Northeast
Utilities System

107 Selden Street, Berlin, CT 06037

Northeast Utilities Service Company
P.O. Box 270
Hartford, CT 06141-0270
(203) 665-5000

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Docket No. 50-423
B15803

Re.: IR 50-423/94-21

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Millstone Nuclear Power Plant Station, Unit No. 3
Pertinent Information Related to the Issue of
Erosion of Cement from the
Millstone Unit No. 3 Containment Mat

During a meeting held on July 1,1996 at the Millstone Site, the NRC Staff made an informal request for pertinent information on a series of topics related to the issue of erosion of porous concrete under the Millstone Unit 3 Containment basemat.

Northeast Nuclear Energy Company (NNECO) has compiled in Attachment 1 to this letter information that responds fully to the NRC Staff request. The material is organized in a manner that correlates the NRC Staff request, formulated as a series of questions and information requests, with answers and documentation that provide responses to the questions.

Additional supportive information was provided when appropriate. Attachment 2, titled "1991 Chemical Analysis of Sump Residue," presents information related to the debris found in the Millstone Unit 3 Engineered Safety Features Building sumps. Attachment 3, titled "1996 Chemical Analysis of Sump Residue and Water," contains results of the analysis of the samples removed from the Millstone Unit 3 containment sump and the mockup samples. Attachment 4, titled "Technical Data on Porous Wall Concrete Drainage Pipe," presents technical information regarding the six inch diameter porous concrete drain pipes.

Should the NRC Staff have any questions regarding the material provided, please contact Mr. R. Laudenat at (860) 444-5248.

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

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E. A. DeBarba
Vice President - Nuclear Technical Services

cc: T. T. Martins, Region I Administrator
V. L. Rooney, NRC Project Manager, Millstone Unit No. 3
A. C. Cerne, Senior Resident Inspector, Millstone Unit No. 3
M. C. Modes, Chief Materials Section, Division of Reactor Safety

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I. CONTAINMENT STRUCTURE DATA - MILLSTONE 3

QUESTION I.1

Provide sketches and description of the structure, materials of construction, sequence of construction.

RESPONSE I.1

1) Sketches and Description of the Structure

The Containment Structure is a steel-lined conventionally reinforced concrete pressurized water reactor Containment Structure. It consists of a vertical cylindrical wall topped by a hemispherical dome supported on a flat circular mat which is founded on bedrock. A typical section is shown on Figure I.1-1. The primary function of the Containment Structure is to contain radioactive fission products in the event of an accident and provide biological shielding to the environment.

a) Base Foundation

The base foundation slab is nominally 10 feet thick with a 157 foot diameter. The bottom reinforcement is a rectangular grid pattern and the top reinforcement consists of concentric circular bars combined with radial bars arranged to permit uniform spacing of the vertical wall reinforcing bars which extend into the mat, Figure I.1-2.

A reinforced concrete slab approximately 2 feet thick was placed over and anchored through the liner to stiffen it against negative pressure and to protect it from heat associated with a Design Basis Accident. This slab also serves as anchorage and support for equipment located on the lowest level of the Containment Structure.

b) Cylindrical Wall

The cylindrical wall is 4 feet 6 inches thick with an inside diameter of 140 feet and a height from the top of the mat to the spring line of 131 feet 3 inches. Penetrations are provided for piping, electrical conductors, fuel transfer tube, purge air ducts. Access openings in the structure are the 7 foot diameter personnel access lock and the 15 foot diameter equipment hatch. The general arrangement of the 4 foot 6 inch thick cylindrical wall reinforcement is shown on Figures I.1-3 and I.1-4.

c) Dome

The inside radius of the 2 foot 6 inch thick dome is 70 feet. The internal height from base mat to the center of dome is 201 feet 3 inches.

d) Steel Liner

The steel liner consists of a 3/8 inch thick vertical cylindrical portion, closed at the top by a 1/2 inch thick hemispherical dome and at the bottom by a 1/4 inch thick mat liner. As shown on Figure I.1-5, the liner is welded to a skirt ring (knuckle plate assembly) that is welded to a plate which, is embedded and anchored into the concrete mat. The floor liner plate is anchored to 7 inch by 1/2 inch continuous vertical plates. These plates are anchored to the mat by reinforcing steel.

The function of the liner is to act as a gas tight membrane under conditions that can be encountered throughout the operating life of the plant. The liner is designed to resist all direct loads and accommodate deformation of the concrete Containment Structure without jeopardizing the leak-tight integrity.

e) Internal Structure

The internal structure which provides support for the NSSS and various other systems within the containment also rests upon the containment mat. This reinforced concrete structure consists of a vertical cylindrical crane wall of 113 feet centerline diameter and a primary shield wall of 29 feet 6 inches centerline diameter, as well as various other slabs and walls, see Figure I.1-6.

f) Ring Girder

A reinforced concrete ring girder is provided which encircles the Containment Structure and is isolated from the containment wall by a 4 inch thick compressible material, Figure I.1-7. The ring girder is provided to prevent postulated sliding of rock wedges toward the containment wall during a seismic event. The ring girder does not interact with the Containment Structure except that the containment mat gives vertical support for the ring gravitational forces.

In the area of the Engineered Safety Features Building, radial walls in the lower chambers act as struts between the ring girder and the Engineered Safety Features Building east wall, Figure I.1-8. Through these walls,

relatively continuous support for the ring is provided around this area of the containment.

g) Containment Enclosure Building

The Containment Enclosure Building is a cylindrical steel framed structure with metal siding and built-up roofing which envelops the Containment Structure above grade. It has a diameter of 156 feet and a height above grade of approximately 166 feet, and is supported on the Containment Structure, Figure I.1-9 and I.1-10. The enclosure building provides a secondary containment which functions along with the supplementary leak collection and release system to contain any minute leakage that might occur from the Containment Structure after a Design Basis Accident and transport it to a filtration system before release to the environment. The enclosure structure also shields the Containment Structure from weather. Any rainwater is directed to roof drainage systems and eventually collected in the site storm drain system.

h) Waterproofing Membrane

A waterproofing membrane, consisting of a 1/16 inch thick butyl rubber, is placed below the containment mat and extends up the face of the containment wall to provide a watertight barrier between the Containment Structure and the 10 inch concrete layer in the foundation, and the containment and subgrade in the wall areas. Below the mat the membrane is placed on a layer of 10 inch thick porous concrete constructed with Portland Cement Type II, resting directly on the bedrock. Above the membrane, a 2 inch thick layer of protective concrete is placed with an additional 9 inch thick layer of calcium aluminate porous concrete on top. The 10 foot thick reinforced concrete mat is placed on top of the 9 inch layer constructed of calcium aluminate porous concrete. The membrane along the face of the containment wall is sandwiched between two 2 inch thick layers of compressible material as indicated on Figure I.1-11.

During construction of the containment mat and walls, the rubber membrane prevents leaking of water into the construction area while the 10 inch thick porous concrete below the membrane is used for dewatering purposes.

After construction and during operation of the containment, the 9 inch thick layer of porous concrete and the embedded 6 inch diameter drain pipes above the membrane provide a flow path to the Engineered Safety Features Building. Any water that might exist within the membrane would be collected through 6 inch diameter perforated drain pipes and forwarded to sumps

3DAS-Sump 7A & B, located in the Engineered Safety Features Building, Figure I.1-12.

2) Materials of Construction - Containment Mat and Below the Mat

Structural design, materials, the tests of material and the methods of testing confirm to the following codes, standards and specifications:

a) Concrete

Proportioning of structural concrete confirms to ACI 301, Chapter 3. Concrete mixes were of a 60-day strength of 3000 psi.

Design mix quantities of 3000 psi concrete for pumping (per cubic yard):

- Portland Cement, Type II, Low Alkali, conforming to ASTM C150...500 lbs.
- Fine Aggregate..1115 lbs.
- Coarse Aggregate, #4; confirm to ASTM C-33 ....752 lbs.
- Coarse Aggregate, #67; confirm to ASTM C-33...........................1122 lbs.
- Percent Air..3 - 6
- Maximum Water Cement Ratio...0.6
- Maximum Slump inches..4.0

b) Porous Concrete (Portland)

The 10 inch thick porous concrete placed above the rock (leveling pour). Concrete mix 28-day strength of 1000 psi constructed with Portland Cement.

Design mix quantities for 1000 psi porous concrete for pumping (per cubic yard):

- Portland Cement, Type II, Low Alkali, conforming to ASTM C150 560.0 lbs.
- Fine Aggregate..Nil
- Coarse Aggregate #57...2670.0 lbs.
- Maximum Water Cement Ratio..0.384

c) Mortar Seal Portland Based

2 inch thick Mortar Seal above the waterproofing membrane, is constructed with Portland Cement. This mortar is also used to choke the voids on top of the portland porous concrete.

Design mix quantities (per cubic yard):

- Portland Cement, Type II, Low Alkali..900.0 lbs.
- Fine Aggregate..2757.0 lbs.
- Coarse Aggregate..Nil
- Maximum Water Cement Ratio..0.509

d) Porous Concrete (Calcium Aluminate)

The 9 inch thick porous concrete placed above the 2 inch thick mortar seal. Concrete mix, 28-day strength of 1000 psi, constructed with calcium aluminate cement.

Design mix quantities (per cubic yard):

- Calcium Aluminate Cement conforming to ASTM C114................560 lbs.
- Fine aggregate..Nil
- Coarse Aggregate...2670 lbs.
- Maximum Water Cement Ratio (placement records show 0.32 used) 0.384

e) Mortar Seal Calcium Aluminate Based

2 inch thick Mortar Seal above the waterproofing membrane, is constructed with Portland Cement. This mortar is also used to choke the voids on top of the calcium aluminate porous concrete.

Design mix quantities (per cubic yard):

- Calcium Aluminate Cement conforming to ASTM C114............. 900 lbs.
- Fine Aggregate (sand)...2757.0 lbs.

- Coarse Aggregate..Nil
- Water Cement ratio..0.509

f) Waterproofing Membrane

The waterproofing membrane is a Butyl Rubber Membrane 1/16 inch thick. The membrane is adhered to the concrete or fiberglass surfaces, and is protected from ongoing construction activities by the compressible Rodofoam, the seal mortar and the protective fiberboard.

g) 6 Inch Diameter Porous Drain Pipe:

- Six inch diameter porous wall concrete drain pipes are embedded in the 9 inch thick porous concrete layer.
- The porous drain pipes are manufactured by Walker Poroswall Pipe and are constructed of portland cement, aggregate, water and limited amounts of sand to achieve the porosity. The six inch porous pipes are designed to have a minimum infiltration porosity of 12 gallons per minute per linear foot.

h) Compressible Material

Two compressible material layers, 2 inch thick are placed in the 4 inch shake space, exterior to containment wall and inside of the ring girder. The compressible material is Rodofoam II as Manufactured by W. R. Grace and Co.

3) Containment Structure Sequence of Construction

a) Excavation

Most of the major safety related structures are founded on bedrock. The extent of excavations and backfill for major Seismic Category I structures is shown on Figure 2.5.4-40. The boring locations are presented on Figure 2.5.4-32. Figure 2.5.4-33; north-south section A-A' looking west, cuts through the Waste Disposal Building, Fuel Building and the Containment Structure. Whereas Figure 2.5.4-34, east-west section looking south, cuts through the Engineered Safety Features Building, Containment and Auxiliary Buildings. It can be seen from these figures that these structures are founded on bedrock. The rock in the containment area along with the lower portion of the Engineered Safety Features Building Recirculation Pump Pit, was removed

by blasting and excavated approximately to elevation (-) 39 feet 3 inches. The various techniques of excavation and the method of blasting are referenced in Section 2.5.4.5. of the Millstone 3 FSAR.

The inflow of water into the excavation was controlled by pumping the water out of local sumps in the area of the Engineered Safety Features Recirculation Pump Pit. This was possible due to the low permeability of the soils and the tightness of the joints in the bedrock. Concrete working mats were poured on all foundation surfaces upon excavating each area in order to minimize the impact of construction activities on the undisturbed founding surfaces.

For the Containment Structure, a 10 inch thick porous concrete layer was constructed with Portland Cement, Type II. This later served as a general drainage media to keep the top surface dry in order to install the rubber membrane. On the top of the rubber membrane a 2 inch thick mortar seal was constructed to protect the rubber membrane from the placement of the 9 inch thick porous concrete layer above. The construction sequence was as follows:

1. Pour fill concrete to fill the overbreak of the rock surface on the bottom of the excavation, and bring the surface up to elevation (-) 39 feet 3 inches.

2. Pour fill concrete to eliminate the overbreak on the vertical rock surface at the containment mat perimeter to create a smooth vertical surface to elevation (-) 27 feet 3 inches.

3. Pour the 10 inch thick Portland Cement porous concrete.

4. Pour a smooth mortar layer on top of the porous Portland Cement concrete.

5. Lay the rubber membrane on top of the porous Portland Cement concrete and glue the membrane to the vertical surface (step 2) up to elevation (-) 27 feet 3 inches.

6. Pour 2 inches of Portland Cement mortar on top of the rubber membrane.

7. Install protective board on the vertical membrane surface and install hollow blocks to the top of the mat elevation (-) 27 feet 3 inches.

8. Install the 6 inch poroswall concrete pipe on the top of the 2 inch mortar seal coat for the 9 inch thick calcium aluminate porous concrete layer. Make holes in the hollow blocks to allow water to flow into the 9 inch

calcium aluminate layer. Place the 9 inch calcium aluminate concrete porous layer.

9. Seal the top surface of the 9 inch porous calcium aluminate concrete with a seal coat of calcium aluminate mortar.

10. Construct the 10 foot thick mat up to elevation (-) 27 feet 3 inches.

11. Construct the containment wall up to elevation 4 feet. Install the fiberglass board and 2 inch Rodofoam on the outside surface of the containment wall.

12. Place a 4 inch thick layer of #4 graded stone on top of the containment mat and a polyethylene membrane on top of the stone layer. Place a 2 inch portland cement mortar on top of the polyethylene membrane.

13. Continue the installation of the butyl rubber membrane from the containment mat perimeter over the top of the 2 inch mortar layer and up the containment wall to the founding elevation of the adjacent structures. The rubber membrane is glued to the 2 inch Rodofoam outside the containment wall. Install an additional 2 inch of Rodofoam to protect the vertical membrane. Place a 2 inch layer of mortar over the horizontal membrane surface.

14. Pour the Ring Beam on top of the containment mat between the containment wall (Rodofoam) and the rock surface.

QUESTION I.2

Provide subsurface drainage arrangement, surface drainage, backfill material, and historical effectiveness of the drainage arrangements.

RESPONSE I.2

1) Subsurface Drainage

A substantial subsurface drainage system is provided for removal of ground water below the major structures for Millstone 3. The drainage system consists of perforated pipes embedded in stone trenches which are either adjacent to or under the structures. These drainlines provide a mechanism for the water from the structure foundation area to be directed to strategically located underdrain sumps which are equipped with pump systems which lift the water into the yard storm drain system. Sump No. 1 is located west of the Emergency Diesel

Generator Building and drains the foundation of the Emergency Diesel Generator Building, the Control Building and the Service Building foundations. Sump No.2 is located north of the Auxiliary Building and drains the Auxiliary Building and Waste Disposal Building foundations. Sump No.3 is located east of the Engineered Safety Features Building and drains it's foundation. The Containment Structure and the adjacent Engineered Safety Features Recirculation Pump Pit is the only structure which utilizes porous concrete as the drainage media. A detail of the subsurface drainage system is shown on Figure I.1-12.

2) Surface Drainage

Surface drainage at Millstone 3 is provided by a gravity system consisting of drainage piping and catch basins. Any surface water collecting in this drainage system is directed and discharged into Long Island Sound through a single drainage pipe. The immediate plant area generally consists of bituminous pavement which has been pitched to the catch basins for collection of the rainwater.

3) Backfill Material

Material used for structural backfill is predominantly obtained from glacial outwash deposits. All structural backfill was processed at the borrow pit by means of passing the soil through a screen, ensuring that the maximum particle size and gradation meet the backfill specification requirements. For structural fill in the vicinity of the safety related structures, the gradation limits are:

U.S. Standard Sieve Size	Cumulative Percent Passing
3 inches	100
3/4 inch	75 to 100
3/8 inch	65 to 90
No. 10	40 to 60
No. 40	15 to 35
No. 100	0 to 20
No. 200	0 to 15

Coefficient of Uniformity, $Cu = D_{60}/D_{10} \geq 10$

All structural backfill was compacted to 95 percent of the maximum dry density determined from the Modified Proctor Test, ASTM D1557, Method D. Moisture content was maintained within 4 percent of optimum. Structural backfill was placed in loose lifts not exceeding 8 inches and uniformly compacted by heavy

vibratory rollers. Additional information on backfill can be found in Section 2.5.4.5.2 of the Millstone 3 FSAR.

4) Historical Effectiveness of Drainage System

Historically the drainage system has performed very well. There have been occasional minor leaks in the lower levels of the Engineered Safety Features Building, Auxiliary Building and Control Building either during heavy rains or when sump pumps have been out of service. These minor leaks have been repaired where they occurred around ductlines, which penetrate the membrane. These repairs have essentially eliminated the leakage.

QUESTION I.3

Provide the results of the latest Inservice Inspection of the Containment Structure, general surface, and at discontinuities. Condition of steel liner-particularly at the junction of the basemat. Water collection from the top of the basemat if any.

RESPONSE I.3

1) Condition of the Containment Structure Surfaces

Inservice Inspection of the Containment Structure is conducted as required by Technical Specification 4.6.1.6.1 and 10 CFR Part 50 Appendix J prior to each Type A leakage test. The inspection of the containment liner is conducted in accordance with procedure SP-31119, Visual Inspection of Containment Liner. The inspection of the containment concrete surfaces is conducted in accordance with procedure SP-31118, Visual Inspection of Accessible Exterior Concrete Containment Surfaces. The latest inspections were performed in September 1993, prior to the Type A leakage test. The results of these inspections show that the exterior containment surfaces and containment liner show no signs of degradation, require no corrective action, and are satisfactory to perform their intended functions.

2) Water Collection from the Basemat

There is no evidence of any water at the top of the basemat. The possibility of water in the vicinity of the containment liner an the basemat is precluded by the containment underdrain system. As designed, this system removes water from the porous concrete layer beneath the containment basemat which does not allow water to reach the elevation of the containment liner.

QUESTION I.4

Is there any evidence of Containment settlement.

RESPONSE I.4

During the construction of Millstone 3 the Containment Structure was routinely monitored for settlement in accordance with Stone & Webster Field Construction Procedure 107, Settlement Monitoring. As Millstone 3 evolved from a construction plant to an operating plant NNECO continued the settlement monitoring for the Containment Structure in accordance with Specification SP-CE-223, Movement Monitoring Program. These programs confirmed there was no settlement of the Containment Structure during this period. Monitoring of benchmarks BM18R and BM34R has been continued, BM18R and BM34R are located on the containment exterior wall at azimuth 322 degrees and 116 degrees respectively, approximately 5 feet abcve grade, see Figure I.1-10. The most recent monitoring data is summarized in the following table which confirms that there has been no detrimental movement of the structure.

Date	Elevation	
	BM 18R	BM 34R
Initial (1985)	28.114'	29.077'
6/29/95	28.119'	29.083'

The indication of an increase in the benchmark elevation is well within the accuracy of a survey with traverse distances required by this survey.

Additional information on settlement monitoring can be found in Section 2.5.4.13 of the Millstone 3 FSAR.

II. HYDROLOGICAL DATA - MILLSTONE 3

QUESTION II

Discuss the probable driving force (source and intensity) that causes the water to flow into the porous concrete from under the containment base mat. Is the flow of water continuous, all through the year. Is there an "artesian" condition at the site. Was any investigation done to see if the geologic faults at the site may serve as the likely paths for the water flow below the containment base mat.

RESPONSE II

1) Source of Water

Ground water conditions were extensively studied during the site investigation process prior to the design of Millstone 3, and during the construction of the unit as discussed in FSAR Sections 2.4.13 and 2.5.4.6. The basic cross section of materials, from top to bottom that were found during the original site investigation are: soil overburden consisting of Artificial Fill, Beach Deposits, Stream Deposits; Ablation Till consisting of glacially deposited silt and sand; Basal Till consisting of glacially compacted sand, gravel and rock fragments; Monson Gneiss Bedrock. Based on the site investigations and observations during construction the permeability of the materials varies within the different layers. The bedrock has very low permeability, this is evidenced by the fact that very little water leaked into excavations through the bedrock, and the results of pressure tests performed prior to plant construction. These water pressure test are summarized in Section 2.5.4.3 of the Millstone 3 FSAR and confirmed little or no groundwater is expected to seep through the bedrock. The Basal Till and Ablation Till are also relatively impervious. The Ablation Till is more pervious than the Basal Till due to the range of its material and lighter compaction. The soil overburden and backfill placed during construction provide the path for recharge of ground water from precipitation. This water could access the face of the Containment Structure through backfill or other areas. Any surface water when circumventing the water proof membrane on the Containment Structure is able to flow down the outside wall of the Containment Structure in the space provided for this purpose. Additional information of groundwater flow and the permeability of the site materials can be found in Sections 2.2.4.13 and 2.5.4.6.1 of the Millstone 3 FSAR.

2) Flow Variability

NNECO has undertaken a study to investigate any correlation between flows in the sumps from the containment foundation, and surface precipitation. Also included in the study were tidal levels to show that there is no correlation with this variable. For the year of 1994 several graphical plots have been developed which show: sump flows per day for pumps 3DAS-P8A & B located in the Engineered Safety Features Building sumps 3DAS-P7A & B; Surface precipitation per day; and average high and low tides per day, see Figures II.2-(1-5). The plots confirm there is a correlation to ground water levels and surface precipitation. In the spring of the year sump flows are maximum and in the summer months sump flows stabilize at a much lower level. The plots also generally show that large rainfalls are followed by increased sump flows with a

lag time of 3 to 4 days. This is consistent with expected ground water migration.

3) Artesian Conditions

There are no known artesian conditions existing at Millstone 3. During the extensive site investigations, discussed in item 1 above, and during plant construction the permeability of the bedrock and Basal and Ablation Till layers was determined to be low, and there was no evidence of any artesian conditions.

4) Geological Faults

Extensive investigation was conducted on the historical joints and foliation surfaces at the site prior to and during plant construction. As noted in Section 2.5.4.6.2 of the Millstone 3 FSAR drainage pipes were installed in the inactive joint at the southwest of the Containment Structure. Very little water was found to flow through these pipes which confirms that this joint or other joints are not a significant source of groundwater.

III. <u>CONSTRUCTION DETAILS - CONTAINMENT STRUCTURE MILLSTONE 3</u>

QUESTION III

Provide the intended Functions, Sizes and Material Properties of: leveling mat; rubber membrane; porous concrete; seal mortar; four inch concrete blocks; compressible material; ribbed fiberglass sheets and perforated drain pipes.

RESPONSE III

1) Leveling Mat

The function of the leveling mat is to provide a level/dry working surface for the construction of the Containment Structure. After the completion of the blasting required for removal of the bedrock, the remaining rock surface is somewhat irregular and must be leveled for the Containment Structure construction to begin. The leveling mat is constructed of fill concrete.

2) Porous Concrete 10 Inch Layer

Any rainwater entering the excavation must be removed to a low point at the side of the excavation so it may be pumped out of the excavation to avoid any impact on the construction activities. For this reason porous portland cement based concrete was used to channel the water to the low points, which were intentionally located at the lowest level of the sump pits for removal of the water.

This layer of concrete is approximately 10 inches thick and approximately 159 feet in diameter, with an extension in one location for the base of the Engineered Safety Features Building. The porous concrete has a design strength of 1000 psi at 28 days, and is constructed of #57 graded stone, portland cement and water as discussed in Section I.2.b. The top of this layer of porous concrete is sealed with portland cement mortar to smooth the top surface, before installing the waterproof membrane.

3) Rubber Membrane

As discussed in the response to Question I.1.h of this report the rubber membrane enclosing the Containment Structure below grade is provided to minimize the leakage from groundwater to the containment walls and foundation. The rubber membrane is 1/16 inch butyl rubber which is adhered to vertical surfaces with a bonding adhesive. Lap joints in the membrane are sealed using butyl rubber tape with polyethylene backing.

4) Seal Mortar

The seal mortar placed directly on top of the rubber membrane is used to provide a layer of protection for the rubber membrane to prevent damage during the placement of the 9 inch thick layer of porous concrete. The seal mortar consists of portland cement, sand and water as discussed in Section I.2.c. The seal mortar is placed in a 2 inch layer over the entire surface of the membrane.

5) Porous Concrete 9 Inch Layer

The porous concrete above the butyl rubber membrane is provided as a media for removal of rainwater which is collected inside of the Containment Structure during the construction process. Since the Containment Structure construction is a lengthy process, and with the encapsulating rubber membrane the water would be trapped at the base of the structure. This porous concrete layer also provides a media for collection of any groundwater which circumvents the rubber membrane in the long term. The water from this media is directed via porous concrete pipe (discussed below) to permanent sump areas in the Engineered Safety Features Building. Since this drainage layer is intended to function for a longer period of time porous calcium aluminate cement based concrete was used, since it contains no free lime and is less likely that the concrete would plug the porous drainage layer, and this would also eliminate corrosive attack on the sump pumps. This layer of concrete is approximately 9 inches thick and approximately 159 feet in diameter, with an extension in one location for the base of the Engineered Safety Features Building. The porous concrete has a design strength of 1000 psi at 28 days, and is constructed of #57 graded stone, calcium aluminate cement and water as discussed in Section I.2.d. This layer of

porous concrete is sealed with calcium aluminate cement mortar to smooth the top surface.

6) Concrete Blocks

Four inch hollow concrete blocks are provided at the edge of the 10 foot thick Containment Structure foundation around the entire perimeter of the foundation. The concrete blocks do not provide a structural function, but do provide an engineered drainage path and serve as a concrete form for the edge of the containment foundation. In the areas where the concrete blocks are contiguous with the porous layer under the containment foundation, and at the crushed stone layer on top of the containment foundation, the face of the blocks are provided with holes or slots to allow the water to enter the hollow portion of the block. The hollow concrete blocks allow for vertical passage of water down the edge of the containment foundation into the calcium aluminate porous concrete layer below the foundation.

7) Compressible Material

The compressible material is primarily provided to decouple the Containment Structure from the other structures surrounding the Containment Structure, during a seismic event, in order to prevent dynamic coupling of the Seismic Category I Structures. Additionally the compressible material provides support and protection of the waterproof membrane. On the inside face of the waterproof membrane the compressible material is used to provide a flat surface for placement of the waterproof membrane, since the contour of ribbed fiberglass sheet would not provide an adequate surface for placement of the waterproof membrane. On the outside face of the waterproof membrane the compressible material is used to protect the waterproof membrane from the subsequent placement of the reinforced concrete ring girder. The rate of concrete placement against the Rodofoam is limited to restrict the displacement of the Rodofoam. The compressible material is Rodofoam II as Manufactured by W. R. Grace and Co.

8) Ribbed Fiberglass Sheets

The ribbed fiberglass sheets are placed against, and anchored to, the outside wall of the Containment Structure to provide an intentional space for vertical flow of water down the containment wall. This flow path provides a direct means for any water which has circumvented the rubber membrane to access the top porous concrete layer beneath the containment foundation.

9) Perforated Drain Pipe

Six inch diameter perforated concrete drain pipe as manufactured by Walker Poroswall Pipe is embedded in the porous concrete layer to channel the water to the Engineered Safety Features sumps. The perforated pipe is installed near the outside circumference of the foundation, Figure I.1-12. In addition two drain pipes are installed through the center area of the porous concrete. These drain pipes terminate into the sumps in the Engineered Safety Features Building. The drain pipes are constructed of portland cement, aggregate, water and limited amounts of sand to achieve the porosity and strength. The six inch porous pipes are designed to have a minimum infiltration porosity of 12 gallons per minute per linear foot. The technical data on the Walker Poroswall pipe is included as Attachment 4.

IV. SUMP INFORMATION - CONTAINMENT STRUCTURE MILLSTONE 3

QUESTION IV

Provide results of water tests from the sumps including PH, and quantities with respect to time. Also provide the amounts of the accumulated residue with respect to time. Identify the sources of the water received in the sumps, if any is from other sources. Provide the sump pump capacity and sump discharge location.

RESPONSE IV

1) Water Chemistry Tests

Water Chemistry test have been completed for samples removed directly from sumps 3DAS-Sump 7A & B (see Attachment 3). The results of these test are provided below:

			Concentrations (ppm)			
Description	pH	Sp. Conductivity (uS/cm)	Cl	SO_4	NO_3	F
Sump 7A	11.8	3700	59	14	28	<0.1
Sump 7B	10.3	330	7.8	2.8	1.7	<0.1

Additional Chemistry tests of ground water samples prior to entering th foundation area and from sumps 3DAS-Sump 7A & B are planned.

2) Water Quantities in Sumps

Water quantities with respect to time tabulated for the sumps have been plotted for the entire year of 1994. These plots are included as Figures II.2-(3-5). The total sump flows for the year of 1994 is approximately 570,000 gallons or 1500 gallons per day. Additional information on this subject is included in the response to Question II above.

