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PUBLIC SERVICE COMPANY OF OKLAHOMA

A CENTRAL AND SOUTH WEST COMPANY

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Public Service Company of Oklahoma
Black Fox Station Units 1 and 2
Excavation Seal Unit 2
U.S. NRC Docket No. STN 50-556, 50-557

October 19, 1979
File 6212.125.3500.21L

Mr. Steven A. Varga, Assistant Director
Division of Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20002

Dear Mr. Varga:

This letter updates and confirms several conversations concerning the excavation of Unit 2 which took place between representatives of PSO and the technical staff of NRR and I&E Region IV during the latter part of July and mid-August of this year. During these discussions, we reported the preliminary results of the field testing activities which were completed in the foundation area for Unit 2 structures and the recommendations of our Architect-Engineer regarding the nature of the subgrade material found in the Unit 2 excavation area.

Excavation for Unit 2 was authorized under Amendment 2 of the Limited Work Authorization on November 30, 1978. The initial work commenced in December, 1978, resumed in April, 1979 after the unusually severe winter forced shutdown and reached the base foundation elevation in mid-June. At that time, field tests showed that a soft, siltstone layer underlaid a large portion of the excavation surface at depths ranging from two to seven feet. Our Architect-Engineer recommended that the depth of the excavation in the Unit 2 foundation areas be extended to remove the soft siltstone layer. Subsection 2.5.4 of the BFS Preliminary Safety Analysis Report predicted such overexcavation below the base foundation elevation and stated that these areas would be backfilled with lean concrete.

As discussed previously with Dr. Cecil O. Thomas, Licensing Project Manager of NRR and William A. Crossman, Chief, Projects Section, I&E Region IV, the soft, siltstone layer material has now been removed from the excavation area, and a nominal six-inch concrete seal coat has been applied to protect the underlying rock structure from weathering.

In order to bring the entire excavation up to design base foundation elevation, a mass fill of lean concrete will be required. The Unit 2 structures (i.e., the

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fuel building, the reactor building, and auxiliary building) would therefore be supported on fill concrete founded directly on the same competent siltstone as Unit 1. However, in accordance with our oral commitment to Mr. Thomas, we intend to provide the NRC Staff with certain analyses prior to taking this action. These analyses involve an assessment of the strength of the concrete as a foundation material as compared with the natural rock structure and the effect of this relative thick concrete fill on the dynamic responses of the safety-related structures.

During our previous discussions, we expected to supply these analyses within a 30 to 60 day time period for Staff review. Unfortunately due to manpower constraints associated with reviewing the Staff's TMI requirements in preparation for our upcoming hearing, we have fallen behind schedule in providing you with this information.

We will advise you further when the engineering effort on the analyses work is completed.

Very truly yours,

T. N. Ewing

T. N. Ewing, Manager
Black Fox Station Nuclear Project

TNE:VLC:jk

cc: BFS Service List

3.8.5 Foundations and Concrete Supports

The foundation mats will be founded on competent subsurface materials which will provide adequate support at appropriate bearing level. As presented in Subsection 2.5.4, unsuitable material is removed and backfilled with a lean concrete mix of 2,000 psi minimum specified compressive strength at 28 days. (Refer to Figure 2.5-50 for excavation detail.)

Since an inordinate amount of unsuitable material had to be removed, additional studies were performed to assess the strength of the lean concrete as a foundation material as compared with a natural rock structure and the effect of this relatively thick concrete fill on the dynamic responses of the safety-related structures. As established by the NRC staff in Table 3.7.2-1 of the Standard Review Plan 3.7.2, the soil-structure interaction effect is negligible for a supporting medium with a minimum shear wave velocity of 3,500 fps. The competent Savannah formation under the expected lean concrete backfill has a minimum shear wave velocity of 3,500 fps (PSAR Subsection 2.5.2.4). The lean concrete backfill provides a shear wave velocity which can be computed as follows: 16

$$E = 57{,}000\sqrt{f'_c} = 57{,}000\sqrt{2{,}000} = 2.549 \times 10^6 \text{ psi}$$

$$\rho_{conc.} = 2.246 \times 10^{-4} \text{ lb sec}^2/\text{in}^4$$

$$\upsilon_{conc.} = 0.17$$

$$V_s = \sqrt{\frac{E}{2(1+\upsilon)\rho}} = 6.964 \times 10^4 \text{ in/sec} = 5{,}800 \text{ fps}$$

Because the shear wave velocity computed above is greater than 3,500 fps, no soil-structure interaction will result due to seismic events. The computed value of the shear wave velocity will be verified by actual tests in the field to ensure that it is not lower than 3,500 fps.

