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4/1/76

CLINCH RIVER

BREEDER REACTOR PROJECT

PRELIMINARY SAFETY ANALYSIS REPORT

VOLUME 22

PROJECT MANAGEMENT CORPORATION

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Question 321.1 (2.4.2)

Provide a summary (preferably tabular) of all cases studied to determine the design basis flood level.

Response:

Sections 2.4.3 and 2.4.4 contain the requested information.

Question 321.2 (2.4.2)

Tabulate the PMP increment and loss rates used in designing the site drainage systems, and present runoff models used including roof drainage. Demonstrate that ponding or flow depths resulting from the local PMP falling directly on the site will not exceed the elevations of accesses to safety related facilities.

Response:

The response to this question has been incorporated in revised Section 2.4.2.3.

Question 321.3 (2.4.4)

Was the failure of Tellico Dam included in the flood analyses?

Response:

The response to this question has been incorporated in revised Section 2.4.4.

Question 321.4 (2.4.4.2.2)

Present the Norris Reservoir inflow and outflow Hydrographs resulting from the critical centering of the PM storm in the Clinch River basin and demonstrate that Norris Dam could pass the PMF without failure.

Response:

Section 2.4.3 contains the requested information.

Question 321.5 (2.4.4.3)

Please supply all input to your unsteady flow analysis of the failure of Norris Dam which resulted in the design basis flood level at the plantsite, including cross-sections, roughness factors, bases therefore, and the analyses and results of physical model studies of the failure.

Response:

The requested information has been transmitted by TVA's Flood Control Branch (J.T. Price and B.J. Buchler) to D. Cordell of the NRC staff in letters dated: December 13, 1974
December 16, 1974
December 18, 1974
December 20, 1974
January 2, 1975
January 9, 1975
January 21, 1975

Question 321.6 (2.4.4.3)

Demonstrate that the 665-foot long failure mode of Norris Dam will discharge at a higher rate than the 833-foot long failure.

Response:

Section 2.4.4.3 contains the requested information.

Question 321.7 (2.4.4)

It is not clear whether Watts Bar Dam was assumed to fail during the floods from seismic causes and if so, the effect on the flood peaks at the site. Please clarify.

Response:

Section 2.4.4.2 contains the requested information.

Question 321.8 (2.4.7)

Discuss the history of formation of ice jams, frazil, and anchor ice in the region.

Response:

Section 2.4.7 contains the requested information.

Question 321.9 (2.4.11.1)

Discuss the effects of Tellico Dam, when completed, on water supply, water levels, flow velocities and direction at the site.

Response:

The response to this question has been incorporated in revised Section 2.4.11.1.

Question 321.10 (2.4.11)

State the amounts of water required for normal and emergency plant operation.

Response:

1. Normal CRBRP water usage with seasonal variations is given in Table 3.3-4 of the Environmental Report.

2. Provision for supplying water for emergency plant operations are discussed in Sections 9.9.2, 9.9.4 and 9.9.6 of the PSAR. There is no requirement for makeup water from the Clinch River during emergency operation.

Question 321.11 (2.4.12)

Discuss possibility and consequences of recirculation of liquid releases during periods of zero or reverse river flow.

Response:

The possibilities and consequences of recirculation of liquid release during periods of zero or reverse river flow are discussed in Section 14.6 of the Environmental Report.

Question 321.12 (2.2)

Provide a map showing lanes or other routes of river traffic near the site.

Response:

Figure Q321.12-1 contains a portion of TVA Tennessee River Navigation Chart #804 showing Clinch River Navigation Channel and navigational aids in the area of the site. Two large scale color copies of this chart will be separately forwarded to be used as a working set for regulatory review.

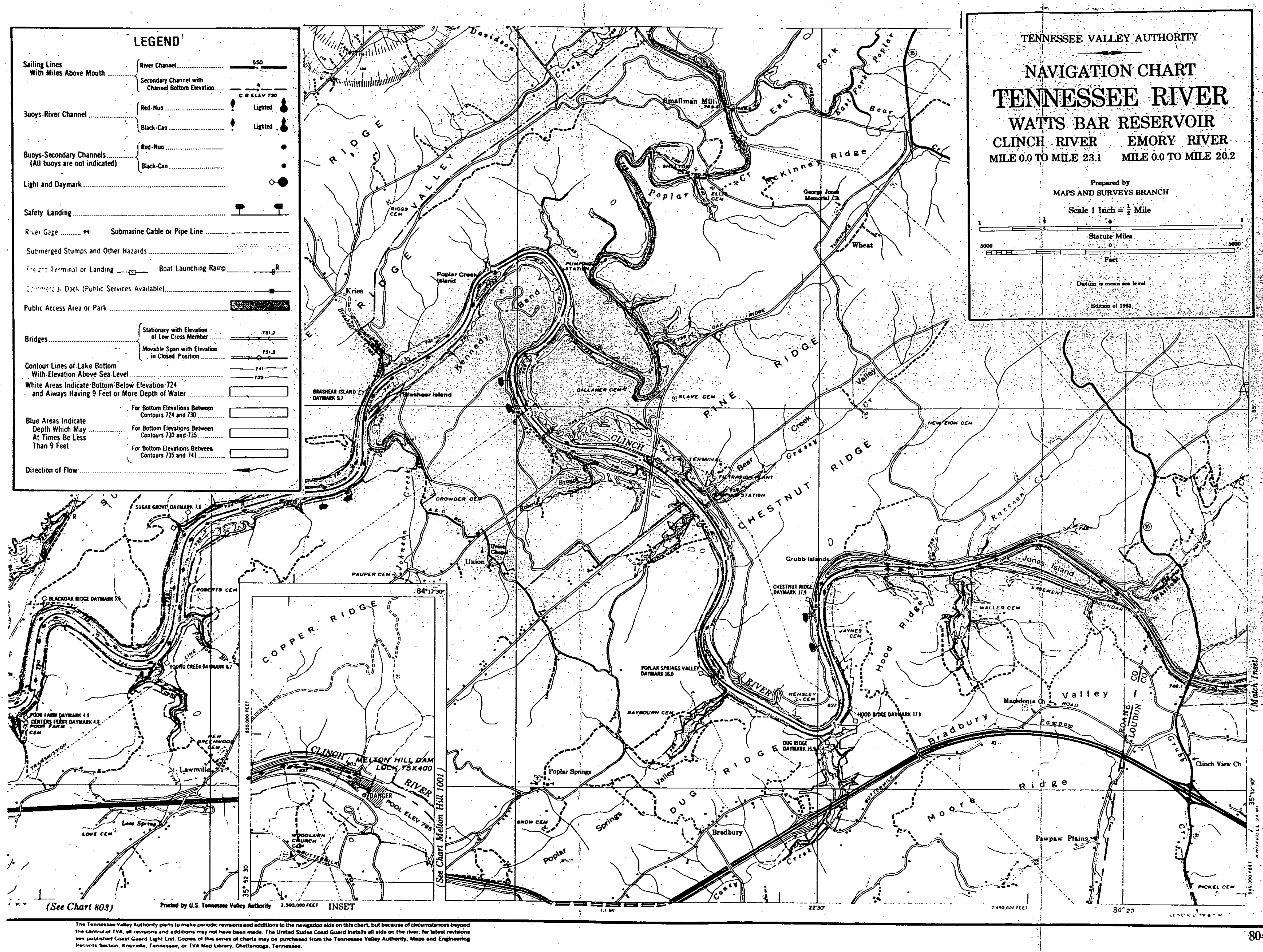

Figure Q321.12-1. Clinch River Navigation Chart

Amend. 1
July 1975

Question 322.1 (2.3.1.3)

Provide the design basis snow and ice load for the plant site. This load should be the total weight of:

1. The maximum observed snowpack in the site region, plus

2. The weight of the maximum winter precipitation (snow or ice) expected from a single storm with a recurrence interval of 100 years in the site region.

Response:

The response to this question has been incorporated in revised Section 2.4.2.3.

Question 322.2 (2.3.1.3)

Provide and substantiate the meteorological data used for the ultimate heat sink, considering:

1. maximum evaporation and drift loss
2. minimum water cooling

Response:

Meterological data to be used for the ultimate heat sink design shall be furnished in the F.S.A.R, along with the analysis discussed in response to Question 020.19.

Question 322.3 (2.3.1.3)

Provide the design basis tornado parameters for the plant including:

1. Maximum wind speed
2. Maximum translational wind speed
3. Maximum rotational wind speed
4. Maximum pressure drop
5. Maximum rate of pressure drop

Response:

The information requested appears in Table 3.3-1.

Amend. 7
Nov. 1975

Question 322.4 (2.3.1.3)

Document in this section all meteorological conditions used as design basis considerations in the PSAR and include appropriate cross-references.

Response:

The information requested is included in the response to Questions 322.3 and 322.16.

Amend. 7
Nov. 1975

Question 322.5 (2.3.1.3)

Provide an estimate of the seasonal and annual frequencies of lightning discharges (based on the frequency of occurrence of thunderstorms) expected in the vicinity of the Site.

Response:

The following formula has been developed (Ref. Q322.5-1) for estimating the frequency of lightning flashes to the earth per thunderstorm day per square kilometer for a particular region:

$$NE = (0.1 + 0.35 \sin \lambda)(0.40 \pm 0.20)$$

where NE is the number of flashes to earth per thunderstorm day per square kilometer, and λ is the location's geographical latitude. The CRBRP site is located at a latitude of 35°53'24". Substituting this for λ produces a value for NE equal to 0.122 flashes per thunderstorm day per square kilometer. An estimate of the seasonal and annual frequencies of lightning discharges expected in the vicinity of the site can be calculated as the product of NE and the average number of thunderstorms occurring in the site region for the time period of interest. These values appear in Table Q322.5-1. The results show an estimated 6.47 flashes per year per square kilometer.

It has been determined that a structure attracts lightning of average intensity up to a distance equal to twice its height. (Ref. Q322.5-1) The dominant structure of the CRBRP is the dome capped, cylindrical steel shell of the Reactor Containment Building which has a height of approximately 52 meters and has a diameter of approximately 57 meters. In order to be conservative, the attraction area of this structure will be calculated for the cubic structure which would enclose it. This cube would have a height equal to that of the Containment Building, and a width and length equal to the Containment Building's diameter. Using this approximation, lightning flashes are expected to be attracted over a surface area of $LW + 4H(L+W) + 4H^2\pi$. (Ref. Q322.5-2) Using L and W = 57 meters and H = 52 meters, the attraction area is calculated to be 0.0609 square kilometers.

The probability of a lightning discharge striking the Reactor Containment Building can be derived using the previously calculated frequencies of discharges expected in the site vicinity (see Table Q322.5-1) and the atraction area of the structure. These results show that the structure is likely to be struck by lightning once in every 2.5 years.

Ref. Q322.5-1 - Golde, R.H., "Protection of Structures Against Lightning", Proc. IEE, 115, No. 10 (October 1, 1968).

Ref. Q322.5-2 - Marshall, J.L., Lightning Protection, John Wiley and Sons, New York, (1973), p.30.

TABLE Q322.5-1

Time Periods	NE (Number Flashes to Earth Per Thunderstorm Day Per km^2)	T (Average Number Thunderstorm Day Per Time Period)	F=frequency of lightning flashes = NE x T (Number Flashes Per Time Period Per km^2)	F x Attractive Area (Number Flashes Striking Structure Per Time Period)	Recurrence Interval (Time Periods)
Spring	0.122	16	1.95	0.119	8.4 seasons
Summer	0.122	29	3.54	0.216	4.6 seasons
Fall	0.122	5	0.610	0.037	27.03 seasons
Winter	0.122	4	0.488	0.0297	33.7 seasons
Annual	0.122	53	6.47	0.394	2.5 years

Attractive area = 0.0609 km^2

Geographical latitude = λ = 35°53'24"

Question 322.8 (2.3.3)

Provide topographic cross-sections indicating the relationship between the present tower and instrument locations and present and proposed grading of the plant site.

Response:

The information requested is provided in Figure Q322.8-1. 27 38

Amend. 38
April 1977

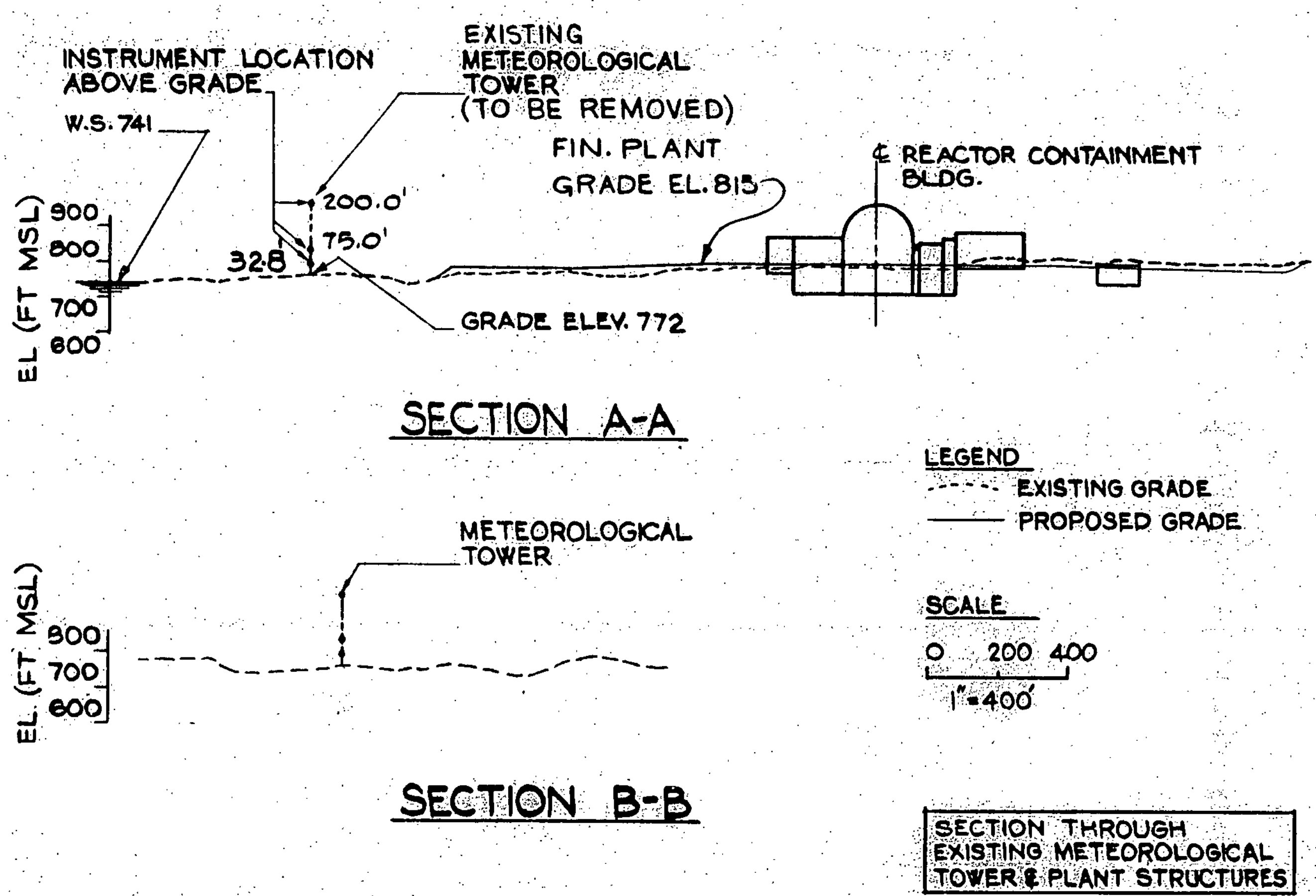

Figure Q322.8-1

Question 322.9 (2.3.3)

Provide a large scale topographic map indicating the location of the proposed plant structures with respect to the present and any other proposed meteorological towers.

Response:

The information requested is provided as Figure Q322.9-1. 27 38

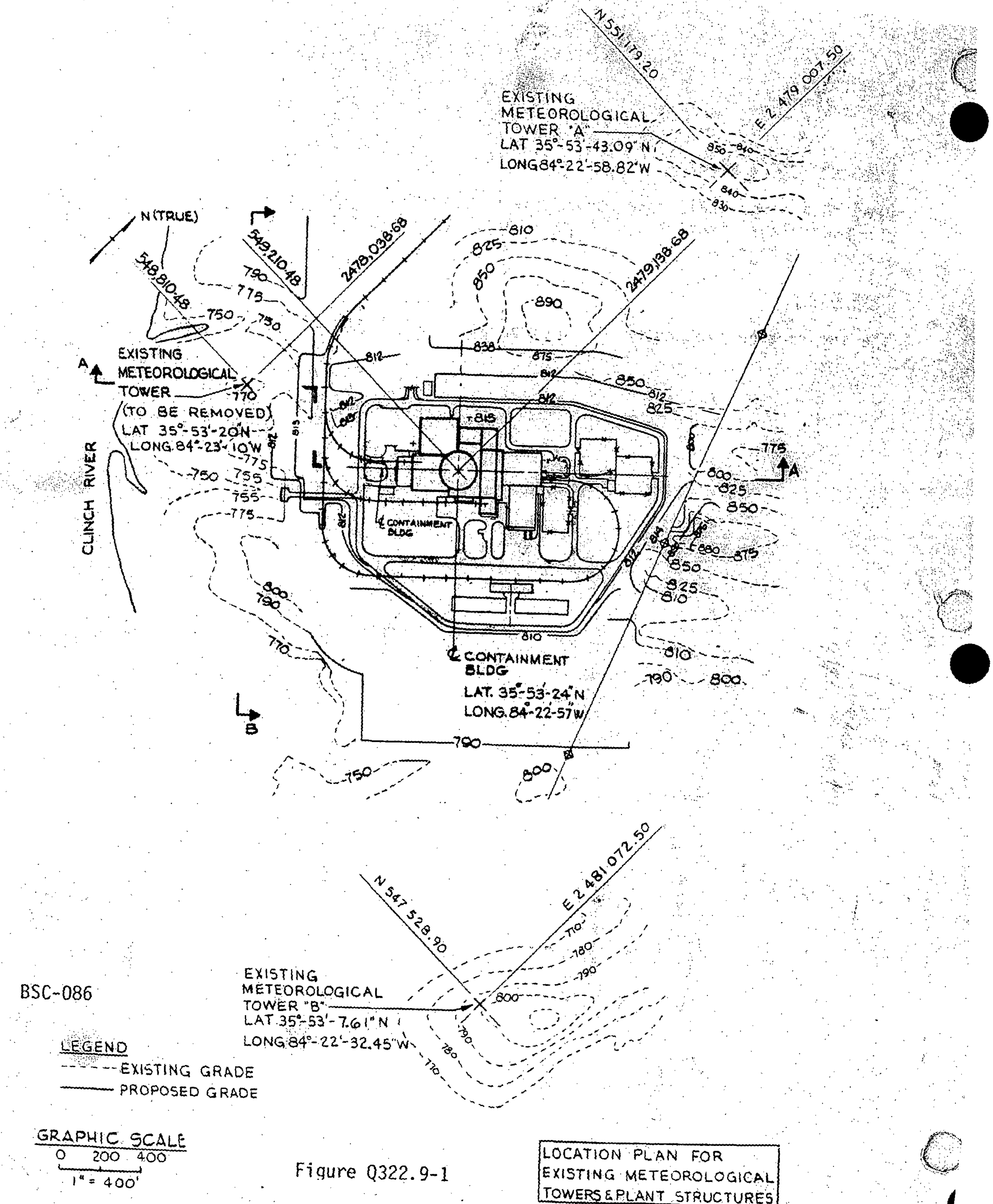

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Figure Q322.9-1

Question 322.11 (2.3.4.2)

Provide revised short-term diffusion estimates based on the joint frequency data as requested under 322.6 above.