3) Quantities of Residue in the Sumps

Residue has been collected since 1987. In the earlier years some of the weights have been estimated since actual weights were not recorded. The weights have generally been recorded as wet weights, and recently most of the residue has been dried and rerecorded as dry weight. The removal of the residue did not occur at the same time of each year, so that the data reported by date may be from a period that is longer or shorter than one year. The following table summarizes the weights of the collected residue by year.

Year	Wet Weight (lb)	Dry Weight (lb)
1987	100 (2)	↓
1988	100 (2)	
1989	100 (2)	
1990	100 (2)	
1991	130	
1992	202	
1993	18	
1994	145	
1995	-	666 (1)
1996	-	86 (3)
	Total	752

(1) Total dry weight for years 1987 - 1995
(2) Estimated weight
(3) Partial year

The average dry weight for years 1987 - 1996 is approximately 80 pounds.

4) Chemistry of Residue in the Sumps

Chemical analysis of the residue found in the sumps was performed in 1991 and additional tests were completed in 1996 by ABB Combustion Engineering Nuclear Operations Laboratory. The chemical analysis consisted of Inductively Coupled Plasma Spectroscopy, X-ray Fluorescence, Ion Chromatography, and Particle analysis. A copy of the 1991 report is included as Attachment 2 and the 1996 report is included as Attachment 3. Additional testing of the water and sump residues is planned.

5) Sources of Water Entering the Sumps

The Engineered Safety Features Sumps which receive water from the containment underdrains also receive water from other sources within the Engineered Safety Features Building. Floor drains within the Recirculation Spray Pump cubicles and the Recirculation Spray Heat Exchangers equipment drains also are sources for water to these sumps. In addition to this, floor drains from the Hydrogen Recombiner equipment cubicles in the Hydrogen Recombiner Building also drain to these sumps. The amount of water from these other sources, would be intermittent and is expected to be very small compared to the flow from the porous concrete drains. Conservatively, this flow has not been excluded from the assumed flows from the porous concrete included in Figures II.2-(3-5).

6) Sump Pump Capacities and Discharge Location

Sumps 3DAS-Sump 7A & B contain Sump Pumps 3DAS-P8A & B. Both these sump pumps are rated at 25 gallons per minute at 105 feet of head. They pump their effluent to sump 3DAS-Sump 10 which is also located within the Engineered Safety Features Building. From Sump 10 the effluent is pumped into the plant radioactive waste system and processed accordingly. The maximum equivalent flow, for the peak flow of the year, per sump is 3.8 gallons per minute.

V. <u>MILLSTONE 1 & 2</u>

QUESTION V

Are there any similar foundation configurations at Millstone Units 1 and 2.

RESPONSE V

There are no similar porous concrete foundation drainage layers at Millstone Units 1 & 2

VI. **COMPONENT SUPPORTS - MILLSTONE 3**

QUESTION VI

Provide a description of the major component (RPV, SGs, NSSS piping) supports and their anchorage into the basemat. Also provide the condition of the shield walls.

RESPONSE VI

The major NSSS equipment supports, which are directly anchored to the containment foundation, are the Safety Injection Accumulator Tanks and the Neutron Shield Tank. Both these are anchored to the containment foundation through the use of bridging bars at elevation (-) 27 feet 3 inches, the top of the containment liner. The anchorage for the accumulator tanks consists of 2 inch diameter anchor bolts connected to the bridging bars. The bridging bars allow for a connection of the anchor bolts, for the accumulator tank, on the top and connection to the reinforcing steel below the containment liner, while maintaining the steel liner as a sealed vessel. The neutron shield tank is of similar construction except that the anchor bolts are 2 1/2 inch diameter.

The primary shield wall, steam generator support columns and cranewall columns are the major interior reinforced concrete structural elements which are anchored to the containment foundation. These structural elements are also connected to the containment foundation by use of bridging bars. The vertical reinforcing steel in these elements is connected to the top of the bridging bar, and reinforcing steel of the foundation is connected to the bottom of the bridging bar. The actual connections of these elements are nominally 10 feet above the porous concrete layer. Since the porous layer is functioning, as designed, to remove the water from the containment foundation area there is no evidence of any water from external sources on the basement floor slab of the containment structure. A visual inspection of these areas confirms there are no signs of degradation of any of these elements.

VII. **GEOLOGICAL, GEOTECHNICAL, AND SEISMIC ANALYSIS DATA - MILLSTONE 3**

QUESTION VII.1

How were the spring constants determined to represent the rock, shown in FSAR Figure 3.7B-9, used in the dynamic model of the Containment Structure.

RESPONSE VII.1

The stiffness of the horizontal, vertical, rocking and torsional subgrade springs have been calculated based on the assumption of a rigid circular plate resting on a semi infinite depth of subgrade material. The stiffness values corresponding to attached FSAR Figure 3.7B-9, are as follows:

Horizontal spring	$K_H = 8.159 \times 10^7$ kips/ft.
Vertical spring	$K_V = 1.077 \times 10^8$ kips/ft.
Rocking spring	$K_R = 4.423 \times 10^{11}$ kip - ft/rad.
Torsional spring	$K_T = 5.307 \times 10^{11}$ kip - ft/rad.

The rock properties and the equations used to calculate the spring constants are included in Figure VII.1-1. These constants have been extracted from calculation 12179-NS(B)-025.

QUESTION VII.2

Was the presence of the two porous concrete layers, with a total thickness of 19 inches, accounted for in the seismic dynamic analysis of the Containment Building, If so, how. What are the engineering properties of the two layers considered in the dynamic analysis.

RESPONSE VII.2

The two porous concrete layers (19 inch thickness) were not accounted for in the seismic dynamic modeling of the containment structure. In the dynamic model of the Containment Structure the 10 foot thick containment foundation is assumed to rest directly on bedrock, and therefore dynamic modeling properties of the porous layers were not specifically developed.

The structural properties of the porous concrete layers were originally specified to provide an appropriate supporting material for the Containment Structure foundation mat. These properties are included in the response to Question I.1. These properties provide a material with the appropriate engineering properties for support of the design basis loads for the Containment Structure.

VIII. <u>OTHER CONDITIONS AT MILLSTONE 3</u>

QUESTION VIII

Is this method of foundation construction typical of other foundations for Millstone 3 structures.

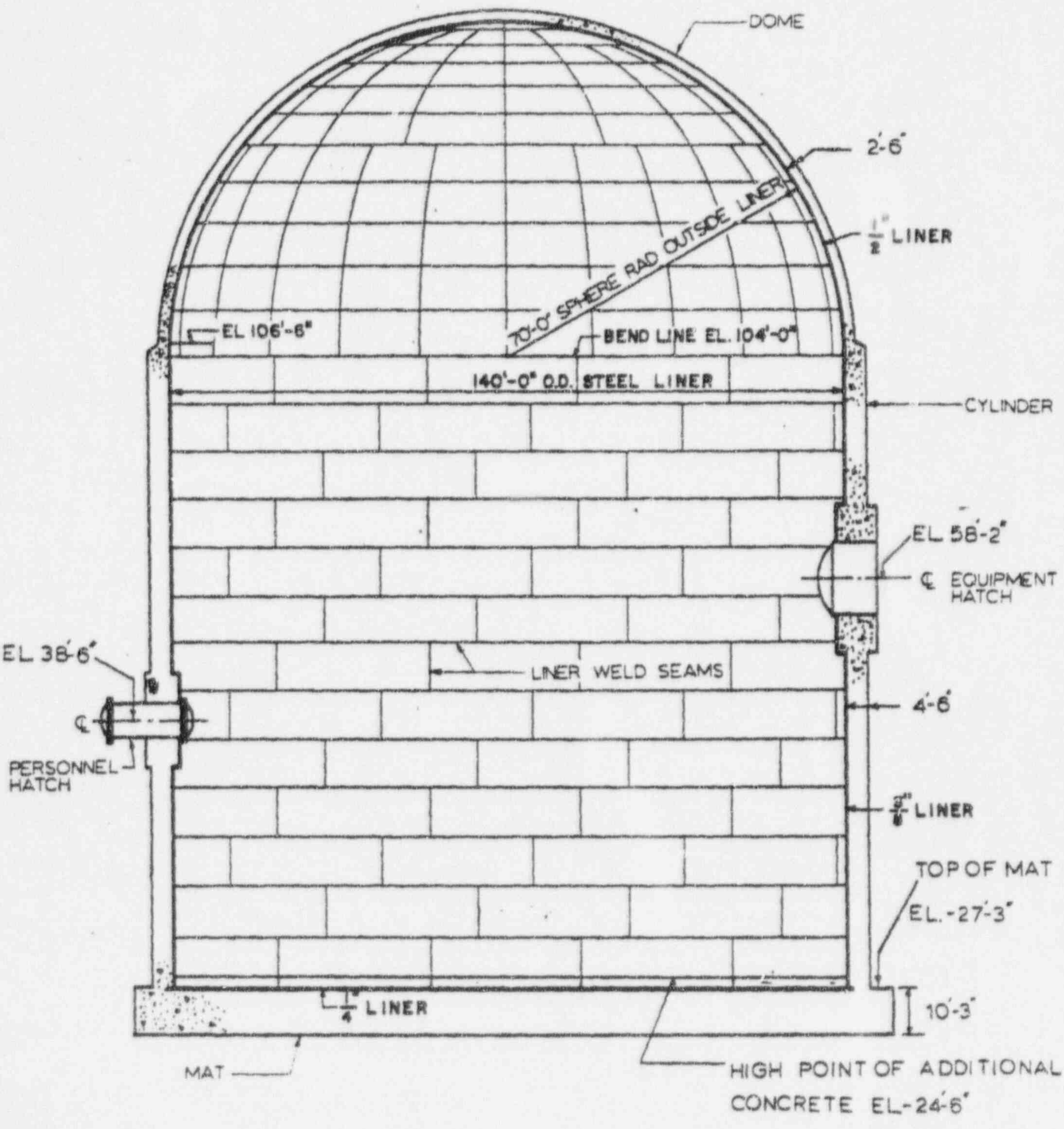
RESPONSE VIII

The Recirculation pump pit and sumps 3DAS-Sump 7A & B in the Engineered Safety Features Building, which is integral with the lower portion of the Containment Structure, is founded on the same porous concrete foundation as the Containment Structure. None of the other structures at Millstone 3, including the majority of the Engineered Safety Features Building, are founded on a porous concrete drainage layer. The other structures are founded on bedrock or structural backfill as discussed Sections 3.8.4.1 and 3.7B.1.4 of the Millstone 3 FSAR.

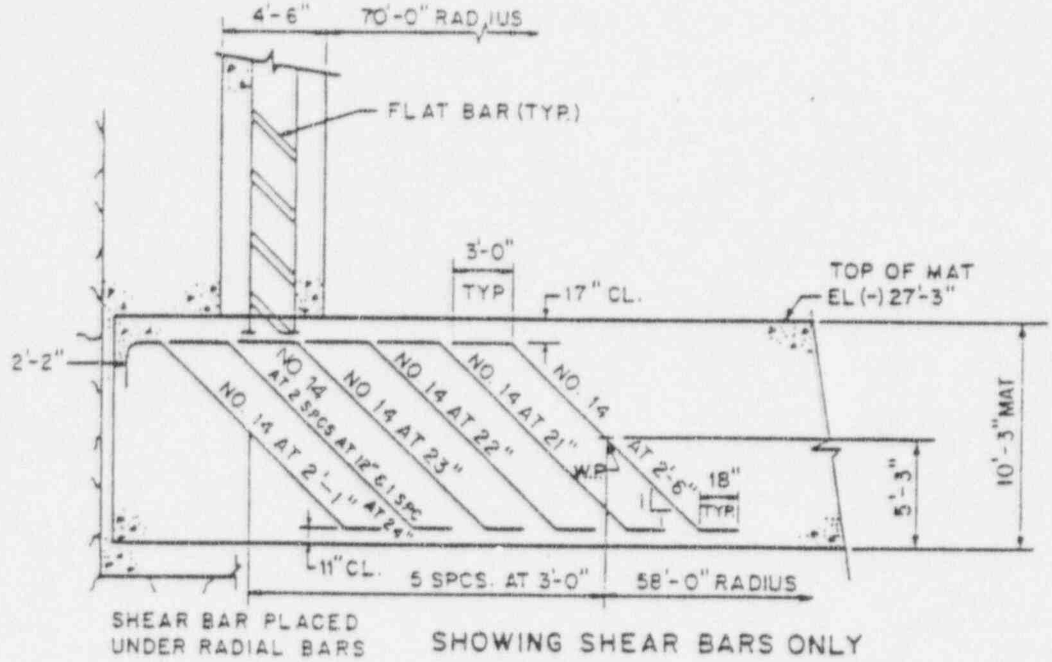
Foundation drainage for the other structures consists of drainage pipes installed in strips of crushed stone either directly under the foundation of the structures or at the face of the building walls.

LIST OF FIGURES

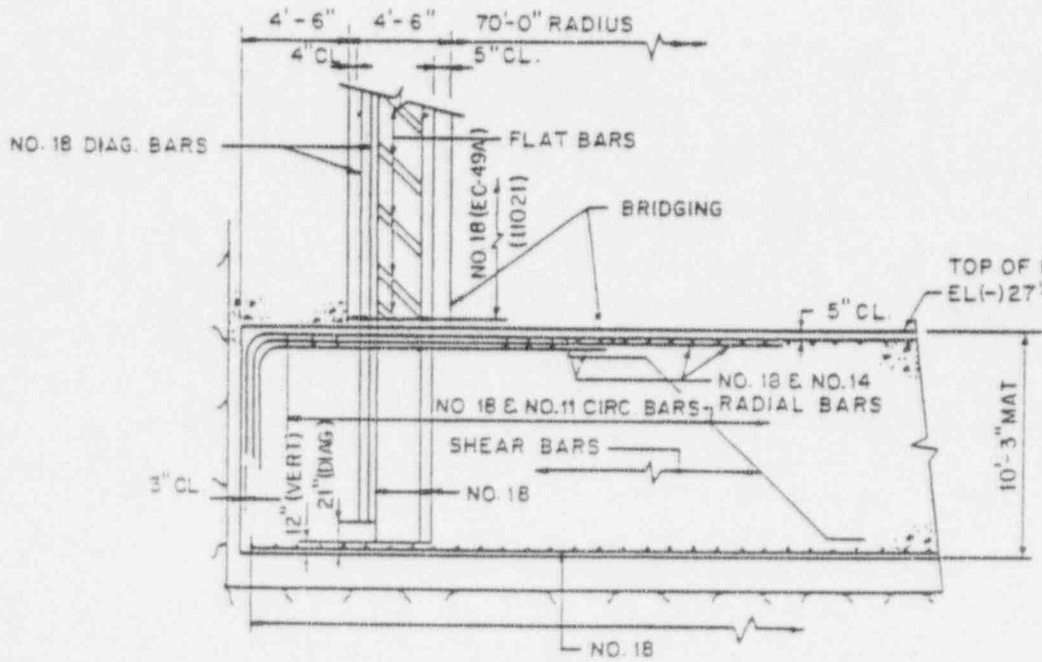
FIGURES



Northeast Utilities System				
FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*				
TITLE *CONTAINMENT STRUCTURE*				
BY *BIBISI*	CHKD.	APP.	APP.	
DATE *7-11-96*	DATE	DATE	DATE	
SCALE *N.T.S.*	DWG. NO. *FIGURE 1.1-1*			
P.A.* ———				



SHOWING SHEAR BARS ONLY



TYP. SECTION

Northeast Utilities System	
FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*	
TITLE *MAT REINFORCEMENT WITH RADIAL SHEAR BAR ASSEMBLY*	

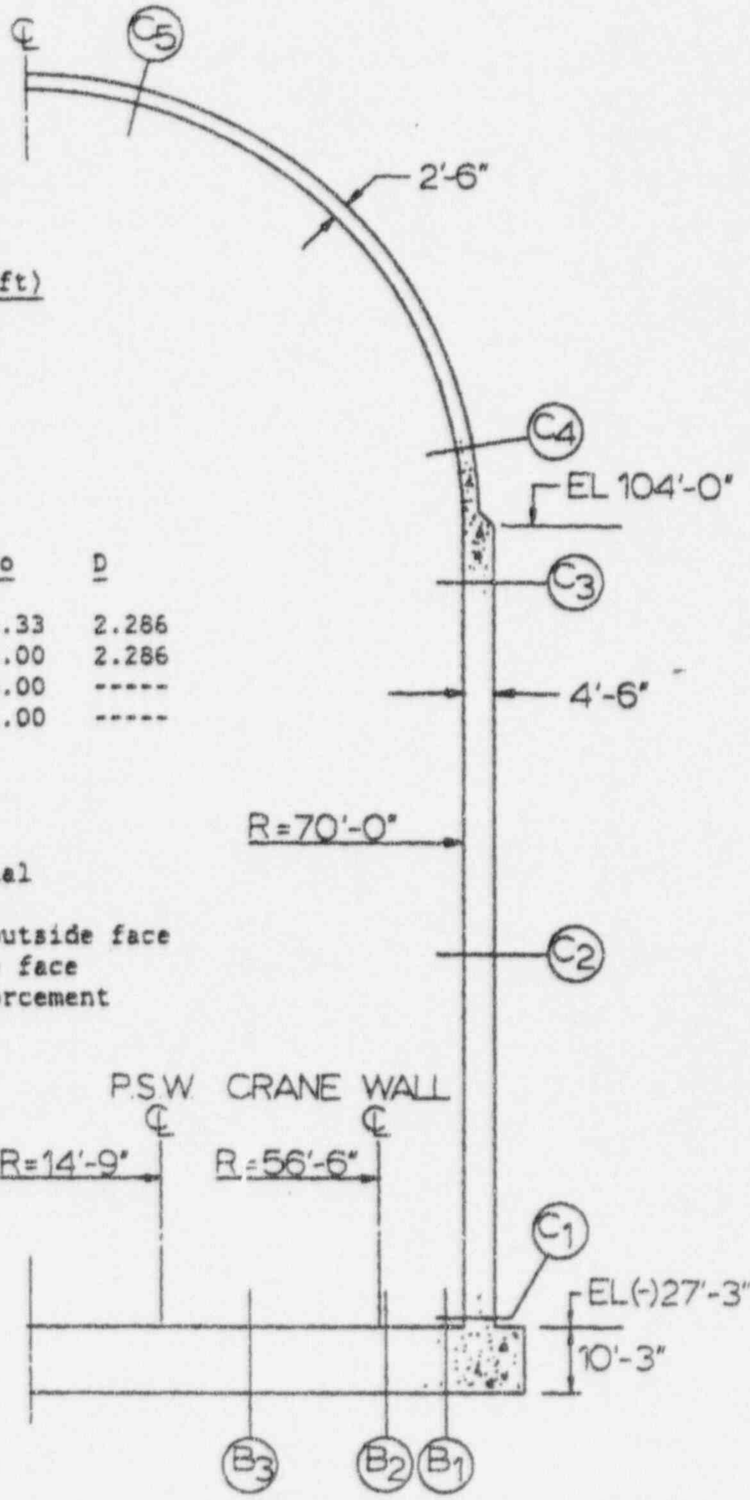
BY *BIBISI*	CHKD.	APP.	APP.
DATE *7-11-96*	DATE	DATE	DATE
SCALE *N.T.S.*	DWG. NO. *FIGURE 1.1-2*		
P.A.# ——			

Section	Steel Area (As) (in²/ft)		
	Tr	Tc	Bg
B1	9.125	4.23	4.00
B2 & B3	4.00	2.67	4.00

Section	Mi	Mo.	Hi	Ho	D
C1	8.00	8.00	5.33	5.33	2.286
C2	4.00	4.00	8.00	8.00	2.286
C3	4.00	4.00	8.00	8.00	-----
C4 & C5	4.00	4.00	4.00	4.00	-----

NOTES:

Tr, Tc = Top radial, circumferential
Bg = Bottom rectangular grid
Mo, Mi = Meridional inside face, outside face
Ho, Hi = Hoop inside face, outside face
D = Effective diagonal reinforcement

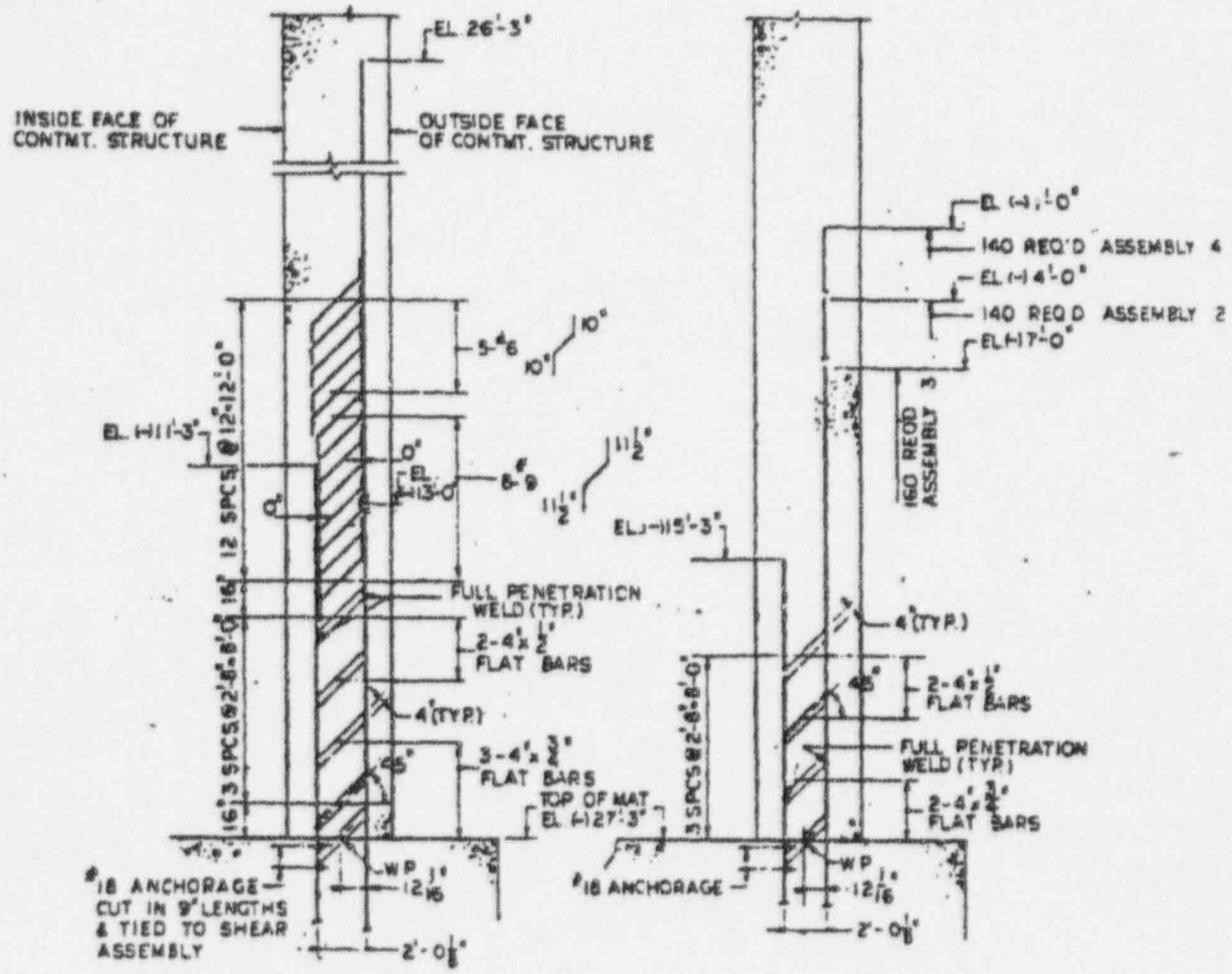


Northeast Utilities System

FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*

TITLE *SECTION PROPERTIES OF CONTAINMENT STRUCTURE*

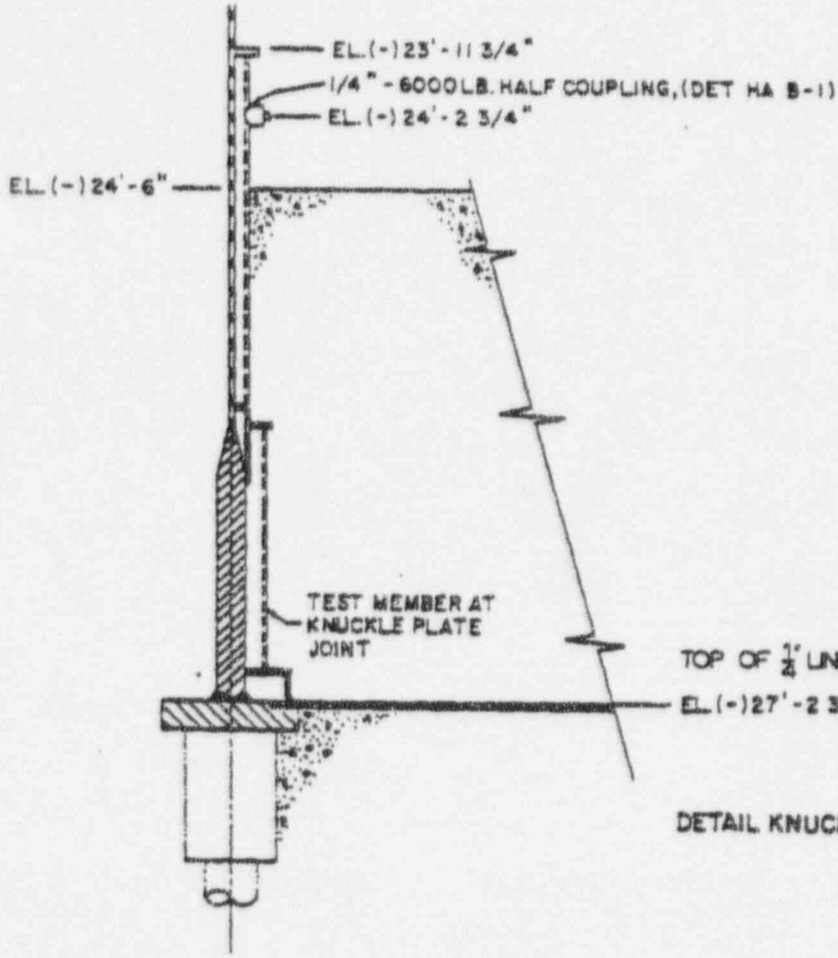
BY *BIBISI*	CHKD.	APP.	APP.
DATE *7-11-96*	DATE	DATE	DATE
SCALE *N.T.S.*	DWG. NO. *FIGURE I.1-3*		
P.A.* ———			



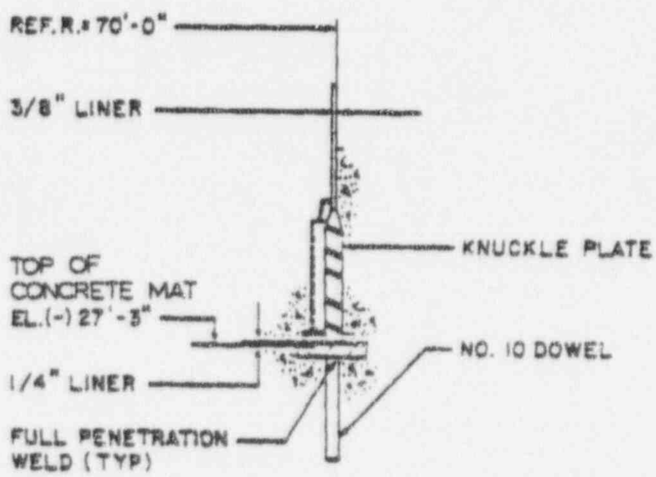
5 FLAT BARS SHEAR ASSEMBLY 1
440 TOTAL REQ'D

4 FLAT BARS SHEAR ASSEMBLIES 2,3 & 4
440 TOTAL REQ'D

Northeast Utilities System			
FOR MILLSTONE NUCLEAR POWER STATION UNIT 3			
TITLE CYLINDER WALL / MAT JUNCTION SHEAR ASSEMBLY DETAILS			
BY BIBISI	CHKD.	APP.	APP
DATE 7-11-86	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE 1.1-4		
P.A.* ——			

