailed observations made during mapping of this fault, provide data and discuss the various ways that the deformation features in the lake bed clays could have developed considering the geologic events that have taken place in this region. What is the most probable cause of these features? Provide the basis for your response.

b. The second line of evidence cited for the age of these structures is experimental data which indicate that a high confining pressure is necessary for a fault to transect thin-bedded strata at angles of 15° to 25°. A personal communication with Donath is cited. Provide the data that supports this conclusion.

c. The third line of evidence stated on page 3-15 is that the sinusoidal forms of folds in the heater bay and radwaste areas suggest higher stress magnitudes and confining pressures that were necessary for buckling on the Cooling Tower fault. It is also stated that dilation does not appear to be associated with these structures as is the case with the Cooling Tower fault. Provide the references and other data that support the interpretation that greater confining pressures were present during formation of these structures than during last movement along the Cooling Tower fault. One

possible argument that should be considered is that the presence of glacio-lacustrine clay within one of the faults is evidence for dilation. Provide additional support for the interpretation that dilatant fractures are not in the heater bay and radwaste area.

d. A fourth line of evidence given is that the necessary stress orientation for causing most of the geologic structures in the main power block island are probably similar in orientation to those responsible for the development of the regional fracture pattern that is believed to have occurred during the Late Paleozoic. However, the current stress regime at this location, based on in situ measurements made during this investigation, are relatively high and also commensurate with the orientations, attitudes and sense of last movements along the thrust faults in the heater bay, radwaste building and the intake shaft. Expand your discussion of the origin of these features including all the data that indicate age and causes of the deformation. Perform an analysis to assess whether or not current existing stresses in the vicinity of Unit 2 will produce adjustment-type movements on the low angle thrust faults. Among the factors to be considered in this analysis are: orientations and magnitudes of stresses, pore pressures, swelling characteristics of bedrock, and effective stresses normal to the fault plane.

<u>RESPONSE</u> Since the completion of the April 1978 report, "Nine Mile Point Nuclear Station Unit 2 - Geologic Investigation" (hereafter referred to as NMPC, 1978), additional data have been obtained from further excavations onsite. This excavation exposed the low-angle faults in the area of the proposed Radwaste Building and in the Intake Shaft.

On August 14, 1979, a bedrock exploratory trench 50 feet long and 10 feet wide was commenced in the North Radwaste Trench. Extending from elevation 231 to elevation 214, this trench was cut as an attempt to determine the depth of extent of the discontinuity in the Radwaste Trench. Consequently, it was discovered that the discontinuity was more extensive than expected. The Nuclear Regulatory Commission was thereby notified of this fact and a visit to the Nine Mile Point Unit 2 site by representatives of the Commission occurred on October 10, 1979. As a result of the Commission's site visit, it was agreed that a report with analysis and discussions would be submitted at a later date.

Since the October 10, 1979 meeting, a considerable amount of additional information has been obtained with respect to both the Radwaste Fault (Heater Bay Fault) and the Intake Shaft faults. The following additional studies were performed:

1. A line of eight vertical borings were drilled along the dip of the Radwaste Structure beginning just east of the Radwaste trench. The bedrock core was logged in detail and a television camera survey was conducted in the borings.

2. Four additional vertical overcore borings were drilled to determine the in situ stress conditions. These borings extend from just east of the reactor excavation to east of the east property line.

3. A detailed investigation was made of the clays encountered in the bedrock of the Radwaste Structure. Evaluations of the age of the clay (including pollen analysis and Carbon-14 dating) as well as the relationship of this age relative to bedrock movements were performed.

In this response, items a. through d. will be addressed in light of the additional data obtained by mapping, drilling, sampling and/or laboratory analysis. A discussion of the significance of the Radwaste Structure is discussed as item e..

a) Relationship of Clay to Faults and Bedrock Mass

From the observations made during mapping in the North Radwaste Trench, unconsolidated clay, both unlaminated and laminated, has been identified within the bedrock mass. The clay was found to be deposited principally upon parting planes coincident with bedding, as well as locally within gently dipping to vertical fractures. Where some of the inclined shear fractures contained breccia and sandy gouge, pockets of both types of clay were also observed locally. Samples of these clays were analyzed in the laboratory. Several types of tests were made, such as:

- analysis of pollen spectra and spores
- analysis of mineralogic composition
- analysis of grain-size distribution

Furthermore, Drs. D.R. Coates, L.A. Sirkin and T.L. Péwé examined the clays in the trench. From the results of the analyses and the site inspections, it seems clear that the laminated clay is glaciolacustrine in origin (Lake Iroquois) and is of Late Wisconsinan age (approxi-

mately 12,000 to 10,000 years B.P. These additional observations and interpretations are in accordance with those made earlier (NMPC, 1978).