Response:

Section 2.3 contains the requested information.

Question 322.12 (2.3.5.2)

Provide revised long-term diffusion estimates based on the joint frequency data, as requested under 322.6 above.

Response:

Section 2.3 contains the requested information.

Question 322.13 (2.3B)

Provide the two sets of joint frequency distribution used to obtain the information in the section Wind and Stability Data and in Table 2.3B-20 of Supplement 1 to Chapter Two - Revised On-site Meteorology of the PSAR. The first set should be based on wind speed and direction measured at the 75-ft. level and vertical temperature difference between the 33- and 200-ft. levels. The second set should be based on the winds measured at the 75-ft. level but with the vertical temperature difference measured between the 75- and 200-ft. levels. The data should be for the period April 3, 1974 through June 30, 1974 and the joint data recovery rates should be provided.

Response:

Tables 322.13-1 through 14 provide the requested information. The first seven tables provide the joint frequency distribution based on wind speed and direction measured at the 75-ft. level and vertical temperature between the 75- and 200-ft. level. The data recovery rate is 73.24%. Tables 322.13-8 through 14 are based on winds measured at the 75-ft. level but with vertical temperature measured between the 33- and 200-ft. level. The data recovery rate is 68.31%. All data is for the period April 3, 1974 through June 30, 1974.

Note: Amendment 38 eliminated Section 2.3B. Table 2.3B-20 is included in Response to NRC Question 322.6 (Part II). Table 2.3-36 in revised Section 2.3 contains a similar comparison of percentage frequency of stability distribution for two temperature differentials for the CRBRP meteorological tower for the period March through August 1976. 38

TABLE 322.13-1
JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED
FOR STABILITY CLASS A
CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL
DELTA-T USED: 200 FEET - 75 FEET
APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00152	0.00000	0.00000	0.00000	0.00000	0.00152
NE	0.00038	0.00114	0.00038	0.00000	0.00000	0.00000	0.00190
ENE	0.00038	0.00342	0.00152	0.00000	0.00000	0.00000	0.00533
E	0.00000	0.00266	0.00076	0.00000	0.00000	0.00000	0.00342
ESE	0.00000	0.00266	0.00076	0.00000	0.00000	0.00000	0.00342
SE	0.00000	0.00266	0.00000	0.00000	0.00000	0.00000	0.00266
SSE	0.00000	0.00266	0.00000	0.00000	0.00000	0.00000	0.00266
S	0.00000	0.00266	0.00076	0.00000	0.00000	0.00000	0.00342
SSW	0.00114	0.00533	0.00457	0.00076	0.00000	0.00000	0.01180
SW	0.00114	0.00457	0.00190	0.00000	0.00000	0.00000	0.00761
WSW	0.00038	0.00342	0.00000	0.00000	0.00000	0.00000	0.00381
W	0.00038	0.00038	0.00000	0.00000	0.00000	0.00000	0.00076
WNW	0.00038	0.00190	0.00038	0.00000	0.00000	0.00000	0.00266
NW	0.00000	0.00038	0.00152	0.00114	0.00000	0.00000	0.00304
NNW	0.00000	0.00076	0.00038	0.00000	0.00000	0.00000	0.00114
TOTAL	0.00419	0.03615	0.01294	0.00190	0.00000	0.00000	0.05518

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Amend. 1
July 1975

TABLE 322.13-2

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS B

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

	WIND SPEED, KNOTS*						
	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00000	0.00038	0.00000	0.00000	0.00000	0.00000	0.00038
NNE	0.00000	0.00304	0.00038	0.00000	0.00000	0.00000	0.00342
NE	0.00038	0.00533	0.00038	0.00000	0.00000	0.00000	0.00609
ENE	0.00190	0.00533	0.00038	0.00000	0.00000	0.00038	0.00799
E	0.00076	0.00571	0.00000	0.00000	0.00000	0.00114	0.00761
ESE	0.00038	0.00266	0.00000	0.00000	0.00000	0.00038	0.00342
SE	0.00076	0.00342	0.00038	0.00000	0.00000	0.00000	0.00457
SSE	0.00114	0.00228	0.00000	0.00000	0.00000	0.00000	0.00342
S	0.00114	0.00304	0.00076	0.00000	0.00000	0.00038	0.00533
SSW	0.00381	0.00875	0.00609	0.00190	0.00000	0.00076	0.02131
SW	0.00571	0.00799	0.00913	0.00038	0.00000	0.00114	0.02435
WSW	0.00381	0.00761	0.00114	0.00076	0.00000	0.00076	0.01408
W	0.00152	0.00342	0.00114	0.00114	0.00000	0.00038	0.00761
WNW	0.00000	0.00190	0.00342	0.00038	0.00000	0.00000	0.00571
NW	0.00000	0.00152	0.00000	0.00000	0.00000	0.00000	0100152
NNW	0.00000	0.00419	0.00038	0.00000	0.00000	0.00000	0.00457
TOTAL	0.02131	0.6659	0.02359	0.00457	0.00000	0.00533	0.12139

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.13-3

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS C

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00038	0.00076	0.00000	0.00000	0.00000	0.00000	0.00114
NNE	0.00000	0.00114	0.00000	0.00000	0.00000	0.00000	0.00114
NE	0.00000	0.00038	0.00000	0.00000	0.00000	0.00000	0.00038
ENE	0.00000	0.00228	0.00000	0.00000	0.00000	0.00038	0.00266
E	0.00038	0.00152	0.00000	0.00000	0.00000	0.00000	0.00190
ESE	0.00076	0.00076	0.00000	0.00000	0.00000	0.00000	0.00152
SE	0.00114	0.00000	0.00000	0.00000	0.00000	0.00000	0.00114
SSE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
S	0.00114	0.00114	0.00000	0.00000	0.00000	0.00000	0.00228
SSW	0.00190	0.00342	0.00266	0.00000	0.00000	0.00038	0.00837
SW	0.00114	0.00342	0.00304	0.00114	0.00000	0.00114	0.00989
WSW	0.00152	0.00342	0.00190	0.00038	0.00000	0.00114	0.00837
W	0.00190	0.00381	0.00076	0.00038	0.00000	0.00000	0.00685
WNW	0.00076	0.00304	0.00076	0.00076	0.00000	0.00000	0.00533
NW	0.00076	0.00152	0.00038	0.00000	0.00000	0.00000	0.00266
NNW	0.00038	0.00114	0.00000	0.00000	0.00000	0.00000	0.00152
TOTAL	0.01218	0.02778	0.00951	0.00266	0.00000	0.00304	0.05518

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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TABLE 322.13-4

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS D

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00309	0.00288	0.00000	0.00000	0.00000	0.00000	0.00538
NNE	0.00386	0.00457	0.00000	0.00000	0.00000	0.00000	0.00842
NE	0.00576	0.00647	0.00000	0.00000	0.00000	0.00000	0.01223
ENE	0.00880	0.00913	0.00000	0.00000	0.00000	0.00076	0.01870
E	0.00766	0.00342	0.00000	0.00000	0.00000	0.00076	0.01185
ESE	0.00500	0.00381	0.00000	0.00000	0.00000	0.00000	0.00880
SE	0.00233	0.00342	0.00000	0.00000	0.00000	0.00000	0.00576
SSE	0.00462	0.00304	0.00000	0.00000	0.00000	0.00038	0.00804
S	0.00386	0.00495	0.00076	0.00000	0.00000	0.00076	0.01032
SSW	0.01070	0.01560	0.00913	0.00076	0.00000	0.00000	0.03620
SW	0.01223	0.01903	0.01941	0.00304	0.00000	0.00114	0.05484
WSW	0.01032	0.01522	0.00723	0.00076	0.00000	0.00000	0.03354
W	0.00842	0.00837	0.00190	0.00000	0.00000	0.00038	0.01908
WNW	0.00652	0.00951	0.00533	0.00000	0.00000	0.00000	0.02136
NW	0.00614	0.00533	0.00381	0.00038	0.00000	0.00000	0.01565
NNW	0.01070	0.00495	0.00038	0.00000	0.00000	0.00038	0.01641
TOTAL	0.10997	0.11910	0.04795	0.00495	0.00000	0.00457	0.28653

The Total Percentage of Calms for this Stability is: 0.00076

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.13-5

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS E

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.01308	0.00076	0.00000	0.00000	0.00000	0.00000	0.01384
NNE	0.01384	0.00228	0.00038	0.00000	0.00000	0.00000	0.01650
NE	0.01460	0.00381	0.00000	0.00000	0.00000	0.00000	0.01840
ENE	0.02449	0.00419	0.00000	0.00000	0.00000	0.00076	0.02944
E	0.01612	0.00152	0.00000	0.00000	0.00000	0.00000	0.01764
ESE	0.01270	0.00190	0.00000	0.00000	0.00000	0.00000	0.01460
SE	0.00965	0.00190	0.00000	0.00000	0.00000	0.00000	0.01155
SSE	0.00813	0.00038	0.00038	0.00000	0.00000	0.00038	0.00927
S	0.01270	0.00190	0.00114	0.00038	0.00000	0.00000	0.01612
SSW	0.01536	0.01180	0.00381	0.00000	0.00000	0.00000	0.03096
SW	0.02145	0.01408	0.00342	0.00038	0.00000	0.00038	0.03971
WSW	0.01270	0.00647	0.00114	0.00000	0.00000	0.00000	0.02031
W	0.00623	0.00152	0.00000	0.00000	0.00000	0.00000	0.00775
WNW	0.00585	0.00533	0.00076	0.00000	0.00000	0.00000	0.01194
NW	0.00737	8.00647	0.00076	0.00000	0.00000	0.00000	0.01460
NNW	0.01764	0.00304	0.00038	0.00000	0.00000	0.00076	0.02183
TOTAL	0.21195	0.06735	0.01218	0.00076	0.00000	0.00228	0.29452

The Total Percentage of Calms for this Stability is: 0.01446

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.13-6

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS F

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00685	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685
NNE	0.00304	0.00000	0.00000.	0.00000	0.00000	0.00000	0.00304
NE	0.00647	0.00038	0.00000	0.00000	0.00000	0.00000	0.00685
ENE	0.00989	0.00076	0.00000	0.00000	0.00000	0.00038	0.01103
E	0.00837	0.00038	0.00000	0.00000	0.00000	0.00000	0.00875
ESE	0.00799	0.00000	0.00000	0.00000	0.00000	0.00038	0.00837
SE	0.00571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00571
SSE	0.00380	0.00000	0.00000	0.00000	0.00000	0.00114	0.00495
S	0.00761	0.00076	0.00000	0.00000	0.00000	0.00000	0.00837
SSW	0.00989	0.00038	0.00000	0.00000	0.00000	0.00038	0.01065
SW	0.00875	0.00076	0.00038	0.00000	0.00000	0.00038	0.01027
WSW	0.00571	0.00000	0.00000	0.00000	0.00000	0.00000	0.00571
W	0.00304	0.00000	0.00000	0.00000	0.00000	0.00000	0.00304
WNW	0.00419	0.00000	0.00000	0.00000	0.00000	0.00000	0.00419
NW	0.00380	0.00000	0.00000	0.00000	0.00000	0.00000	0.00380
NNW	0.01142	0.00038	0.00000	0.00000	0.00000	0.00000	0.01180
TOTAL	0.10655	0.00381	0.00038	0.00000	0.00000	0.00266	0.11340

The Total Percentage of Calms for this Stability is: 0.00609

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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TABLE 322.13-7

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS G

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 75 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

	WIND SPEED, KNOTS*						
	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00131	0.00000	0.00000	0.00000	0.00000	0.00000	0.00131
NNE	0.00169	0.00000	0.00000	0.00000	0.00000	0.00000	0.00169
NE	0.00055	0.00038	0.00000	0.00000	0.00000	0.00000	0.00093
ENE	0.00283	0.00000	0.00000	0.00000	0.00000	0.00000	0.00283
E	0.00321	0.00038	0.00000	0.00000	0.00000	0.00000	0.00359
ESE	0.00550	0.00038	0.00000	0.00000	0.00000	0.00000	0.00588
SE	0.00359	0.00038	0.00000	0.00000	0.00000	0.00000	0.00388
SSE	0.00512	0.00000	0.00000	0.00000	0.00000	0.00000	0.00512
S	0.00702	0.00000	0.00000	0.00000	0.00000	0.00152	0.00854
SSW	0.00930	0.00000	0.00000	0.00000	0.00000	0.00038	0.00968
SW	0.00588	0.00076	0.00000	0.00000	0.00000	0.00038	0.00702
WSW	0.00283	0.00000	0.00000	0.00000	0.00000	0.00038	0.00321
W	0.00093	0.00000	0.00000	0.00000	0.00000	0.00000	0.00093
WNW	0.00512	0.00038	0.00000	0.00000	0.00000	0.00038	0.00588
NW	0.00474	0.00038	0.00000	0.00000	0.00000	0.00000	0.00512
NNW	0.00816	0.00000	0.00000	0.00000	0.00000	0.00000	0.00816
TOTAL	0.06773	0.00304	0.00000	0.00000	0.00000	0.00304	0.07382

The Total Percentage of Calms for this Stability is: 0.00266

* knot = 0.515 m/sec; 1 knot =1.16 mph

Amend. 1
July 1975

TABLE 322.13-8

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS A

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

	WIND SPEED, KNOTS*						
	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00163	0.00000	0.00000	0.00000	0.00000	0.00163
NE	0.00041	0.00000	0.00041	0.00000	0.00000	0.00000	0.00082
ENE	0.00000	0.00163	0.00163	0.00000	0.00000	0.00000	0.00326
E	0.00041	0.00082	0.00041	0.00000	0.00000	0.00000	0.00163
ESE	0.00000	0.00082	0.00082	0.00000	0.00000	0.00000	0.00163
SE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SSE	0.00000	0.00122	0.00000	0.00000	0.00000	0.00000	0.00122
S	0.00000	0.00041	0.00041	0.00000	0.00000	0.00000	0.00082
SSW	0.00041	0.00082	0.00082	0.00041	0.00000	0.00000	0.00245
SW	0.00041	0.00163	0.00122	0.00000	0.00000	0.00041	0.00367
WSW	0.00041	0.00041	0.00000	0.00000	0.00000	0.00000	0.00082
W	0.00041	0.00000	0.00000	0.00000	0.00000	0.00041	0.00082
WNW	0.00041	0.00163	0.00000	0.00000	0.00000	0.00000	0.00204
NW	0.00000	0.00000	0.00000	0.00041	0.00000	0.00000	0.00041
NNW	0.00041	0.00082	0.00041	0.00000	0.00000	0.00000	0.00163
TOTAL	0.00326	0.01183	0.00612	0.00082	0.00000	0.00082	0.02285

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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Amend. 1
July 1975

TABLE 322.13-9

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS B

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00000	0.00082	0.00000	0.00000	0.00000	0.00000	0.00082
NNE	0.00000	0.00245	0.00000	0.00000	0.00000	0.00000	0.00245
NE	0.00041	0.00245	0.00000	0.00000	0.00000	0.00000	0.00286
ENE	0.00041	0.00449	0.00000	0.00000	0.00000	0.00000	0.00490
E	0.00000	0.00408	0.00000	0.00000	0.00000	0.00041	0.00449
ESE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SE	0.00000	0.00204	0.00000	0.00000	0.00000	0.00000	0.00204
SSE	0.00000	0.00082	0.00000	0.00000	0.00000	0.00000	0.00082
S	0.00000	0.00082	0.00041	0.00000	0.00000	0.00000	0.00122
SSW	0.00082	0.00326	0.00326	0.00082	0.00000	0.00041	0.00857
SW	0.00000	0.00326	0.00204	0.00041	0.00000	0.00041	0.00612
WSW	0.00041	0.00326	0.00000	0.00000	0.00000	0.00041	0.00408
W	0.00000	0.00082	0.00000	0.00000	0.00000	0.00000	0.00082
WNW	0.00000	0.00041	0.00041	0.00000	0.00000	0.00000	0.00082
NW	0.00041	0.00082	0.00122	0.00082	0.00000	0.00000	0.00326
NNW	0.00041	0.00204	0.00041	0.00000	0.00000	0.00000	0.00286
TOTAL	0.00286	0.03182	0.00775	0.00204	0.00000	0.00163	0.04610