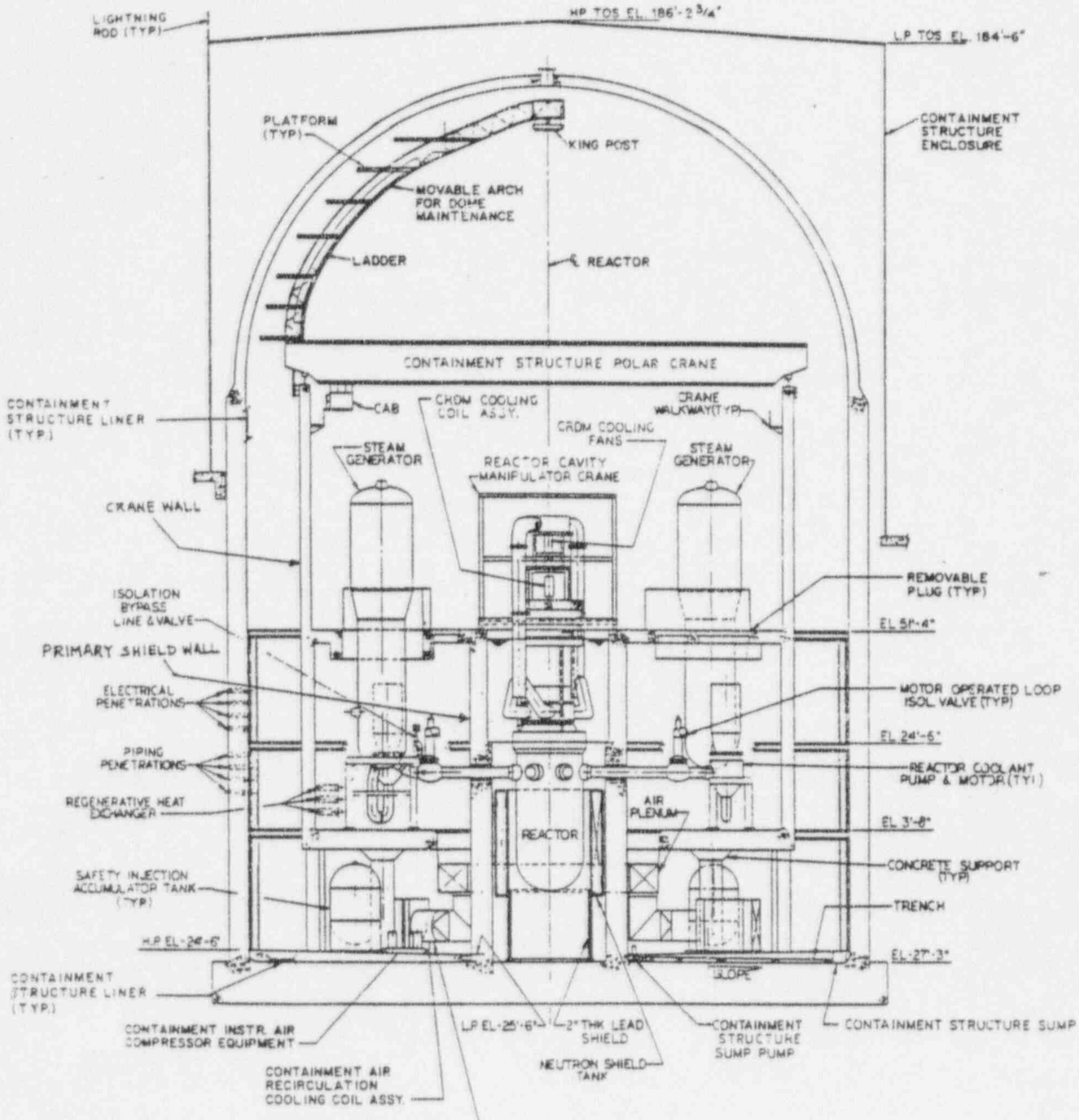


DETAIL KNUCKLE PLATE

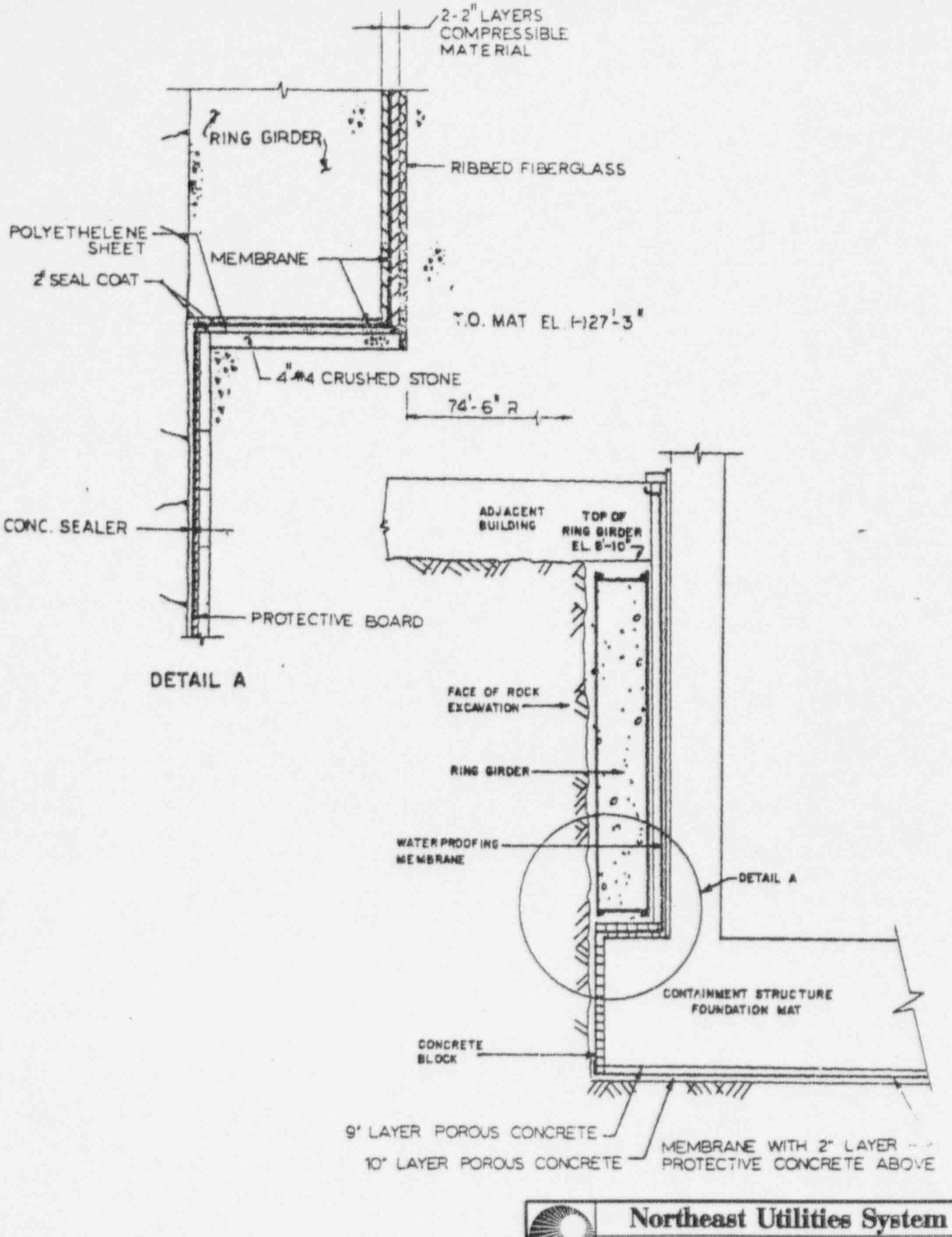


TYP SECTION
KNUCKLE PLATE

Northeast Utilities System			
FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*			
TITLE *KNUCKLE PLATE*			
BY *BIBISI*	CHKD.	APP.	APP.
DATE *7-11-96*	DATE	DATE	DATE
SCALE *N.T.S.*	DWG. NO. *FIGURE 1.1-5*		
P.A.# ———			



Northeast Utilities System			
FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*			
TITLE *CONTAINMENT INTERNAL STRUCTURE*			
BY *BIBISI*	CHKD.	APP.	APP.
DATE *7-11-96*	DATE	DATE	DATE
SCALE *N.T.S.*	DWG. NO. *FIGURE 1.1-6*		
P.A.#			

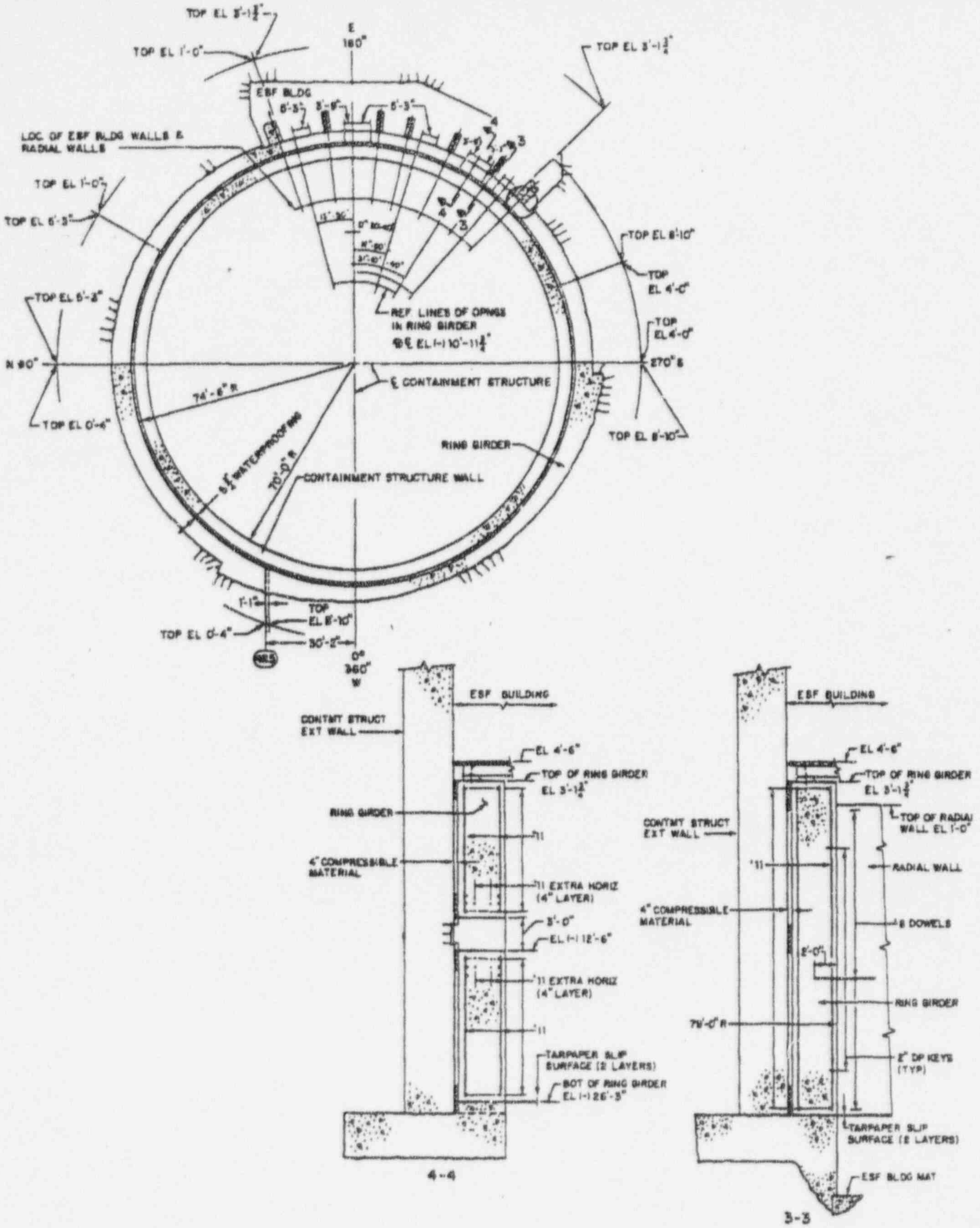


Northeast Utilities System

FOR MILLSTONE NUCLEAR POWER STATION UNIT 3

TITLE CONTAINMENT STRUCTURE FOUNDATION DETAIL

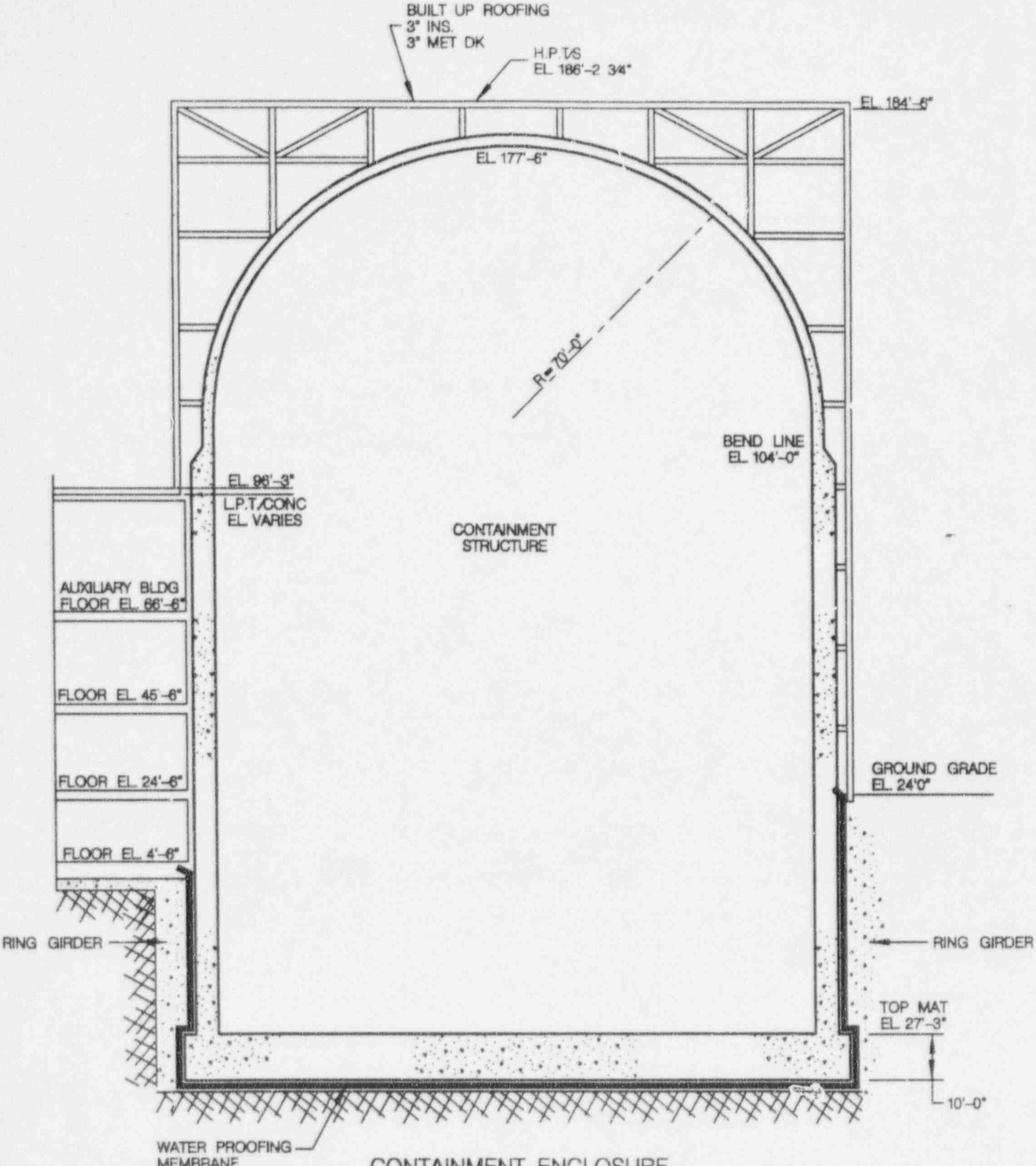
BY BIBISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE I.1-7		
P.A.# ———			



Northeast Utilities System

FOR MILLSTONE NUCLEAR POWER STATION UNIT 3

TITLE	DETAILS OF RING GIRDER AT ESF BUILDING		
BY BIBISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE 1.1-8		
P.A.# ———			



CONTAINMENT ENCLOSURE

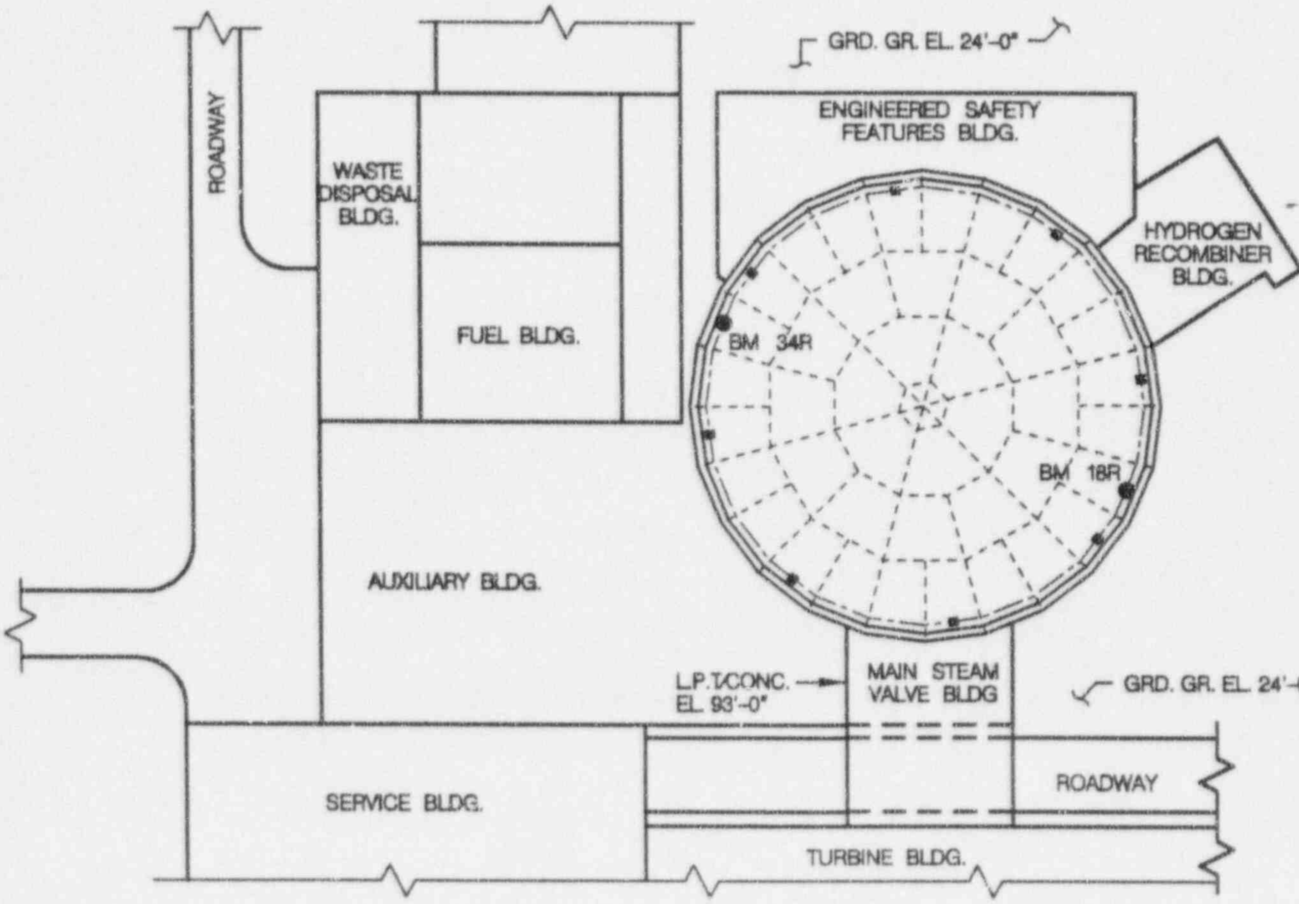
(NOT TO SCALE)

Northeast Utilities System

FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*

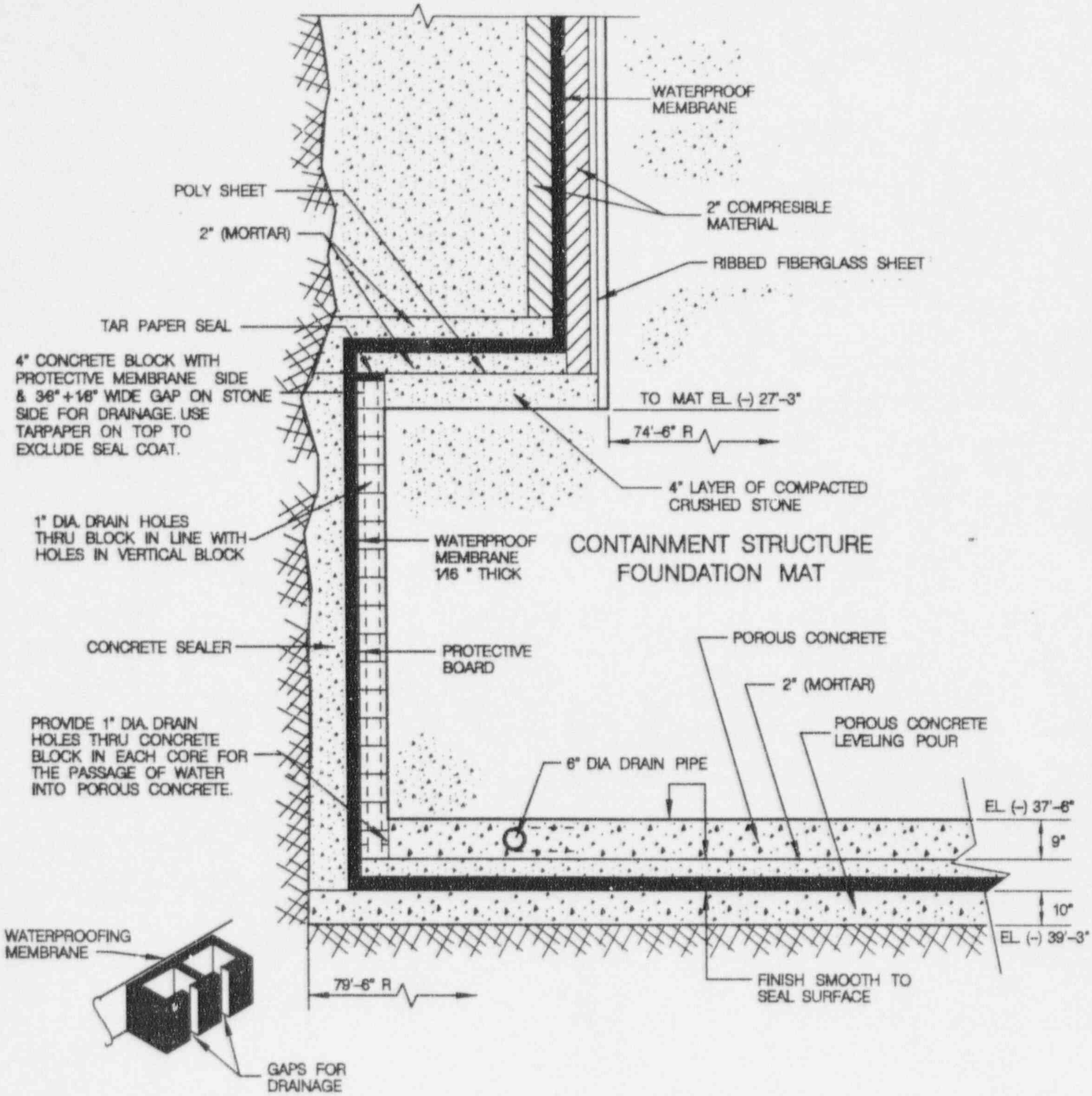
TITLE *CONTAINMENT ENCLOSURE BUILDING*

BY BIBIS!	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. *FIGURE 1.1-9*		
P.A.*			



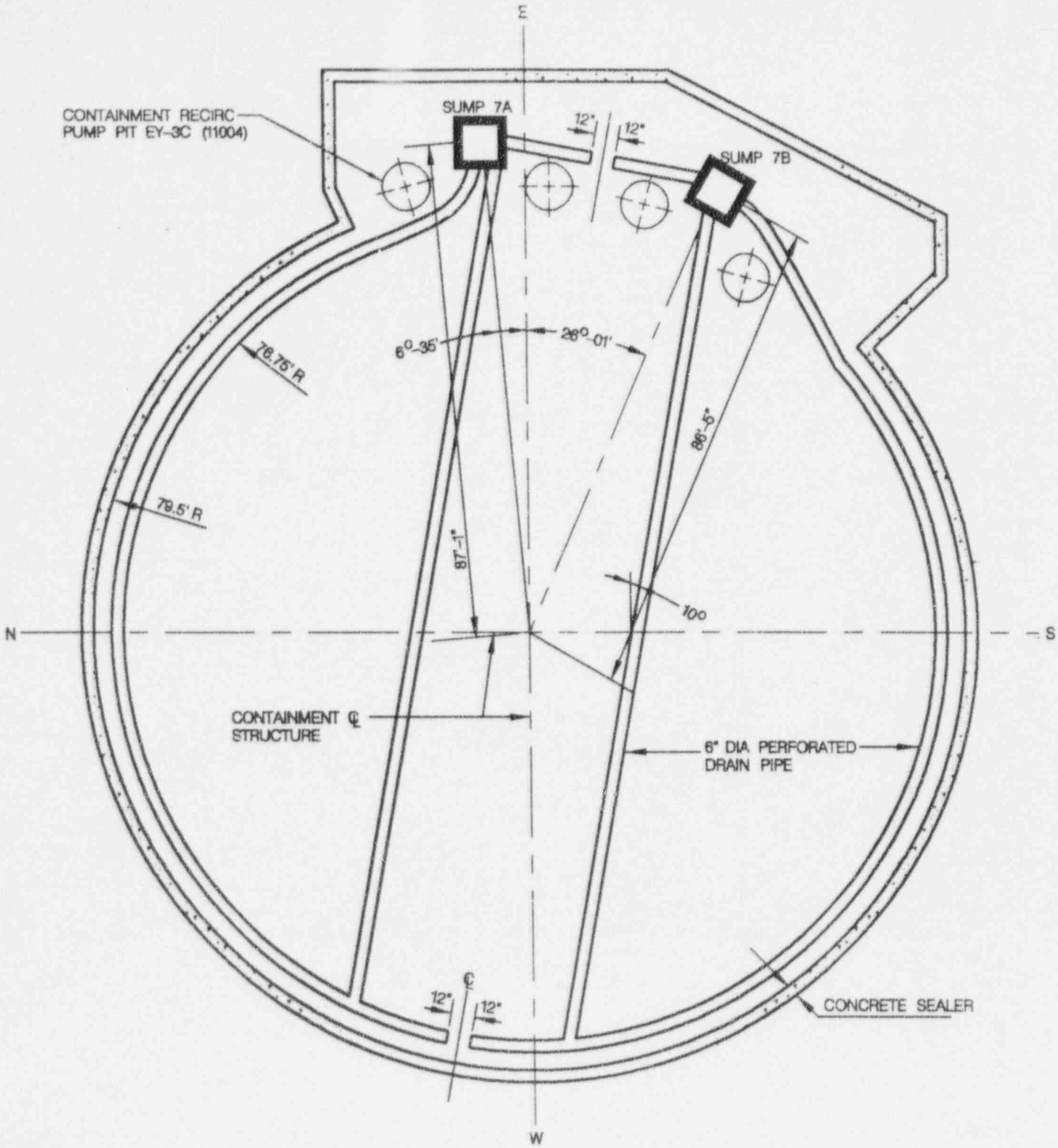
KEY PLAN

Northeast Utilities System			
FOR MILLSTONE NUCLEAR POWER STATION UNIT 3			
TITLE CONTAINMENT ENCLOSURE BUILDING			
BY B/BISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE I.1-10		
P.A.* ——			



ETAIL OF MEMBRANE & FOUNDATION MAT
(NOT TO SCALE)

Northeast Utilities System	
FOR MILLSTONE NUCLEAR POWER STATION UNIT 3	
TITLE MEMBRANE & FOUNDATION MAT DETAIL	
BY BIBISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE I.1-11		
P.A.* ———			



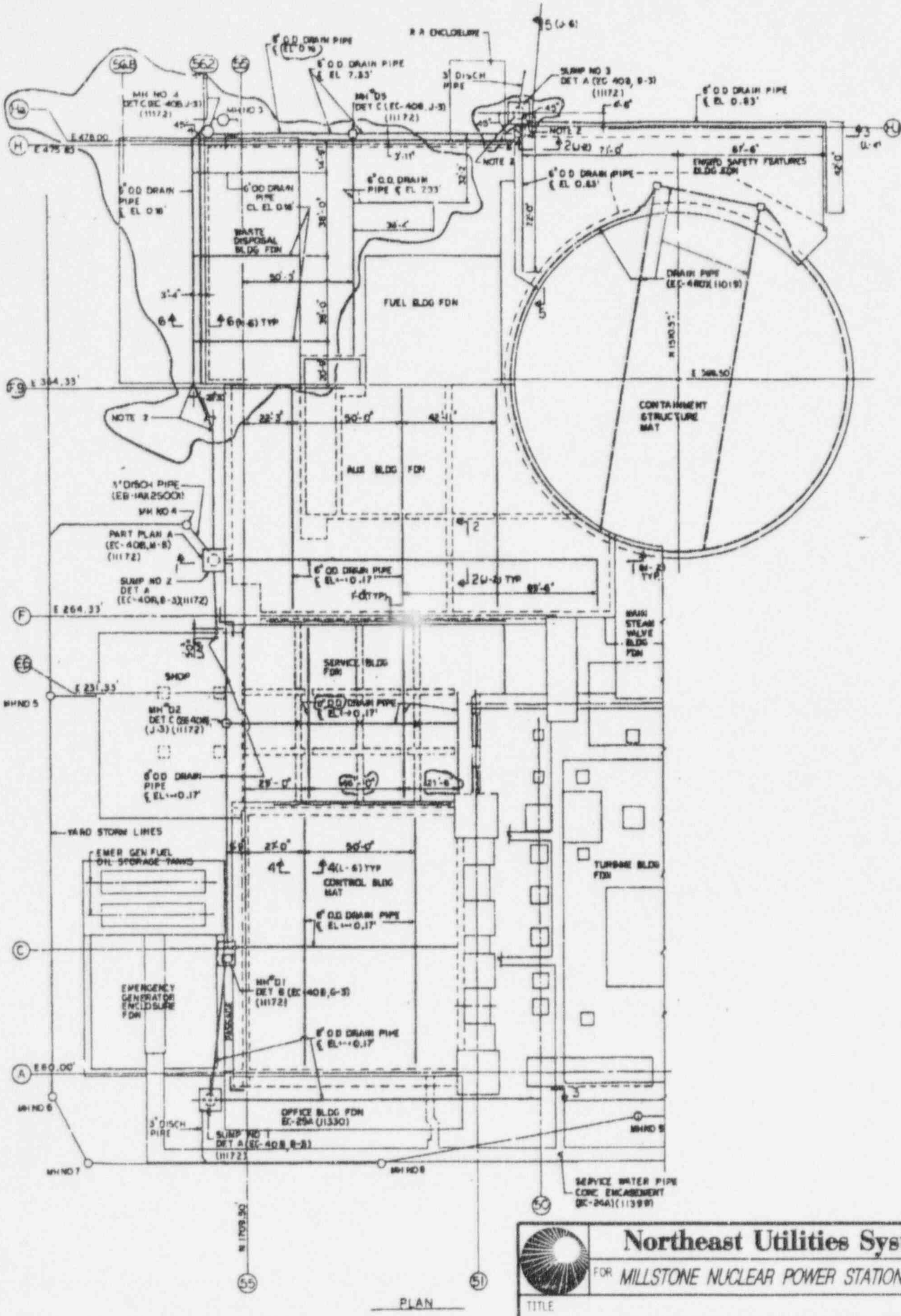
PLAN EL. (-)37'-6"
LAYOUT OF SUMP DRAINAGE