The glaciolacustrine clays exhibit numerous indications of deformation in the Radwaste exposures. The number and type of deformational structures in the clays are more complex than that reported previously (NMPC, 1978; Volume I). They consist mostly of folds and crenulations characteristic of internal heterogeneous strain caused mainly by plastic flowage of the clay during deformation. Dislocations of the laminae were locally observed within the clay layers. Moreover, it was not uncommon to find non-crenulated clay with laminae parallel to the bedding surface of the bedrock, but at various inclinations reflecting the geometry of the folds in the bedrock within the Radwaste fault zone.

As suggested in the question, the origin of these deformational features can be interpreted in various ways. One interpretation is that the clay was deposited after bedrock movement and the clay deformation is gravitationally induced penecontemporaneous sliding (that is, not related to movement of the bedrock). On the other hand, it has been interpreted that the clay was deformed in response to bedrock movement at a time subsequent to the deposition of the clay. In order to evaluate which interpretation is the most probable, Dr. T.L. Péwé was contacted to comment on the origin of the deformational features. Dr. Péwé made two site visits and reviewed the data developed from extensive investigations of the North Radwaste Trench. He concluded that the clays were deposited after the formation of the buckle and therefore, in essence, adopted the latter proposed interpretation (that is: the clay post dates bedrock movement). Dr. Péwé's specific conclusions are:

"1. The grey and tan slightly plastic clayey silts fills voids in the bedrock associated with a low angle thrust fault exposed in Radwaste Trench.

2. The clayey silt originated from the overlying glaciolacustrine deposits of Lake Iroquois that formerly overlay the site.

3. The clayey silt is therefore late Wisconsinan in age, 10,000-13,500 years BP.

4. During deposition of the clay by small vertical and horizontal water currents in the bedrock, as well as settling from non-moving groundwater, the fine-grained sediment layers were minutely

deformed by slumping and plastic deformation of the water-saturated sediments and perhaps by some liquefaction. These structures are syn-depositional and post-depositional and are similar to those reported in glaciolacustrine sediments in many places in the world.

5. Because the deformed structures in the clay are syndepositional and because it can be shown that the clay layers in places overlie without disturbance the deformed broken bedrock structures and sharp broken edges of the sandstone layers, I believe the clay post dates the bedrock deformation."

b. <u>Fault Intersection with Thin-Bedded Strata</u>

At the time of the 1978 report, only the intake shaft itself provided a clear exposure of the low-angle faults cross-cutting thin-bedded strata at angles of 15 degrees to 25 degrees. That interpretation was based upon an existing exposure of very limited extent. Nevertheless, since then, the east-dipping fault in the shaft has been further exposed by excavation for the east Lake Water Tunnel. Based upon the observations recorded during the mapping of this new exposure, it was seen that only locally thin-bedded strata are cross-cut at such angles by the discontinuity. Elsewhere along the exposure, the structure follows the bedding plane contacts between lithologies of different composition and strength. By comparison, similar observations from mapping of the bedrock slot in the Radwaste Trench are in accordance with those from the tunnel. Presently, it is clear that the structural geometry of the low-angle faults at the site is profoundly influenced by the bedding plane anisotropy of the rock mass.