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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TABLE 322.13-10

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS C

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

	WIND SPEED, KNOTS*						
	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00082	0.00041	0.00000	0.00000	0.00000	0.00000	0.00122
NNE	0.00000	0.00163	0.00041	0.00000	0.00000	0.00000	0.00204
NE	0.00000	0.00326	0.00041	0.00000	0.00000	0.00000	0.00367
ENE	0.00122	0.00204	0.00041	0.00000	0.00000	0.00000	0.00367
E	0.00041	0.00245	0.00000	0.00000	0.00000	0.00041	0.00326
ESE	0.00041	0.00082	0.00000	0.00000	0.00000	0.00041	0.00163
SE	0.00082	0.00082	0.00041	0.00000	0.00000	0.00000	0.00204
SSE	0.00000	0.00082	0.00000	0.00000	0.00000	0.00000	0.00082
S	0.00082	0.00163	0.00000	0.00000	0.00000	0.00041	0.00286
SSW	0.00122	0.00775	0.00204	0.00041	0.00000	0.00041	0.01183
SW	0.00326	0.00530	0.00443	0.00000	0.00000	0.00122	0.01428
WSW	0.00163	0.00490	0.00082	0.00000	0.00000	0.00082	0.00816
W	0.00326	0.00245	0.00000	0.00082	0.00000	0.00000	0.00653
WNW	0.00000	0.00122	0.00122	0.00000	0.00000	0.00000	0.00245
NW	0.00041	0.00082	0.00041	0.00000	0.00000	0.00000	0.00163
NNW	0.00082	0.00367	0.00000	0.00000	0.00000	0100000	0.00449
TOTAL	0.01510	0.03998	0.01061	0.00122	0.00000	0.00367	0.07058

The Total Percentage of Calms for this Stability is: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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Amend. 1
July 1975

TABLE 322.13-11

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS D

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00377	0.00245	0.00000	0.00000	0.00000	0.00000	0.00622
NNE	0.00418	0.00367	0.00000	0.00000	0.00000	0.00000	0.00785
NE	0.00622	0.00816	0.00000	0.00000	0.00000	0.00000	0.01438
ENE	0.01112	0.01183	0.00000	0.00000	0.00000	0.00204	0.02499
E	0.00867	0.00653	0.00041	0.00000	0.00000	0.00122	0.01683
ESE	0.00540	0.00816	0.00000	0.00000	0.00000	0.00000	0.01356
SE	0.00418	0.00612	0.00000	0.00000	0.00000	0.00000	0.01030
SSE	0.00581	0.00408	0.00000	0.00000	0.00000	0.00041	0.01030
S	0.00500	0.00898	0.00163	0.00000	0.00000	0.00082	0.01642
SSW	0.01601	0.01754	0.01346	0.00204	0.00000	0.00041	0.04947
SW	0.01724	0.02203	0.02244	0.00367	0.00000	0.00163	0.06701
WSW	0.01520	0.01591	0.00734	0.00163	0.00000	0.00082	0.04090
W	0.00704	0.01142	0.00204	0.00082	0.00000	0.00041	0.02172
WNW	0.00663	0.01061	0.00653	0.00122	0.00000	0.00000	0.02499
NW	0.00453	0.00694	0.00408	0.00000	0.00000	0.00000	0.01560
NNW	0.01030	0.00408	0.00041	0.00000	0.00000	0.00041	0.01520
TOTAL	0.13137	0.14851	0.05834	0.00938	0.00000	0.00816	0.35577

The Total Percentage of Calms for this Stability is: 0.00163

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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TABLE 322.13-12

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS E

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

April 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.01260	0.00041	0.00000	0.00000	0.00000	0.00000	0.01301
NNE	0.01097	0.00204	0.00041	0.00000	0.00000	0.00000	0.01342
NE	0.01015	0.00204	0.00000	0.00000	0.00000	0.00000	0.01219
ENE	0.02035	0.00408	0.00000	0.00000	0.00000	0.00041	0.02484
E	0.01342	0.00204	0.00000	0.00000	0.00000	0.00000	0.01546
ESE	0.01219	0.00286	0.00000	0.00000	0.00000	0.00000	0.01505
SE	0.00393	0.00286	0.00000	0.00000	0.00000	0.00000	0.01179
SSE	0.00689	0.00204	0.00041	0.00000	0.00000	0.00082	0.01015
S	0.00975	0.00286	0.00122	0.00000	0.00000	0.00000	0.01383
SSW	0.01301	0.01510	0.00775	0.00000	0.00000	0.00000	0.03586
SW	0.01872	0.01714	0.00898	0.00122	0.00000	0.00041	0.04647
WSW	0.00811	0.01265	0.00408	0.00041	0.00000	0.00000	0.02525
W	0.00730	0.00367	0.00204	0.00000	0.00000	0.00000	0.01301
WNW	0.00648	0.00816	0.00286	0.00000	0.00000	0.00000	0.01750
NW	0.00771	0.00694	0.00122	0.00041	0.00000	0.00000	0.01627
NNW	0.01393	0.00367	0.00041	0.00000	0.00000	0.00082	0.01872
TOTAL	0.18033	0.08854	0.02938	0.00204	0.00000	0.00245	0.30273

The Total Percentage of Calms for this Stability is: 0.01224

*1 knot = 0.5.5 m/sec; 1 knot = 1.16 mph

TABLE 322.13-13

JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED

FOR STABILITY CLASS F

CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL

DELTA-T USED: 200 FEET - 33 FEET

APRIL 3, 1974 THROUGH JUNE 30, 1974

	WIND SPEED, KNOTS*						
	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00403	0.00000	0.00000	0.00000	0.00000	0.00000	0.00403
NNE	0.00322	0.00041	0.00000	0.00000	0.00000	0.00000	0.00362
NE	0.00526	0.00122	0.00000	0.00000	0.00000	0.00000	0.00648
ENE	0.00852	0.00082	0.00000	0.00000	0.00000	0.00041	0.00974
E	0.00648	0.00041	0.00000	0.00000	0.00000	0.00000	0.00689
ESE	0.00730	0.00000	0.00000	0.00000	0.00000	0.00041	0.00770
SE	0.00607	0.00041	0.00000	0.00000	0.00000	0.00000	0.00648
SSE	0.00485	0.00000	0.00000	0.00000	0.00000	0.00082	0.00566
S	0.00852	0.00082	0.00000	0.00000	0.00000	0.00000	0.00934
SSW	0.00852	0.00041	0.00000	0.00000	0.00000	0.00041	0.00934
SW	0.00974	0.00163	0.00041	0.00000	0.00000	0.00041	0.01219
WSW	0.00811	0.00122	0.00000	0.00000	0.00000	0.00000	0.00934
W	0.00403	0.00041	0.00000	0.00000	0.00000	0.00000	0.00444
WNW	0.00322	0.00082	0.00000	0.00000	0.00000	0.00000	0.00403
NW	0.00444	0.00041	0.00000	0.00000	0.00000	0.00000	0.00485
NNW	0.01178	0.00122	0.00000	0.00000	0.00000	0.00000	0.01301
TOTAL	0.10404	0.01020	0.00041	0.00000	0.00000	0.00245	0.11709

The Total Percentage of Calms for this Stability is: 0.00571

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

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TABLE 322.13-14
JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED
FOR STABILITY CLASS G
CRBRP METEOROLOGICAL TOWER, 75 FOOT LEVEL
DELTA-T USED: 200 FEET - 33 FEET
APRIL 3, 1974 THROUGH JUNE 30, 1974

WIND SPEED, KNOTS*

	0.0-3.0	3.1-6.0	6.1-10.0	10.1-16.0	16.1-21.0	21.1-99.0	TOTAL
N	0.00224	0.00000	0.00000	0.00000	0.00000	0.00000	0.00224
NNE	0.00224	0.00000	0.00000	0.00000	0.00000	0.00000	0.00224
NE	0.00183	0.00041	0.00000	0.00000	0.00000	0.00000	0.00224
ENE	0.00469	0.00000	0.00000	0.00000	0.00000	0.00000	0.00469
E	0.00387	0.00041	0.00000	0.00000	0.00000	0.00000	0.00428
ESE	0.00591	0.00041	0.00000	0.00000	0.00000	0.00000	0.00632
SE	0.00306	0.00041	0.00000	0.00000	0.00000	0.00000	0.00346
SSE	0.00591	0.00000	0.00000	0.00000	0.00000	0.00000	0.00591
S	0.00795	0.00000	0.00000	0.00000	0.00000	0.00163	0.00958
SSW	0.01081	0.00041	0.00000	0.00000	0.00000	0.00041	0.01162
SW	0.00714	0.00041	0.00041	0.00000	0.00000	0.00041	0.00836
WSW	0.00346	0.00041	0.00000	0.00000	0.00000	0.00041	0.00428
W	0.00102	0.00000	0.00000	0.00000	0.00000	0.00000	0.00102
WNW	0.00510	0.00041	0.00000	0.00000	0.00000	0.00041	0.00591
NW	0.00428	0.00041	0.00000	0.00000	0.00000	0.00000	0.00469
NNW	0.00795	0.00000	0.00000	0.00000	0.00000	0.00000	0.00795
TOTAL	0.07752	0.00367	0.00041	0.00000	0.00000	0.00326	0.08486

The Total Percentage of Calms for this Stability is: 0.00326

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Question 322.14

The information in the section Wind and Stability Data indicates that a temperature sensor was installed on the tower at the 33-ft level on April 3, 1974 and that subsequent to this date, vertical temperature difference measurements between the 33- and 200-ft level on the meteorological tower are available. Since the installation date was over one year ago, provide joint frequency distributions of wind speed and direction measured at the 75-ft level and atmospheric stability determined by the vertical temperature difference between the 33- and 200-ft levels for one full year period subsequent to April 3, 1974 as soon as the data reduction process is completed. The data recovery rate should equal or exceed 90%.

Response:

A temperature sensor was installed on the meteorological tower at the 33-ft. level on April 3, 1974. However, data at this sensor was found to be in error for a six week period occurring in October - November, 1974. Therefore, the requested one full year of joint frequency distributions of wind speed and direction measured at the 75-ft. level and atmospheric stability determined by the vertical temperature difference between the 33- and 200-ft. levels is not available with a data recovery rate equal or exceeding 90%. The site data, however, was processed for a shorter period of record where data recovery rate did exceed 90% to provide meaningful information on site meteorological conditions and the results are presented below.

The data recovery rate and sensor failures for each of the three attached data sets are summarized in Table 322.14-1. The attached Tables 322.14-2 through 322.14-22 provide the joint frequency distribution of wind speed and direction by Pasquill stability classes for the on-site meteorological data. The tables are based upon wind speed and direction as measured at the 75-foot level. The tables are further classified by the following:

Table Numbers	Differential Temperature	Extent of Period	Dates
322.14-2 - 322.14-8	200 ft minus 75 ft	6 months	12/1/74-5/31/75
322.14-9 - 322.14-15	200 ft minus 33 ft	6 months	12/1/74-5/31/75
322.14-16 - 322.14-22	200 ft minus 75 ft	12 months	6/1/74-5/31/75

Table 322.14-23 is a summary of the stability distributions for the three sets of data. A comparison between the 200 to 75-ft differential temperature data and the 200 to 33-ft differential temperature data show that a maximum variation of 2% is all that occurs between the stability classes. The following further indicates that little variation between the two differential temperatures occur, especially in the stable cases:

	ΔT 200-75	ΔT 200-33
Stable	54.73%	54.63%
Neutral	34.56%	36.10%
Unstable	10.71%	9.28%

In Table 322.14-23, comparing the two six month cases with the annual case, the major observed difference is a shift from neutral stability to both the stable and unstable conditions. This shift is because the data now includes the summer and fall seasons which normally have more occurrences at both ends of the stability scale. The slight increase in unstable conditions is most likely due to the intense solar heating in the summer season causing more thermal atmospheric instability. The increase in the stable conditions is probably due to rapid nighttime solar radiational cooling of the fall season. The following compares the annual to the two six month cases:

	Annual	Six Months	
	ΔT200-75	ΔT200-75	ΔT200-33
Stable	56.72%	54.73%	54.63%
Neutral	30.75%	34.56%	36.10%
Unstable	12.53%	10.71%	9.28%

The data indicates that it does not make a difference whether the lower temperature sensor is at 33-feet or 75-feet aboveground; the atmospheric stability has little variation.

TABLE 322.14-1

DATA RECOVERY OF THE CLINCH RIVER SITE

	75-FOOT LEVEL WIND DIRECTION AND SPEED		
	ΔT200-75	ΔT200-75	ΔT200-33
Period of record	6/1/74-5/31/75	12/1/74-5/31/75	12/1/74-5/31/75
Total good records	8,410	4,268	4,258
Total records	8,760	4,368	4,368
Data recovery rate	96.00%	97.71%	97.48%
Number of wind direction records in error	45	26	22
Number of wind speed records in error	82	6	6
Number of upper temperature records in error	223	68	68
Number of lower temperature records in error	0	0	14

TABLE 322.14-2

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS A

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NE	0.00000	0.00000	0.00000	0.00023	0.00094	0.00000	0.00000	0.00000	0.00117
ENE	0.00000	0.00000	0.00023	0.00047	0.00094	0.00000	0.00000	0.00000	0.00164
E	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
ESE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
SE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
SSE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
S	0.00000	0.00000	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00070
SSW	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SW	0.00000	0.00023	0.00094	0.00000	0.00023	0.00000	0.00000	0.00000	0.00141
WSW	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
W	0.00000	0.00000	0.00023	0.00023	0.00023	0.00000	0.00000	0.00000	0.00070
WNW	0.00000	0.00000	0.00000	0.00000	0.00047	0.00047	0.00000	0.00000	0.00094
NW	0.00000	0.00000	0.00000	0.00047	0.00141	0.00023	0.00000	0.00000	0.00211
NNW	0.00000	0.00000	0.00023	0.00047	0.00047	0.00000	0.00000	0.00000	0.00117
TOTAL	0.00000	0.00023	0.00211	0.00305	0.00469	0.00070	0.00000	0.00000	0.01078

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-3

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS B

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00001	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00024
NNE	0.00001	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00024
NE	0.00001	0.00000	0.00164	0.00141	0.00047	0.00000	0.00000	0.00000	0.00352
ENE	0.00001	0.00000	0.00117	0.00422	0.00094	0.00000	0.00000	0.00000	0.00634
E	0.00001	0.00000	0.00117	0.00234	0.00000	0.00000	0.00000	0.00000	0.00352
ESE	0.00001	0.00000	0.00141	0.00023	0.00000	0.00000	0.00000	0.00000	0.00165
SE	0.00001	0.00000	0.00070	0.00070	0.00000	0.00000	0.00000	0.00000	0.00142
SSE	0.00001	0.00000	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.00095
S	0.00001	0.00047	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00118
SSW	0.00001	0.00023	0.00187	0.00070	0.00117	0.00047	0.00000	0.00000	0.00446
SW	0.00001	0.00047	0.00375	0.00117	0.00094	0.00117	0.00000	0.00000	0.00751
WSW	0.00001	0.00094	0.00117	0.00000	0.00023	0.00023	0.00000	0.00000	0.00259
W	0.00001	0.00047	0.00070	0.00094	0.00047	0.00070	0.00000	0.00000	0.00329
WNW	0.00001	0.00000	0.00164	0.00047	0.00375	0.00070	0.00023	0.00000	0.00680
NW	0.00001	0.00023	0.00070	0.00094	0.00211	0.00023	0.00000	0.00000	0.00423
NNW	0.00001	0.00000	0.00070	0.00023	0.00023	0.00000	0.00000	0.00000	0.00118
TOTAL	0.00023	0.00281	0.01828	0.01382	0.01031	0.00351	0.00023	0.00000	0.04920

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00023

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-4

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS C

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00023
NNE	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00023
NE	0.00000	0.00000	0.00187	0.00047	0.00023	0.00000	0.00000	0.00000	0.00258
ENE	0.00000	0.00000	0.00305	0.00117	0.00047	0.00000	0.00000	0.00000	0.00469
E	0.00000	0.00023	0.00117	0.00070	0.00000	0.00000	0.00000	0.00000	0.00211
ESE	0.00000	0.00000	0.00070	0.00023	0.00000	0.00000	0.00000	0.00000	0.00094
SE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SSE	0.00000	0.00047	0.00141	0.00023	0.00000	0.00000	0.00000	0.00000	0.00211
S	0.00000	0.00023	0.00141	0.00000	0.00023	0.00000	0.00000	0.00000	0.00187
SSW	0.00000	0.00023	0.00211	0.00047	0.00117	0.00094	0.00000	0.00000	0.00492
SW	0.00000	0.00211	0.00305	0.00070	0.00234	0.00117	0.00023	0.00000	0.00961
WSW	0.00000	0.00117	0.00187	0.00164	0.00023	0.00070	0.00000	0.00000	0.00562
W	0.00000	0.00000	0.00094	0.00023	0.00094	0.00070	0.00023	0.00000	0.00305
WNW	0.00000	0.00023	0.00023	0.00070	0.00281	0.00117	0.00000	0.00000	0.00515
NW	0.00000	0.00000	0.00023	0.00047	0.00070	0.00070	0.00000	0.00000	0.00211
NNW	0.00000	0.00000	0.00047	0.00047	0.00094	0.00000	0.00000	0.00000	0.00187
TOTAL	0.00000	0.00469	0.01898	0.00750	0.01007	0.00539	0.00047	0.00000	0.04709