To investigate the effect of the mass fill of lean concrete on the structural behavior under other dynamic loads, the safety/relief valve (S/RV) discharge loads were chosen as representative of the dynamic loads which act on the Reactor Building structures. The other dynamic loads, besides seismic, are those associated with the loss-of-coolant accident (LOCA). It was decided to select the SRV loads because they produce greater structural responses and soil-structure interaction effects.

The S/RV load case selected for the study was the all (19) valve case, random actuation. This case produces the largest structural response in both the vertical and the horizontal (rocking) directions. For this study, an axisymmetric finite element model of the Reactor Building and support soil was analyzed. See Figure 3.8-49 for a plot of the model used. The analysis was performed using program S73 (Ghosh-Wilson program ASHSD2 described in Appendix 3A). The dynamic load is input in the form of a Fourier Series to describe the load variation around the circumference.

Based on a large number of computer analyses of the S/RV loads, it was evident that the structural response, including particularly the rocking motion, was dominated by the first Fourier harmonic, i.e., the term $A_1 \cos \theta$, where A_1 represents the magnitude of the load and $\cos \theta$ represents the circumferential distribution of the load. Since the first harmonic represented the dominant structural response, it was not necessary to extend the analyses to include the full range of the Fourier harmonics.

Three computer analyses were performed to investigate the effects of fill concrete on structural response. The first analysis assumed normal bedrock with a minimum fill of lean concrete, the second analysis assumed the mass fill concrete of 9.25 feet thick under the mat, expected for Black Fox, and the third analysis had a layer 29.25 feet thick. The natural soil properties in the model, as represented by the shear wave velocity V_s, for all runs were as follows: 16

Elevation 539 to 510	V_s = 3,500 fps
Elevation 510 to 480	V_s = 4,000 fps
Below Elevation 480	V_s = 4,400 fps

The calculations were performed replacing the layer of soil immediately under the Reactor Building foundation with lean concrete (V_s = 5,800 fps) 150 feet in diameter and 9.25 feet and 29.25 feet thick. All deviations in the resulting structural responses lie within 5 per cent of the response compared with only natural material, i.e., minimum fill concrete under the building. Since this is within the calculational range of accuracy, it is concluded that the use of lean concrete backfill results in an insignificant effect on the structural response.

To simplify computer modeling, the shear wave velocity of the natural material, i.e., 3,500 fps, will be used for any future dynamic analyses of the Reactor Building because of the similarity in structural response using fill concrete or natural material. 16

3.8.5.1 Reactor Building Foundation

3.8.5.1.1 Description of the Foundation. The reactor building foundation is a circular reinforced concrete mat 138 feet in diameter and 11 feet thick. It supports the shield building, the steel containment vessel, the RPV pedestal, the drywell, the weirwall and other internal structures. The mat is structurally independent of other foundations. B 3 16

Within the perimeter of the containment structure the foundation mat is lined with steel plate. The liner is a part of the containment system, refer to 3.8.2.1. The embedded skirts of the drywell and the RPV pedestal pass through the liner plate, as indicated on Figures 3.8-4a and 3.8-4b. However, continuity of the steel membrane is maintained. Q130.13

The liner is covered by about 10 feet of concrete in the area between the RPV pedestal and the weir wall, and 3 feet of fill inside the pedestal. There is no fill on the liner in the suppression pool. B

3.8.5.1.2 Applicable Codes, Standards and Specifications. Same as 3.8.3.1.2, except that Reference (3), ASME code Subsection NE, applies to the liner plate suppression pool floor. B

3.8.5.1.3 Loads and Loading Combinations. Same as 3.8.3.1.3, except that reference to 500 cycles of temperature variation under 3.8.3.1.3.2 is omitted.