During March 1980, eight vertical borings were drilled. This line of borings extended approximately 850 feet east from the Radwaste Trench and parallel to the dip direction of the Radwaste structure. The borehole depths ranged from 100 to 300 feet. Evidence was obtained from the extracted rock core which indicates that the Radwaste "fault" is not simply a single discontinuity. Instead, there is a "stack" of at least three zones of discontinuity characterized by evidence of bedding plane slip, low-angle shear fracture, and local folds in the bedrock. The lowest of these three structures occurs at a depth of approximately 70 feet from the bedrock surface. At depths below these three zones, there are additional occurrences of breccia along bedding and gently inclined shear fractures with slickensides. The lateral continuity of these lowest features has not been clearly established from the results of these boreholes. Nevertheless, it is important to

note that the three abovementioned discontinuities (including the one mapped in the Radwaste Trench) appear to pass eastward into bedding planes, and cannot be traced as discrete discontinuities beyond approximately 150 feet to the east of the Radwaste Trench.

Together, the above data strongly suggest that the final depths of these structures must be influenced by the pronounced anisotropy of the bedrock. Such anisotropy is manifested in part by the influence of bedding planes on the geometry of these low-angle discontinuities, and this is indicative of low vertical confining pressure at the time of their development.

c. Dilation and the Low-Angle Faults

The most recent exposures of the Radwaste Fault have revealed evidence that both the bedrock mass and the stratigraphic section do indeed exhibit dilation. Locally, where the bedrock has been folded and/or brecciated, voids and open fracture planes are common.

Various displacements have been observed to be caused by shear dislocation and folding. Typically the vertical component of displacement is more consistent than the horizontal component, and is approximately 1.5 to 2.0 feet.

At this time, there seems to be reliable, but indirect, evidence of dilation in a vertical plane of the stratigraphic section penetrated by the boreholes drilled east of the Radwaste Trench. This is based upon correlation of lithologies and the site stratigraphic section in the closely spaced boreholes. From the Radwaste Trench to a point 120 feet east-southeast, where the discontinuities pass into bedding planes, both the Transition Zone of the Oswego Sandstone Formation and Unit A of the Pulaski Formation seem to thicken toward the west approximately 1.5 feet. This agrees well with actual observed dilation in the trench.

On the basis of the observations set forth in a. of this response, and the foregoing observations, it is clear that dilation of the bedrock mass is associated with deformation by the low-angle faults at the Unit 2 site. The complete extent of dilation, however, is not known. Nevertheless, dilation to depths of 250 feet, and possibly greater, is suspected from the occurrence of laminated clay on parting planes parallel to the bedding as recovered in the rock cores from the line of boreholes just described. Laboratory analysis of this clay from elevations below 214 feet (North Radwaste Trench) has been completed, and it appears reasonable to interpret that the clay is of similar age and origin as the clay in the trench.

d. Age of Development and Stability of the Low-Angle Faults

The response in b. above, points to the likelihood of a relatively near-surface origin for the low-angle faults, that is, under relatively low vertical confining pressure. The geometry of these structures, moreover, indicates that the maximum principal effective stress extant when these features were formed was horizontal or nearly so. The data presented from the studies of epigenetic mineralization of joints and the Cooling Tower Fault (NMPC, Volume I, 1978), as well as our analysis of the mechanism of formation of these structures (NMPC, Volumes I and III, 1978), demonstrate that high overburden pressure existed when the joints were formed. The newly acquired data clearly indicate that the development of the Radwaste and Intake Shaft faults cannot be attributed to conditions that existed during the time of development of the jointing and strike-slip movement at the Unit 2 site. Instead, the data indicate that the Radwaste and related structures were formed after the normal faults when the confining pressure was reduced considerably.

Ongoing study of the Radwaste and Intake Shaft faults has shown that calcite minerals are present along shear planes and on some open vertical fractures within the zone of deformation. These minerals are deformed. To date, studies of this mineralization indicate that all of the calcite occurring on the low-angle structures is younger than the latest stage of epigenetic calcite previously reported from the site. This statement is based upon the following lines of evidence:

(1) fluid inclusion temperatures of less than 40 degrees centigrade

(2) very low fluid inclusion salinity of approximately five percent by weight NaCL indicating freshwater is contained within the inclusions.

(3) two ^{14}C age determinations on deformed calcite yielding

   a) greater than 36,000 years before present
   b) 14,180 ± 550 years before present

(4) isotopic ratios ^{13}C and ^{18}O indicating low burial depths and freshwater crystallization of calcite.