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-5

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS D

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00047	0.00117	0.00047	0.00000	0.00023	0.00000	0.00000	0.00000	0.00234
NNE	0.00023	0.00258	0.00351	0.00094	0.00000	0.00000	0.00000	0.00000	0.00726
NE	0.00117	0.00609	0.00914	0.00211	0.00023	0.00000	0.00000	0.00000	0.01874
ENE	0.00094	0.01359	0.01125	0.00258	0.00047	0.00000	0.00000	0.00000	0.02882
E	0.00094	0.00422	0.00305	0.00070	0.00000	0.00000	0.00000	0.00000	0.00890
ESE	0.00047	0.00375	0.00187	0.00047	0.00023	0.00000	0.00000	0.00000	0.00679
SE	0.00000	0.00141	0.00094	0.00000	0.00047	0.00023	0.00000	0.00000	0.00305
SSE	0.00070	0.00187	0.00141	0.00000	0.00070	0.00000	0.00000	0.00000	0.00469
S	0.00141	0.00281	0.00211	0.00070	0.00094	0.00047	0.00000	0.00000	0.00843
SSW	0.00023	0.00633	0.00562	0.00375	0.01125	0.01101	0.00023	0.00000	0.03843
SW	0.00070	0.00820	0.00984	0.01078	0.01664	0.01429	0.00070	0.00000	0.06115
WSW	0.00187	0.01007	0.00961	0.00773	0.00843	0.00422	0.00094	0.00000	0.04288
W	0.00117	0.00375	0.00398	0.00422	0.00469	0.00164	0.00023	0.00000	0.01968
WNW	0.00047	0.00539	0.01078	0.01289	0.02320	0.00633	0.00000	0.00000	0.05904
NW	0.00070	0.00539	0.00586	0.00539	0.00539	0.00164	0.00000	0.00000	0.02437
NNW	0.00187	0.00539	0.00187	0.00164	0.00023	0.00000	0.00000	0.00000	0.01101
TOTAL	0.01336	0.08201	0.08130	0.05389	0.07310	0.03983	0.00211	0.00000	0.34560

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-6

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS E

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00165	0.00375	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00563
NNE	0.00188	0.00890	0.00211	0.00047	0.00000	0.00000	0.00000	0.00000	0.01337
NE	0.00352	0.01382	0.00703	0.00047	0.00070	0.00000	0.00000	0.00000	0.02555
ENE	0.00540	0.01828	0.00492	0.00141	0.00023	0.00023	0.00000	0.00000	0.03047
E	0.00774	0.00750	0.00187	0.00094	0.00000	0.00000	0.00000	0.00000	0.01805
ESE	0.00376	0.00375	0.00211	0.00023	0.00000	0.00000	0.00000	0.00000	0.00985
SE	0.00306	0.00234	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00563
SSE	0.00399	0.00187	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00634
S	0.00493	0.00187	0.00164	0.00023	0.00070	0.00000	0.00000	0.00000	0.00938
SSW	0.00329	0.00726	0.00539	0.00492	0.00961	0.00351	0.00023	0.00000	0.03422
SW	0.00259	0.00984	0.00867	0.01078	0.00984	0.00258	0.00000	0.00000	0.04429
WSW	0.00306	0.00375	0.00515	0.00375	0.00351	0.00000	0.00000	0.00000	0.01922
W	0.00212	0.00328	0.00305	0.00211	0.00047	0.00023	0.00000	0.00000	0.01126
WNW	0.00212	0.00375	0.00328	0.00492	0.00398	0.00000	0.00000	0.00000	0.01805
NW	0.00282	0.00539	0.00445	0.00234	0.00117	0.00000	0.00000	0.00000	0.01618
NNW	0.00376	0.00750	0.00305	0.00023	0.00000	0.00000	0.00000	0.00000	0.01454
TOTAL	0.05576	0.10286	0.05366	0.03280	0.03022	0.00656	0.00023	0.00000	0.28210

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00023

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-7

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS F

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00238	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00309
NNE	0.00332	0.00187	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00519
NE	0.00355	0.00375	0.00141	0.00000	0.00000	0.00000	0.00000	0.00000	0.00871
ENE	0.00660	0.00703	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.01410
E	0.00379	0.00164	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00543
ESE	0.00543	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00590
SE	0.00402	0.00023	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00449
SSE	0.00590	0.00117	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00707
S	0.00871	0.00187	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.01082
SSW	0.00613	0.00469	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.01176
SW	0.00473	0.00398	0.00187	0.00094	0.00000	0.00000	0.00000	0.00000	0.01152
WSW	0.00332	0.00328	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00660
W	0.00121	0.00023	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00168
WNW	0.00238	0.00094	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00355
NW	0.00379	0.00141	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00566
NNW	0.00590	0.00328	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00918
TOTAL	0.07122	0.03655	0.00609	0.00094	0.00000	0.00000	0.00000	0.00000	0.11480

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00070

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*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-8

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS G

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00218	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00265
NNE	0.00124	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00148
NE	0.00148	0.00187	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00358
ENE	0.00429	0.00305	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00733
E	0.00335	0.00164	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00499
ESE	0.00944	0.00351	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01296
SE	0.01038	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01108
SSE	0.01296	0.00164	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01460
S	0.01530	0.00258	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01788
SSW	0.01366	0.00984	0.00070	0.00047	0.00000	0.00000	0.00000	0.00000	0.02467
SW	0.00921	0.00515	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.01507
WSW	0.00405	0.00141	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00616
W	0.00335	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00405
WNW	0.00476	0.00141	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00616
NW	0.00710	0.00187	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00897
NNW	0.00640	0.00234	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00874
TOTAL	0.10918	0.03843	0.00234	0.00047	0.00000	0.00000	0.00000	0.00000	0.15042

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00117

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*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-9

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS A

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NE	0.00000	0.00000	0.00000	0.00023	0.00023	0.00000	0.00000	0.00000	0.00047
ENE	0.00000	0.00023	0.00047	0.00047	0.00023	0.00000	0.00000	0.00000	0.00141
E	0.00000	0.00000	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00070
ESE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
SSE	0.00000	0.00000	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00070
S	0.00000	0.00000	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00047
SSW	0.00000	0.00000	0.00023	0.00000	0.00023	0.00000	0.00000	0.00000	0.00047
SW	0.00000	0.00000	0.00047	0.00023	0.00047	0.00023	0.00000	0.00000	0.00141
WSW	0.00000	0.00000	0.00023	0.00023	0.00023	0.00000	0.00000	0.00000	0.00070
W	0.00000	0.00000	0.00000	0.00047	0.00070	0.00023	0.00000	0.00000	0.00141
WNW	0.00000	0.00000	0.00000	0.00023	0.00164	0.00070	0.00000	0.00000	0.00258
NW	0.00000	0.00000	0.00000	0.00070	0.00235	0.00141	0.00000	0.00000	0.00446
NNW	0.00000	0.00000	0.00070	0.00047	0.00094	0.00000	0.00000	0.00000	0.00211
TOTAL	0.00000	0.00023	0.00376	0.00352	0.00705	0.00258	0.00000	0.00000	0.01714

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-10

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS B

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
NE	0.00000	0.00000	0.00117	0.00094	0.00070	0.00000	0.00000	0.00000	0.00282
ENE	0.00000	0.00000	0.00070	0.00047	0.00117	0.00000	0.00000	0.00000	0.00235
E	0.00000	0.00000	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00070
ESE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
SE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SSE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
S	0.00000	0.00047	0.00023	0.00023	0.00023	0.00000	0.00000	0.00000	0.00117
SSW	0.00000	0.00023	0.00047	0.00023	0.00094	0.00000	0.00000	0.00000	0.00188
SW	0.00000	0.00047	0.00094	0.00117	0.00117	0.00188	0.00000	0.00000	0.00564
WSW	0.00000	0.00000	0.00047	0.00070	0.00141	0.00000	0.00000	0.00000	0.00258
W	0.00000	0.00000	0.00023	0.00047	0.00047	0.00023	0.00000	0.00000	0.00141
WNW	0.00000	0.00000	0.00047	0.00070	0.00188	0.00094	0.00000	0.00000	0.00399
NW	0.00000	0.00023	0.00023	0.00047	0.00188	0.00000	0.00000	0.00000	0.00282
NNW	0.00000	0.00000	0.00000	0.00047	0.00000	0.00000	0.00000	0.00000	0.00047
TOTAL	0.00000	0.00141	0.00540	0.00658	0.00986	0.00305	0.00000	0.00000	0.02630

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-11

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS C
CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL
DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NE	0.00000	0.00000	0.00235	0.00094	0.00070	0.00000	0.00000	0.00000	0.00399
ENE	0.00000	0.00000	0.00235	0.00258	0.00070	0.00000	0.00000	0.00000	0.00564
E	0.00000	0.00023	0.00141	0.00141	0.00000	0.00000	0.00000	0.00000	0.00305
ESE	0.00000	0.00023	0.00117	0.00047	0.00000	0.00000	0.00000	0.00000	0.00188
SE	0.00000	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
SSE	0.00000	0.00000	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00047
S	0.00000	0.00000	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00070
SSW	0.00000	0.00000	0.00070	0.00023	0.00094	0.00047	0.00000	0.00000	0.00235
SW	0.00000	0.00000	0.00376	0.00211	0.00258	0.00352	0.00000	0.00000	0.01198
WSW	0.00000	0.00070	0.00023	0.00117	0.00117	0.00023	0.00000	0.00000	0.00352
W	0.00000	0.00000	0.00023	0.00047	0.00188	0.00047	0.00000	0.00000	0.00305
WNW	0.00000	0.00023	0.00141	0.00117	0.00282	0.00117	0.00023	0.00000	0.00705
NW	0.00000	0.00047	0.00117	0.00070	0.00094	0.00047	0.00000	0.00000	0.00376
NNW	0.00000	0.00000	0.00094	0.00023	0.00047	0.00000	0.00000	0.00000	0.00164
TOTAL	0.00000	0.00188	0.01691	0.01174	0.01221	0.00634	0.00023	0.00000	0.04932

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-12

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS D

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00070	0.00141	0.00023	0.00023	0.00000	0.00000	0.00000	0.00000	0.00258
NNE	0.00000	0.00305	0.00376	0.00117	0.00000	0.00000	0.00000	0.00000	0.00798
NE	0.00070	0.00611	0.00986	0.00258	0.00070	0.00000	0.00000	0.00000	0.01996
ENE	0.00070	0.01456	0.01339	0.00564	0.00094	0.00023	0.00000	0.00000	0.03546
E	0.00117	0.00446	0.00399	0.00258	0.00000	0.00000	0.00000	0.00000	0.01221
ESE	0.00094	0.00376	0.00258	0.00070	0.00000	0.00000	0.00000	0.00000	0.00798
SE	0.00023	0.00141	0.00141	0.00047	0.00000	0.00000	0.00000	0.00000	0.00352
SSE	0.00094	0.00211	0.00235	0.00047	0.00047	0.00000	0.00000	0.00000	0.00634
S	0.00164	0.00235	0.00305	0.00070	0.00047	0.00000	0.00000	0.00000	0.00822
SSW	0.00000	0.00681	0.00869	0.00352	0.00916	0.00916	0.00000	0.00000	0.03734
SW	0.00023	0.01104	0.01386	0.00963	0.01409	0.01010	0.00094	0.00000	0.05989
WSW	0.00188	0.01104	0.01127	0.00822	0.00705	0.00423	0.00094	0.00000	0.04462
W	0.00094	0.00399	0.00634	0.00470	0.00305	0.00211	0.00047	0.00000	0.02161
WNW	0.00047	0.00564	0.01080	0.01362	0.02583	0.00587	0.00000	0.00000	0.06224
NW	0.00070	0.00446	0.00470	0.00517	0.00446	0.00094	0.00000	0.00000	0.02043
NNW	0.00117	0.00517	0.00235	0.00141	0.00047	0.00000	0.00000	0.00000	0.01057
TOTAL	0.01245	0.08736	0.09864	0.06083	0.06670	0.03264	0.00235	0.00000	0.36097

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-13

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS E

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

	WIND SPEED, KNOTS*								
	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00118	0.00282	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.00424
NNE	0.00236	0.00728	0.00211	0.00023	0.00000	0.00000	0.00000	0.00000	0.01199
NE	0.00377	0.01245	0.00611	0.00000	0.00023	0.00000	0.00000	0.00000	0.02256
ENE	0.00659	0.01597	0.00329	0.00070	0.00000	0.00000	0.00000	0.00000	0.02655
E	0.00753	0.00705	0.00094	0.00047	0.00000	0.00000	0.00000	0.00000	0.01598
ESE	0.00306	0.00258	0.00235	0.00000	0.00023	0.00000	0.00000	0.00000	0.00823
SE	0.00283	0.00235	0.00047	0.00000	0.00047	0.00023	0.00000	0.00000	0.00635
SSE	0.00471	0.00211	0.00070	0.00000	0.00023	0.00000	0.00000	0.00000	0.00776
S	0.00494	0.00235	0.00188	0.00023	0.00094	0.00047	0.00000	0.00000	0.01081
SSW	0.00424	0.00681	0.00470	0.00564	0.01174	0.00634	0.00047	0.00000	0.03993
SW	0.00283	0.00822	0.00728	0.00845	0.01127	0.00352	0.00000	0.00000	0.04158
WSW	0.00283	0.00446	0.00517	0.00282	0.00258	0.00070	0.00000	0.00000	0.01856
W	0.00212	0.00352	0.00164	0.00141	0.00070	0.00023	0.00000	0.00000	0.00964
WNW	0.00212	0.00305	0.00282	0.00329	0.00211	0.00000	0.00000	0.00000	0.01340
NW	0.00283	0.00517	0.00493	0.00258	0.00117	0.00000	0.00000	0.00000	0.01668
NNW	0.00447	0.00681	0.00235	0.00047	0.00000	0.00000	0.00000	0.00000	0.01410
TOTAL	0.05847	0.09300	0.04674	0.02630	0.03194	0.01151	0.00047	0.00000	0.26843

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.0023

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*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-14

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS F

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00265	0.00117	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00406
NNE	0.00312	0.00235	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00547
NE	0.00430	0.00470	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.00993
ENE	0.00594	0.00681	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.01369
E	0.00406	0.00235	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00641
ESE	0.00712	0.00141	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00852
SE	0.00406	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00477
SSE	0.00618	0.00117	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00735
S	0.01087	0.00188	0.00000	0.00000	0.00023	0.00000	0.00000	0.00000	0.01299
SSW	0.00759	0.00540	0.00094	0.00023	0.00000	0.00000	0.00000	0.00000	0.01416
SW	0.00618	0.00517	0.00070	0.00188	0.00000	0.00000	0.00000	0.00000	0.01393
WSW	0.00359	0.00235	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00641
W	0.00171	0.00047	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00289
WNW	0.00242	0.00117	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00430
NW	0.00453	0.00164	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00688
NNW	0.00618	0.00470	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01087
TOTAL	0.08055	0.04321	0.00634	0.00235	0.00023	0.00000	0.00000	0.00000	0.13269

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00117

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*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-15

SEMI-ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS G

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

DECEMBER 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00215	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00286
NNE	0.00121	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00215
NE	0.00098	0.00235	0.00094	0.00000	0.00000	0.00000	0.00000	0.00000	0.00427
ENE	0.00403	0.00446	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00849
E	0.00309	0.00117	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00427
ESE	0.00802	0.00352	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01155
SE	0.01037	0.00047	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01084
SSE	0.01178	0.00141	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01319
S	0.01272	0.00282	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.01578
SSW	0.01155	0.00939	0.00070	0.00047	0.00000	0.00000	0.00000	0.00000	0.02212
SW	0.00802	0.00517	0.00188	0.00070	0.00000	0.00000	0.00000	0.00000	0.01578
WSW	0.00403	0.00211	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00685
W	0.00309	0.00047	0.00023	0.00000	0.00000	0.00000	0.00000	0.00000	0.00380
WNW	0.00474	0.00164	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00638
NW	0.00638	0.00235	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00873
NNW	0.00615	0.00188	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00802
TOTAL	0.09840	0.04086	0.00470	0.00117	0.00000	0.00000	0.00000	0.00000	0.14513

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.0070

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-16

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS A

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
NNE	0.00000	0.00000	0.00036	0.00024	0.00000	0.00000	0.00000	0.00000	0.00059
NE	0.00000	0.00012	0.00012	0.00059	0.00059	0.00000	0.00000	0.00000	0.00143
ENE	0.00000	0.00012	0.00095	0.00119	0.00119	0.00000	0.00000	0.00000	0.00345
E	0.00000	0.00000	0.00024	0.00083	0.00000	0.00000	0.00000	0.00000	0.00107
ESE	0.00000	0.00000	0.00024	0.00024	0.00000	0.00000	0.00000	0.00000	0.00048
SE	0.00000	0.00000	0.00036	0.00024	0.00000	0.00000	0.00000	0.00000	0.00059
SSE	0.00000	0.00000	0.00024	0.00012	0.00000	0.00000	0.00000	0.00000	0.00036
S	0.00000	0.00000	0.00071	0.00024	0.00012	0.00000	0.00000	0.00000	0.00107
SSW	0.00000	0.00024	0.00059	0.00083	0.00012	0.00000	0.00000	0.00000	0.00178
SW	0.00000	0.00048	0.00095	0.00000	0.00024	0.00000	0.00000	0.00000	0.00166
WSW	0.00000	0.00024	0.00048	0.00000	0.00000	0.00000	0.00000	0.00000	0.00071
W	0.00000	0.00024	0.00024	0.00012	0.00012	0.00000	0.00000	0.00000	0.00071
WNW	0.00000	0.00012	0.00024	0.00012	0.00024	0.00024	0.00000	0.00000	0.00095
NW	0.00000	0.00000	0.00012	0.00036	0.00071	0.00012	0.00000	0.00000	0.00131
NNW	0.00000	0.00000	0.00036	0.00036	0.00059	0.00000	0.00000	0.00000	0.00131
TOTAL	0.00000	0.00155	0.00618	0.00547	0.00392	0.00036	0.00000	0.00000	0.01748