In addition to the load combinations referenced above, the combinations utilized as minimum design criteria against sliding and overturning due to earthquakes, winds, and tornadoes, and against flotation due to floods, are listed below. 3 Q130.12

a. D + H + Feqo

b. D + H + W

c. D + H_2 + Feqs

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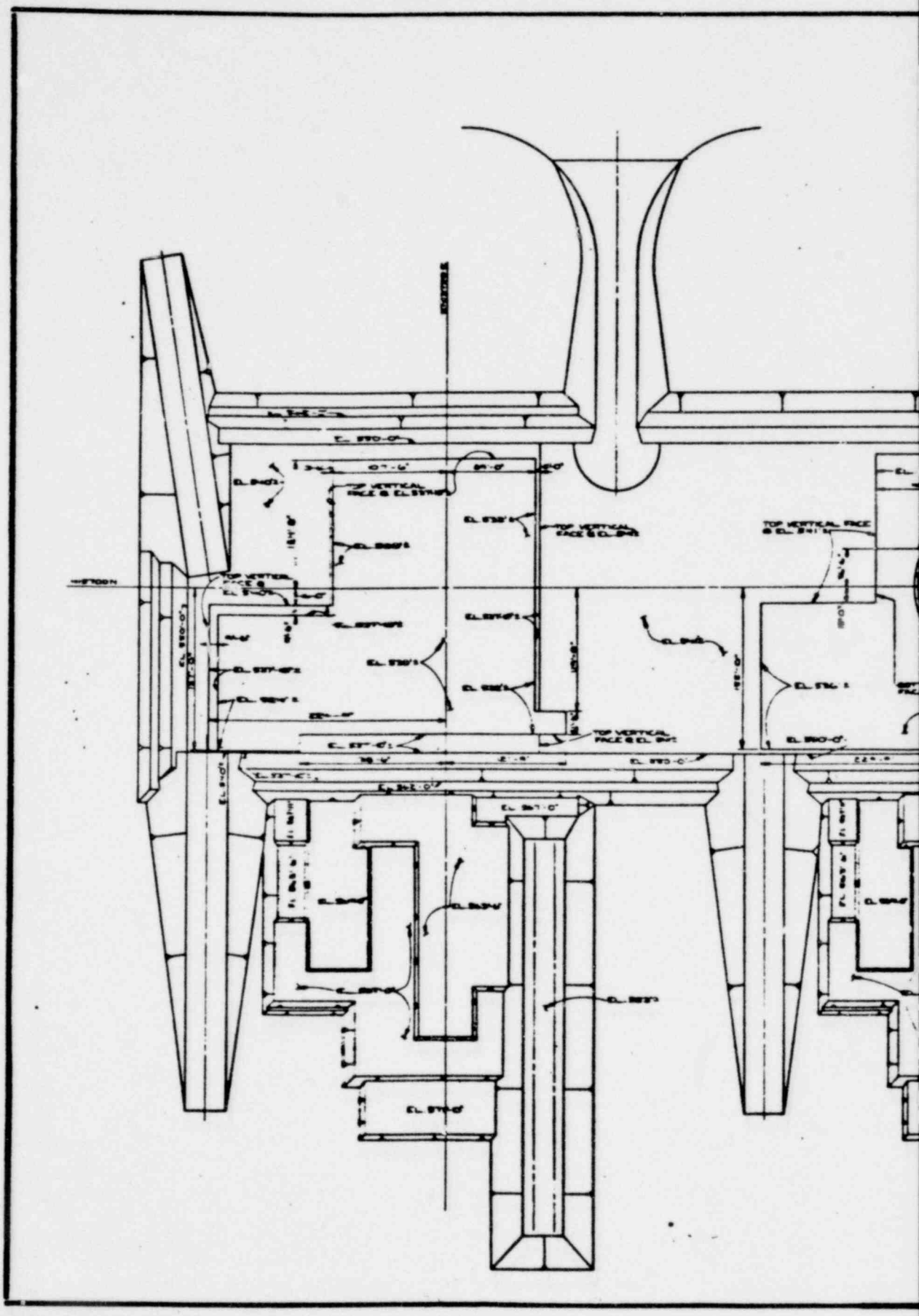
POOR ORIGINAL