The stress tensor determined from strain-relief measurements in the Intake Shaft (NMPC, Vol. III, 1978) is commensurate with the orientation and sense of the slip vector indicated by the displacements identified along the Radwaste Fault and the east-dipping shaft fault. The stability of these faults has been evaluated as shown on Figure 361.1-1. For two cases (Table 3-18, Vol. III, NMPC, 1978) the normal stress and shear stress on the faults and on bedding were resolved from the three principal stresses, and the results are tabulated for each case (Figure 361.1-1).

Comparison of the computed values of shear stress with the shear strength for the east-dipping inclined faults reveals they are approximately equal if friction and cohesion parameters from laboratory testing are applied to analysis of the entire fault as a hypothetical, idealized plane. The irregular geometry of the fault (ranging in dip from 0 to 50 degrees) and the asperities on the fault plane contribute to the stability of the faults.

e. Significance of the Radwaste Structure

Because of the complexities of the Radwaste Structure, Dr. Shailer Philbrick and Dr. Richard Jahns were contacted to review the geologic program and comment on the genesis and stability of the Radwaste Structure. Over a period of approximately five months, Drs. Philbrick and Jahns reviewed the data and analysis and concluded that:

"1. The structure was initially developed in pre-Holocene time, and in the Illinoian time interval between 500,000 and 140,000 years before the present with glacial erosion of rock and consequent reduction of vertical confining pressure. That at least most of its movement occurred in pre-Holocene time is indicated by the partial infilling of structurally-formed openings by silts that are about 11,000 years old.

2. Initial formation of the structure probably was abrupt, with displacements at a given place relatively large at first and attenuating with time.

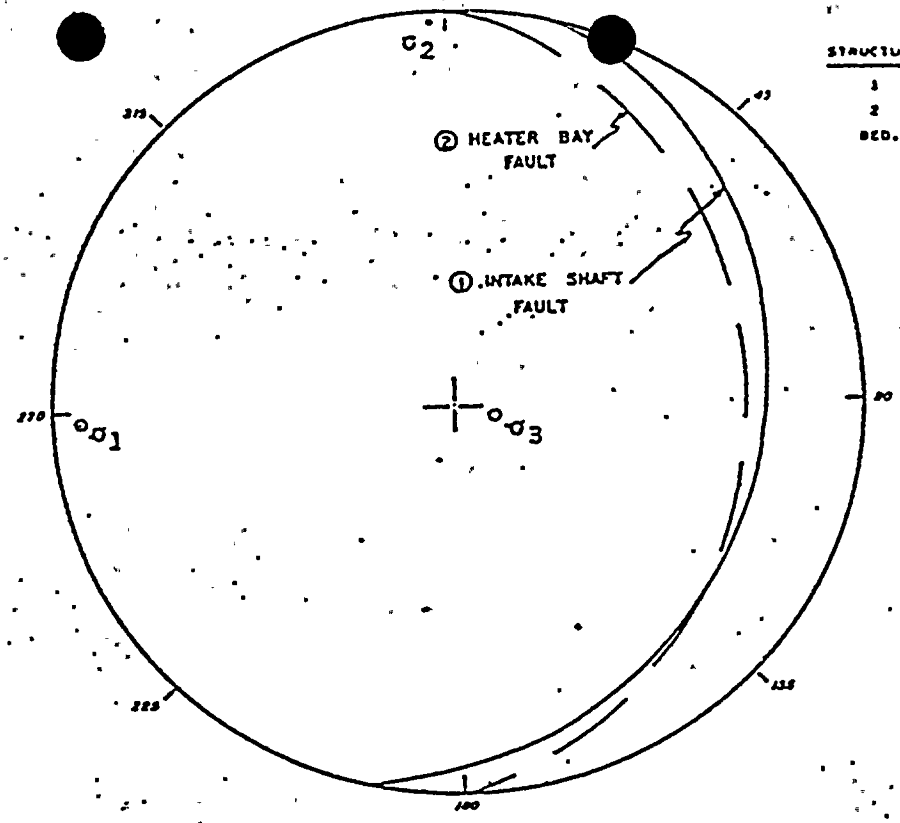
3. Movements along the structure probably occured during Pleistocene time, as prompted by episodes of glacial loading and unloading.