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-17

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR

STABILITY CLASS B

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00001	0.00000	0.00012	0.00012	0.00000	0.00000	0.00000	0.00000	0.00025
NNE	0.00001	0.00000	0.00059	0.00071	0.00024	0.00000	0.00000	0.00000	0.00156
NE	0.00001	0.00000	0.00202	0.00155	0.00036	0.00000	0.00000	0.00000	0.00393
ENE	0.00001	0.00024	0.00166	0.00309	0.00155	0.00000	0.00000	0.00000	0.00655
E	0.00001	0.00012	0.00166	0.00190	0.00000	0.00000	0.00000	0.00000	0.00370
ESE	0.00001	0.00012	0.00107	0.00012	0.00000	0.00000	0.00000	0.00000	0.00132
SE	0.00001	0.00036	0.00095	0.00036	0.00012	0.00000	0.00000	0.00000	0.00179
SSE	0.00001	0.00036	0.00119	0.00000	0.00000	0.00000	0.00000	0.00000	0.00156
S	0.00001	0.00083	0.00107	0.00059	0.00012	0.00000	0.00000	0.00000	0.00263
SSW	0.00001	0.00095	0.00345	0.00226	0.00155	0.00059	0.00000	0.00000	0.00881
SW	0.00013	0.00190	0.00380	0.00166	0.00202	0.00059	0.00000	0.00000	0.01012
WSW	0.00001	0.00143	0.00202	0.00071	0.00024	0.00036	0.00000	0.00000	0.00477
W	0.00001	0.00095	0.00131	0.00095	0.00048	0.00036	0.00000	0.00000	0.00405
WNW	0.00001	0.00000	0.00155	0.00071	0.00238	0.00036	0.00012	0.00000	0.00512
NW	0.00001	0.00012	0.00095	0.00059	0.00143	0.00012	0.00000	0.00000	0.00322
NNW	0.00001	0.00012	0.00119	0.00083	0.00059	0.00000	0.00000	0.00000	0.00274
TOTAL	0.00024	0.00749	0.02461	0.01617	0.01106	0.00238	0.00012	0.00000	0.06207

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00012

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-18

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS C

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00000	0.00012	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.00024
NNE	0.00000	0.00000	0.00024	0.00012	0.00000	0.00000	0.00000	0.00000	0.00036
NE	0.00000	0.00012	0.00143	0.00036	0.00036	0.00000	0.00000	0.00000	0.00226
ENE	0.00000	0.00000	0.00226	0.00095	0.00024	0.00000	0.00000	0.00000	0.00345
E	0.00000	0.00024	0.00119	0.00083	0.00000	0.00000	0.00000	0.00000	0.00226
ESE	0.00000	0.00012	0.00083	0.00012	0.00000	0.00000	0.00000	0.00000	0.00107
SE	0.00000	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00036
SSE	0.00000	0.00048	0.00083	0.00012	0.00000	0.00000	0.00000	0.00000	0.00143
S	0.00000	0.00059	0.00143	0.00012	0.00012	0.00000	0.00000	0.00000	0.00226
SSW	0.00000	0.00083	0.00202	0.00083	0.00119	0.00048	0.00000	0.00000	0.00535
SW	0.00000	0.00202	0.00262	0.00107	0.00238	0.00083	0.00012	0.00000	0.00904
WSW	0.00000	0.00166	0.00190	0.00119	0.00036	0.00048	0.00000	0.00000	0.00559
W	0.00000	0.00059	0.00119	0.00048	0.00071	0.00036	0.00012	0.00000	0.00345
WNW	0.00000	0.00024	0.00095	0.00095	0.00214	0.00071	0.00000	0.00000	0.00499
NW	0.00000	0.00024	0.00059	0.00024	0.00071	0.00036	0.00000	0.00000	0.00214
NNW	0.00000	0.00012	0.00048	0.00024	0.00059	0.00000	0.00000	0.00000	0.00143
TOTAL	0.00000	0.00773	0.01807	0.00761	0.00880	0.00321	0.00024	0.00000	0.04566

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00000

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*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-19

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS D

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00091	0.00190	0.00036	0.00036	0.00012	0.00000	0.00000	0.00000	0.00365
NNE	0.00079	0.00238	0.00238	0.00131	0.00000	0.00000	0.00000	0.00000	0.00686
NE	0.00139	0.00547	0.00725	0.00190	0.00012	0.00000	0.00000	0.00000	0.01613
ENE	0.00139	0.01165	0.01011	0.00262	0.00059	0.00000	0.00000	0.00000	0.02636
E	0.00115	0.00428	0.00333	0.00071	0.00000	0.00000	0.00000	0.00000	0.00947
ESE	0.00091	0.00369	0.00214	0.00048	0.00012	0.00000	0.00000	0.00000	0.00733
SE	0.00032	0.00119	0.00155	0.00000	0.00024	0.00012	0.00000	0.00000	0.00341
SSE	0.00103	0.00262	0.00166	0.00024	0.00036	0.00000	0.00000	0.00000	0.00591
S	0.00103	0.00333	0.00250	0.00059	0.00095	0.00024	0.00000	0.00000	0.00864
SSW	0.00067	0.00654	0.00654	0.00511	0.00844	0.00654	0.00012	0.00000	0.03397
SW	0.00103	0.00904	0.00963	0.01046	0.01391	0.00939	0.00036	0.00000	0.05383
WSW	0.00174	0.00927	0.00844	0.00678	0.00678	0.00238	0.00048	0.00000	0.03587
W	0.00079	0.00476	0.00488	0.00309	0.00285	0.00095	0.00012	0.00000	0.01744
WNW	0.00079	0.00499	0.00999	0.00999	0.01474	0.00452	0.00000	0.00000	0.04503
NW	0.00091	0.00476	0.00499	0.00476	0.00511	0.00107	0.00000	0.00000	0.02160
NNW	0.00186	0.00595	0.00250	0.00107	0.00059	0.00000	0.00000	0.00000	0.01197
TOTAL	0.01677	0.08181	0.07824	0.04946	0.05493	0.02521	0.00107	0.00000	0.30749

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00131

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

Amend. 3
Aug. 1975

TABLE 322.14-20

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS E

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00483	0.00416	0.00048	0.00000	0.00000	0.00000	0.00000	0.00000	0.00947
NNE	0.00483	0.00939	0.00321	0.00024	0.00012	0.00000	0.00000	0.00000	0.01780
NE	0.00591	0.01058	0.00654	0.00083	0.00036	0.00000	0.00000	0.00000	0.02422
ENE	0.01042	0.01593	0.00380	0.00071	0.00012	0.00012	0.00000	0.00000	0.03111
E	0.01292	0.00832	0.00143	0.00048	0.00000	0.00000	0.00000	0.00000	0.02315
ESE	0.00828	0.00345	0.00166	0.00012	0.00000	0.00000	0.00000	0.00000	0.01352
SE	0.00460	0.00202	0.00059	0.00000	0.00000	0.00000	0.00000	0.00000	0.00721
SSE	0.00519	0.00190	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.00745
S	0.00602	0.00309	0.00143	0.00024	0.00036	0.00012	0.00000	0.00000	0.01126
SSW	0.00591	0.00749	0.00595	0.00357	0.00630	0.00214	0.00012	0.00000	0.03147
SW	0.00448	0.01058	0.00761	0.00785	0.00606	0.00155	0.00000	0.00000	0.03813
WSW	0.00424	0.00416	0.00476	0.00333	0.00309	0.00000	0.00000	0.00000	0.01958
W	0.00246	0.00321	0.00238	0.00178	0.00119	0.00024	0.00000	0.00000	0.01126
WNW	0.00341	0.00297	0.00285	0.00369	0.00285	0.00012	0.00000	0.00000	0.01589
NW	0.00460	0.00369	0.00309	0.00178	0.00083	0.00000	0.00000	0.00000	0.01399
NNW	0.00745	0.00880	0.00190	0.00024	0.00012	0.00000	0.00000	0.00000	0.01851
TOTAL	0.09548	0.09976	0.04804	0.02485	0.02140	0.00428	0.00012	0.00000	0.29394

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.01641

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-21

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS F

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

	WIND SPEED, KNOTS*								
	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00448	0.00143	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00591
NNE	0.00400	0.00131	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.00543
NE	0.00496	0.00345	0.00071	0.00012	0.00000	0.00000	0.00000	0.00000	0.00924
ENE	0.00793	0.00630	0.00036	0.00024	0.00000	0.00000	0.00000	0.00000	0.01483
E	0.00745	0.00190	0.00000	0.00012	0.00000	0.00000	0.00000	0.00000	0.00947
ESE	0.00710	0.00095	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00805
SE	0.00626	0.00083	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.00722
SSE	0.00781	0.00107	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00888
S	0.01019	0.00166	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.01221
SSW	0.00710	0.00452	0.00071	0.00000	0.00000	0.00000	0.00000	0.00000	0.01233
SW	0.00567	0.00404	0.00143	0.00083	0.00024	0.00000	0.00000	0.00000	0.01221
WSW	0.00496	0.00214	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00710
W	0.00293	0.00059	0.00024	0.00000	0.00000	0.00000	0.00000	0.00000	0.00377
WNW	0.00377	0.00083	0.00012	0.00012	0.00000	0.00000	0.00000	0.00000	0.00484
NW	0.00436	0.00131	0.00024	0.00000	0.00000	0.00000	0.00000	0.00000	0.00591
NNW	0.00817	0.00428	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01245
TOTAL	0.09714	0.03662	0.00440	0.00143	0.00024	0.00000	0.00000	0.00000	0.13983

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.02033

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-22

ANNUAL JOINT FREQUENCY OF WIND DIRECTION AND WIND SPEED FOR STABILITY CLASS G

CRBRP METEOROLOGICAL TOWER, 75-FOOT WIND LEVEL

JUNE 1, 1974 THROUGH MAY 31, 1975

WIND SPEED, KNOTS*

	0.0-1.3	1.4-2.9	3.0-4.7	4.8-6.4	6.5-10.0	10.1-16.0	16.1-21.0	21.1-99.0	Total
N	0.00200	0.00048	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00247
NNE	0.00140	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00176
NE	0.00211	0.00131	0.00012	0.00012	0.00000	0.00000	0.00000	0.00000	0.00366
ENE	0.00425	0.00309	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00735
E	0.00449	0.00166	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.00628
ESE	0.01068	0.00285	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.01365
SE	0.00949	0.00059	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.01020
SSE	0.01115	0.00095	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01210
S	0.01246	0.00202	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.01448
SSW	0.01068	0.00690	0.00048	0.00024	0.00000	0.00000	0.00000	0.00000	0.01829
SW	0.00770	0.00321	0.00059	0.00000	0.00000	0.00000	0.00000	0.00000	0.01151
WSW	0.00378	0.00107	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.00521
W	0.00259	0.00048	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00307
WNW	0.00425	0.00119	0.00012	0.00000	0.00000	0.00000	0.00000	0.00000	0.00556
NW	0.00580	0.00214	0.00000	0.00012	0.00000	0.00000	0.00000	0.00000	0.00806
NNW	0.00735	0.00250	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00984
TOTAL	0.10023	0.03080	0.00202	0.00048	0.00000	0.00000	0.00000	0.00000	0.13353

THE TOTAL PERCENTAGE OF CALMS FOR THIS STABILITY IS: 0.00725

*1 knot = 0.515 m/sec; 1 knot = 1.16 mph

TABLE 322.14-23

SUMMARY OF STABILITY DISTRIBUTION FOR P.M.C. ON-SITE METEOROLOGICAL DATA

Stability	ΔT200-75, 75-ft. Winds June 1, 1974-May 31, 1975	ΔT200-75, 75-ft. Winds Dec. 1, 1974-May 31, 1975	ΔT200-33, 75-ft. Win Dec. 1, 1974-May 31,
A	1.75%	1.08%	1.72%
B	6.21%	4.92%	2.63%
C	4.57%	4.71%	4.93%
D	30.75%	34.56%	36.10%
E	29.39%	28.21%	26.84%
F	13.98%	11.48%	13.27%
G	13.35%	15.04%	14.51%
TOTAL	100.00%	100.00%	100.00%
Calms	4.54%	0.23%	0.21%
Data Recovery	96.00%	97.71%	97.48%

Question 322.15 (2.3B)

Provide information, preferably in the Tables, concerning whether the percentage of calms listed at the bottom of Tables 2.3B-21 through 2.3B-36 are also included in the main section of the Table and, if so, the method by which the calms are distributed among the different wind direction categories.

Response:

The total percentage of calms listed at the bottom of Tables 2.3-13
through 2.3-28 are evenly distributed throughout the various direction 38
groups in the first wind speed category. The distribution is done by
using the total percentage of calms for each stability and dividing by
the number of wind direction groups. This one-sixteenth of the calm
percentage is then added to each direction's classification of 0.0-1.3
knots.

Tables 2.3-13 through 2.3-28 list separately the percentage of 38
calm winds added to the first wind speed category for each direction.

Question 322.16 (2.3.1 & 2.3.2)

With the exception of the tornado, provide a summary of all meteorological conditions (e.g. 100 year recurrence sustained (astest mile) wind speed, maximum and minimum ambient air temperatures) used as design basis considerations for the plant and include appropriate cross-references. Where design basis meteorological conditions vary for different plant systems, the applicable conditions should be presented.

Response:

The response to this question has been incorporated into Section 2.3.2.5. 27

Question 322.17

The response to item 322.14 indicates that a temperature sensor malfunction went undetected for a six-week period in October and November of 1974. In view of the statement made in Section 2.3.3 of the PSAR on page 2.3-13 that "The site is inspected weekly by an electrical engineer or an instrument technician to ensure all instruments are in good working order," provide information explaning how the sensor malfunction went undetected for a six-week period, and indicate what additional measures have been taken to prevent similar occurrences in the future.

Response:

1. The 33-foot temperature data were invalid during the period October 19, 1974, through November 29, 1974, due to a failure of the aspirator motor in the temperature sensor shield. Several factors contributed to the length of the period between the failure and the repair of the aspirator motor.

   a. During this period, no 33-foot temperature data analog strip chart recorder was installed. Thus, field maintenance personnel had no on-site source of hourly average 33-foot temperature data. Therefore, an on-site comparison to detect a data abnormality could not be made between the hourly average 75-foot data (on a strip chart recorder) and the hourly average 33-foot data (not on strip chart recorder).

   b. A system to monitor aspirator motor operation and to display abnormal operation was not installed.

   c. A computer printout of the October and November 1974 data was not available until mid-December 1974. Upon receipt the data was immediately reviewed and the 33-foot temperature data abnormally was detected. Field maintenance personnel, in the meantime, had detected and corrected the aspirator motor failure during a tower climb to exchange wind sensors.

2. A number of steps have been taken to prevent reoccurrence of a lengthy period of invalid data.

   a. Analog strip-chart recorders are now in operation for all data points being recorded at CRBRP. They provide a backup data record for the Pulse-O-Matic (POM) data logging system which uses magnetic tape cassettes. Data recorded on both magnetic tape and on strip charts are: Delta T 200'-75', 75'T, 33'T, 33' dewpoint; and wind speed and direction at 200', 75', and 33'. Station service procedures provide that strip charts are removed weekly and that spot checks of data logged on these recorders be reviewed onsite at least once per week and compared with a list of meteorological condition validity tests. Any detected condition that indicates invalid data is reported to maintenance personnel who repair as required and recalibrate.

b. A system has been installed to detect and display abnormal operation of each aspirator motor. This will provide early detection of aspirator failure during the frequent station inspections by service personnel. The system monitors the revolutions of the fan and lights an alarm lamp when the rpm is abnormal.

c. Service or maintenance personnel visit the station at least two days per week and compare current data with observed meteorological conditions existing during the visit.

Maintenance personnel visit the station at least once per week for data comparison as above and to perform more detailed equipment tests. Each month signal conditioners, chart recorders, and magnetic tape recorders are checked and calibrated.

d. Magnetic tape processing and data printout are handled on a high priority basis to shorten the period before data are reviewed in detail by a meteorologist.

e. A NOVA data logging system will be installed by March 1, 1976. This system includes: (1) a minicomputer which controls the system and performs calculations; (2) a digital voltmeter (DVM) which digitizes data directly without a signal conditioners (except wind speed); (3) a teletype with paper tape punch. Digital printout of hourly averages of data and instantaneous digital display of data readings will be available onsite. This will provide more accurate data than the strip-chart pen traces for onsite data evaluation. Service, maintenance, and data review procedures indicated in a, b, and c above will also apply to the NOVA system.

f. POM system magnetic tape cassettes are removed monthly for data processing. NOVA system teletype paper tapes will be removed weekly for data processing. NOVA system paper tape processing is less complex than that for the magnetic tape and therefore data printouts are available after less processing time. The NOVA system data printout will be reviewed by a meteorologist more frequently and with less delay than the present POM system data.

Question 323.2 (2.5.1.1)

Provide a regional geologic cross section which passes through the site area and includes the Valley and Ridge and Blue Ridge provinces. This cross section should show the relationship of surface structures in this region to the regional geology, including "basement" geology.