Northeast Utilities System

FOR *MILLSTONE NUCLEAR POWER STATION UNIT 3*

TITLE *CONTAINMENT MAT LAYOUT OF DRAINAGE*

BY *BIBISI*	CHKD.	APP	APP
DATE *7-11-96*	DATE	DATE	DATE
SCALE *N.T.S.*	DWG. NO. *FIGURE 1.1-12*		
P.A.# ———			



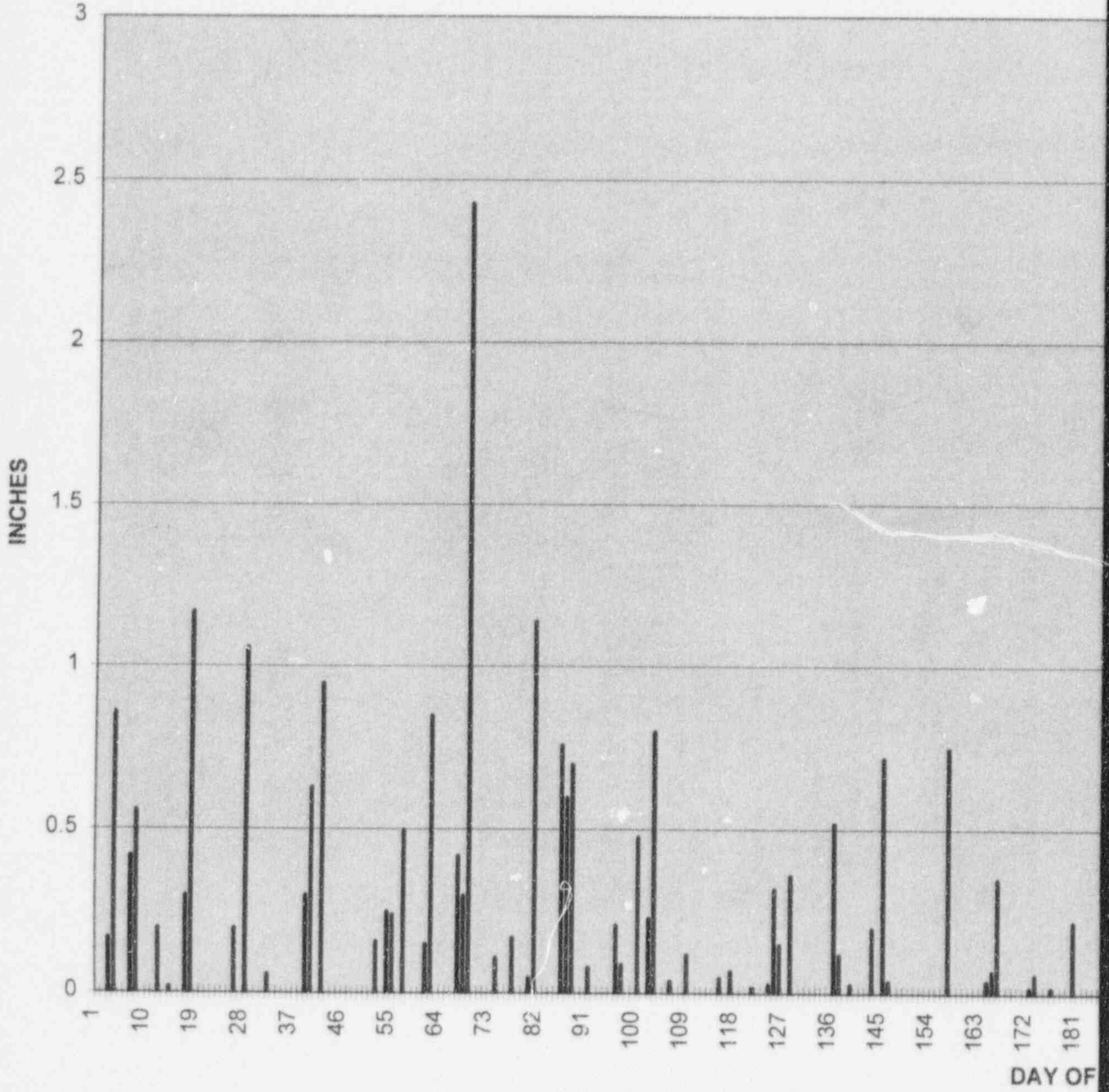
Northeast Utilities System

FOR MILLSTONE NUCLEAR POWER STATION UNIT 3

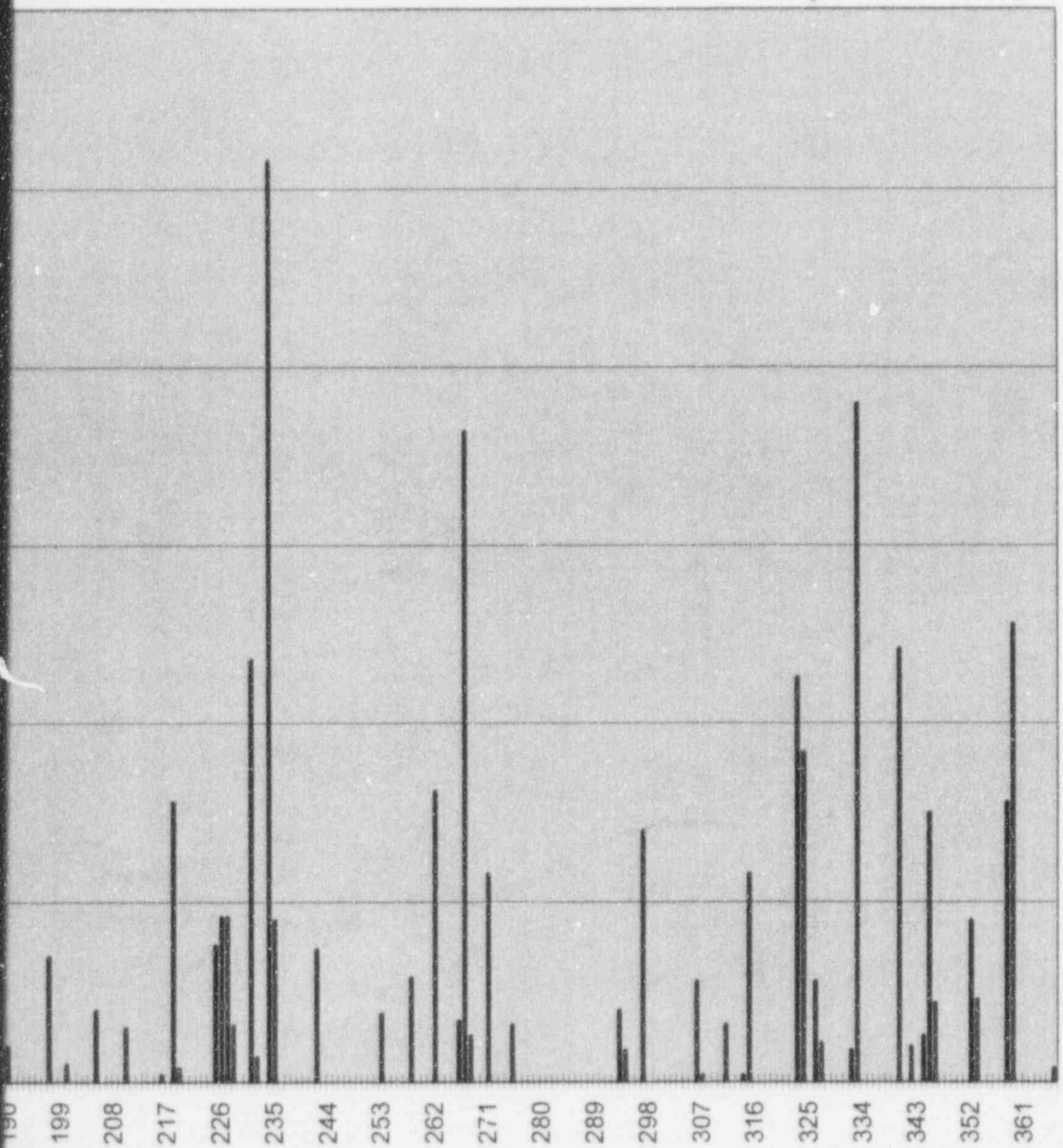
TITLE CONTAINMENT STRUCTURE PLAN VIEW

BY BIBISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE 1.2-1		
P.A.# ——			

FIGURE II.2-1 199



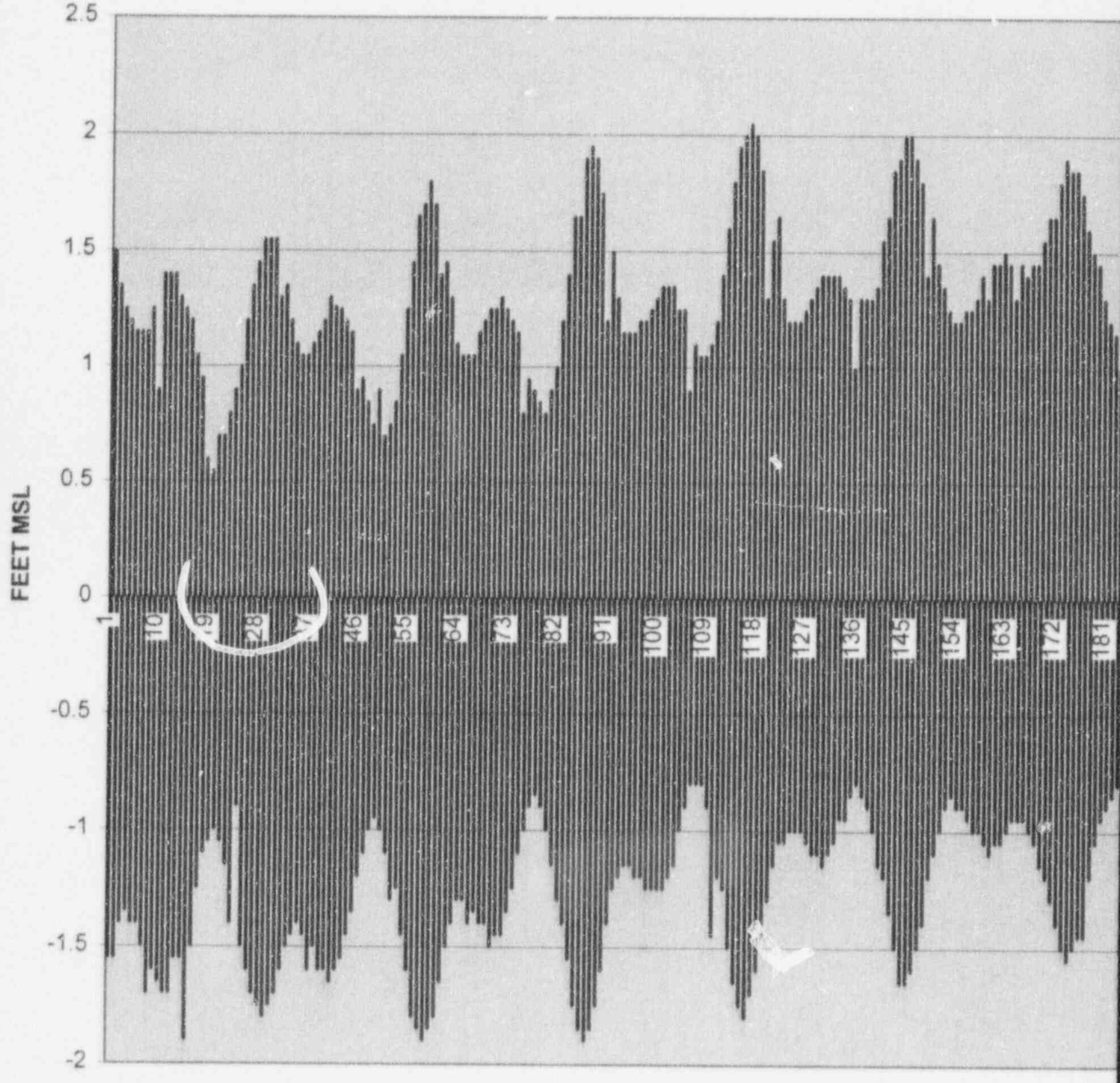
RAINFALL DATA



9607160140-01

City of Groton WTP Station 06-3207-3

FIGURE II.2-2 1



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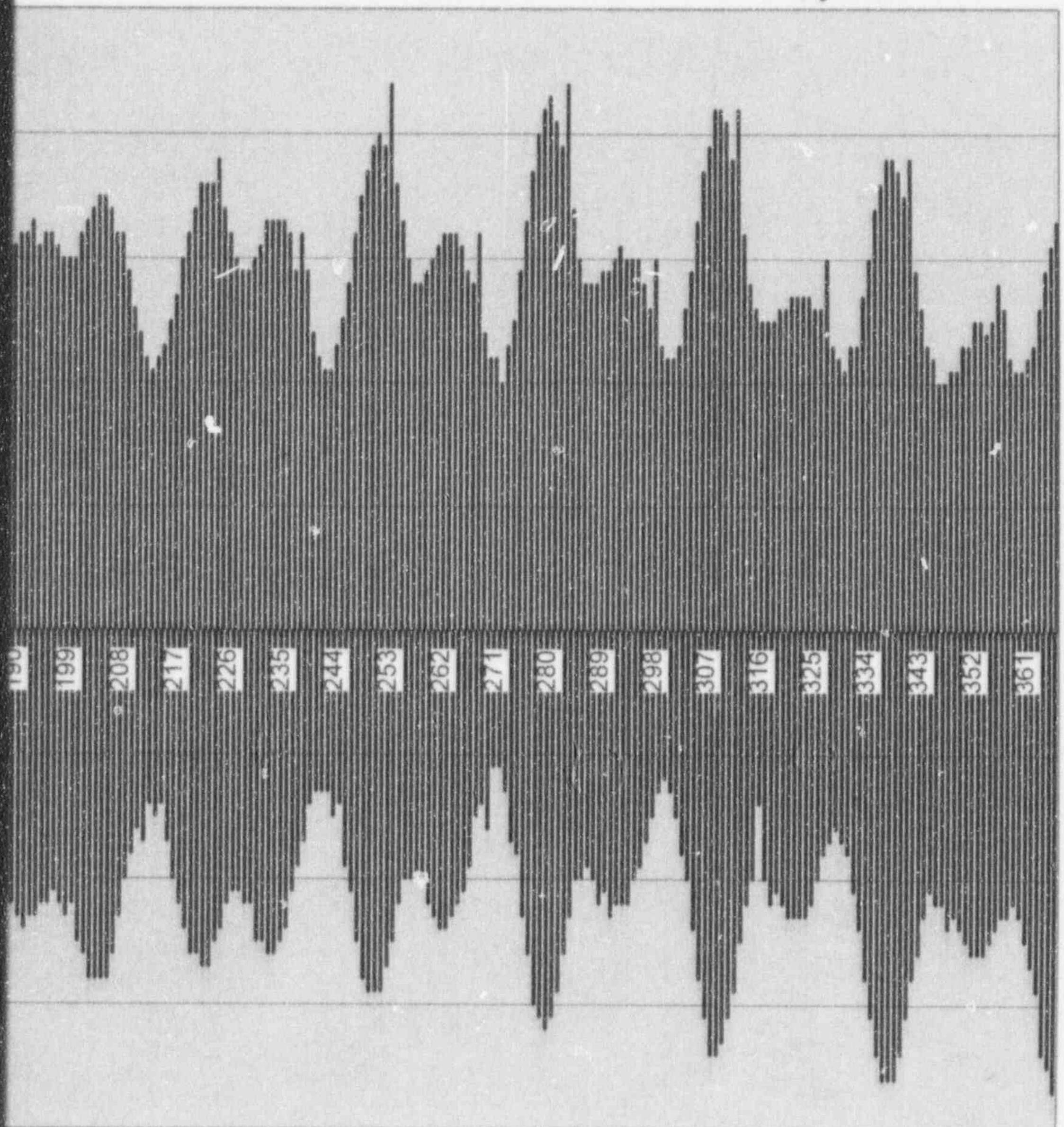
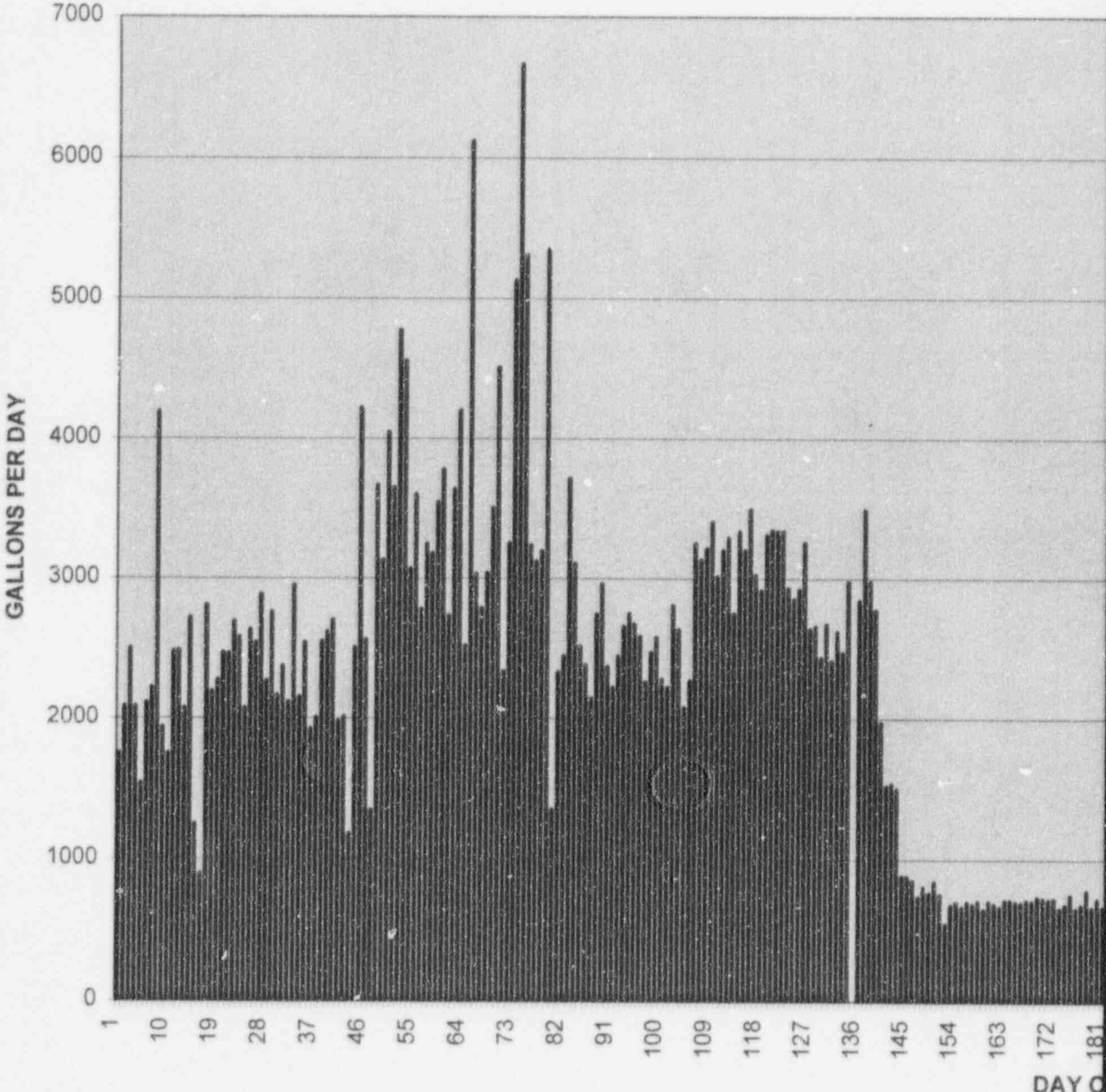


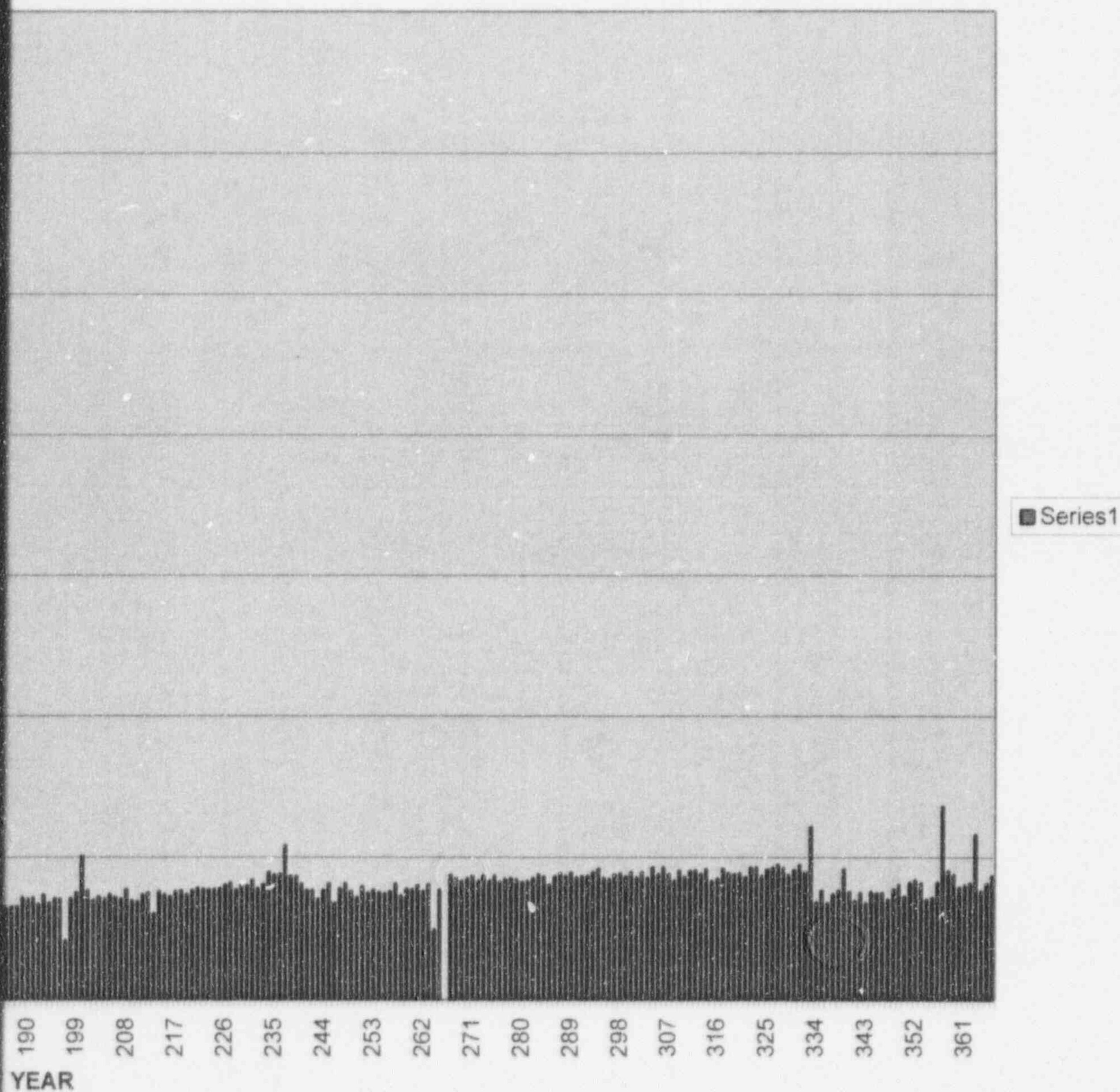
EAR

FIGURE II.2-3 1994 T



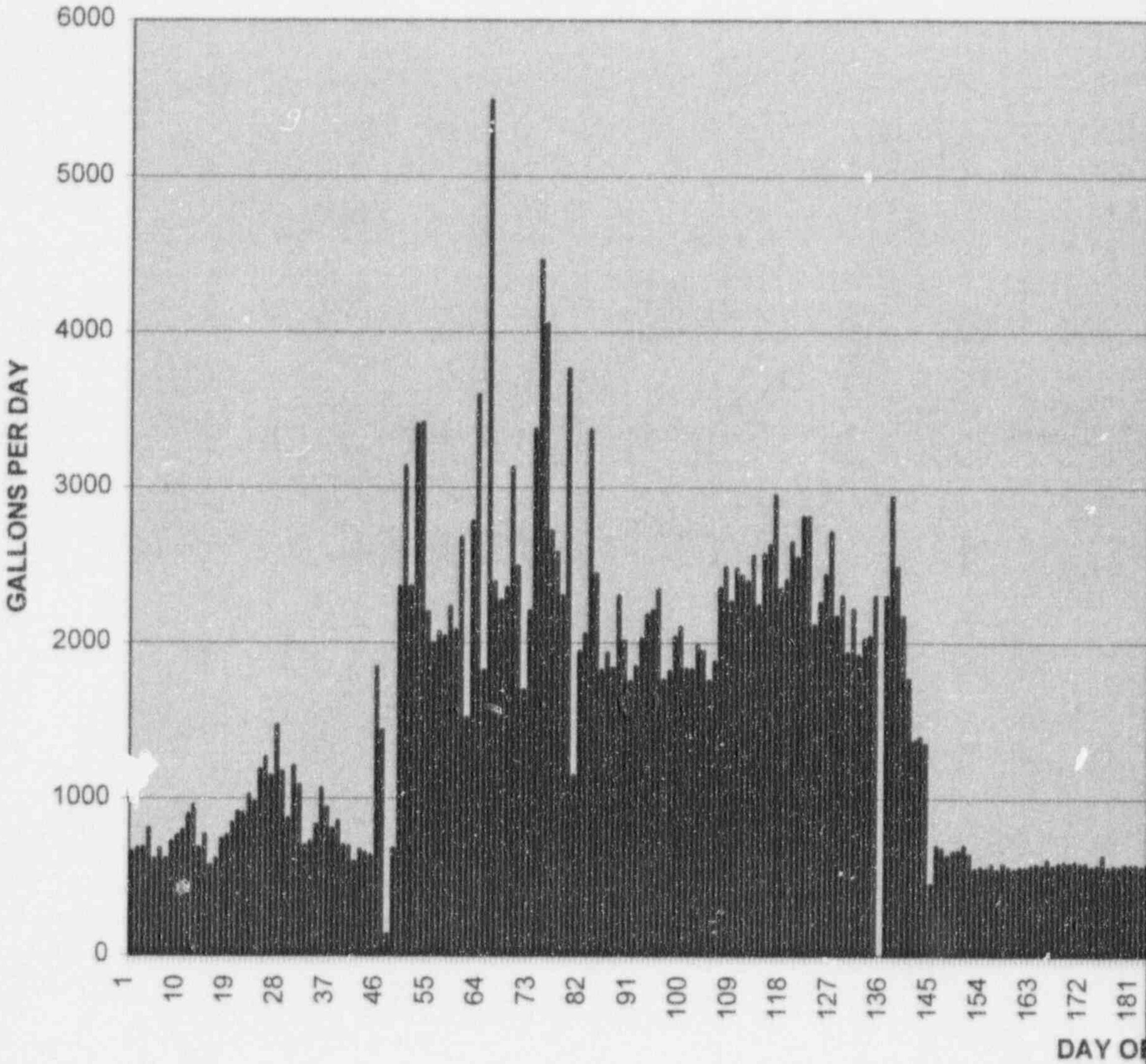
Notes: 1. No data availa

OTAL SUMP FLOWS



e on days 135 and 265. 2. There are minor contributers to sump flows which have not been excluded.