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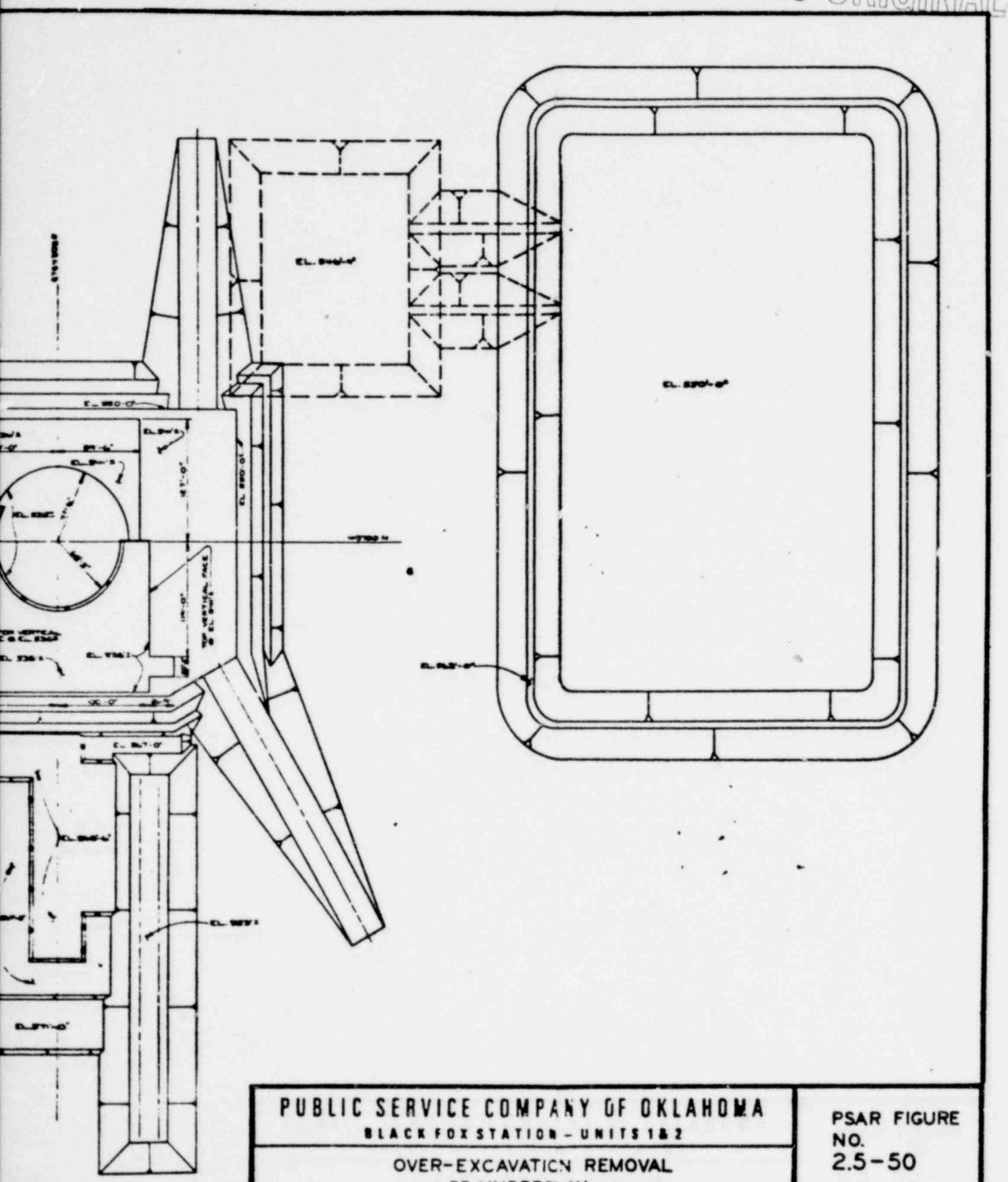