Response:

The response to this question has been incorporated into revised section
59 2.5.1.1.2. 27

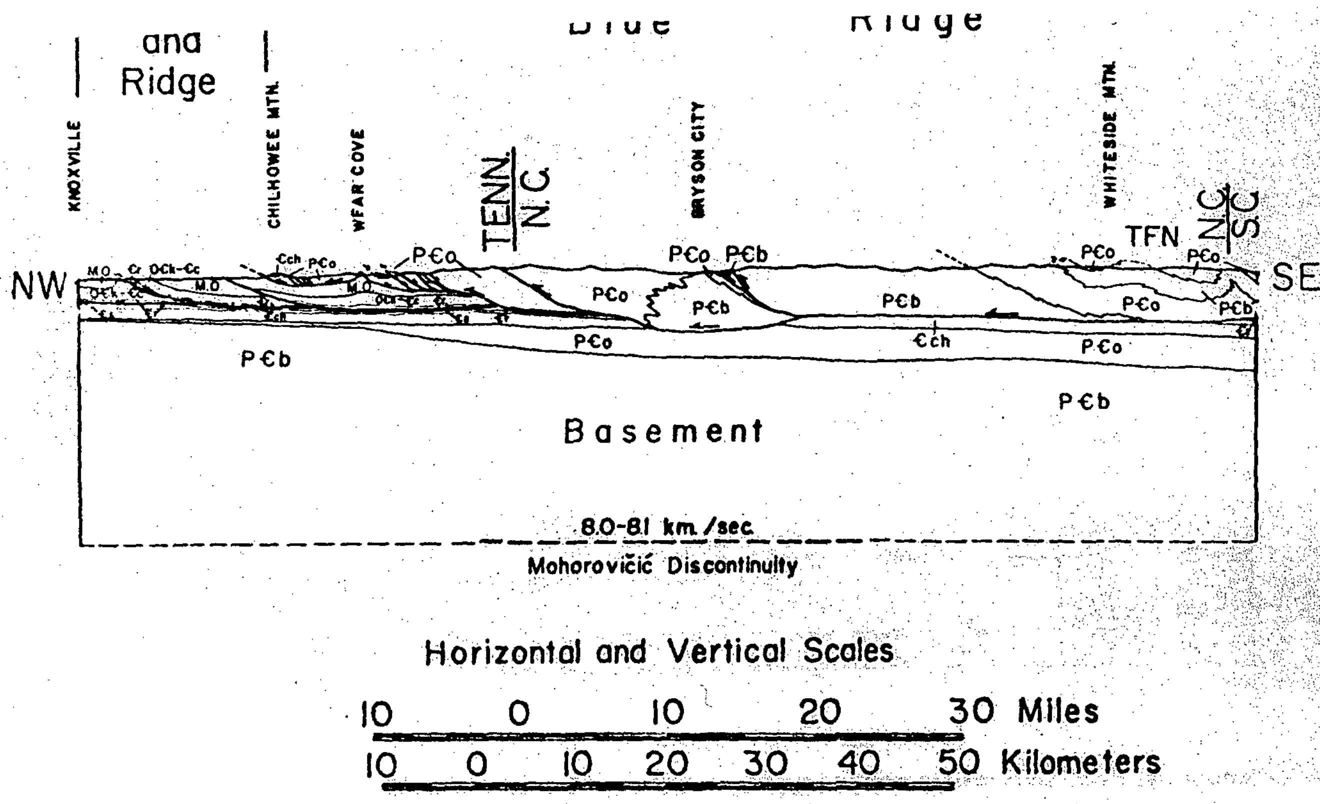
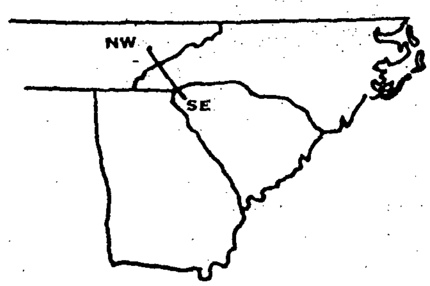


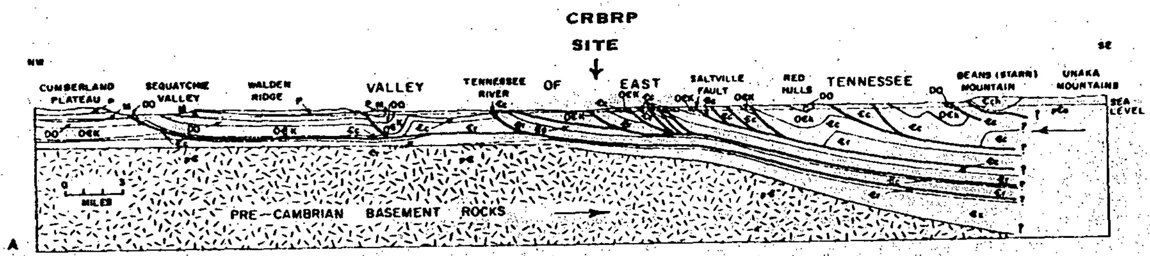
Figure 3. Section showing the present structural configuration across a portion of the southern Appalachians, as interpreted by the writer. Interpretation was made from geologic and geophysical maps by Stuckey (1958), King (1964), Watkins (1964), Neuman and Nelson (1965), Overstreet and Bell (1965b), Livingston (1966), McKniff (1967), Wilden and others (1968), Hatcher and Griffin (1969), and Hatcher (1971b). TFN Tallulah Falls Nappe. BZ–Brevard Zone. TF–Towaliga Fault. PCb–earlier Precambrian basement rocks. PCbms–earlier to late Precambrian basement and metasedimentary and metavolcanic rocks. PCo–Ocoee Series. PCmsv–late Precambrian metasedimentary and metavolcanic rocks. PC–Cms and PC and Cmsv–late Precambrian and Cambrian metasedimentary and metavolcanic rocks. PZi–Paleozoic intrusive rocks. Cch–Chilhowee Group. Cs–Shady Dolomite. Cr–Rome Formation. OCk-Cc–Knox and Conasauga Groups. M.O.–middle Ordovician Chickamauga Group rocks. KT–Cretaceous and Tertiary sediments.



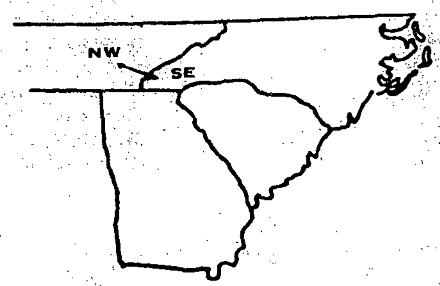
NOTES:
1) ONLY NORTHWESTERN PORTION OF PROFILE SHOWN
2) MODIFIED FROM HATCHER (1972)

Figure Q323.2-2

Amend. 7
Nov. 1975



CROSS-SECTION ILLUSTRATES THE "THIN-SKINNED" HYPOTHESIS OF THRUST FAULTING. THIS HYPOTHESIS SUGGESTS A MAJOR DECOLLEMENT ABOVE THE LEVEL OF THE BASEMENT.



NOTES:
1) CRBRP SITE PROJECTED ALONG STRIKE
2) MODIFIED FROM RODGERS (1953), KY. GEOL. SUR. SER. 9, SPEC. PUB. 1

Figure Q323.2-3

Amend. 7
Nov. 1975

Question 323.4 (2.5.1.1)

Provide information on the extent and nature of the Rome Formation "sole thrust" in this area. This should include evidence such as seismic profiles or drill hole data if available.

Response:

The response to this question has been incorporated into revised Section
59 2.5.1.1.2.

27

Question 323.6 (2.5.1.1.2)

Provide futher information on the location of the Rough Creek and Kentucky River fault zones. Include information concerning the structural evaluation and history of these faults.

Response:

The response to this question has been incorporated into revised Section 2.5.1.1.2. 27

(160) Stauder, W. 1970 — (and Nuttli, O.W.) Seismic Studies: South Central Illinois Earthquake of November 9, 1968: Bulletin of the Seismological Society of America, Vol. 60, No. 3, p.980.

(161) Stearns, R. G. 1972 — (and Wilson, C.W., Jr.) Relationships of Earthquakes and Geology in West Tennessee and Adjacent Areas: Tennessee Valley Authority, January.

(163) Swingle, G. D. 1959 — Geology, Mineral Resources, and Ground Water of the Cleveland Area, Tennessee: Tennessee Department of Conservation, Division of Geology Bulletin 61, pp. 38-41 and 56-57.

(164) U.S. Geological Survey 1968 — Bethel Valley Quadrangle, Tennessee, 7.5 Minute Series Topographic Map: U.S. Department of the Interior, Washington, D.C.

(165) U.S. Geological Survey) 1968 — Lenoir City Quadrangle, Tennessee, 7.5 Minute Series Topographic Map: U.S. Department of the Interior, Washington, D.C.

(166) U.S. Geological Survey 1968 — Cave Creek Quadrangle, Tennessee, 7.5 Minute Series Topographic Map: U.S. Department of the Interior, Washington, D.C.

(167) U.S. Geological Survey 1968 — Elverton Quadrangle, Tennessee, 7.5 Minute Series Topographic Map: U.S. Department of the Interior, Washington, D.C.

(168) Tennessee Valley Authority — Watts Bar Nuclear Plant PSAR, with Responses to Questions and Amendment 1

(169) Hatcher, R. D., Jr. 1972 — Developmental Model for the Southern Appalachians: Geological Society of America Bulletin, Vol. 83, pp. 2735-2760, September.

(172) U. S. Geological Survey 1973 — Preliminary Determination of Epicenters, November

(173) Chinnery, M. A. 1969 — Earthquake Magnitude and Source Parameters: Bulletin of the Seismological Society of America, Vol. 59, No. 5, pp. 1969-1982, October

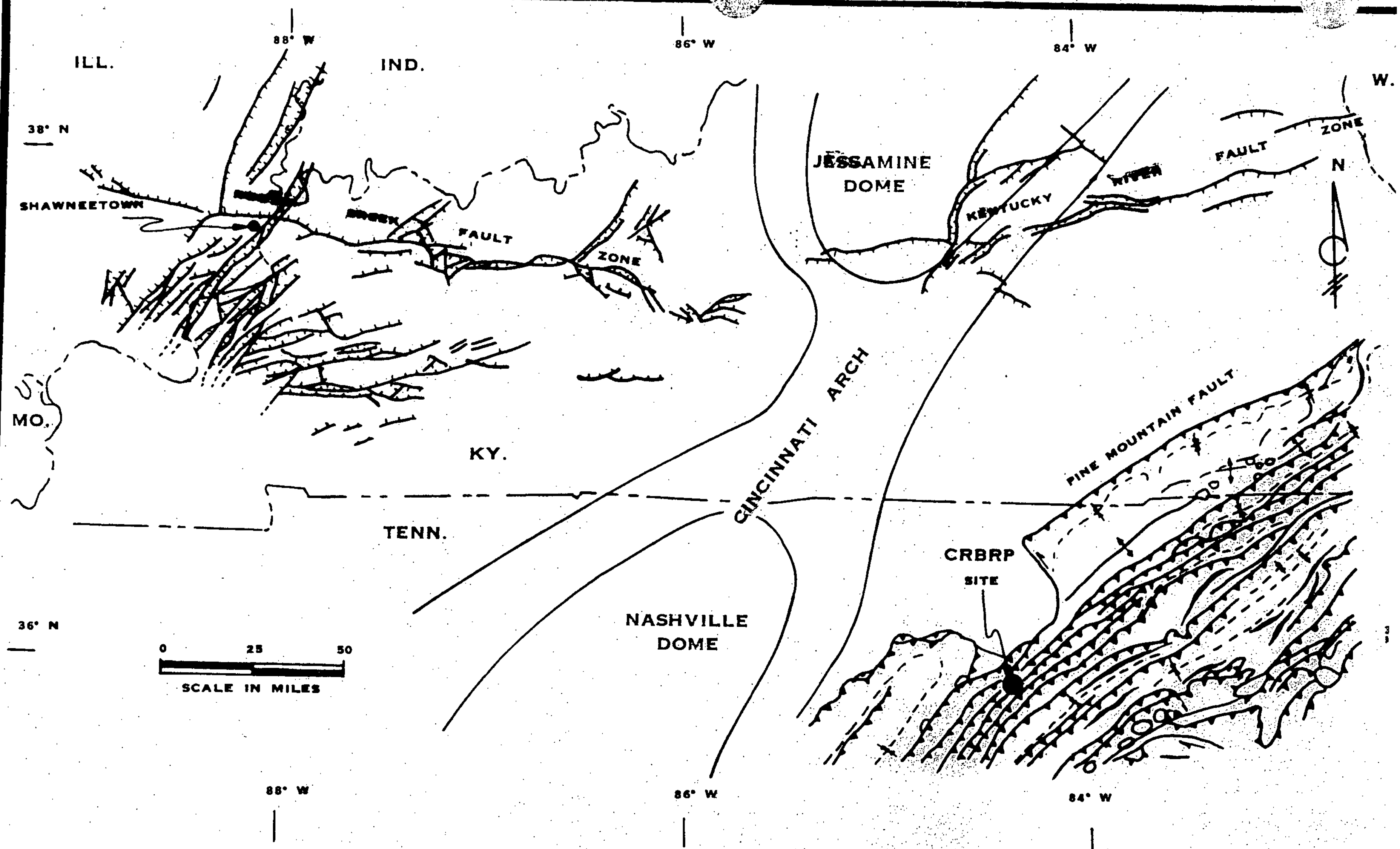
(174) Bollinger, G. A. 1973 — (and Harding, S.T.; and Langer, C.J.) Maryville-Alcoa Earthquake Sequence of November-December, 1973; Preliminary Report (subject to revision): Department of Geological Science, V.P.I. and State University, Blacksbury, VA.

(175) Bristol. H. M. 1971 — (and Buschbach, T.C.) Structural Features of the Eastern Interior Region of the United States: In Background Materials for Symposium on Future Petroleum Potential of NPC Region 9 (Illinois Basin, Cincinatti Arch, and Northern Part of Mississippi Embayment), Illinois State Geological Survey Petroleum Bulletin 96, pp. 21-28

(176) Sutton, D. G. 1971 — Exploration Potential of the Rough Creek Fault System: in Proceedings of Symposium on Future Petroleum Potential of NPC Region 9 (Illinois Basin, Cincinatti Arch, and Northern Part of Mississippi Embayment), Illinois State Geological Survey Petroleum Bulletin 95,pp. 69-78.

(177) Bond, D. C. 1971 — (and Atherton, E.; Briston, H. M.; Buschbach, T.C.; Stevenson, D. L.; Becker, L.E.; Dawson, T. A.; Fernalld, E. C.; Schwalb, H.; Wilson, E. N.; Statler, A. T.; Stearns, R. G.; and Buehner, J. H.) Possible Future Petroleum Potential of Region 9 (Illinois Basin, Cincinatti Arch, and Northern Mississippi Embayment); in Future Petroleum Provinces of the United States-Their Geology and Potential, AAPG Memoir, 15 Vol. 2, pp. 1165-1218

(178) U.S. Geological Survey and American Assoc. of Petroleum Geologists 1962 — Tectonic Map of the United States: George V. Cohee, Committee Chairman



NOTES:
1) USED REFERENCE 178 AS BASE.
2) ADDED CRBRP SITE LOCATION.
3) ADDED SHAWNEETOWN, ILL. LOCATION.

Figure Q323.6-1

Amend. 7
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Question 323.8 (2.5.1.1.4.1)

Locate northeasterly trending small caves on regional and subregional geologic maps.

Response:

The response to this question has been incorporated in revised Section 2.5.1.1.4.1.

Question 323.9 (2.5.1.1.4.1)

This section states that only a few small diameter holes were noted in Unit A limestone outcrop area. Describe these features and show locations on the topographic or geologic map.

Response:

The response to this question has been incorporated in revised Section 2.5.1.1.4.1. 27

Question 323.22 (2.5.1.2)

Provide a regional topographic map showing nearest towns, cities and regional terrain.

Response:

The response to this question has been incorporated in revised Section 2.5.1.2.2.

23

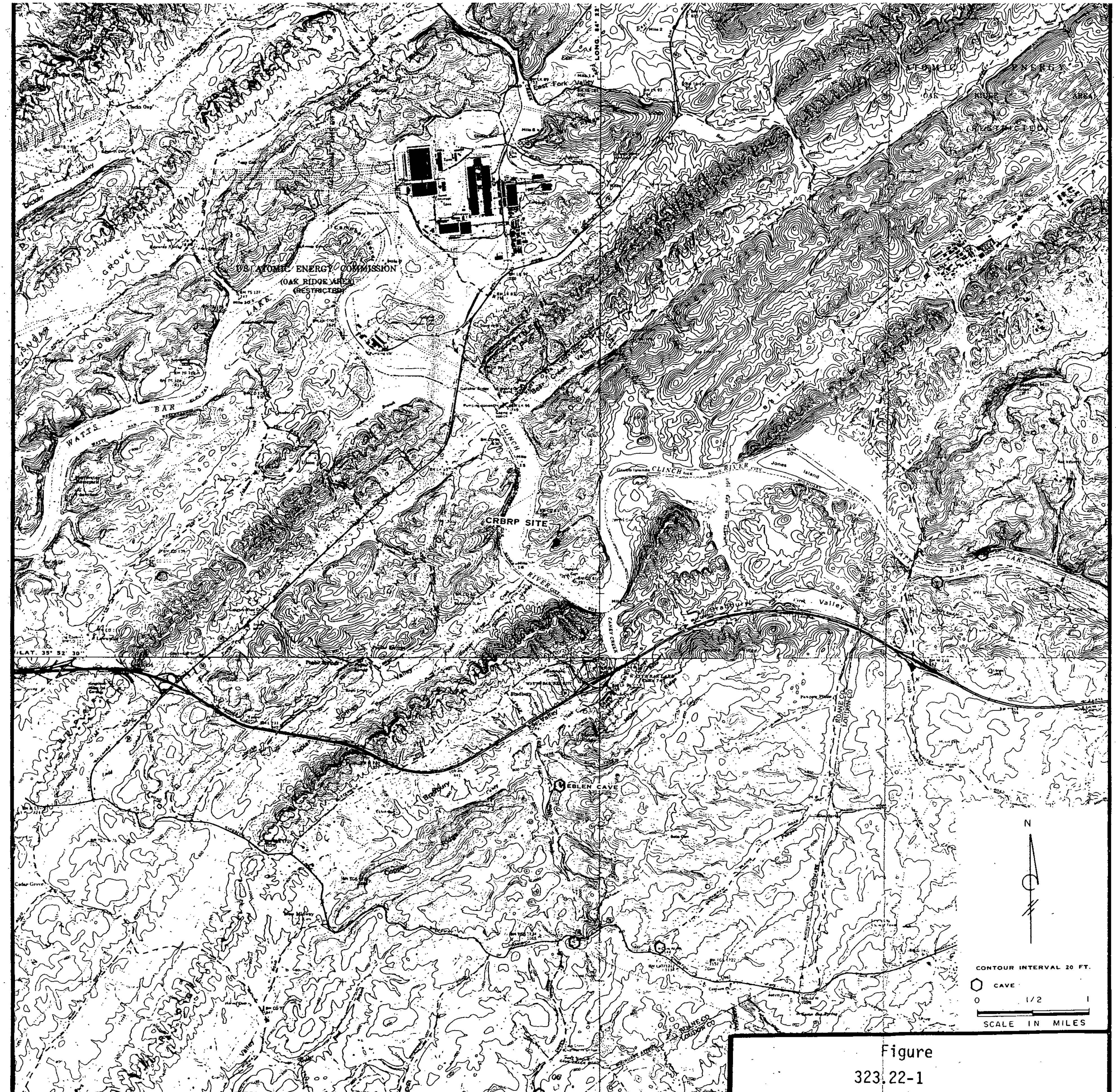

Figure
323.22-1

Question 323.23 (2.5.1.2)

Provide a regional geologic map which encompasses an area about 5 miles from the site.