FIGURE II.2-4 1994 SU



ANSTEC
APERTURE
CARD

Also Available on
Aperture Card

MP FLOW 3DAS-P8A

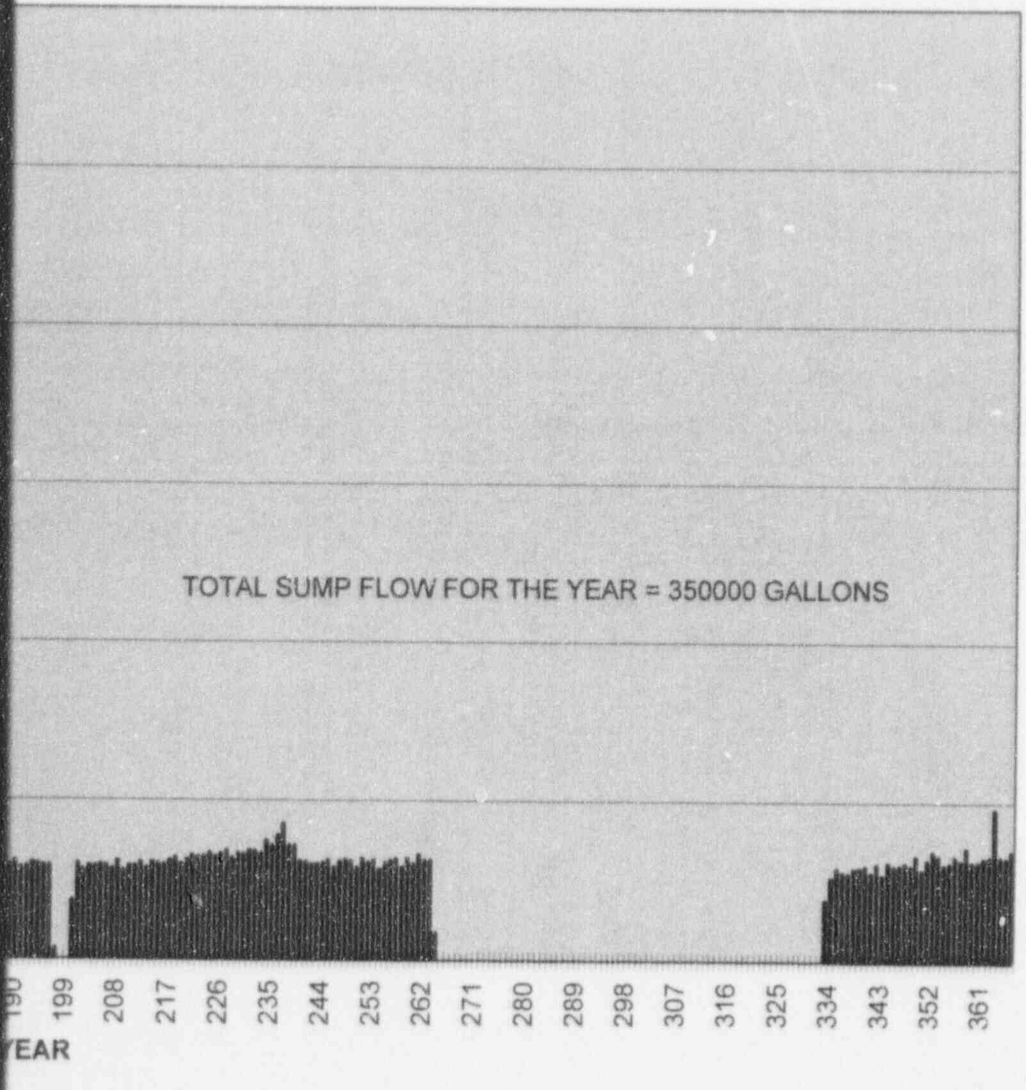


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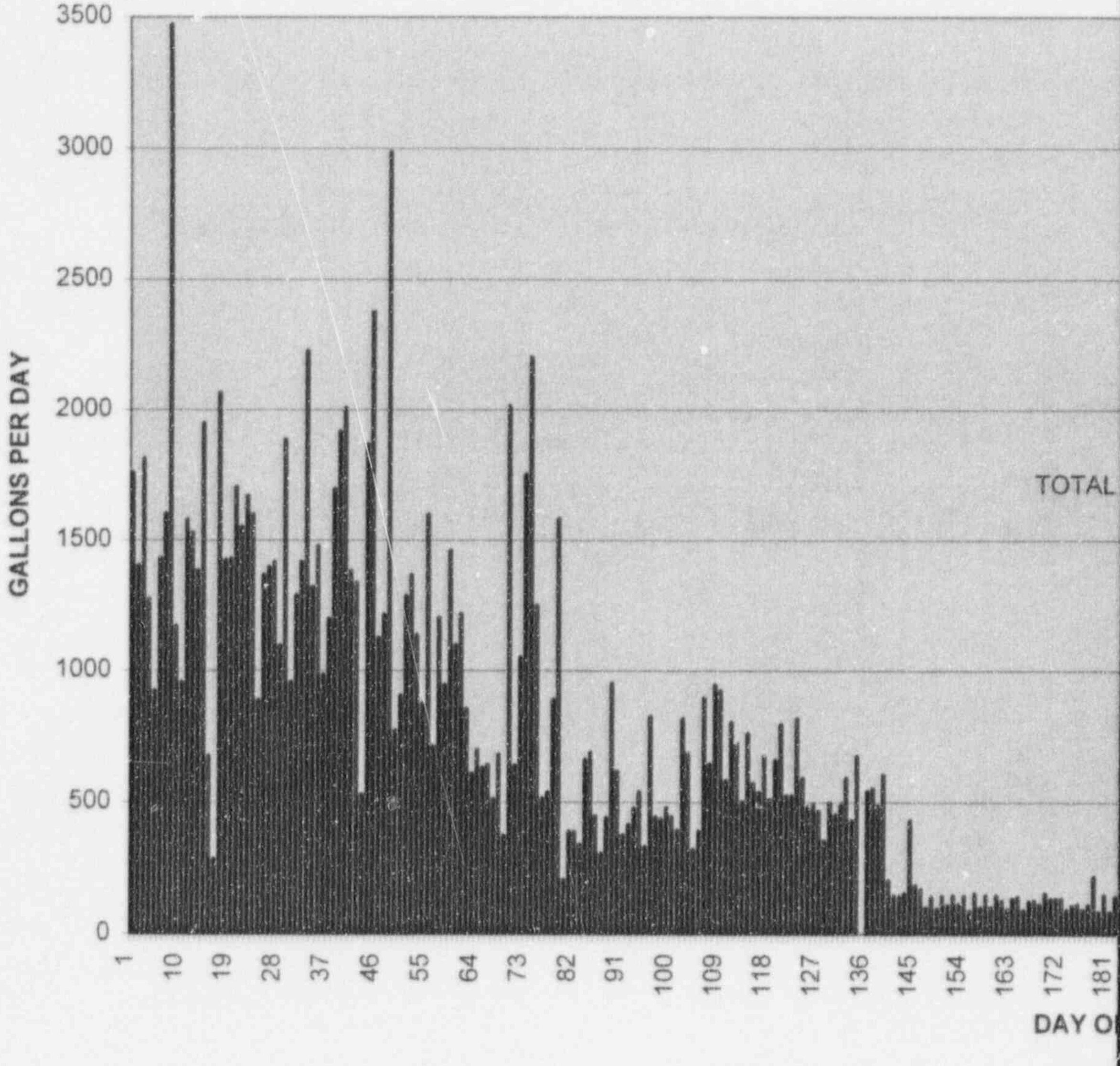
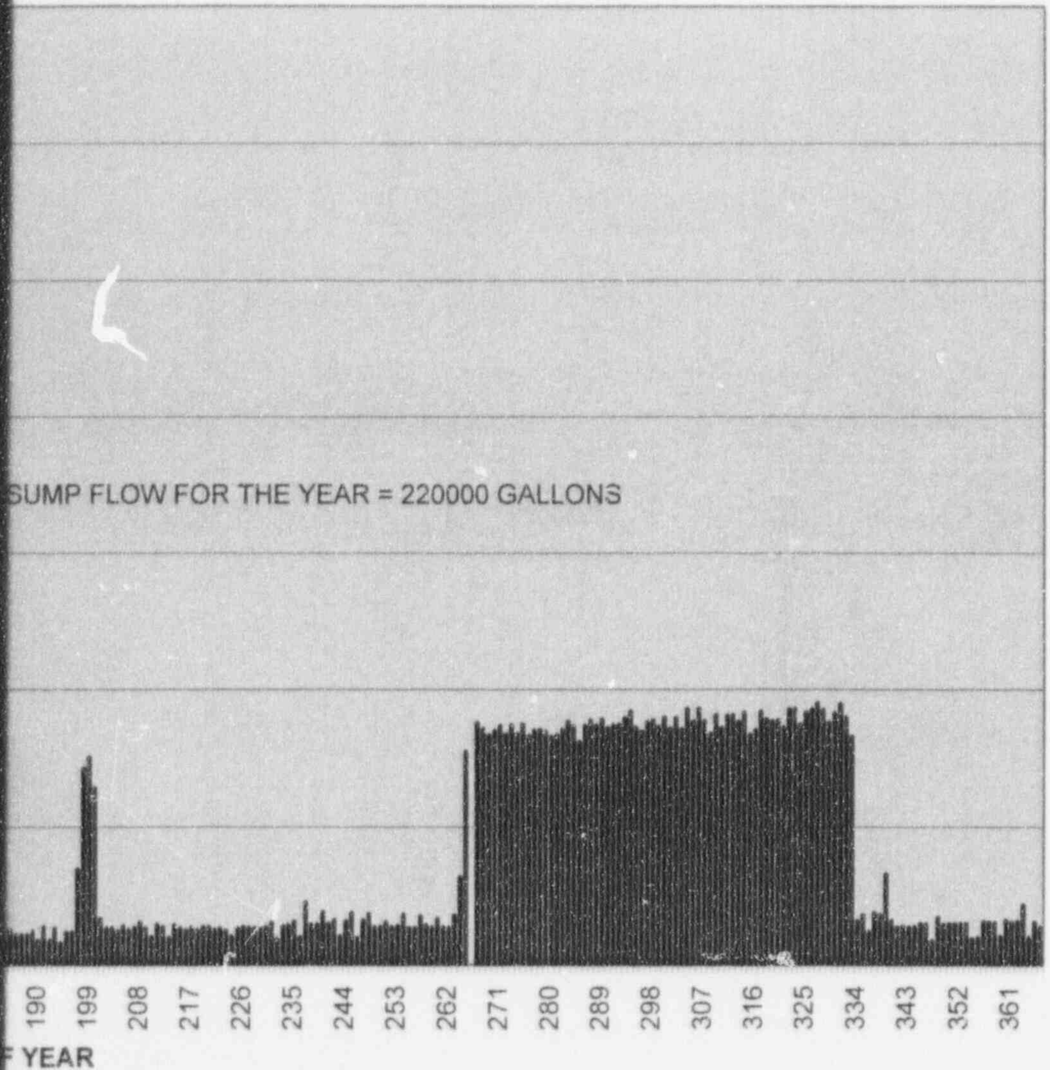
FIGURE II.2-5 1994 S



UMP FLOW 3DAS-P8B



9607160140-05

CONTAINMENT STRUCTURE DYNAMIC MODEL
SPRING CONSTANTS

Kx = 32 * (1-U) * G * R / (7-8 * U) ;	HORIZONTAL SPRING
Ky = 4 * G * R^3 / (1-U) ;	VERTICAL SPRING
Kr = (8/3) * (G * R^3 / (1-U)) ;	ROCKING SPRING
Kt = (16/3) * G * R^3 ;	TORSION SPRING

WHERE: G = SHEAR MODULUS
R = RADIUS
U = POISSON'S RATIO

REF: DESIGN PROCEDURES FOR DYNAMICALLY LOADED FOUNDATIONS, JOURAL OF SOIL MECHANICS & FOUNDATION DIVISION, ASCE NOV. 1967 BY R.V. WHITMAN, AND F.E. RICHART.

FOR MP3:

CONCRETE MAT RADIUS	R = 78'-6"
ROCK	G = 205714 ksf U = 0.4
Kx = 32*0.6*205714*78.5/(7-3.2) =	8.159E+07 k/ft
Ky = 4*205714*78.5/0.6 =	1.077E+08 k/ft
Kr = (8/3)*205714*78.5^3/0.6 =	4.423E+11 k/r
Kt = (16/3)*205714*78.5^3 =	5.307E+11 k/r

Northeast Utilities System

FOR MILLSTONE NUCLEAR POWER STATION UNIT 3

TITLE CONTAINMENT STRUCTURE DYNAMIC MODEL SPRING CONSTANT

BY BIBISI	CHKD.	APP.	APP.
DATE 7-11-96	DATE	DATE	DATE
SCALE N.T.S.	DWG. NO. FIGURE VII.1-1		
P.A.# ———			

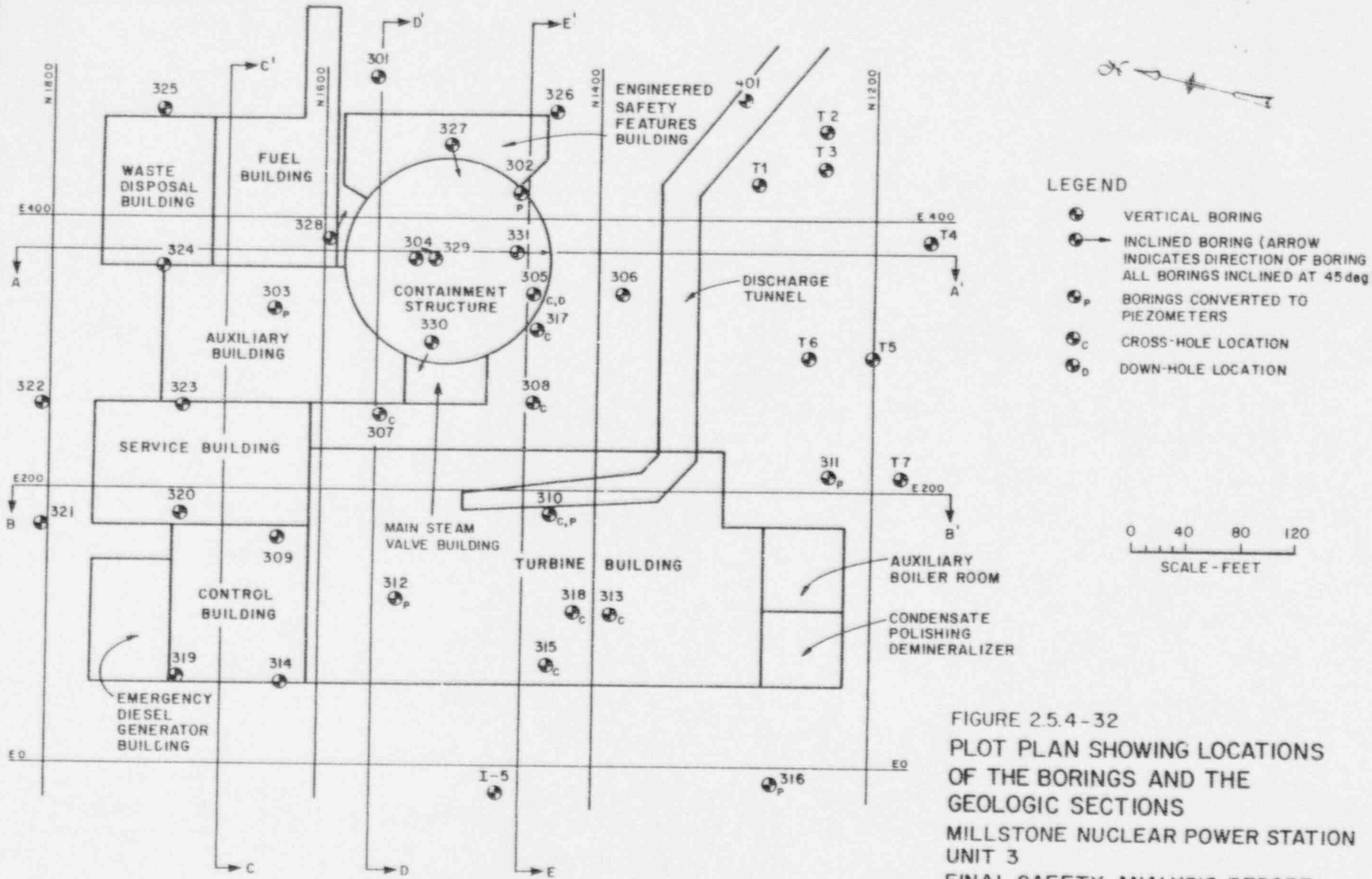


FIGURE 2.5.4-32

PLOT PLAN SHOWING LOCATIONS OF THE BORINGS AND THE GEOLOGIC SECTIONS

MILLSTONE NUCLEAR POWER STATION UNIT 3

FINAL SAFETY ANALYSIS REPORT

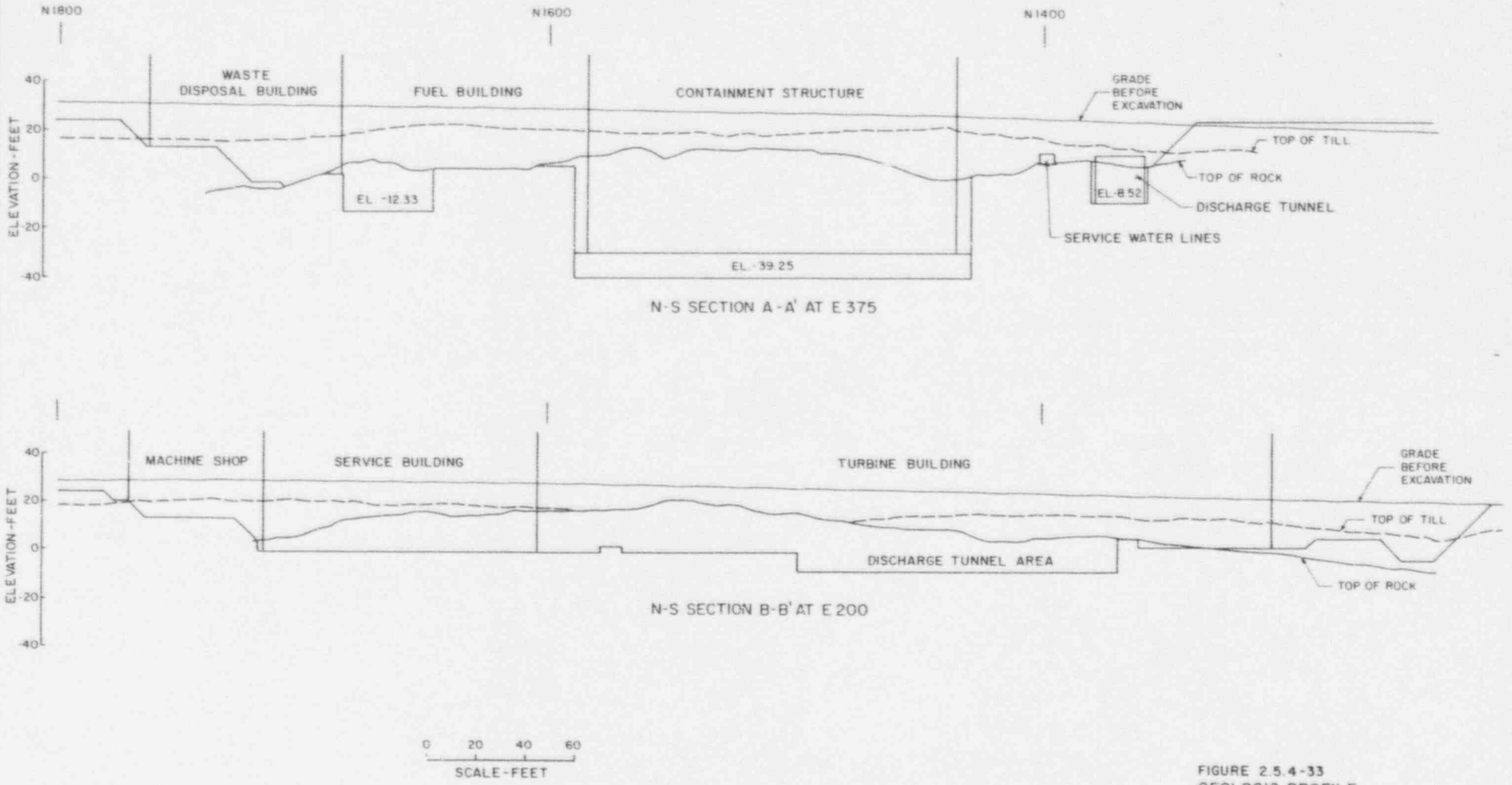


FIGURE 2.5.4-33
GEOLOGIC PROFILE
SECTIONS A-A' AND B-B'
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

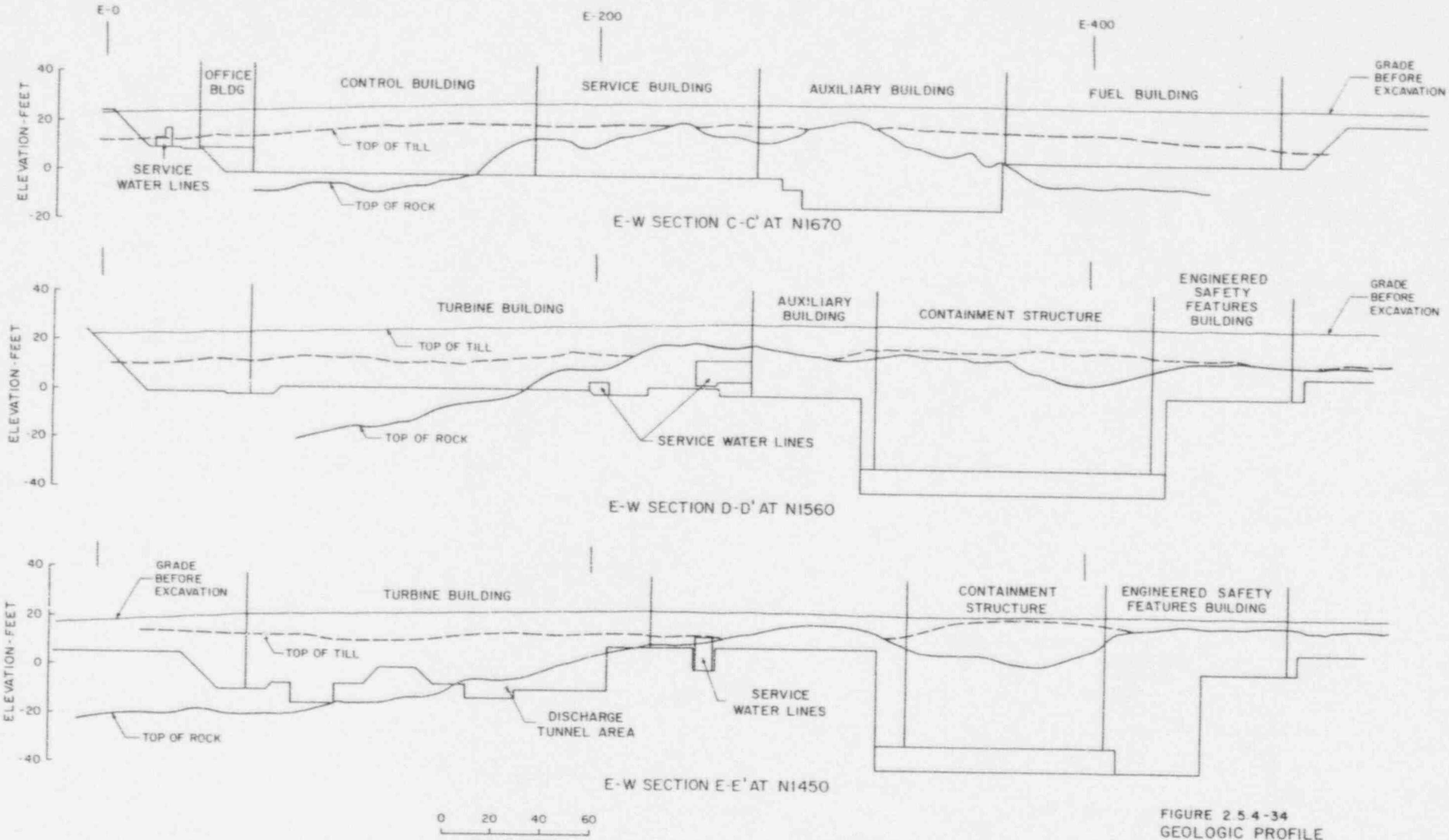
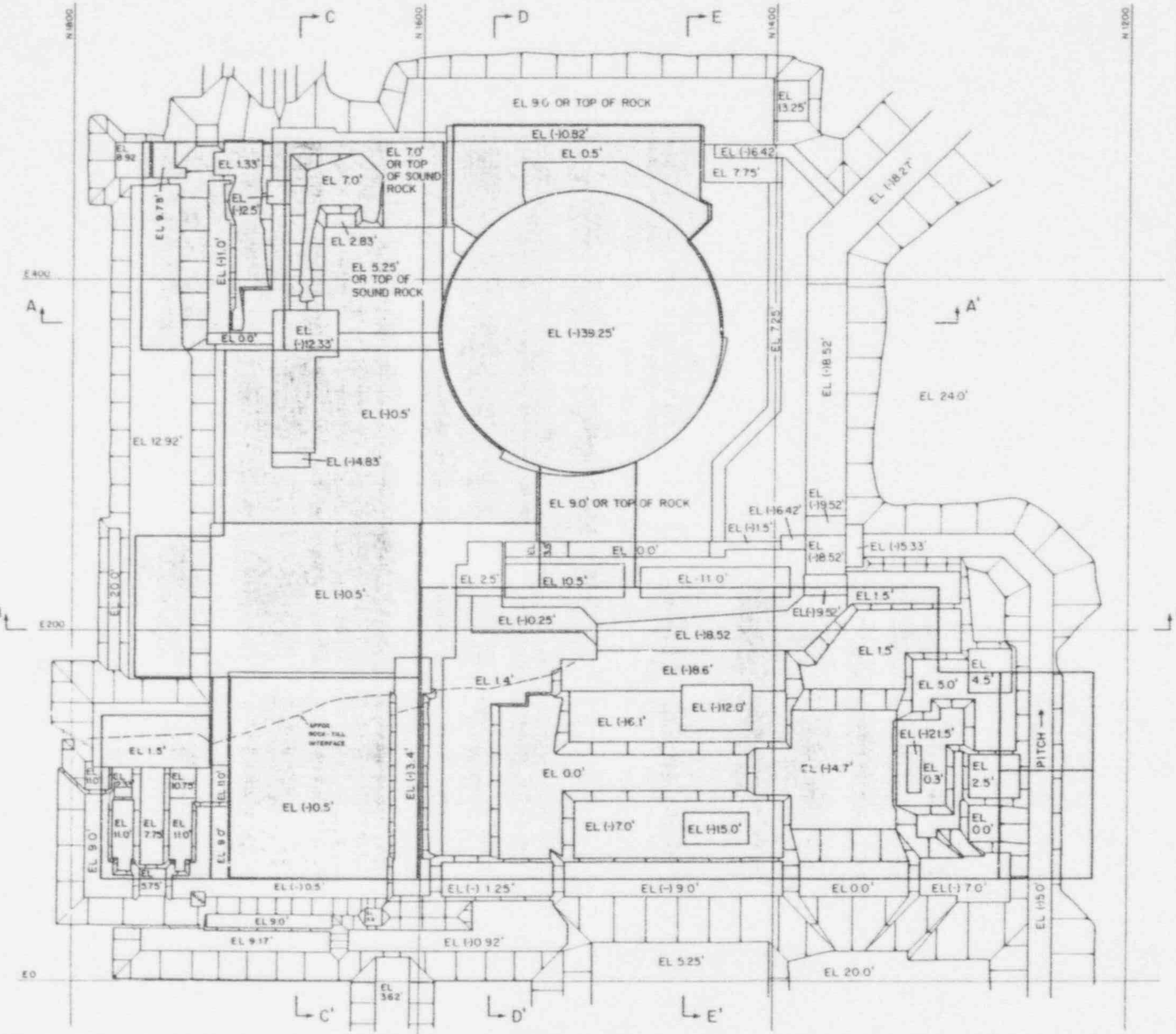
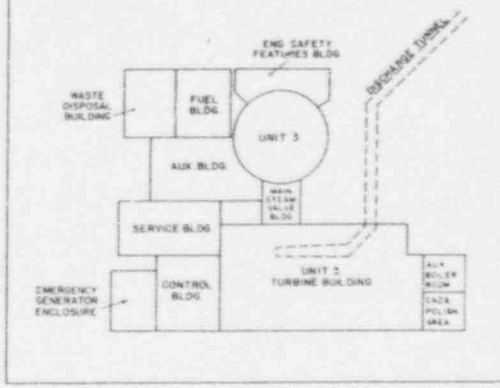