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BLACK FOX STATION - UNITS 1 & 2

OVER-EXCAVATION REMOVAL OF UNDERCLAY

PSAR FIGURE NO. 2.5-50

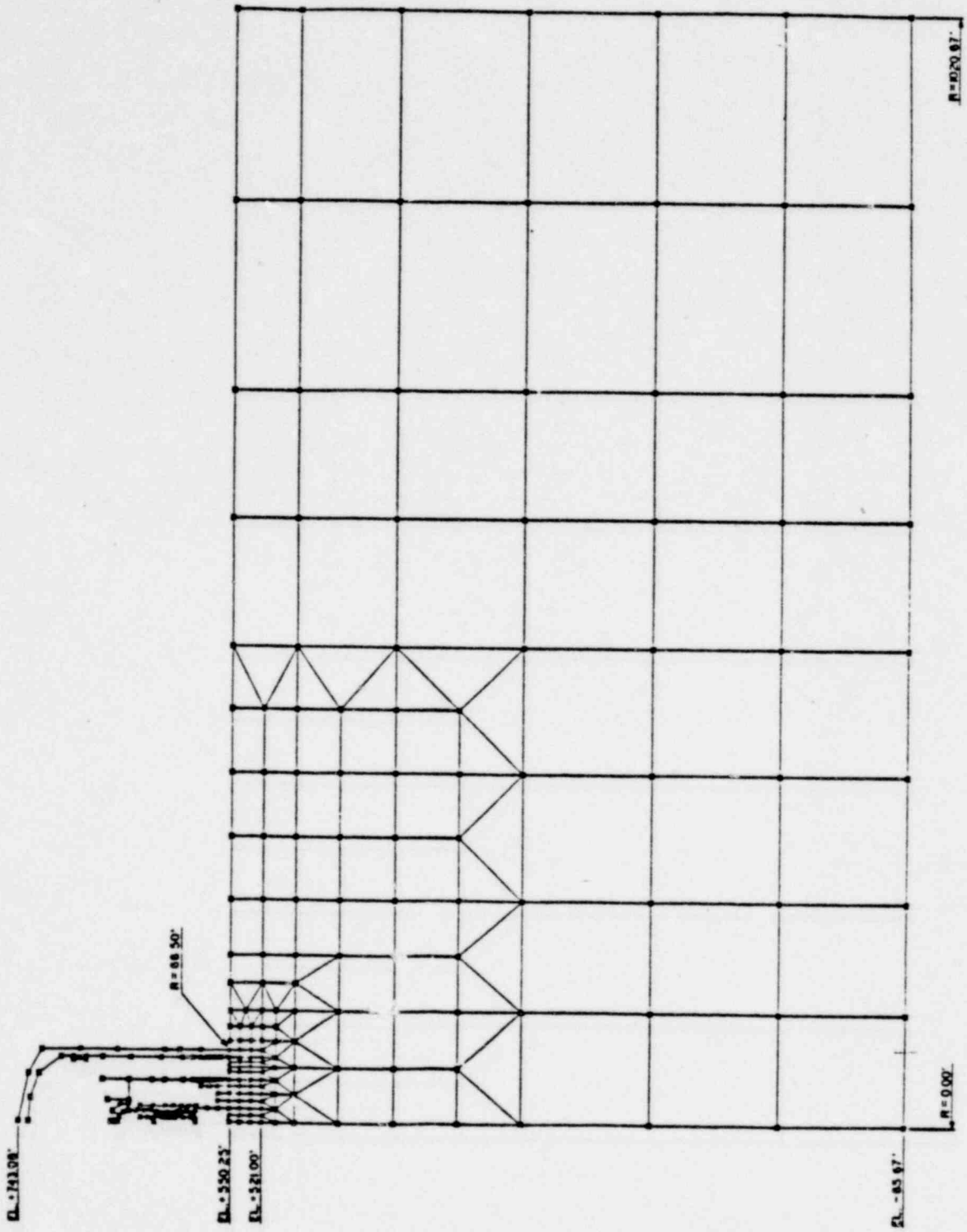

Figure 3.8-49. RB/Soil Axisymmetric Model - Horizontal RPV Model