Response:

Illustration 6 of Supplement 2 is a geologic map encompassing an area of about 100 square miles around the CRBRP site.

Amend. 7
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Question 323.24 (2.5.1.2.3)

This paragraph refers to Figure 2.5.6 as showing aerial distribution of geologic formations. This should be Figure 2.5-5. Please modify.

Response:

The paragraph which refers to the areal distribution of geologic formations has been corrected to indicate Figure 2.5-5.

Question 323.25 (2.5.1.2.3.3)

What is the age of the terrace material in the site area? Discuss any absolute age dating which relates to these terrace deposits.

Response:

The information requested is provided in revised Section 2.5.1.2.3.3. 27

Question 323.26 (2.5.1.2.4.1)

Provide the location of drag folds, tight folds, and shears which occur in the site area. Provide specific information on the character of the shears and the amount of displacement along these shears.

Response:

59 The information requested is provided in revised Section 2.5.1.2.4.3.

27

Question 323.27 (2.5.1.2)

Provide fold line trace of subsurface anticline on geologic map.

Response:

The response to this question is included in the response to Question 323.26.

Question 323.28 (2.5.1.2.4.1)

Provide specific references for documentation of the lack of residual stress alluded to as included in the Bellefonte PSAR.

Response:

Reference to unrelieved residual stress was made in the Bellefonte Nuclear Plant PSAR in two sections of the report. In Section 2.5.1.2.9, Evaluation of Geologic Conditions, page 2.5-13a, dated 10/10/73, the following was presented:

> "There is no evidence at this time to assume that unrelieved residual stress may be found in the bedrock. Core discing, which is indicative of stress zones, was not encountered, and no difficulty was experienced in introducing a 2.54 inch television into the 3.0 inch holes."

In Section 2.5.4.1, Geologic Features, pages 2.5-26 and 2.5-27, the following was presented:

> "No specific investigations of residual stress accumulations in the foundation strata have been made. Experience at numerous previous major construction projects in the region has shown that this is not a consideration. Such stress effects as "popping," rock bursts, and foundation "heaving" have never been observed and there is no reason to assume that they will occur at this time."

The foundation rocks for the Bellefonte Nuclear Plant are the same as the foundation rocks for the Clinch River Breeder Reactor Project, the Chickamauga formation of Middle Ordovician age. Tennessee Valley Authority has indicated that their experience in numerous previous major construction projects has shown that unrelieved residual stress in the bedrock is not a major consideration. In addition, TVA has contacted the Tennessee Department of Highways concerning their experience in major construction projects in the Valley and Ridge Province. The Tennessee Department of Highways has indicated that they have not observed residual stress effects in the area.

Question 323.29 (2.5.1.2)

Provide a definition of the term "minor dislocation" and if they are faults, provide information on their locations and amounts and directions of displacements.

Response:

The response to this question is included in the response to Question 323.26.

Question 323.30 (2.5.1.2)

Clarify the term "offsets" and describe the marker beds or units which are displaced.

Response:

The response to this question is included in the response to Question 323.26.

Question 323.35 (Figure 2.5-10)

Explain the existence of several 10 foot clay seams noted in several basehole logs. Show all shear zones and large cavities on geologic cross sections.

Response:

59 The information requested is provided in revised Section 2.5.1.2.4.4.

27

Question 323.36 (2.5.4)

Page 2.5-32, 1st paragraph states that site plot and profiles are shown on Figures 2.5-20 through 2.5-24. This should be Figures 2.5-24 through 28. Please modify.

Response:

The paragraph which refers to the site plot and profiles has been corrected to indicate Figures 2.5-24 through 2.5-28.

Question 323.37 (2.5.4.2.1)

Page 2.5-35 1st paragraph and Figure 2.4-33 give summary information on the Q D evaluation. Please indicate Q D and core recovery percentiles on the boring logs.

Response:

The percent recovery and rock quality designation (RQD) for borings 25
59| through 105 and 127 through 149 are provided in Appendix 2-A.

Amend. 59
Dec. 1980

Question 323.38 (2.5.4.5.1.5)

Page 2.5-42 1st paragraph states that Class A structural backfill information will be provided at a later date. This information is required prior to completion of our review in sufficient time to evaluate the results. Provide a schedule for the submittal of information on Class A backfill including: sources, mechanical analyses, compaction data, permeability, density, dynamic and static test results performed on samples compacted to design specifications, and quality control information. In lieu of dynamic testing the applicant should commit to emplace backfill compacted to 85% relative density or to 95% of maximum as determined by modified Proctor, whichever produces the best results.

Response:

The requested information is provided in revised section 2.5.4.5.1.5. 27

Question 323.39 (2.5.4.12)

Page 2.5-47, last paragraph, mentions that careful control will be exercised during excavation to ensure that minimum disturbance will occur during blasting. Describe the procedures and criteria for this quality control.

Response:

The response to this questions has been incorporated in revised Section 2.5.4.12. 27

Question 323.40 (Appendix 2A)

Page 2A-3, show the locations of each fluid pressure test on the logs, and give the results of each test.

Response:

The location and result of each fluid pressure test (packer test) are shown on the Graphic Logs and are listed on Table 2.14-17. The packer test results shown on the Graphic Logs are presented as the "take" (in gallons per minute) and the corresponding pump pressure (in psi) for each test. Both single packer and double packer tests are shown on the Graphic Logs. The results of single packer tests are representative of the entire open—hole section below the test level. The results of double packer tests are representative of the interval indicated by the brackets.

Question 323.41 (Appendix 2A)

Page 2A-5. Provide copies of the recorder charts obtained during the in situ 3-D velocity survey.

Response;

Copies of the Elastic Properties Log for each boring surveyed during the in situ 3-D velocity testing program were provided to Mr. R. Jackson, NRC geologist, on December 19, 1974, in a meeting at the CRBRP site.

Question 323.42 (2.5.2.6)

Discuss the Maryville, Tennessee, earthquake (its focal depth and source mechanism) of November 1, 1973 in the context of the geologic structure of the Valley and Ridge province, and your statement that earthquakes in this province are "well within the basement rocks".

Response;

The Maryville-Alcoa, Tennessee earthquake occurred at 2:48 a.m. EST, November 30, 1973 at latitute 35.80° North and longitude 83.96° West. Intensity reports from surrounding communities determined that the earthquake felt area was about 65,000 square kilometers (25,000 square miles) and that the epicentral intensity was VI MM. The nearest seismic recording station to the epicenter that recorded the earthquake was the Cumberland Plateau Observatory which is 90 miles west of the epicenter.

The U.S.G.S. Preliminary Determination of Epicenter (PDE) has reported that this earthquake had a magnitude (m_b) of 4.6. The PDE also lists the depth of focus for this event at a depth of 2.7 kilometers (9,000 feet) on the basis of 18 phases from regional seismograph station records. The seismograph data had a standard deviation of 0.4, which implies an accuracy of $\pm$ 6 kilometers. This precision is inadequate to specify the earthquake focal depth; however, it is implied that the focal depth is probably below the sedimentary rock sequence.

In addition to the PDE report, depth estimates of 12 aftershock observations are available (Reference 174). The aftershock reports are based on data from portable seismographs that were set up in the epicentral area as well as from the regional seismograph stations. Aftershock depths ranged from 3.1 to 25.1 km (10,000 to 80,000 ft.). These depths are consistent with the contention that Valley and Ridge earthquakes originate in the basement. The depth estimates of aftershocks are dependent on the accuracy of the velocity model and the location of the recording stations. Therefore, they may be subject to about the same degree of precision as the PDE focal depth estimate. Reference 174 states "...the determination of accurate focal depths was prevented by the small number of stations (5) and the absence of a station in the northeast quadrant. The epicenters are estimated to be accurate to $\pm$ 5 km. It is not possible to reliably estimate the accuracy of the focal depths but the better determinations. . . would indicate a 3-4 km depth. . ." Recent discussions with C. J. Langer of the U.S.G.S. and G. A. Bollinger of Virginia Polytechnic Institute revealed that additional instrumental aftershock data have been obtained subsequent to the preliminary report of February 1974 on the earthquake. These new data result in revisions to the preliminary report that was presented at the Seismological Society of America 1974 Annual meeting (March 25 - 27 at Los Angeles).

Although the PDE focal depth estimate and the depths of aftershocks of the Maryville-Alcoa earthquake are imprecise, both data sources support the contention that the earthquake originated below the Rome decollement.

Information regarding the source mechanism of the earthquake is available from Reference 174. Based on 17 regional recording stations and measured pressure wave first motions, two fault plane solutions were achieved:

1) Reverse Faulting — Strike N 35° W, Dip 41° NE
2) Normal Faulting — Strike N 49° E, Dip 70° SE

The spatial distribution of aftershock epicenters does not favor one solution over the other. Neither of the fault plane solutions are consistent with the Valley and Ridge sedimentary structural trends.

The geology of the Valley and Ridge has been studied by numerous geologists for over 100 years. During this period, no data has been revealed that suggests surface faulting is occurring. Even in the epicentral area of historic earthquakes, there is no evidence of associated surface faults. No evidence of surface faulting exists in the area of the Maryville-Alcoa earthquake fault plane projections. The fault associated with the Maryville-Alcoa earthquake is unrelated to any observable regional fault because: 1) fault plane solutions yield attitudes contrary to the regional trend and 2) surface faulting does not occur.

References used are listed at the end of Question 323.6.

Question 323.43 (2.5.1.1.4.2)

Provide further information and clarification of the several unexplainable "signals" which were detected during monitoring of several injection episodes. This information should include occurrence of signals on the well-head pressure-time plots. Provide relevant seismograph records which show background seismicity and "signals" as well as a map of well locations with accompanying noise generating equipment and seismograph station locations.

Response:

Information regarding seismic monitoring of the waste injections has been provided by Mr. W. C. McClain, Health Physics Division, Oak Ridge National Laboratory. In a meeting at the ORNL offices on July 9, 1975, Mr. McClain provided information relative to the injections from the project files and from his notes and recollection of the operations. The contents of this response are based on the information obtained during this personal communication (Ref. 188) and the information contained in publications and articles about the injections (Ref. 133-149).*

Seismic monitoring operations were performed for injections made during the period from November 28, 1967 through December 5, 1972 (ILW-3 through ILW-11). Several unexplainable, unusual or unidentifiable "signals" were detected, received or recorded during injections ILW-3, the water injection test, ILW-4, ILW-5, ILW-7.

The first seismic monitoring operations were conducted during injection ILW-3 on November 28-29, 1967. The seismic monitoring was performed by increasing the gain and chart speed of the ORNL seismograph (station ORT) located about one mile from the injection well. The location of the ORT seismograph station with respect to the injection well is shown on Figure Q323.43-1.

The seismograph monitoring records obtained during the injection were examined for any unusual signals, especially those of higher than normal frequency, which would imply a nearby source. Results of this examination are summarized below.

1. There was a considerable amount of noise of about 8 cps frequency superimposed on the normal seismograph record throughout the whole two days. Some of this noise occurred during actual pumping and some was not. This noise usually arrived in either short bursts of approximately 40-second duration or as a long wave train lasting from 4 to 7 minutes. This type of disturbance had been recorded occasionally in the past but rarely more than two or three of the trains per month. It was believed that this noise was related to operation of the high-pressure injection pump (but not necessarily actual pumping) in some sort of resonance with its foundation, the

* References 133-149 are identified in Chapter 2 - Supplement 2, page 97.

injection well, or both. The short bursts would then represent a speed change passing through the resonant frequency, while the longer periods would represent a short time of operation at or near the resonant frequency.

2. There was noise of 8 cps frequency and 10-second duration observed at 1533 hr. (EST), November 28, 1967. This noise was isolated and had a high and regular amplitude.

3. At 1455 hr (EST) November 28, 1967, there was a 90-second duration wave train of 3 cps energy. This signal had a relatively constant amplitude.

4. On three occasions (beginning at 153420 hours, November 28, 1967 and 125300 and 155530 on November 29, 1967) there was a period of 8 cps noise, similar to that described in item 1, which lasted 1 to 2 minutes and then changed in character, becoming larger in amplitude, lower in frequency, and more ragged for about a minute. This wave train then reverted to noise similar to the usual item 1 noise for several more minutes.

Figure Q323.43-2 and 3 are plots of well-head pressure-time relationships observed during injection ILW-3. Superimposed on these figures are the occurrence of signals described in items 2 through 4 discussed above. Figure Q323.43-4 and 5 are copies of the seismograph records obtained during monitoring of injection ILW-3.

Seismic monitoring operations performed during the water injection test on December 13, 1967, were as in ILW-3 (station ORT was operated at an increased gain and chart speed). Results of examination of the seismograph record are discussed below.

1. There were three periods of 8 to 9 cps noise (at 1306, 1446, and 1500 EST) of the type attributed to the operation of the injection pump. The amplitude of these 3 to 5 minute wave trains was much less than observed on the previous occasion. The reduced amplitude probably resulted because the water injection test was carried out using pumps mounted on a truck parked at the plant. Pumping during the prior injection (ILW-3) was carred out using the principal ground-level, injection pump.

2. Signals resulting from local blasting operations and one teleseism were recorded during the injection. After removing these events from consideration, there remained a total of 25 unidentified signals. These signals were divided into three groups primarily on the basis of their envelope amplitude according to the following criterion:

Type A High Amplitude --- easily recognizable, definite signals, with an amplitude at least four to five times background noise level and a duration of about 20 seconds.

Type A Low Amplitude --- definite signals of the same type but with a much smaller amplitude (two to three times background), making discrimination difficult.

Type B--- very strong signals with amplitude more than ten times background and of much longer duration.

Figure Q323.43-6 is a copy of the seismograph record obtained during the water test injection. Table Q323.43-1 lists the unidentifiable signals by their approximate times, duration, and the coincident pumping rate. Figure Q323.43-7 is a plot of well-head pressure-time relationships observed during the water injection test and shows the occurrence of the signals described above.

Seismic monitoring operations were performed during injection ILW-4 on April 3 and 4, 1968, by using two short-period seismometers which were installed at the hydraulic fracturing plant site. The seismometers were installed on the concrete leveling bench mark stations at points C-4 and B-5, as shown by Figure Q323.43-8. The short-period seismometers used for the monitoring operations were the short-period seismometer from the ORT station and a short-period seismometer that was specifically purchased for the monitoring operations.

Conditons for detection of seismic signals were less than ideal during injection ILW-4. The injection was made through an existing slot in the well casing and presumably into the fracture into which the water injection test had been performed. This condition, based on results of the first two seismic tests, was expected to produce a lower level of seismic signal generation than an injection into unfractured rock. In addition, abnormally high background noise resulting from gusty winds, operation of one of the seismometers at less than its highest capability, and heavy ground shaking by the injection pump provided conditions that were less than ideal for detection of seismic signals.

The seismic signals obtained during the monitoring operations were examined and all signals which could be readily identified as originating from local blasting operations or distant earthquakes (teleseisms) were eliminated from consideration. In addition, the signals previously identified as possibly originating from operation of the high-pressure injection pump at certain speeds were positively identified and were also eliminated. A total of 51 unidentifiable signals on the records of the 8 hour 32 minute injection period and 18 such signals for the 7 hour period following completion of the injection remained (Ref. 188). Of the signals occurring during the injection, only nine had sufficient amplitude and character to be of interest (Ref. 188). However, it was not possible to correlate any of the signals with the various phases of the pumping operation nor to identify any of them as having originated in the area (Ref. 188).

Figure Q323.43-9 and 10 are plots of the well-head pressure-time relationships observed during injection ILW-4. The occurrence of the signals described above are not shown on the pressure-time plots for injection ILW-4, since listings of the time of the events could not be located in the files (Ref. 188). However, Figures Q323.43-11 through 16 are copies of the seismograph records obtained during the monitoring of injection ILW-4.

Seismic monitoring operations were performed during injection ILW-5 on October 30 and 31, 1968, using the two vertical short-period seismometers that were used during injection ILW-4. However, the seismometers were located on concrete leveling bench marks A-7 and B-5 during injection ILW-5, as shown by Figure Q323.43-17.

Injection ILW-5 was made into a new slot in the well casing, and presumably into a new fracture. Injections of this type generally appear to produce both more and better seismic signals than an injection into a fracture which had been used previously. In addition, the factors which produced the less than ideal seismic monitoring conditions during injection ILW-4 were either absent or reduced.

The new slot in the injection well casing was made on October 30, 1968, and the fracture process initiated by pressurizing the well starting at 1703 EST. The pressure was increased to 5000 psi over the next 5 minutes and held for the next 12 minutes. At 172010 the fracture initiated as indicated by a change in the sound of the pump motor. Also at 172010 a definite seismic signal of 25 second duration was received at both seismometers. Pumping into the fracture was continued for 11 minutes, during which time there was one much larger amplitude seismic signal received (at 172930) lasting 90 seconds. The signal coincided with an increase in the pumping rate.