FIGURE 2.5.4-34
GEOLOGIC PROFILE
SECTIONS C-C', D-D', AND E-E'
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT





KEY MAP

NOTES

1. CONTOUR INTERVAL 2 FEET
2. FOR SECTIONS REFER TO FIGURES 2.5.4-33 & 34

FIGURE 2.5.4-40

GENERAL EXCAVATION PLAN

MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

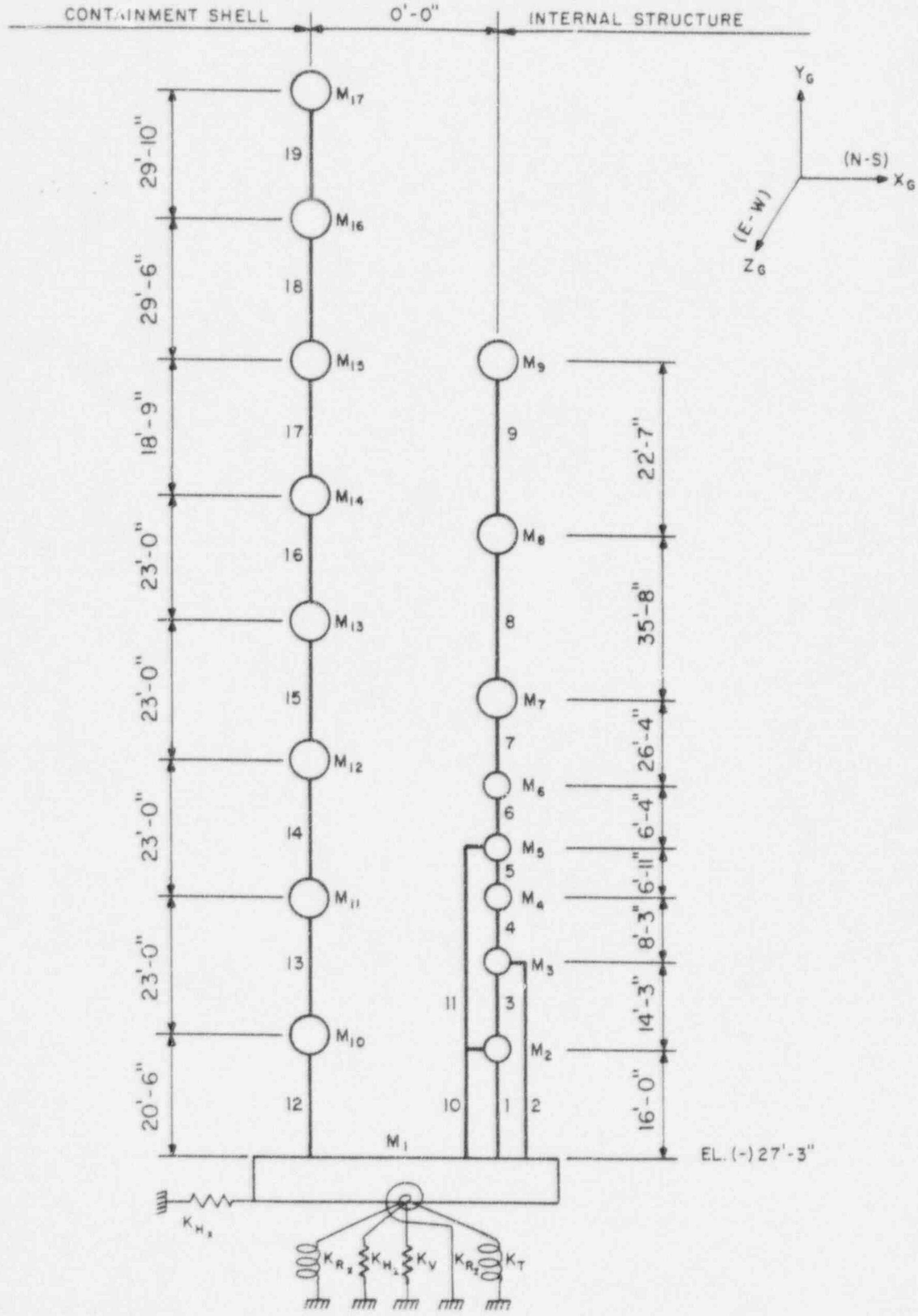


FIGURE 3.7B-9
DYNAMIC MODEL OF
THE CONTAINMENT STRUCTURE
MILLSTONE NUCLEAR POWER STATION
UNIT 3
FINAL SAFETY ANALYSIS REPORT

K_H, K_V, K_R, K_T =
HORIZONTAL, VERTICAL, ROCKING AND
TORSIONAL SUBGRADE SPRINGS

ATTACHMENT 2

1991 CHEMICAL ANALYSIS of SUMP RESIDUE

NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

MEMO

September 19, 1991
MCE-CM-91-099

TO: G. Swider
MP3 Engineering

FROM: R. Y. Schonenberg
Chemistry & Materials
Berlin, W138 (Ext. 5364)

SUBJECT: PA 86-261, ANALYSIS OF DEBRIS FOUND IN MP3 ESF SUMPS

Per your request a sample of the debris found in the ESF sumps has been analyzed. Because the sample was mildly radioactive the actual laboratory work was done by ABB-CE.

When dried the sample was a homogeneous grayish-white granular material. Two types of analysis were done. First, x-ray fluorescence was done to identify what elements were present and then x-ray diffraction was done to identify how these elements are arranged, i.e. what compounds were present. Second a portion of the sample was tested on a CILAS Granulometre to determine the particle size distribution. Tables 1 and 2 summarize the results of the x-ray fluorescence and x-ray diffraction respectively. Table 3 summarizes the requirements for the two different types of cement suggested as possible sources for the debris. Table 4 summarizes the size distribution of the particles.

The x-ray fluorescence results show that only three elements had significant concentrations; calcium, carbon, and magnesium. The x-ray diffraction results shown that the sample was mostly calcite, $CaCO3$, with a trace of iron oxide sulfate hydroxide (green rust). Comparing these results with the requirements of the concretes listed in Table 3 leads to the conclusion that the debris is coming from the ASTM C114 type cement. This conclusion is based upon:

1) concretes are the only source of calcium in this area.

2) CaO found in ASTM C114, is soluble in water at ambient temperatures. Ca_3Al is insoluble in water.

3) the debris has a trace amount of iron oxide in it.

It is felt that the debris is being generated by water flowing over or through the concrete. Rain water is slightly acidic, pE 5-6, which would help to leach material from the concrete. Concrete is made of complex silicates, aluminates and ferrates of calcium. The fact that the calcium was not found as a silicate, etc. is not important since the leaching could have changed the way the calcium was complexed as could the drying of the debris.

CM2.42 jec

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The chain of events described above can be tested by immersing a small sample of each type of concrete in water, allowing some leaching to occur and then analyzing the contents of the water. Since this water won't be radioactive this analysis would be straight forward.

Analysis of the particle size distribution shows that a 50 micron filter will catch about 85% of the debris by weight. Reducing this to a 25 micron filter would catch about 95% by weight of the debris. The smaller the size of the filter the more frequently it will need to be changed.

Please call if you wish to pursue the test described above or if there are any questions.

RYS:jec

attachments

cc: W. J. Briggs
M. D. Hess (MP3)
K. Lakshmipathiah

Route: J. W. Klisiewicz
M. Kupinski

ABB
ASEA BROWN BOVERI

August 2, 1991
MCC-91-357

Mr. Bob Schonenberg
Northeast Utilities Service Company
P. O. Box 270
Hartford, CT 06141-0270

Subject: Analyses Results of Cement Samples.

References:

1. NU Purchase Order #005658
2. Combustion Engineering, Inc., Kreisinger Development Laboratory (KDL) Procedure No. 0104-88.
3. Combustion Engineering, Inc., KDL Procedure No. 0105-80.
4. Combustion Engineering, Inc., KDL Procedure No. 86-49.
5. A. L. Tyler to M. L. Fortier, "KDL X-Ray Laboratory Report: Northeast Utilities, Millstone-3 Residue from Sump", Combustion Engineering, Inc., KDL Report No. ALT09691, July 29, 1991.
6. Bateman, A. M., "Economic Mineral Deposits", Second Edition, John Wiley & Sons, Inc., 1950.
7. K. W. Johnson to M. L. Fortier, "Physical Properties of Cement Sample from Sump", Combustion Engineering, Inc., KDL Report No. 11512-M, July 17, 1991.

Dear Mr. Schonenberg:

A cement sample collected from the sump floor at Millstone Unit 3 was submitted to ABB's Windsor laboratories for chemical analysis and physical characterization (1). The purpose of the analysis was to identify the type of cement and to obtain a statistical particle size distribution of the cement particles.

Tables 1 and 2 present ASTM compositional specifications for the two types of Portland cement suggested by NUSCO as possibly representative of the sump sample composition.

Table 1
Cement Type 1

Compound	Weight %
Silicon Dioxide (SiO_2)	20.0 (min)
Aluminum Oxide (Al_2O_3)	6.0 (max)
Ferric Oxide (Fe_2O_3)	6.0 (max)
Magnesium Oxide (MgO)	6.0 (max)
Sulfur Trioxide (SO_3)	3.0 (max)
Loss on Ignition	3.0 (max)
Insoluble Residue	0.75 (max)
Tricalcium Aluminate (Ca_3Al)	8.0 (max)

ABB Combustion Engineering Nuclear Power

Combustion Engineering, Inc.
1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500
Telephone (203) 688-1911
Fax (203) 285-9512
Telex 99297 COMBEN WSOR

2

Table 2
Cement Type 2

Compound	Weight %
$Al_2O_3 + TiO_2$	42.0 (min)
CaO	38.0 (max)
SiO_2	10.0 (max)
Fe_2O_3	18.0 (max)

An initial inspection of the cement sample showed it to be a dry greyish-white granular material with a homogeneous morphology, consisting of mixed sized particles. As such, only one specimen from the sample was analyzed.

Two x-ray samples were prepared from the bulk cement sample and were submitted for both x-ray fluorescence and x-ray diffraction analysis. Both samples were prepared by collecting the powdered mass on a filter paper resulting in a thin, uniform, adherent sample. The samples were mounted on a lucite base and covered with an ultra thin mylar sheet. The prepared samples were then submitted for x-ray analysis.

The cement specimen was analyzed in compliance with the referenced procedures and using the following analysis techniques:

- Semi-quantitative X-Ray Fluorescence Spectrometry (XRF) for elemental composition and relative abundance (2). Analyses were performed using the Siemens SRS 200 X-Ray Fluorescence Spectrometer equipped with automated control and data acquisition systems. Counts were obtained for elements having atomic numbers greater than 10. A clean Millipore type HA filter paper was used as a blank reference for background correction on sample count rates.

- Qualitative X-Ray Diffraction (XRD) for compound identification (3). Analyses were performed using the Siemens D-500 Diffractometer with data evaluation system. The computerized powder diffraction file search system provided the best match compounds within the constraints imposed by input data and indicated relative amounts of those compounds present. This technique provides for the identification of major polycrystalline phases only. Amorphous, colloidal and microcrystalline phases are not distinguished using XRD.

- CILAS Granulometre to determine the statistical particle size distribution of the sump sample (4). A Granulometre Model 715 Particle Size Analyzer was used to perform the analysis. The instrument measures the intensity of diffracted light and the data is processed to produce a sixteen point particle size distribution.

X-Ray Fluorescence spectrometry was performed on the two x-ray samples that were prepared from the sump sample to identify and determine the relative proportions of the elements present. Results (5) for both samples are presented in Table 3. The weight percentage calculations are based on normalized elemental and assumed oxide concentrations. For both samples, the results are semi-quantitative.

Table 1

X-ray Fluorescence Results[1]

Compound	Sample 1	Sample 2
Fe_2O_3	<1.0	<1.0
CuO	<1.0	<1.0
NiO	<1.0	<1.0
ZnO	<1.0	<1.0
MnO	<1.0	<1.0
Cr_2O_3	<1.0	<1.0
MoO_3	<1.0	<1.0
TiO_2	<1.0	<1.0
PbO	<1.0	<1.0
SiO_2	<1.0	<1.0
Al_2O_3	<1.0	<1.0
P_2O_5	<1.0	<1.0
SO_3	<1.0	<1.0
Cl	<1.0	<1.0
K_2O	<1.0	<1.0
CaO	54.0	54.0
Na_2O	<2.0	<2.0
MgO	2.0	2.0
CO_2	44.0	44.0

Note 1 - all numbers are weight %

Table 2

X-Ray Diffraction Results

Sample	Calcite	Iron Oxide
1	major	trace
2	major	trace

Table 3

Composition of Concretes[1]

Compound	ASTM C114	ASTM C150 Type II
SiO_2	10.0 max.	20.0 min.
Al_2O_3		6.0 max.
Fe_2O_3	18.0 max.	6.0 max.
MgO		6.0 max.
SO_3		3.0 max.
Ca_3Al		8.0 max.
CaO	38.0 max.	
Al_2O_3+TiO_2	42.0 min.	

Note 1 - all numbers is weight %

Table 4

Cilas Granulometre Results

Particle Size (microns)	Weight % of Sample
<1.0	.15
<1.5	.30
<2.0	.95
<3.0	1.40
<4.0	1.40
<6.0	1.40
<8.0	2.05
<12.0	2.45
<16.0	3.95
<24.0	3.95
<32.0	6.75
<48.0	13.95
<64.0	19.55
<96.0	38.80
<128.0	84.65
>128.0	15.35

Table 3
X-Ray Fluorescence Results

Compound	Weight Percent Sample 1	Weight Percent Sample 2
Fe_2O_3	< 1.0	< 1.0
CuO	< 1.0	< 1.0
NiO	< 1.0	< 1.0
ZnO	< 1.0	< 1.0
MnO	< 1.0	< 1.0
Cr_2O_3	< 1.0	< 1.0
MoO_3	< 1.0	< 1.0
TiO_2	< 1.0	< 1.0
PbO	< 1.0	< 1.0
SiO_2	< 1.0	< 1.0
Al_2O_3	< 1.0	< 1.0
P_2O_5	< 1.0	< 1.0
SO_3	< 1.0	< 1.0
Cl	< 1.0	< 1.0
K_2O	< 1.0	< 1.0
CaO	54.0 ✓	54.0
Na_2O	< 2.0 ✓	< 2.0
MgO	2.0 ✓	2.0
CO_2	44.0 ✓	44.0

Analysis results indicated that the major constituent in both samples was calcium (54% expressed as the assumed oxide) and carbon (44% expressed as the assumed oxide). Magnesium was the only other element present at levels above the detection limit of the equipment. Several other species were detected in trace quantities.

X-Ray Diffraction scans were performed on both of the submitted x-ray samples and the findings are summarized in Table 4. Analysis results (5) are illustrated in the diffraction scans shown in Figures 1 and 2. Evaluation of the diffraction data reveals that both samples contain calcite, with trace amounts of iron oxide sulfate hydroxide (green rust), or a similar phase.

Table 4
X-Ray Diffraction Results

Sample	$CaCO_3$ Calcite	$Fe_3 \cdot 6FeO \cdot 9(O, OH, SO_4)_9$ Iron Oxide Sulfate Hydroxide
1	Major	Trace
2	Major	Trace

Portland cement is made by calcining a finely ground mixture of about 75% calcium carbonate, 25% clay like minerals (silica, alumina, and hematite), and 5% magnesia (6). The calcining releases carbon dioxide, and the remaining constituents combine to form complex silicates, aluminates, and ferrates of

calcium, which in turn break down to form other compounds. Tricalcium and dicalcium silicate and tricalcium aluminate are the chief constituents in a Portland cement.

The XRF results show that there only trace quantities of aluminum and silicon present and large quantities of calcium in the sample. XRD results show that the major polycrystaline phase is calcium carbonate with no evidence of calcium complexes. Based on these results, the sample submitted to ABB was concluded to be neither of the two types of Portland cement suggested. The x-ray results even challenge the claim that the sample is a Portland cement.

<u>CILAS Granulometre Analysis</u> was used to determine the particle size distribution of the sample. The sump sample was placed in the Cilas granulometre and the analysis was performed even though a small percentage of the particles were known to be larger than 180 microns. The results (<u>7</u>) from the granulometre analysis are presented in Table 5. The data were converted into graphical form and is presented in Figure 3 for the Millstone-3 sump cement sample.

The granulometre results show that most of the sample has particle sizes larger than 96.0 microns, but 84.65% of the sample has particle sizes smaller than 128.0 microns. Only 15.35% of the sample however has particle sizes larger than 128.0 microns. Most of the sample was found to have particle sizes between 96.0 and 128 microns.

Table 5.
Cilas Granulometre Results

Particle Size (microns)	Weight % of Sample
< 1.0	0.15
< 1.5	0.30
< 2.0	0.95
< 3.0	1.40
< 4.0	1.40
< 6.0	1.40
< 8.0	2.05
< 12.0	2.45
< 16.0	3.95
< 24.0	3.95
< 32.0	6.75
< 48.0	13.95
< 64.0	19.55
< 96.0	38.80
<128.0	84.65
>128.0	15.35

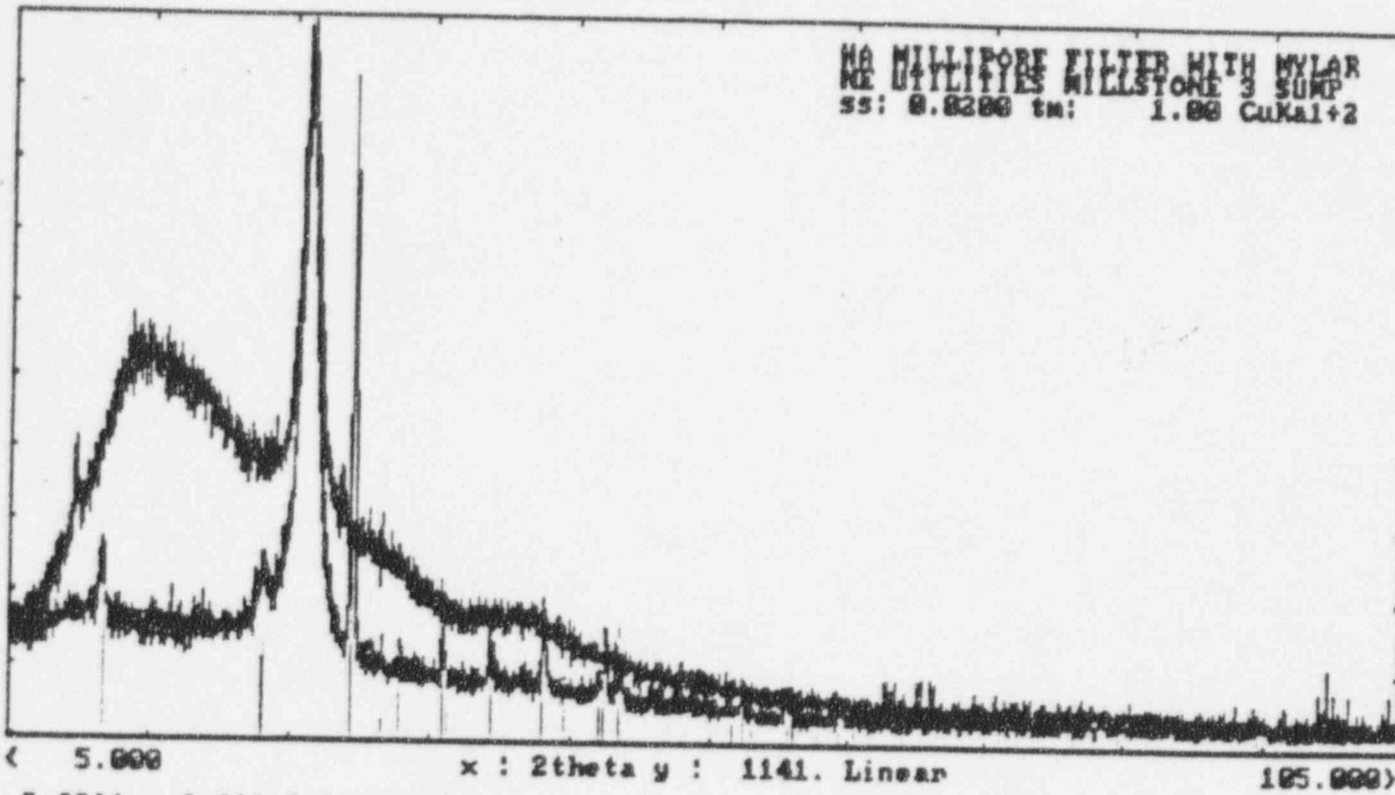
If you have any question or comments concerning these results, please feel free to contact me at your convenience. My telephone number is (203) 285-3863.

P.E. House

PEH/peh

P. E. House

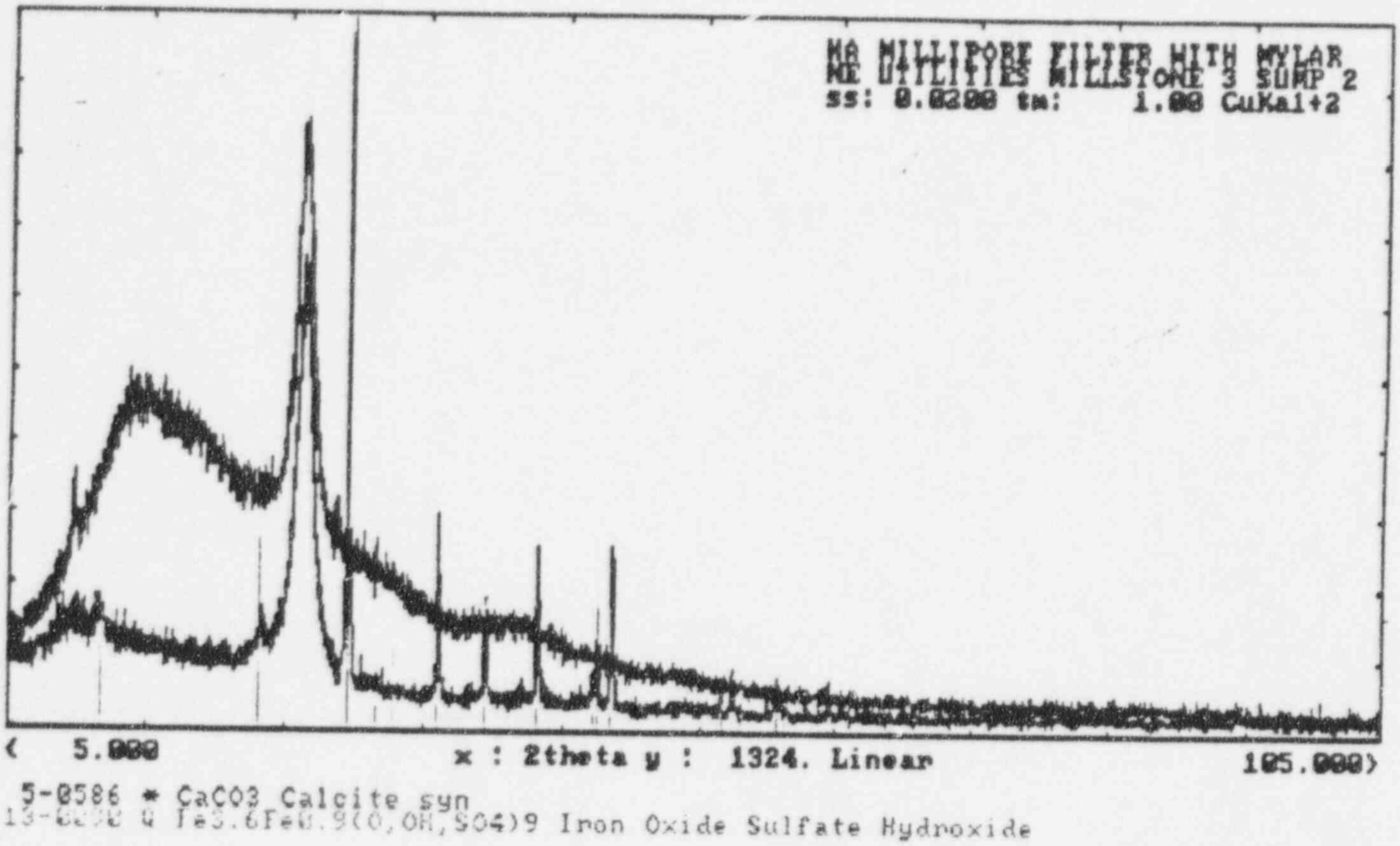
Figure 1. X-Ray Diffraction Study
Millstone-3 Sump Sample 1



5-0586 * $CaCO_3$ Calcite syn
$Fe_{3.6}Fe_{0.9}(O,OH,SO_4)_9$ Iron Oxide Sulfate Hydroxide

?help Zoom Match File Clear Back. Null K a2 Peaks Smoo. Comp. Wfile -> M

Figure 2. X-Ray Diffraction Study
Millstone 3 Sump Sample 2



?help Zoom Match File Clear Back. Null K a2 Peaks Smoo. Comp. Wfile -> M

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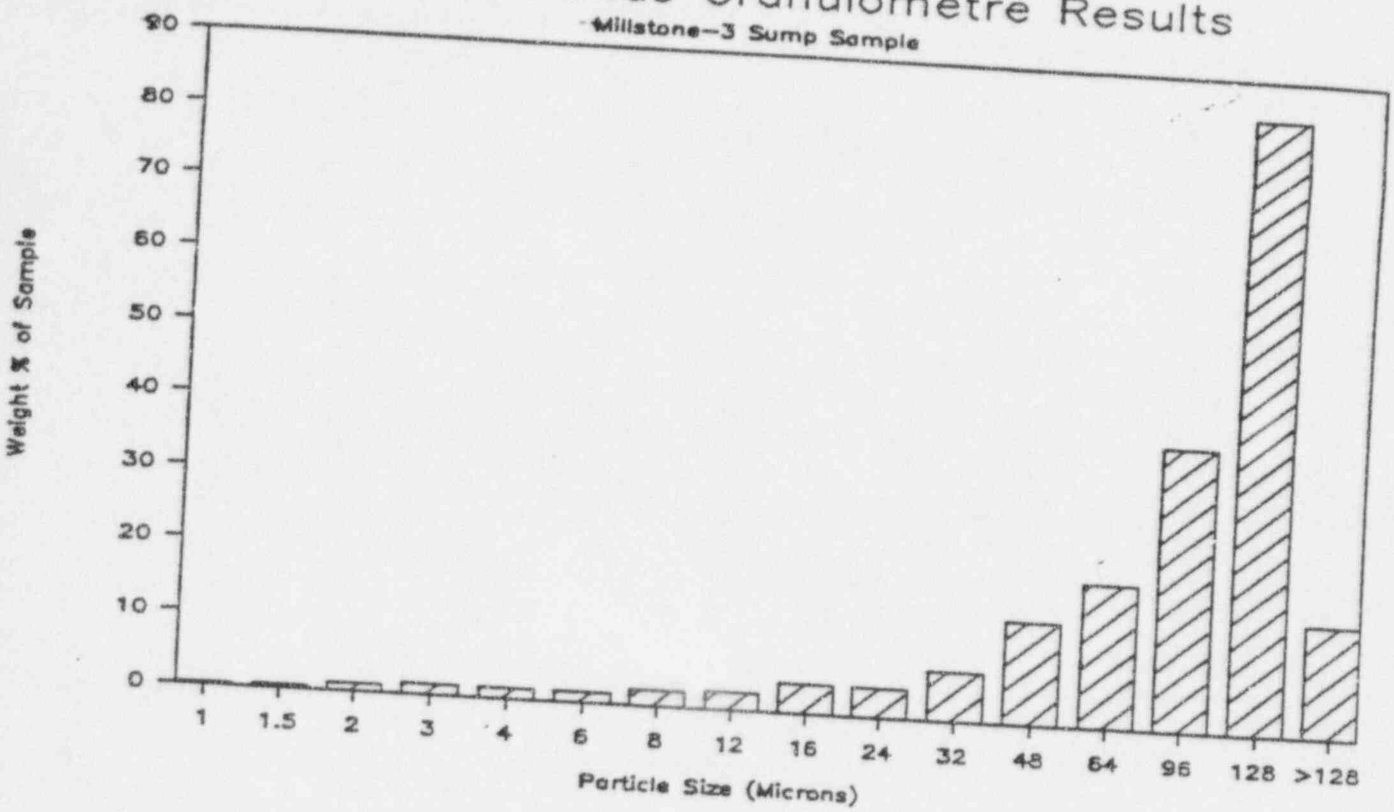
Figure 3. Cilas Granulometre Results



Docket No. 50-423
B15803

ATTACHMENT 3

1996 CHEMICAL ANALYSIS
of
SUMP RESIDUE and WATER

ABB

Mr. David Dakers
Northeast Nuclear Energy Co.
Millstone-3 Station
P. O. Box 128
Waterford, CT 06385

July 9, 1996
PENG-96-370

Subject: Analysis Results of Millstone-3 Containment Sump and Mockup Samples

Reference: 1) Verbal Request, D. Dakers (MP-3) to S. Lurie (ABB CE) June 29, 1996

2) "Analyses Results of Cement Samples", P. House (ABB CE) to B. Schonenberg (NUSCO), ABB CE letter report MCC-91-357, dated August 2, 1991

Dear Mr. Dakers:

Based on your verbal request on June 29, 1996 and subsequent telephone discussions, ABB CE is pleased to report the analysis results of samples removed from the Millstone-3 containment sump and Unit-3 mockup samples. This report provides the analysis results of these samples, analyzed for elemental content by inductively coupled plasma (ICP) spectroscopy, x-ray fluorescence (XRF), ion chromatography and particle size analysis. The report describes the analysis methods used, the analysis results and a brief discussion of results. Details of the particle size analyses are also included as an appendix to this report.