4. Post-Pleistocene (Holocene) movements have been small if they have occurred at all. It cannot be demonstrated that no Holocene movements have occurred, as no reference features (e.g. dated infilling sediments) extend entirely across the zones of disturbance.

5. Future movements along the structure are not likely to occur. Further relief of the limited amounts of strain now in the rocks will be distributed in the affected ground as dilation and small movements along fractures and bedding surfaces. The Radwaste Structure is so nearly dead at present levels of exposure that its participation in such future movements would amount to no more than a small fraction of inch ($\leq$ 1/4 inch).

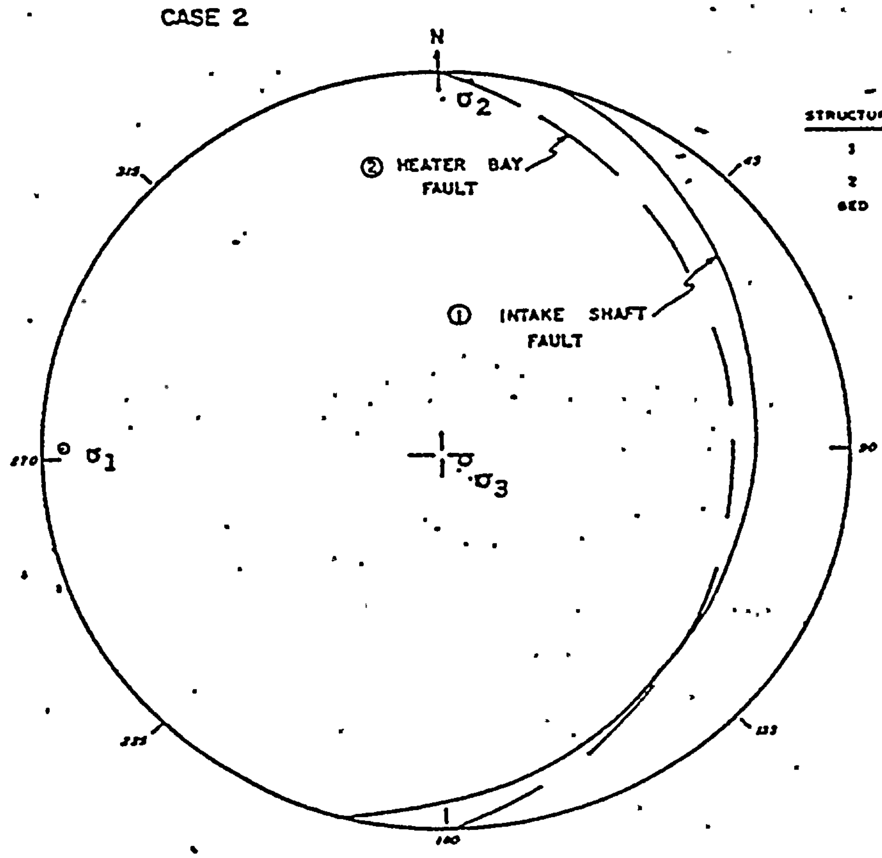
6. The Radwaste Structure is not seismotectonic."

Based on these conclusions it was judged that movements of the Radwaste Structure (if any) would be of no consequence to the operation of the plant.



STRUCTURE	σ_n	τ	PSI
1	307	410	σ_1 = 1165
2	560	437	σ_2 = 806
BED.	249	111	σ_3 = 233
			ELEV. 243

CASE 2



CASE 2

STRUCTURE	σ_n	τ	PSI
1	382	514	σ_1 = 1326
2	706	572	σ_2 = 463
BED	308	106	σ_3 = 298
			ELEV. 243

LOWER HEMISPHERE EQUAL AREA PROJECTIONS

SHOWING RELATION OF PRINCIPAL STRESS ORIENTATIONS TO EAST-DIPPING THRUST FAULTS

NOTES:

1. BEDDING IS ASSUMED TO BE HORIZONTAL
2. PRINCIPAL STRESS MAGNITUDES AND ORIENTATIONS ARE FROM TABLE 3-16, VOL. III OF 1978 DAMES & MOORE REPORT

NINE MILE POINT NUCLEAR STATION
UNIT 2
NIAGARA MOHAWK POWER CORP.

FIGURE 361.1-1