Background

On June 29, 1996, ABB CE was contacted with a request to perform chemical analyses of material obtained from the Millstone Unit 3 containment sump. Reference was made to work performed by ABB CE in 1991 (Reference 2) in which analyses were performed to compare residue removed from Millstone Unit 3 containment sump to the types of cement used beneath the Unit 3 containment. The request for analysis work on June 29, 1996 was to perform a similar type of analysis on containment samples recently obtained.

The samples requested to be analyzed arrived at ABB CE's Windsor Site approximately 5:00 p.m. on June 29, 1996 and were receipt inspected by ABB CE's health physics department. Following the receipt inspection and surveys, the samples were turned over to the Combustion Engineering Nuclear Operations (CENO) laboratories for analyses.

Samples Received

ABB CE received samples from Millstone-3 identified as follows:

Sample	Sample Description	Condition on Receipt
1	A&C Sump 7A-34	liquid
2	B&D Sump 7B-34	liquid
3	Pump Side Sump 7A O/S Wier	wet solid
4	Ground Water Side Sump 7A I/S Wier	wet solid
5	Sump 7B taken from drum	wet solid
6	Basement Mockup Sample from U3	dry solid

ICP Analyses

Samples 1 through 6 were analyzed for cation elemental content using a Fisons ARL 3560 AES Inductively Coupled Plasma Spectrometer. The wet samples were first divided, by approximate volume into two vials for the direct solids analyses by acid digestion (0.1g sample size) and the second for DI water leach (1.0g sample size). The samples were then dehydrated by microwave evaporation during the early evening of June 29, 1996. Dryness criteria was established by obtaining two successive sample weights in close agreement. Following dehydration, the samples for direct solids analysis were digested in a mixture of ultrapure HNO_3, H_2O_2 and HCl using EPA Method 3050, Acid Digestion of Sediments, Sludge, and Solids. The water leach samples were prepared by exposing known weights of material to a known mass of demineralized water and analyzing the water phase. The liquid samples were analyzed, as received.

The analysis results of the solid and water leach samples are provided in Tables 1 and 2.

TABLE 1
ICP RESULTS
ACID DIGESTED SAMPLES (ppm)

Sample	Description	Ba	Mg	Al	Ca	Zn	Cu
3	Sump 7A O/S Wier	15.5	128.9	65954.9	263996.0	28.2	241.6
6	Basement Mockup	7.6	118.4	70827.6	256040.7	17.6	193.8
5	Sump 7B	25.4	510.5	51743.1	305834.8	34.2	226.5
4	Sump 7A I/S Wier	85.0	167.5	30161.1	308483.4	28.5	262.5
1	A&C Sump 7A-34	0.18	0.065	1.510	413.62	0.01	0.311
2	B&D Sump 7B-34	0.01	0.07	11.617	3.196	0.00	0.01

Sample	Description	Ag	Pb	Co	Ni	Mn	Fe
3	Sump 7A O/S Wier	0.8	94.3	4.1	55.5	43.9	3350.2
6	Basement Mockup	1.5	96.2	4.5	6.9	1.5	78.5
5	Sump 7B	0.5	71.9	4.6	32.4	44.9	3517.3
4	Sump 7A I/S Wier	5.3	52.1	2.5	80.6	76.1	4318.8
1	A&C Sump 7A-34	0.00	0.00	0.00	0.00	0.00	0.01
2	B&D Sump 7B-34	0.01	0.023	0.012	0.00	0.00	0.00

Sample	Description	Cr	P	B	Li	Cd
3	Sump 7A O/S Wier	25.7	84.4	6495.2	3.1	7.0
6	Basement Mockup	18.4	53.3	94.8	16.6	6.5
5	Sump 7B	33.1	146.5	5152.9	1.2	5.7
4	Sump 7A I/S Wier	118.6	94.2	4050.5	6.7	4.9
1	A&C Sump 7A-34	0.00	0.039	0.028	0.065	0.00
2	B&D Sump 7B-34	0.003	0.062	1.572	0.027	0.00

TABLE 2
ICP RESULTS
WATER LEACHED SAMPLES (ppm)

Sample	Description	Ba	Mg	Al	Ca	Zn	Cu
3 (water leach)	Sump 7A O/S Wier	0.2	6.7	2887.5 4255.3[1]	9438.9 9330.3[1]	0.1	11.7
6 (water leach)	Basement Mockup	0.1	3.9	3329.1 3999.2[1]	6018.6 5913.5[1]	0.1	4.9
5 (water leach)	Sump 7B	0.5	7.5	3366.1 2885.3[1]	7248.6 7181.0[1]	0.2	8.4
4 (water leach)	Sump 7A I/S Wier	1.9	41.4	8259.9 8618.2[1]	15560.0 15531.0[1]	0.7	18.0

Sample	Description	Ag	Pb	Co	Ni	Mn	Fe
3 (water leach)	Sump 7A O/S Wier	0.3	7.1	0.6	0.8	0.1	0.3
6 (water leach)	Basement Mockup	0.2	6.1	0.5	0.7	0.1	0.1
5 (water leach)	Sump 7B	0.6	6.8	0.5	1.3	0.0	1.0
4 (water leach)	Sump 7A I/S Wier	4.5	28.0	2.0	8.8	0.9	15.0

Sample	Description	Cr	P	B	Li	Cd
3 (water leach)	Sump 7A O/S Wier	0.2	3.3	3941.8	2.5	0.6
6 (water leach)	Basement Mockup	1.9	0.3	0.2	0.8	0.3
5 (water leach)	Sump 7B	1.3	4.9	3520.6	9.8	0.6
4 (water leach)	Sump 7A I/S Wier	7.4	15.0	4341.5	6.4	3.1

Ion Chromatography Analyses

Samples 1 and 2 were analyzed for pH, specific conductivity and for anion content by ion chromatography, using a Dionex Model 16 ion chromatograph. The results are shown in Table 3.

TABLE 3
pH, SPECIFIC CONDUCTIVITY AND ION CHROMATOGRAPHY RESULTS

				Concentrations (ppm)			
Sample	Description	pH	Sp. Cond (uS/cm)	Cl	SO_4	NO_3	F
1	A&C Sump 7A-34	11.8	3700	59	14	28	<0.1
2	B&D Sump 7B-34	10.3	330	7.8	2.8	1.7	<0.1

X-Ray Fluorescence Results

Samples 5 and 6 were prepared for x-ray fluorescence analyses using a dispersion/filtration technique to produce a thin, uniform solid sample. The samples were then mounted on a lucite base and covered with an ultra-thin mylar sheet. The x-ray analyses were performed using a Siemens SRS 200 X-Ray Fluorescence Spectrometer equipped with automated control and data acquisition systems. Counts were obtained for all elements having atomic numbers greater than 10. Results were obtained for all elements with an abundance by mass greater than 0.1%. All results are standardized to the chemical forms indicated and the results of the analysis are normalized accordingly. Table 4 provides the x-ray fluorescence analysis results.

---

[1] Values achieved following filtration through a 0.2 um filter to remove colloidal matter

TABLE 4
X-RAY FLUORESCENCE RESULTS

Component	U3 Basement Mockup Concentration:	Sump 7B Drum Concentration:
CaO	43.4 %	43.3 %
Al_2O_3	17.5 %	10.9 %
Fe_2O_3	0.1 %	1.8 %
SiO_2	0.2 %	0.2 %
Na_2O	0.1 %	0.1 %
ZnO	0.1 %	0.1 %
WO_3	10^{-1} %	10^{-1} %
P_2O_5	<0.1 %	0.1 %
Cr_2O_3	0.1 %	≤0.1 %
Total	61.6 %	56.7 %

Particle Size Results
An aliquot of the same samples analyzed by x-ray flucrescence were also analyzed for particle size distribution using a CILAS Granulometre, Model 715 Particle Size Analyzer. This instrument measures the distribution of particle sizes proportional to the intensity of scattered light as a function of particle size. The results are reported as the cumulative percentage of sample mass found to exceed each incremental step of particle size diameter, beginning with a diameter of 0.1 micron and ending with a diameter of 500 microns. Results are tabulated in Table 5. Graphical illustrations of the particle size frequency distributions are included with the raw data in the Appendix.

A comparison of results indicates a smaller particle size in the U-3 mockup sample compared to the sump sample. Overall, particle sizes in the mockup sample were <110 micron with a median diameter of 19 microns. The sump 7B sample was found to have particles up to 400 microns and a median particle size of 39 microns. These observations were consistent with the visual appearances of the two samples. The mockup sample appeared to be a uniform powder-like material whereas the sump sample was somewhat more granular and non-uniform in appearance, including flecks of dark material. Also, it was found that the sump material was somewhat more agglomerated than the mockup sample and required processing through a 30 mesh sieve prior to analysis in the granulometer. This tendency may have caused the sump sample results to trend toward larger particle sizes compared to the mockup sample.

TABLE 5
CILAS PARTICLE SIZE ANALYSIS OF DRIED SUMP PARTICULATE

SAMPLE ID:	BASEMENT MOCKUP	7B DRUM
MEDIAN SIZE (uM):	19.34	38.57
DIAMETER @ 10% UNDERSIZE (uM):	5.1	7.18
DIAMETER @ 90% UNDERSIZE (uM):	54.97	118.11

MICRON DIAMETER	WEIGHT % UNDERSIZE BASEMENT MOCKUP	WEIGHT % UNDERSIZE 7B DRUM
0.1	0.0%	0.0%
0.2	0.0%	0.0%
0.3	0.0%	0.0%
0.4	0.0%	0.0%
0.5	0.0%	0.0%
0.6	0.0%	0.0%
0.7	0.1%	0.0%
0.8	0.3%	0.1%
0.9	0.5%	0.3%
1	0.8%	0.5%
1.1	1.0%	0.7%
1.2	1.2%	0.9%
1.3	1.5%	1.1%
1.4	1.7%	1.3%
1.5	1.9%	1.5%
1.6	2.1%	1.7%
1.7	2.3%	1.9%
1.8	2.5%	2.1%
2	2.9%	2.5%
2.2	3.3%	2.8%
2.4	3.7%	3.2%
2.6	4.0%	3.5%
2.8	4.4%	3.8%
3	4.8%	4.1%
3.2	5.2%	4.5%
3.4	5.7%	4.8%
3.6	6.1%	5.1%
3.8	6.6%	5.5%
4	7.1%	5.8%
4.3	7.9%	6.2%
4.6	8.7%	6.7%
5	9.7%	7.3%
5.3	10.5%	7.7%
5.6	11.4%	8.1%
6	12.4%	8.6%
6.5	13.8%	9.2%
7	15.1%	9.8%

MICRON DIAMETER	WEIGHT % UNDERSIZE BASEMENT MOCKUP	WEIGHT % UNDERSIZE 7B DRUM
7.5	16.5%	10.4%
8	17.8%	10.9%
8.5	19.2%	11.5%
9	20.7%	12.1%
10	23.6%	13.2%
11	26.5%	14.3%
12	29.4%	15.4%
13	32.4%	16.5%
14	35.3%	17.6%
15	38.2%	18.8%
16	41.1%	19.9%
17	43.8%	21.0%
18	46.5%	22.1%
19	49.1%	23.2%
20	51.6%	24.4%
21.5	55.2%	26.2%
23	58.6%	28.2%
24.5	61.7%	30.2%
26	64.6%	32.3%
28	68.1%	35.2%
30	71.3%	38.1%
32	74.1%	41.1%
34	76.5%	43.9%
36	78.6%	46.7%
38	80.4%	49.3%
40	82.0%	51.8%
43	84.0%	55.3%
46	85.7%	58.4%
50	87.8%	62.2%
53	89.1%	64.8%
56	90.4%	67.1%
60	92.0%	70.0%
63	93.1%	72.0%
66	94.2%	73.8%
70	95.4%	75.9%
75	96.7%	78.3%
80	97.7%	80.4%
85	98.5%	82.3%
90	99.1%	83.9%
95	99.5%	85.4%
100	99.8%	86.7%
110	100.0%	88.8%
120	100.0%	90.3%
130	100.0%	91.4%
140	100.0%	92.2%
150	100.0%	92.9%
160	100.0%	93.5%
170	100.0%	94.0%
180	100.0%	94.5%
190	100.0%	95.0%
200	100.0%	95.5%
210	100.0%	95.9%

MICRON DIAMETER	WEIGHT % UNDERSIZE BASEMENT MOCKUP	WEIGHT % UNDERSIZE 7B DRUM
220	100.0%	96.4%
240	100.0%	97.3%
260	100.0%	98.1%
280	100.0%	98.7%
300	100.0%	99.2%
330	100.0%	99.6%
360	100.0%	99.9%
400	100.0%	100.0%
430	100.0%	100.0%
460	100.0%	100.0%
500	100.0%	100.0%

Discussion of Results

The elemental analyses performed independently by ICP and XRF on the solid samples are in good agreement. The major elements present are calcium, aluminum and iron. Except for a small variation in percentage composition, comparing the ICP to the XRF results, it was noted that a small quantity of iron was found in the sump sample 7B (sample 5) whereas iron was found below 1% in the Unit 3 Mockup sample (sample 6) by both methods.

The anion analyses of samples 1 and 2 show that chloride, sulfate and nitrate were present in measurable quantities. Some carbonate was also believed to be present, based on the observation that both samples 1 and 2 effervesced upon exposure to a drop of HCl. The higher pH in sample 1 (11.8) compared to sample 2 (10.3) also correlates with the additional calcium found in sample 1 (413 ppm) compared to sample 2 (3 ppm). The elevated pH also suggests that the calcium was mostly in an alkaline chemical form (CaO, $Ca(OH)_2$) vs. a neutralized form ($CaCO_3$).

The x-ray fluorescence results do not account for the possible presence of CO_3 in the samples (most likely as $CaCO_3$). Any CaO originally present in the material would be expected to undergo partial to complete conversion to $CaCO_3$ upon exposure to aerated water. A simple chemical test was performed on both samples analyzed by XRF whereby each sample effervesced upon exposure to a drop of HCl, indicating the presence of carbonate. Had the XRF results included CO_3 in calculated amounts (CO_3 is assumed to be stoichiometrically equal to Ca), without further normalization, the total quantities of material would calculate to between 90 and 95% accountability. Further normalization to 100% accountability would therefore indicate an upward adjustment in the reported results of 5-10% relative abundance of the reported species.

The water leach analyses obtained by ICP on samples 3,4,5 and 6 showed that both calcium and aluminum were leached from the solid samples, but at concentrations below 1% (with the exception of calcium leached from sample 4 at approximately 1.5%).

Conclusions

The overall results show that the elemental analyses of samples of solid material obtained from the Millstone-3 containment sump are in good agreement with the same analyses performed on the solid material from the Unit 3 basement mockup.

Differences in the particle size distribution, comparing the sump sample to the U-3 mockup sample are most likely due to differences in the duration and the chemical nature of the water environment to which these solid materials were exposed.

Should you have any questions or would like any additional information, please do not hesitate to contact me at (860) 285 9263 or by FAX at (860) 285 3253. Thank you for the opportunity to provide our analytical services to Northeast Nuclear Energy Co.

Sincerely yours,
ABB COMBUSTION ENGINEERING NUCLEAR OPERATIONS

Stephen W. Lurie
Supervisor, Materials and Chemistry

cc: R. Whipple
E. Silva
J. Klisiewicz (NUSCO)

APPENDIX
TO
PENG-96-370

ANALYSIS RESULTS OF MILLSTONE-3 CONTAINMENT SUMP AND MOCKUP SAMPLES

PARTICLE SIZE ANALYSIS RESULTS

Granulometer 1064 number 71
Version V 3.24x
File name : C:\CILAS\DATA\M0788.MES
07/03/1996 12:58:58

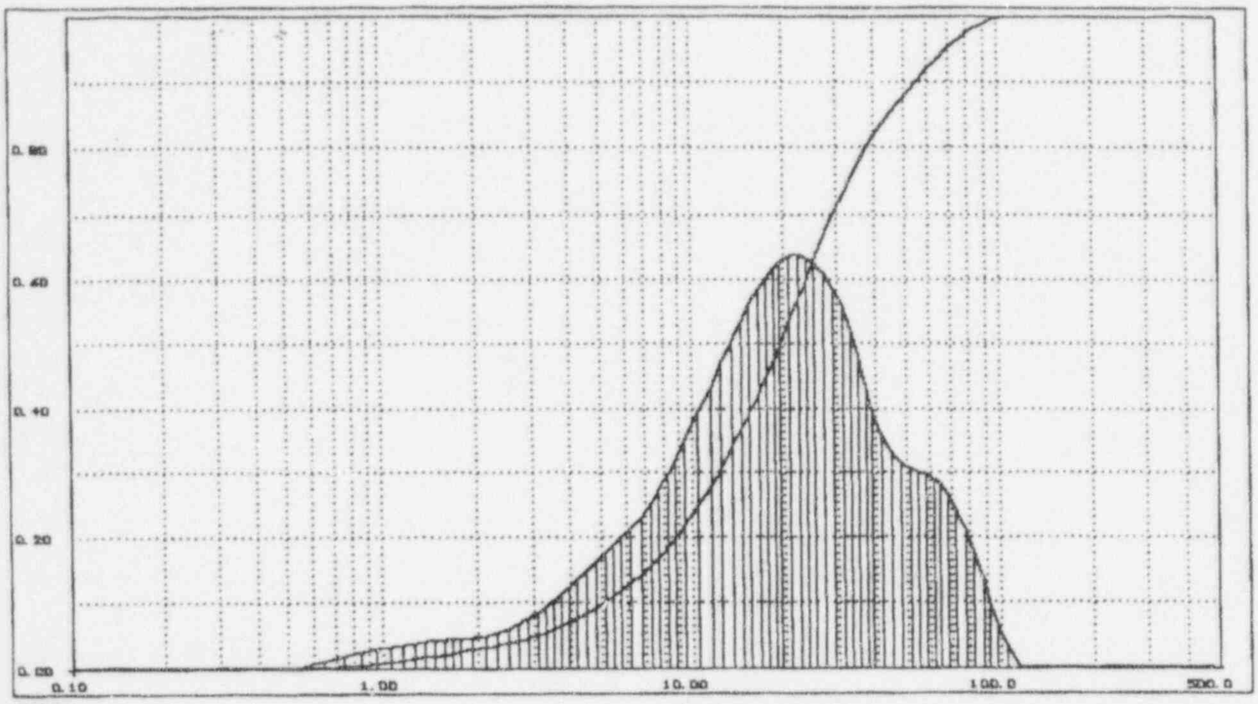
Sample : 6-0788-M

Liquid : H2O
Ultrasonic mixer : 60 s. / Dispersing agent : CO660/990
Comment : BASEMENT MOCK UP
User name : CET
Plant : ABB PPL CAS
Place : MILLSTONE
Concentration : 104

Median size : 19.34 mu
Diameter at 10.0 % : 5.10 mu
Diameter at 90.0 % : 54.97 mu
Cumulat. at100.00 mu : 99.77 % Shape factor : 1.000
Results : Weight distribution / Undersize

D	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C%	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5	0.8
D	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.2
C%	1.0	1.2	1.5	1.7	1.9	2.1	2.3	2.5	2.9	3.3
D	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.3
C%	3.7	4.0	4.4	4.8	5.2	5.7	6.1	6.6	7.1	7.9
D	4.6	5.0	5.3	5.6	6.0	6.5	7.0	7.5	8.0	8.5
C%	8.7	9.7	10.5	11.4	12.4	13.8	15.1	16.5	17.8	19.2
D	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
C%	20.7	23.5	26.5	29.4	32.4	35.3	38.2	41.1	43.8	46.5
D	19.0	20.0	21.5	23.0	24.5	26.0	28.0	30.0	32.0	34.0
C%	49.1	51.6	55.2	58.6	61.7	64.6	68.1	71.3	74.1	76.5
D	36.0	38.0	40.0	43.0	46.0	50.0	53.0	56.0	60.0	63.0
C%	78.6	80.4	82.0	84.0	85.7	87.8	89.1	90.4	92.0	93.1
D	66.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	110.0	120.0
C%	94.2	95.4	96.7	97.7	98.5	99.1	99.5	99.8	100.0	100.0
D	130.0	140.0	150.0	160.0	170.0	180.0	190.0	200.0	210.0	220.0
C%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
D	240.0	260.0	280.0	300.0	330.0	360.0	400.0	430.0	460.0	500.0
C%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Granulometer 1064 number 71
Version V 3.24x
File name : C:\CILAS\DATA\M0788.MES
07/03/1996 12:58:58



H* 5

CILAS 1064 N.71
COMPAGNIE INDUSTRIELLE DES LASERS

Granulometer 1064 number 71
Version V 3.24x
File name : C:\CILAS\DATA\M0789.MES
07/03/1996 13:15:58

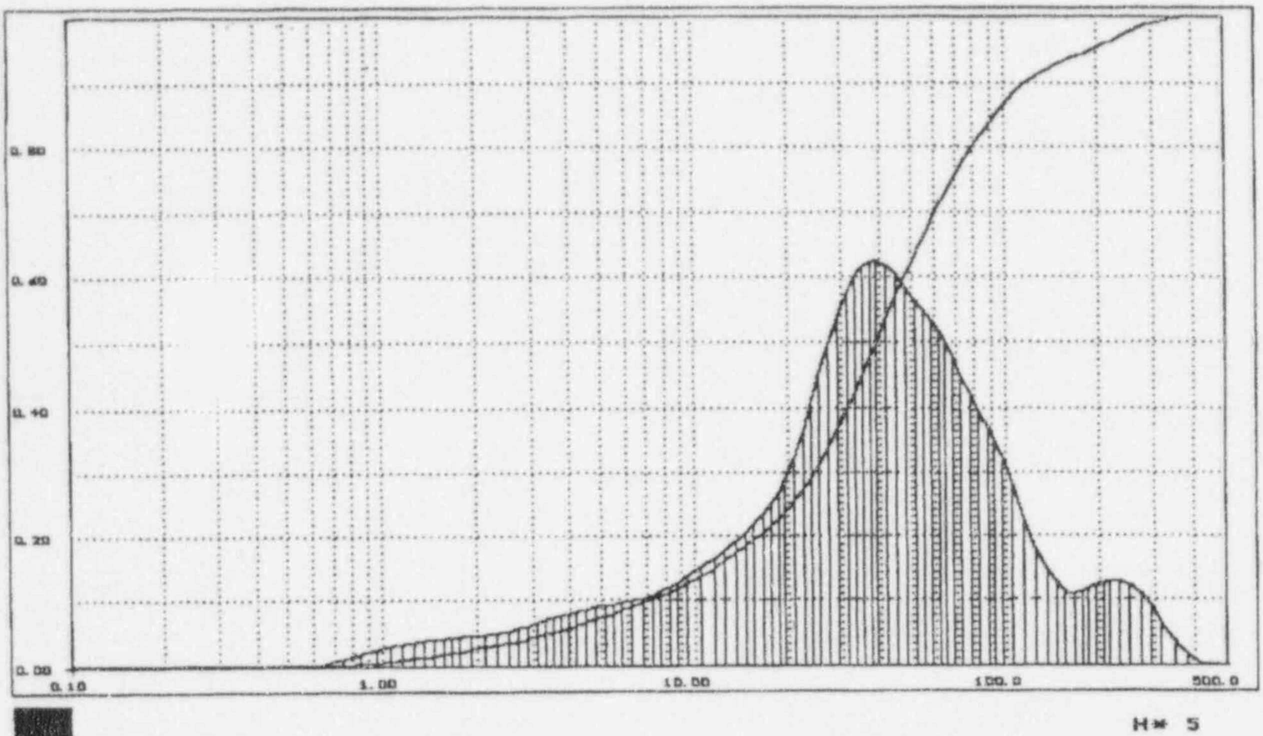
Sample : 6-0789-M (sieved -30m)

Liquid : H_2O
Ultrasonic mixer : 60 s. / Dispersing agent : CO660/990
Comment : 7B DRUM
User name : CET
Plant : ABB PPL CAS
Place : MILLSTONE
Concentration : 35

Median size : 38.57 mu
Diameter at 10.0 % : 7.18 mu
Diameter at 90.0 % : 118.11 mu
Cumulat. at100.00 mu : 86.68 % Shape factor : 1.000
Results : Weight distribution / Undersize

D	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
C%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.5
D	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	2.0	2.2
C%	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.5	2.8
D	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.3
C%	3.2	3.5	3.8	4.1	4.5	4.8	5.1	5.5	5.8	6.2
D	4.6	5.0	5.3	5.6	6.0	6.5	7.0	7.5	8.0	8.5
C%	6.7	7.3	7.7	8.1	8.6	9.2	9.8	10.4	10.9	11.5
D	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
C%	12.1	13.2	14.3	15.4	16.5	17.6	18.8	19.9	21.0	22.1
D	19.0	20.0	21.5	23.0	24.5	26.0	28.0	30.0	32.0	34.0
C%	23.2	24.4	26.2	28.2	30.2	32.3	35.2	38.1	41.1	43.9
D	36.0	38.0	40.0	43.0	46.0	50.0	53.0	56.0	60.0	63.0
C%	46.7	49.3	51.8	55.3	58.4	62.2	64.8	67.1	70.0	72.0
D	66.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	110.0	120.0
C%	73.8	75.9	78.3	80.4	82.3	83.9	85.4	86.7	88.8	90.3
D	130.0	140.0	150.0	160.0	170.0	180.0	190.0	200.0	210.0	220.0
C%	91.4	92.2	92.9	93.5	94.0	94.5	95.0	95.5	95.9	96.4
D	240.0	260.0	280.0	300.0	330.0	360.0	400.0	430.0	460.0	500.0
C%	97.3	98.1	98.7	99.2	99.6	99.9	100.0	100.0	100.0	100.0

Granulometer 1064 number 71
Version V 3.24x
File name : C:\CILAS\DATA\M0789.MES
07/03/1996 13:15:58



CILAS 1064 N.71
COMPAGNIE INDUSTRIELLE DES LASERS

ATTACHMENT 4

TECHNICAL DATA
on
POROUS WALL CONCRETE DRAINAGE PIPE

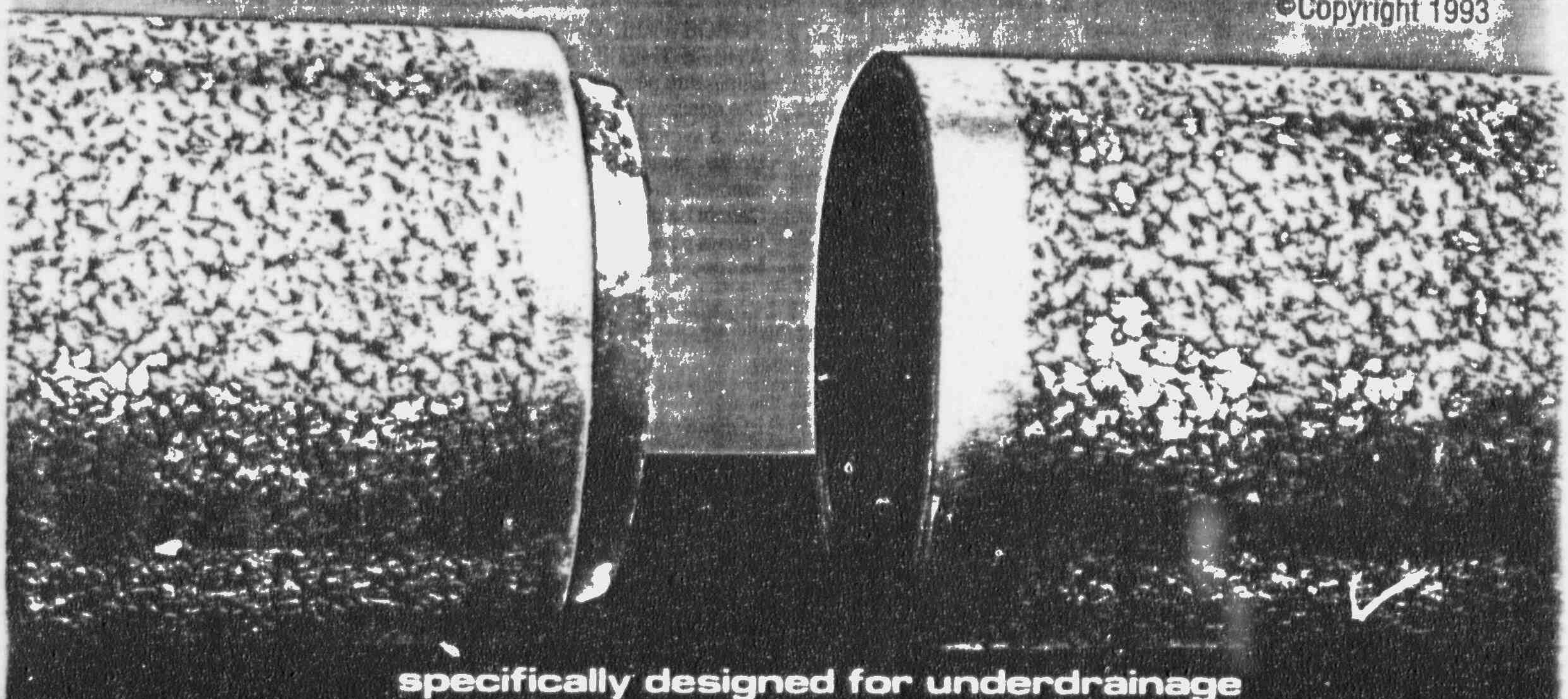
02712/WAL
BUYLINE 0916

POROSWALL

FOR UNDERDRAINAGE and GROUND WATER RECHARGING

available in
standard 4″ to 24″ I.D.
extra strength 6″ to 18″ I.D.

THE QUALITY UNDERDRAIN ENVIRONMENTALLY SOUND



specifically designed for underdrainage

WALKER POROSWALL PIPE CO., LITTLE FERRY, N.J.

route 46 — traffic circle

110 Bergen Turnpike

(201) 440-2542-3-4
FAX (201) 440-3394

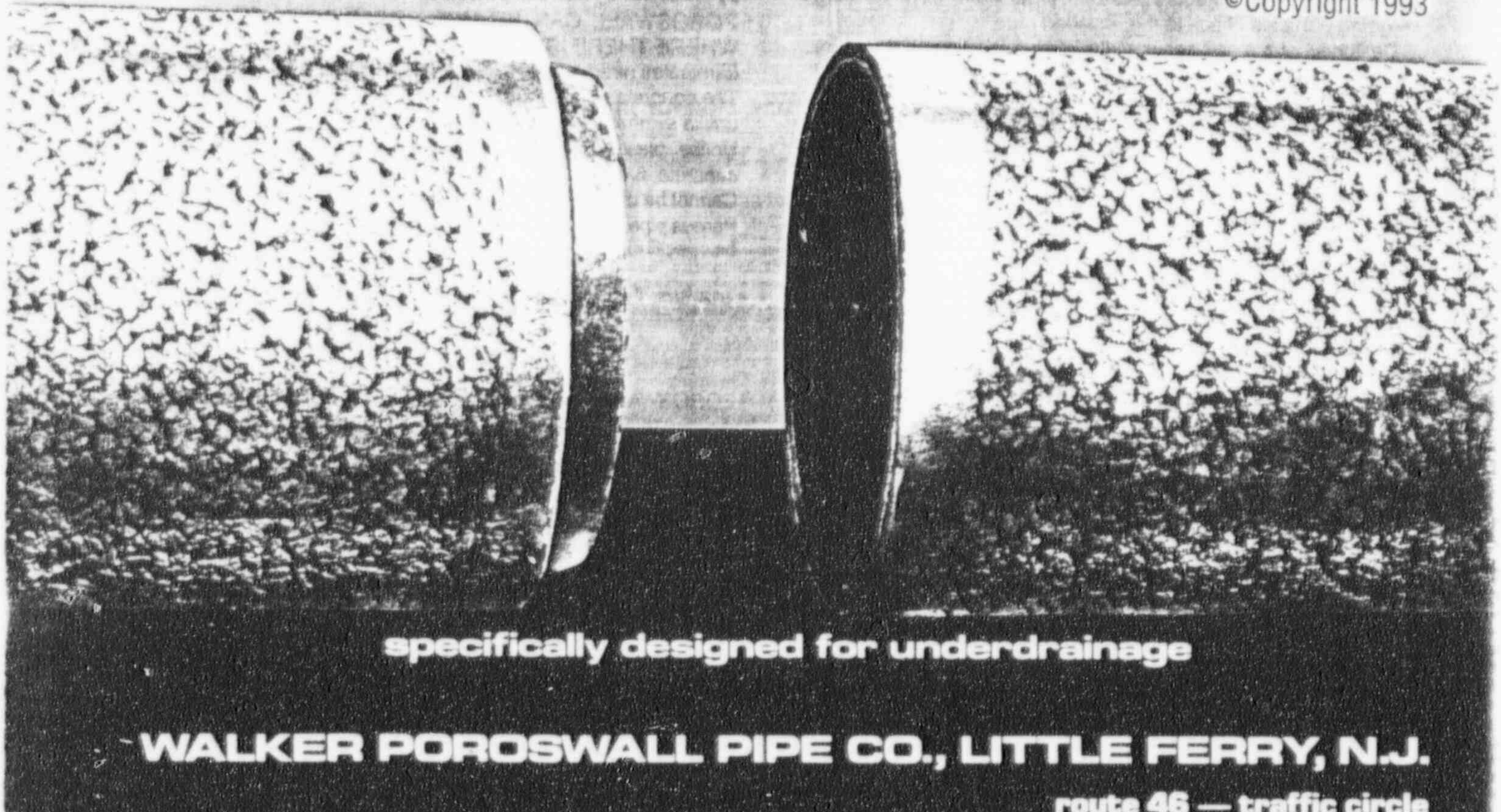
02712/WAL
BUYLINE 0916

®POROSWALL

FOR UNDERDRAINAGE and GROUND WATER RECHARGING

available in
standard 4″ to 24″ I.D.
extra strength 6″ to 18″ I.D.

THE QUALITY UNDERDRAIN ENVIRONMENTALLY SOUND



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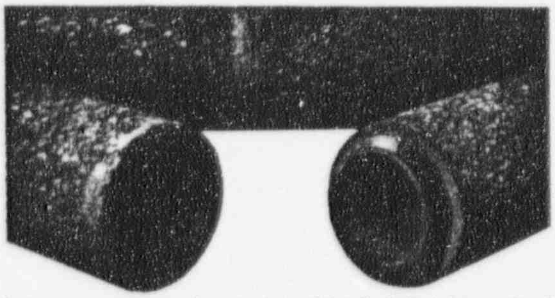
route 46 — traffic circle

110 Bergen Turnpike

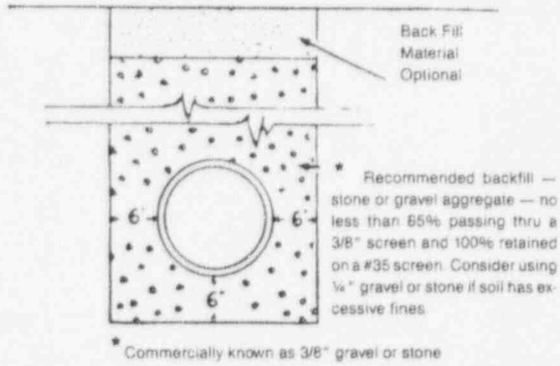
(201) 440-2542-3-4
FAX (201) 440-3394

® POROSWALL UNDERDRAIN PIPE



Note porous texture of concrete and detail of slip joint, made of solid concrete. Requires no wrapping or mortar when joined.

RECOMMENDED INSTALLATION
TYPICAL CROSS SECTION



For Best Results We Advise The Use of The Porous Backfill Specified Above.

® **POROSWALL UNDERDRAIN PIPE** is the only drain pipe specifically designed and manufactured for use in underdrainage and exfiltration. It is **not** an adaption or modification of an existing all purpose pipe. **POROSWALL** is porous for its entire length and circumference. Manufactured with the finest Portland cement, basaltic trap rock and sand it achieves its unique porosity through thousands of minute channels too small to allow the passage of anything but water. The manufacturing process was developed over fifty years ago.

Because of its porosity **POROSWALL** is the only underdrain pipe which can be used with a fine graded filter. Elimination of large voids in backfill aggregates prevents water from carrying clogging particles of soil to the installed pipe.

Designed with a self-sealing slip joint which does not require mortar or wrapping of any kind **POROSWALL UNDERDRAIN PIPE**, both under prolonged use and impartial test, has less tendency to clog than any other drain tile on the market today. Upon request we will gladly send you a reprint of the results of U.S. Government tests by the U.S. Army Engineers giving first place in non-clogging characteristics to **POROSWALL** Underdrain Pipe.

solves drainage problems

® POROSWALL Underdrain Pipe is especially recommended for handling drainage and environmental problems in the following:

AIRPORTS	**COMMERCIAL INSTALLATIONS**
FLOOD CONTROL PROJECTS	**PARKS & REACREATION AREAS**
FOUNDATION DRAINAGE	**RETAINING WALLS**
FUEL STORAGE AREAS	**SCHOOLS AND INSTITUTIONS**
GOLF COURSES	**WATER COLLECTION**
HIGHWAYS AND ROADS	**WATER TREATMENT PLANTS**
LEACHING FIELDS	**NUCLEAR POWER PLANTS**
PARKING FIELDS	**LANDFILL REFUSE AREAS**
HOUSING DEVELOPMENTS	**RAILROADS**

Federal, State, Municipal and private engineers and architects as well as other recognized authorities are specifying POROSWALL Underdrain Pipe for permanent, rapid and economical drainage wherever excessive ground water is a problem.

Modern ecology calls for the recharging of underground water bearing stratas wherever possible. Surface water carried away in solid pipe eventually ends up in the oceans.

Used as a combination underdrain for the disposal of surface water, POROSWALL returns a large percentage of the surface water to the ground below its invert.

In recent years POROSWALL has been used to vent methane and radon gases from sub surface areas.

None of the material used in the making of POROSWALL is in short supply at this time or will be in the foreseeable future, and does not require any petroleum products.

advantages

- POROSWALL drainage pipe is the fastest drainage medium known to the engineering and architectural professions.
- POROSWALL accepts more infiltration per square foot of surface and can be laid with minimum grades needed to reach an outfall.
- Dirt and other solids cannot clog POROSWALL because of its unique porosity. It does not need a specially wrapped or mortared joint or filter cloth.
- POROSWALL used with foundations assures dry basements in homes and industrial buildings.
- Installed under floors, POROSWALL prevents break up caused by excessive hydrostatic pressure.
- POROSWALL CAN BE USED TO DISSIPATE WATER WHERE THERE IS NO OUTFALL.
- Eliminates need for cleanouts when properly installed.
- The concrete used in making POROSWALL improves with age unlike synthetic pipes which have a relatively short life span.
- Unlike plastic pipe, POROSWALL does not flex. Being of concrete, a cleaning augur will not damage POROSWALL.
- Cannot be destroyed by termites, moles and other rodents.
- Porous pipe is more efficient and therefore smaller diameters can be specified.

Manning N Factor

.012 Smooth Concrete Pipe .016 Poroswall

.024 Corrugated Metal or Plastic Pipe

extra strength POROSWALL

® POROSWALL is manufactured in EXTRA STRENGTH to meet the growing demand for underdrain pipe combining the effectiveness of POROSWALL and the crushing strength of reinforced concrete pipe. EXTRA STRENGTH is available in 6" to 18" internal diameters inclusively. The infiltration factor has been maintained at the standard POROSWALL rate.

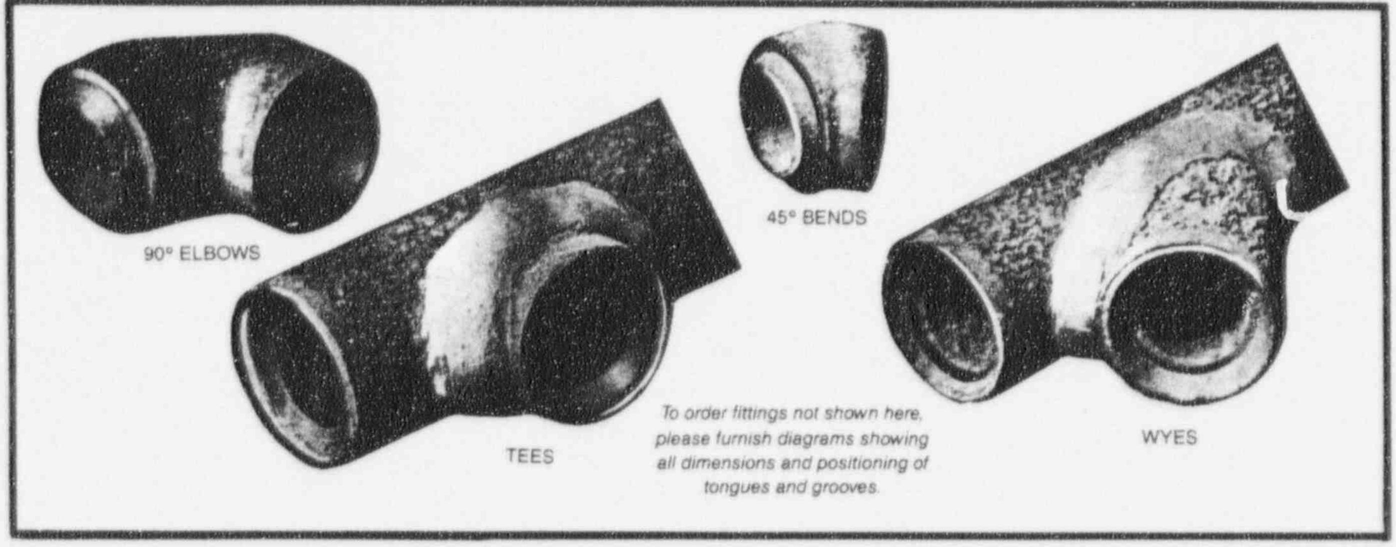
POROSWALL EXTRA STRENGTH solves the problem of the engineer or architect who needs the efficiency of POROSWALL plus extra strength under roads, in deep trenches or other projects where additional crushing strength is an important factor. No longer is it necessary to use inefficient open joint or perforated pipe for these purposes. Ask for data on installation depths. Especially useful as a combination underdrain.

® POROSWALL EXTRA STRENGTH exceeds in strength the ASTM C76 Class III specification for reinforced concrete pipe.

advisory service

The Company maintains an advisory service to consult with engineers and architects in the design of efficient drainage and water collection systems. This service is free and without obligation.

equal in strength to solid concrete pipe



When you specify the use of porous concrete underdrain pipe, the major portion of field inspection is eliminated. Designed and manufactured for underdrain use only, **POROSWALL PIPE** features a closed joint and complete porosity for its entire length and circumference. Because of complete porosity it can be laid almost level.

It is not a solid pipe modified by perforations. All of these features combined make for long-lived underdrainage.

The manufacture of POROSWALL requires more cement than solid pipe eliminating breakage in handling unless abused.

We recommend outright specification of porous concrete pipe using ASTM C-654 or AASHO M-176. The use of a wide open specification almost always results in the use of the cheapest of the alternates, thereby downgrading your design of an efficient underdrain system. We carry a complete stock of all sizes and use a standard price list which only varies as to destination. Specify POROSWALL and you can forget underdrain problems when installed as recommended on opposite page.

Filter Cloth is not needed when POROSWALL is properly installed with recommended backfill material. If filter cloth is used it should also be protected by filter material on its outer perimeter to prevent its being clogged.

Only POROSWALL should be used in tunnels and confined spaces because it is fireproof, or when in proximity to fuel storage.

There is some evidence that plastic pipe releases substances harmful to sub surface water.

when underdrainage problems are critical nothing will do but POROSWALL

Walker POROSWALL works as an underdrain under adverse conditions long after other underdrain pipes have failed. As shown at right, POROSWALL pipe will continue to function as an underdrain even if partially filled with silt. Perforated pipe will fail as soon as the perforations in the lower third are covered.

When using underdrain other than POROSWALL, backfill material should not contain any aggregate smaller in diameter than the perforations. Inflow of water is concentrated at the open joints or perforations. The higher velocity carries fines into the pipe. POROSWALL, being completely porous for its entire length and circumference, accepts water in a seeping action of low velocity.

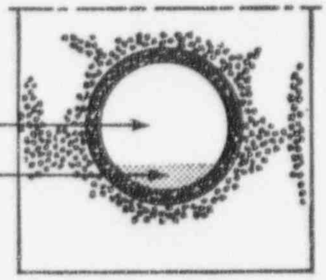
Because of the minute pores in POROSWALL, finer aggregate can be used as backfill. The smaller voids in such aggregate prevents fines from readily coming to the pipe.

DON'T VIOLATE THE INTEGRITY OF YOUR DESIGN BY ACCEPTING THE SUBSTITUTION OF AN INFERIOR UNDERDRAIN PIPE. CAN YOU AFFORD TO DESIGN OR BUILD AN UNDERDRAIN WITH LESS THAN THE BEST? CHEAPER IS NOT BETTER!

WALKER POROSWALL PIPE

still functioning as an underdrain

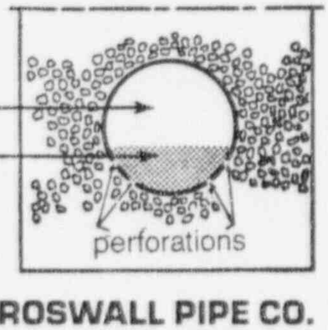
silt



ANY PERFORATED PIPE

no longer an underdrain

silt



WALKER POROSWALL PIPE CO.

® POROSWALL DRAIN PIPE

A few of the many installations:

AIRPORTS: Kennedy, LaGuardia, Buffalo, Stewart Airport, all N.Y., Teterboro, Newark, McGuire Air Force Base, all N.J., Martin Airport, Balt., MD., McCarron Airport, Las Vegas, NV., Andrews Air Force Base, Wash., D.C., Washington Nat'l. Airport, Alex., VA., George Air Force Base, Victorville, CA., Jet Fuel Storage, Boise, ID., Alexander Hamilton Airport, St. Croix, V.I., Hubert Humphrey, Huron, SD.

COLLEGES: MIT, Stevens Institute of Technology, Rensselaer-Polytechnic Institute, CAL-TECH, Princeton, UCLA, Yale, Coast Guard Academy, West Point Academy, U.S. Merchant Marine Academy, Cornell University, Albert Einstein, John Hopkins University.

HIGHWAYS AND TURNPIKES: New Jersey, New York, Pennsylvania, Maine, Mass., Virginia, Rhode Island, Ontario, Connecticut.

PUBLIC BUILDINGS: United Nations, Rockefeller Institute, Columbia Presbyterian Hospital, Executive Mansion, all N.Y., British Embassy, House of Representatives Office Building, Smithsonian Institute, Library of Congress, all Washington, D.C., Space Science Center, Greenbelt, MD., Children's Medical Center, Dallas, TX., Kennedy Memorial Grave Site, Arlington, VA., Salt Lake County Civic Auditorium, Utah, Lyndon B. Johnson Library, Austin, TX., Statue of Liberty, Bear Hill Correctional Facility, Malone, N.Y.

INDUSTRIAL INSTALLATIONS: U.S. Steel Corp., So. Chicago, IL. and Fairfield, AL., Western Electric Co., Charlotte, N.C., A.T.&T. Repeater Stations, Johnson & Johnson, New Brunswick, NJ., Exxon Refinery, Elizabeth, NJ., Sinclair Refining, E. Chicago, IL., Florida Power & Light, Parrish, FL., Bethlehem Steel Graving Dock, Quincy, MA., American Cyanamid, Wayne, NJ., Alcoa, Badin, NC, A.I. DuPont, Wilmington, DL., Armstrong Cork Co., Macon, GA. Pacific Gas & Elec., San Francisco, Calif.

NUCLEAR POWER PLANTS: Conn., N.Y., N.C., Phillipines, S.C.

RAILROADS: NJ., Washington D.C., MA., OH., Los Angeles CA.

RAPID TRANSIT SYSTEMS: N.Y., Boston, Cleveland, Philadelphia, Washington, D.C.

OFFICE BUILDINGS: House of Seagram, Chase Manhattan Bank, A.T.&T., World Trade Center Twin Towers, Battery Park Complex, all New York., Exchange Park Complex, Dallas, TX., Western Electric, Indianapolis, IN., Prudential Insurance Co., Kansas City, MO., IBM, Baltimore, MD. and N.Y., Doctor's Bldg., Omaha, NE.

PUBLIC WORKS: Lincoln Tunnel, George Washington Bridge, Tri-Boro Bridge Authority Adm. Bldg., Randalls Island, all N.Y., Submarine Base, New London, CT., Hampton Roads Tunnel, Norfolk, VA., Delaware River Bridge, Camden, NJ., City of Anchorage, Alaska, Greeley Wastewater Treatment Facility, CO., Kings Bay Submarine Base, Kings Bay, GA.

OTHER INSTALLATIONS: Meadowlands Sports Complex, Monmouth Park Jockey Club, Earle Ammunition Depot, all N.J., Belmont, Aqueduct, Jamaica Race Tracks, United Engrg. Center, Winged Foot Golf Club, Shea Stadium, Lincoln Center, Fresh Kill Landfill, all N.Y., Flood Control Project, N. Adams, MA., Cloverdale Shopping Center, Etobicoke, Ontario, Canada, National Center for Atmospheric Research, Boulder, Co., Iowa Gas & Elec., Life George Bldg., Atlanta, Ga., Power Plant, Okinawa, Sturgeon Bay Graving Dock, WI., Coca Cola Co., Shrevesport, LA., Dome Stadium, Minn., MN., Kennedy Space Center, Tennessee Valley Authority, Greater Lebanon Refuse, PA., Universal Studios, Universal City, CA.

OVERSEAS INSTALLATIONS: Africa, Mid-east, Central America, Aleutian Islands, Okinawa, St. Croix, Libya, Spain, Saudi Arabia, South America, South Pacific, Andros Island, Republic of Guinea, Kuwait, United Arab Emirates, Puerto Rico, Bermuda, Philippines, Hawaii, Moscow, Russia, Muscat, Oman, Nicosia, Cypress.

specifications:

To Specify, Use the Following:

COMPOSITION: *Porous concrete drain pipe to be as manufactured by Walker Poroswall Pipe Co., Little Ferry, N.J. from a mixture of Portland Cement, Water, ⅜" trap rock and sand.

SHAPE: The cross section of the pipe to be circular inside and out.

TYPE OF JOINT: The tongue and groove to be formed of solid concrete extending into barrel for approximately one inch at each end. All joints to be of the interlocking tongue and groove type with the exterior of the groove in the same plane as the exterior of the barrel.

CURING AND AGING: All porous concrete pipe to be thoroughly cured in modern steam curing rooms and stored until properly aged before shipping.

PHYSICAL PROPERTIES: The finished pipe to be straight, free from cracks, checks or other defects and reasonably uniform in color and texture.

INFILTRATION: The infiltration rate to be not less than two gallons per minute per inch of internal diameter per lineal foot of pipe for 4" to 8" pipe inclusively. See tables below for infiltration rates on sizes larger than 8".

SHORT FORM: All drainage pipe to be *POROSWALL UNDERDRAIN PIPE manufactured in accordance with the standard specifications of the WALKER POROSWALL PIPE CO., Little Ferry, New Jersey, or use ASTM-Specification C-654 and AASHO Specification M-176.

*To specify Extra Strength, insert words Extra Strength here. We recommend inclusion of dimension and weight data when you specify Extra Strength.

Standard Strength — TABLE A

inside diameter	laying length in feet	weight per foot in pounds	wall thickness in inches	3 edge bearing lbs. per lineal foot min. crushing strength	*infiltration & exfiltration rate - gals per min. per ft.
4"	2	16	1.00	1500	8
6"	2½	23	1.00	1700	12
8"	2½	37	1.25	1800	16
10"	3	51	1.375	2100	17
12"	3	67	1.50	2400	18
15"	3	97	1.75	2500	23
18"	3	144	2.00	2500	24
21"	3	162	2.25	2500	25
24"	3	224	2.50	2600	26

Extra Strength — TABLE B

inside diameter	laying length in feet	weight per foot in pounds	wall thickness in inches	3 edge bearing lbs. per lineal foot min. crushing strength	*infiltration & exfiltration rate - gals per min. per ft.
6"	2½	29	1.25	2600	12
8"	2½	46	1.50	3000	16
10"	3	64	1.625	3000	17
12"	3	84	2.00	3600	18
15"	3	122	2.25	3900	23
18"	3	180	2.50	4000	24

You can specify or order POROSWALL Underdrain Pipe, Standard or Extra Strength, for shipment to any part of the United States or Canada directly from our plant in Little Ferry, N.J. We have and are prepared to ship abroad. All sizes and strengths are maintained in substantial quantities at all times for *prompt* shipment.

POROSWALL

Walker Poroswall Pipe Co.

[illegible]

® POROSWALL DRAIN PIPE

A few of the many installations:

AIRPORTS: Kennedy, LaGuardia, Buffalo, Stewart Airport, all N.Y., Teterboro, Newark, McGuire Air Force Base, all N.J., Martin Airport, Balt., MD., McCarron Airport, Las Vegas, NV., Andrews Air Force Base, Wash., D.C., Washington Nat'l. Airport, Alex., VA., George Air Force Base, Victorville, CA., Jet Fuel Storage, Boise, ID., Alexander Hamilton Airport, St. Croix, V.I., Hubert Humphrey, Huron, SD.

COLLEGES: MIT, Stevens Institute of Technology, Rensselaer-Polytechnic Institute, CAL-TECH, Princeton, UCLA, Yale, Coast Guard Academy, West Point Academy, U.S. Merchant Marine Academy, Cornell University, Albert Einstein, John Hopkins University.

HIGHWAYS AND TURNPIKES: New Jersey, New York, Pennsylvania, Maine, Mass., Virginia, Rhode Island, Ontario, Connecticut.

PUBLIC BUILDINGS: United Nations, Rockefeller Institute, Columbia Presbyterian Hospital, Executive Mansion, all N.Y., British Embassy, House of Representatives Office Building, Smithsonian Institute, Library of Congress, all Washington, D.C., Space Science Center, Greenbelt, MD., Children's Medical Center, Dallas, TX., Kennedy Memorial Grave Site, Arlington, VA., Salt Lake County Civic Auditorium, Utah, Lyndon B. Johnson Library, Austin, TX., Statue of Liberty, Bear Hill Correctional Facility, Malone, N.Y.

INDUSTRIAL INSTALLATIONS: U.S. Steel Corp., So. Chicago, IL. and Fairfield, AL., Western Electric Co., Charlotte, N.C., A.T.&T. Repeater Stations, Johnson & Johnson, New Brunswick, NJ., Exxon Refinery, Elizabeth, NJ., Sinclair Refining, E. Chicago, IL., Florida Power & Light, Parrish, FL., Bethlehem Steel Graving Dock, Quincy, MA., American Cyanamid, Wayne, NJ., Alcoa, Badin, NC, A.I. DuPont, Wilmington, DL., Armstrong Cork Co., Macon, GA. Pacific Gas & Elec., San Francisco, Calif.

NUCLEAR POWER PLANTS: Conn., N.Y., N.C., Phillipines, S.C.

RAILROADS: NJ., Washington D.C., MA., OH., Los Angeles CA.

RAPID TRANSIT SYSTEMS: N.Y., Boston, Cleveland, Philadelphia, Washington, D.C.

OFFICE BUILDINGS: House of Seagram, Chase Manhattan Bank, A.T.&T., World Trade Center Twin Towers, Battery Park Complex, all New York., Exchange Park Complex, Dallas, TX., Western Electric, Indianapolis, IN., Prudential Insurance Co., Kansas City, MO., IBM, Baltimore, MD. and N.Y., Doctor's Bldg., Omaha, NE.

PUBLIC WORKS: Lincoln Tunnel, George Washington Bridge, Tri-Boro Bridge Authority Adm. Bldg., Randalls Island, all N.Y., Submarine Base, New London, CT., Hampton Roads Tunnel, Norfolk, VA., Delaware River Bridge, Camden, NJ., City of Anchorage, Alaska, Greeley Wastewater Treatment Facility, CO., Kings Bay Submarine Base, Kings Bay, GA.

OTHER INSTALLATIONS: Meadowlands Sports Complex, Monmouth Park Jockey Club, Earle Ammunition Depot, all N.J., Belmont, Aqueduct, Jamaica Race Tracks, United Engrg. Center, Winged Foot Golf Club, Shea Stadium, Lincoln Center, Fresh Kill Landfill, all N.Y., Flood Control Project, N. Adams, MA., Cloverdale Shopping Center, Etobicoke, Ontario, Canada, National Center for Atmospheric Research, Boulder, Co., Iowa Gas & Elec., Life George Bldg., Atlanta, Ga., Power Plant, Okinawa, Sturgeon Bay Graving Dock, WI., Coca Cola Co., Shrevesport, LA., Dome Stadium, Minn., MN., Kennedy Space Center, Tennessee Valley Authority, Greater Lebanon Refuse, PA., Universal Studios, Universal City, CA.

OVERSEAS INSTALLATIONS: Africa, Mid-east, Central America, Aleutian Islands, Okinawa, St. Croix, Libya, Spain, Saudi Arabia, South America, South Pacific, Andros Island, Republic of Guinea, Kuwait, United Arab Emirates, Puerto Rico, Bermuda, Philippines, Hawaii, Moscow, Russia, Muscat, Oman, Nicosia, Cypress.

specifications:

To Specify, Use the Following:

COMPOSITION: *Porous concrete drain pipe to be as manufactured by Walker Poroswall Pipe Co., Little Ferry, N.J. from a mixture of Portland Cement, Water, 3/8" trap rock and sand.

SHAPE: The cross section of the pipe to be circular inside and out.

TYPE OF JOINT: The tongue and groove to be formed of solid concrete extending into barrel for approximately one inch at each end. All joints to be of the interlocking tongue and groove type with the exterior of the groove in the same plane as the exterior of the barrel.

CURING AND AGING: All porous concrete pipe to be thoroughly cured in modern steam curing rooms and stored until properly aged before shipping.

PHYSICAL PROPERTIES: The finished pipe to be straight, free from cracks, checks or other defects and reasonably uniform in color and texture.

INFILTRATION: The infiltration rate to be not less than two gallons per minute per inch of internal diameter per lineal foot of pipe for 4" to 8" pipe inclusively. See tables below for infiltration rates on sizes larger than 8".

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12"	3	84	2.00	3600	18
15"	3	122	2.25	3900	23
18"	3	180	2.50	4000	24

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Prices and Additional Information Available on Request