The waste injection and seismic monitoring operations started at 0936 EST on October 31, 1968. Beginning at 093605 EST a teleseism of about 6 1/2 minute duration from an earthquake in the Caribbean was receive on the monitoring system. This signal would have masked any local microseisms during this period, which was the initial stage of the pumping operations. Table Q323.43-2 lists those signals obtained during the injection period which were recorded with different features at the two seismographs. The table lists the signals by time (EST) and contains a description of the signal. The occurrence of the signals are shown on Figure Q323.43-18, the well-head pressure-time relationship for the injection. Figure Q323.43-19 through 27 are copies of the seismograph records obtained during monitoring of injection ILW-5. These records contain time markings which are based on GMT.

The Rock Mechanics Laboratory of the U.S. Bureau of Mines provided all of the equipment to detect, amplify, record on magnetic tape, and playback through a high-speed recording oscillograph the seismic signals generated by Injection ILW-6. The detection equipment primarily consisted of seven vertical velocity transducers, having a frequency response of about 1000 cps, which were installed at leveling bench marks A-3, A-5, B-2, B-5, C-2, D-3 and D-4, as shown by Figure Q323.43-28.

During the injection, noise levels related to the operation of the many diesel engines, pumps, air compressors, etc. limited the gain which could be attained on the seismic instruments to about 50,000 (on previous experiments, the ORNL seismographs had been operated at gains of about 100,000). Initial monitoring of the transducer output quickly indicated that very few signals were being recorded. Consequently, two of the velocity transducers were replaced by accelerometers (capable of detecting seismic signals with frequencies greater than several thousand cps) taped to the well casings at the Joy well and at well 220-S. At this same time (about three hours into the injection) a 100-gram charge was fired in the Joy well at a depth of 1000 feet to provide a calibration of the seismic array and to permit calculation of the transmission velocity of the signals arriving from the vicinity of the fracture and to estimate the energy of the source function.

Detailed examination of the record produced by injection ILW-6 revealed that quite a few events were picked up but that all of them could be accounted for by causes other than the hydraulic fracturing (Ref. 143). The calibration shot in the Joy well was recorded only through the accelerometer attached to the Joy well casing, not at any of the other transducers. The output from this accelerometer was also monitored using earphones for several hours late in the injection. This monitoring indicated a considerable amount of low-amplitude seismic activity, which was probably being transmitted up the steel well casing, consisting of pops, bangs, crackles, growls, gurgles, sloshes, and splashes. All of these noises can be attributed to the hydraulic fracturing operation, since output from the instrument was absolutely quiet the following day.

Century Geophysical Corporation of Tulsa, Oklahoma assisted with the seismic monitoring and data analysis carried out during injection ILW-7 on September 23, 1970. An array of five short-period seismometers (four vertical and one horizontal) with natural periods of 0.5 sec. were installed at the ORNL site according to the layout shown on Figure Q323.43-29. This array was operated continuously for 3 days prior to, during, and for 3 days after the injection by recording all seismometer outputs and timing signals on magnetic tape.

Playback of the magnetic tapes through a recording oscillograph indicated that the background noise was completely masking any seismic signals. However, by filtering the records by filters with adjustable cutoff frequencies, a number of seismic events were revealed in the records. Table Q323.43-3 lists the distribution of the seismic events distinguished during the 168 hours of continuous recording.

Twenty-nine of the 89 events occurring on the date of the injection were selected for analysis. The arrival times of these signals were picked independently by three analysts and the results averaged to 1 msec. (This level of accuracy was utilized in spite of the fact that the true resolution was estimated to be ± 5 msec). These arrival times were then used, along with the seismic transmission velocity model derived from the geologic log of the Joy well, to calculate the point source of each event. Table Q323.43-4 lists the calculated foci of the 29 events.

Injections performed during the period extending from September 29 to December 5, 1972, (ILW-8 through ILW-11) were monitored by Senturion Sciences, Inc., of Tulsa, Oklahoma. Seismic arrays consisting of six seismometers were used during each of the four injections as shown by Figure Q323.43-30 through 32. Despite the array configurations or the incorporation of a down hole seismometer (during (ILW-11), induced seismicity generated by injection fluids during the 1972 tests was not found.

Detailed seismic monitoring of waste injections has been suspended. However, the new ORT station is operational (see Question 323.44) and should any seismic events that are above noise levels be provided by the injections, records would be obtained in the course of normal station operation.

The seismic monitoring operations were initially begun in an attempt to determine the orientation and location of fractures induced by the injection of wastes. However, since the monitoring operations did not provide an accurate, consistent, nor reliable means of detecting grout sheet extentions, this method of monitoring was suspended. The success of the monitoring technique was limited by several factors inherent with the waste injection process and the host rock formation. Failure or only marginal success in detecting signals at the surface near the waste injections was probably due to a combination of:

1. Only relatively low amplitude signals are generally produced by the extension of a propagating fracture. The seismic energy resulting from the extension of a propagating fracture is apparently very small.

2. The transmission properties of the rock overlying the grout sheet are very poor. In addition, the plant site is covered by a relatively deep soil mantle. The relatively poor transmission properties of the materials overlying the grout sheets was evidenced by failure of all the ground surface seismometers to pick up signals from the calibration explosion (consisting of approximately 300,000 ft-lbs. of energy) during injection ILW-6.

3. The background noise during an injection is relatively high. However, this noise is a consequence of the injection process and there does not appear to be any way to reduce it.

4. Equipment limitations, such as the time resolution capabilities, and the gain limitations resulting from high noise levels make detection of the apparently low amplitude and low energy seismic signals from the injection difficult, if not impossible to detect.

The principal features of the hydraulic fracturing surface plant facility are shown in their relative locations in Figure Q323.43-33 A pictorial representation of the surface plant and the injected grout sheet is shown by Figure Q323.43-34. These illustrations show the locations of noise generating equipment that are permanently installed at the plant. Other mobile noise generating equipment, such as auxiliary pumps, air compressors, diesel engines, etc., are also occasionally used during an injection.

Seismograph monitoring records (Figures Q323.43-4 through 6, 11 through 16, and 19 through 27) have been forwarded under separate cover. A list of these Figures is provided on pages Q323.43-15 and Q323.43-16.

List of Unidentified Seismic Signals from Water Injection Test

Time (EST)	Duration (sec)	Flow Rate (gpm)
	Type A Low Amplitude	
1352	0	7.5
1359	40	40
1419	40	100
1520	20	40
1525	20	40
1809	20	40
	Type A High Amplitude	
1302	35	*
1318	35	7.5
1347	20	40
1439	90	250 **
1449	10	250
1537	20	100 ***
1554	10	100
1611	5	250
1717	25	100
1722	90	250 ***
1728	40	250
1738	15	250
1748	50	250
1902	40	250
	Type B	
1558	150	250 **
1626	90	40
1632	90	40
1702	150	100
1734	60	250

*Coincident with breakdown
**Coincident with step from 100 gpm to 250 gpm
***Coincident with step from 40 gpm to 100 gpm

TABLE Q323.43-1
Source Reference 188
Law Engineering Testing Co.
July 1975

TIME (EST)	SIGNAL DESCRIPTION
095545	A train of short (10 to 30 seconds) high-frequency (6.0 cycles/second) signals lasting a total of about 4 minutes. Seis A (north) has much larger amplitude and much more detail than Seis B (east).
101900	Very similar to above, but the 6.0 cycles/second signal is nearly continuous for 8-minute duration. Seis A again is much larger and more detailed than Seis B.
105500	A short (30 seconds) burst of high-frequency (6 cycles/second) signal which does not have the same appearance as the preceding. Seis B has nearly twice the amplitude and much more detail than Seis A.
113500	Forty-five-second duration signal, same as 105500.
120930	A small, short (30-second duration) signal, similar to 105500, except that Seis A has more amplitude and considerably more detail than Seis B.
130400	One-hundred-second duration signal. On Seis A it consists of an almost continuous train of high-amplitude (5X background) very high-frequency (about 10 cycles/second) signals. On Seis B it consists of short bursts of low-amplitude signals (2X background) of about the same frequency. Very distinctive difference.
141320 141430 141630 143230 151420	Throughout the pumping period, but especially in the 20-minute interval following 1413, there are many (average about 1 every 2 minutes) very short (1 to 3 seconds) signals of only a few cycles duration, of which these are typical. Usually there is a larger, more detailed signal on Seis A than on Seis B; occasionally, there is no comparable signal at all on Seis B; sometimes (1/4 to 1/3 of the time) the signal on Seis B is larger than Seis A.
150300	Fifty-second duration signal, similar to 120930. (A is greater than B.)
153900 153930 175700	On these three occasions, a quite large signal was received with about the same average amplitude at both seismometers. They are included because the details of the wave are recorded at the two sites are completely different.

TABLE Q323.43-2
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

Frequency of Occurrence

Date	Number of Events
September 1970	
20	21
21	23
22	25
23 (waste injection)	89
24	28
25	31
26	21

TABLE Q323.43-3
SOURCE: REFERENCE 143, PAGE 22
LAW ENGINEERING TESTING CO.
JULY 1975

Event	X (ft)	Y (ft)	Depth (ft)	Remarks
Rejected				
F	5,129	-1,446	5,240	Out of area.
I	7,949	2,500	300	Refracted.
K	2,680	- 396	1,814	Out of area.
R	2,835	718	59	Refracted.
T	1,449	- 159	3,517	Out of area.
V	4,196	10,409	8,325	Out of area.
Y	2,480	1,080	100	Refracted.
AA	13,733	10,349	11,190	Out of area.
Cluster I				
G	4,548	1,822	2,878	
J	5,539	2,579	3,789	
L	5,120	2,389	3,656	
M	3,202	2,173	1,792	
N	3,447	2,160	1,843	
Q	3,448	1,935	1,893	
S	3,646	1,738	1,681	
W	3,662	1,966	1,925	
Z	1,663	4,490	1,053	Out of area.
BB	2,783	1,199	1,467	
Cluster II				
A	2,941	1,641	844	
H	3,787	1,980	728	
U	2,891	1,859	823	
X	3,811	2,127	417	
CC	3,832	1,780	730	
Cluster III				
B	2,734	1,424	758	
C	2,762	1,268	706	
D	2,662	1,245	613	
E	2,844	1,042	556	
Cluster IV				
O	2,183	1,465	774	
P	1,828	931	743	

TABLE Q323.43-4
SOURCE: REFERENCE 143, PAGE 24
LAW ENGINEERING TESTING CO.
JULY 1975

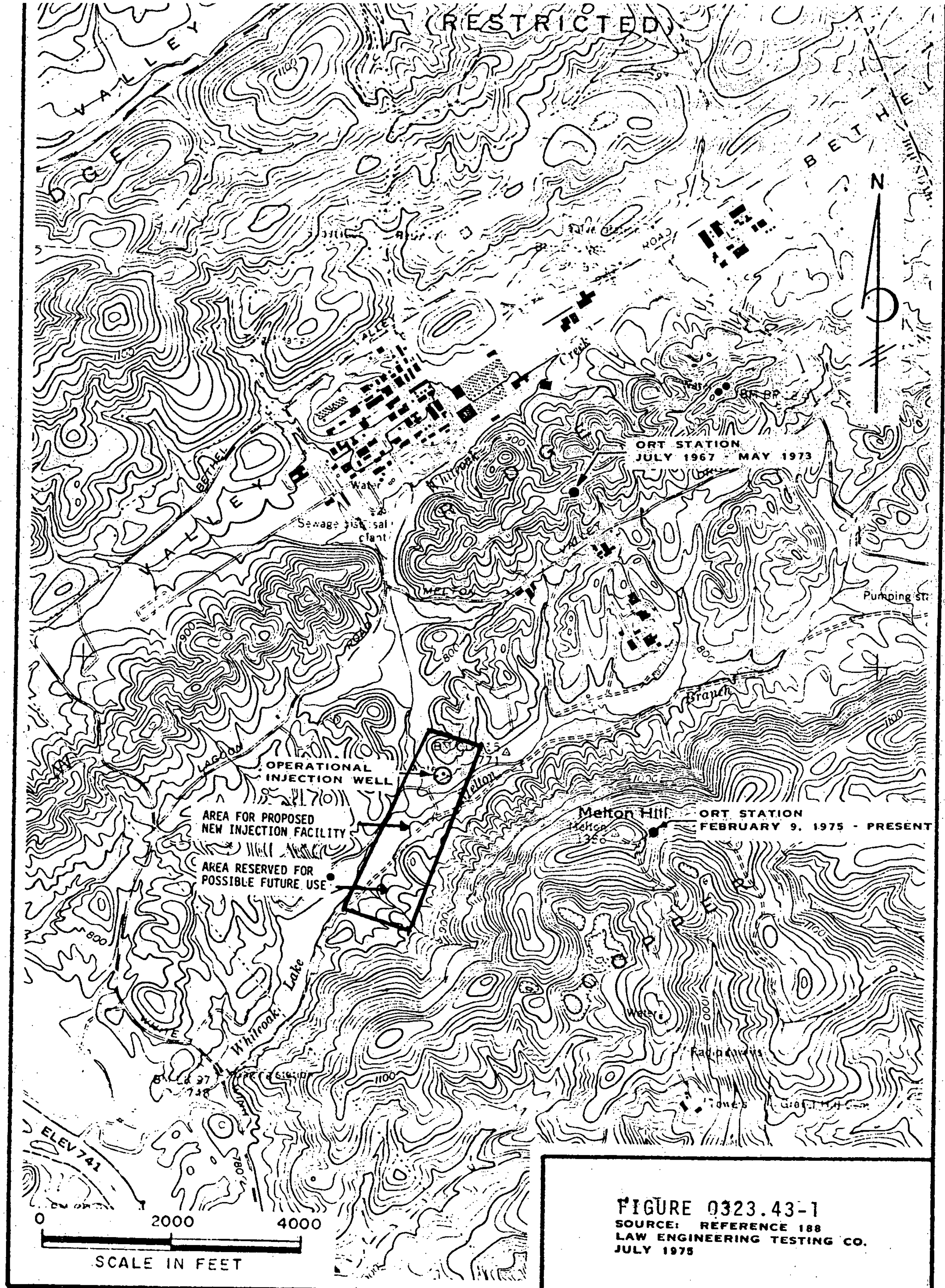
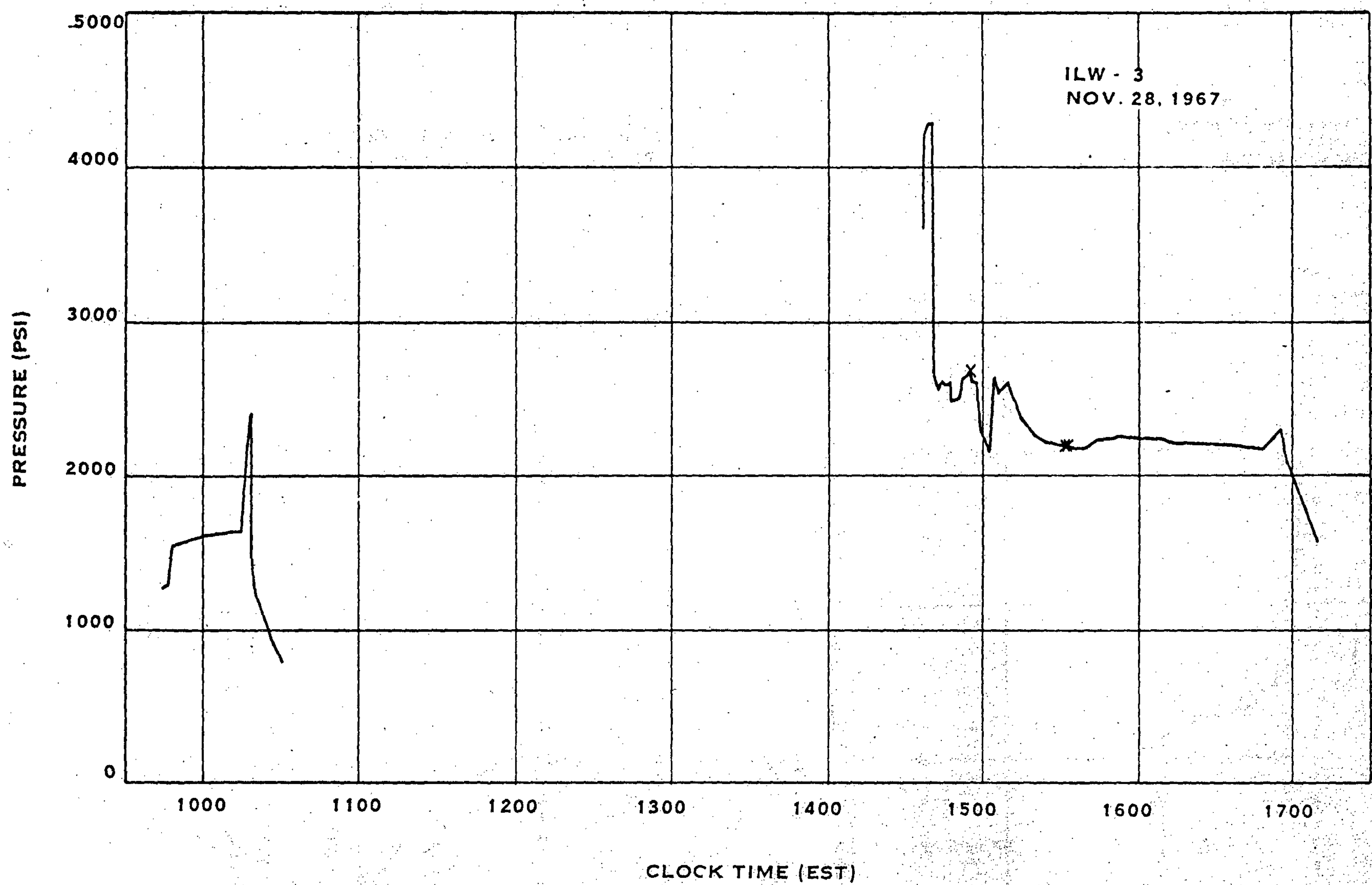


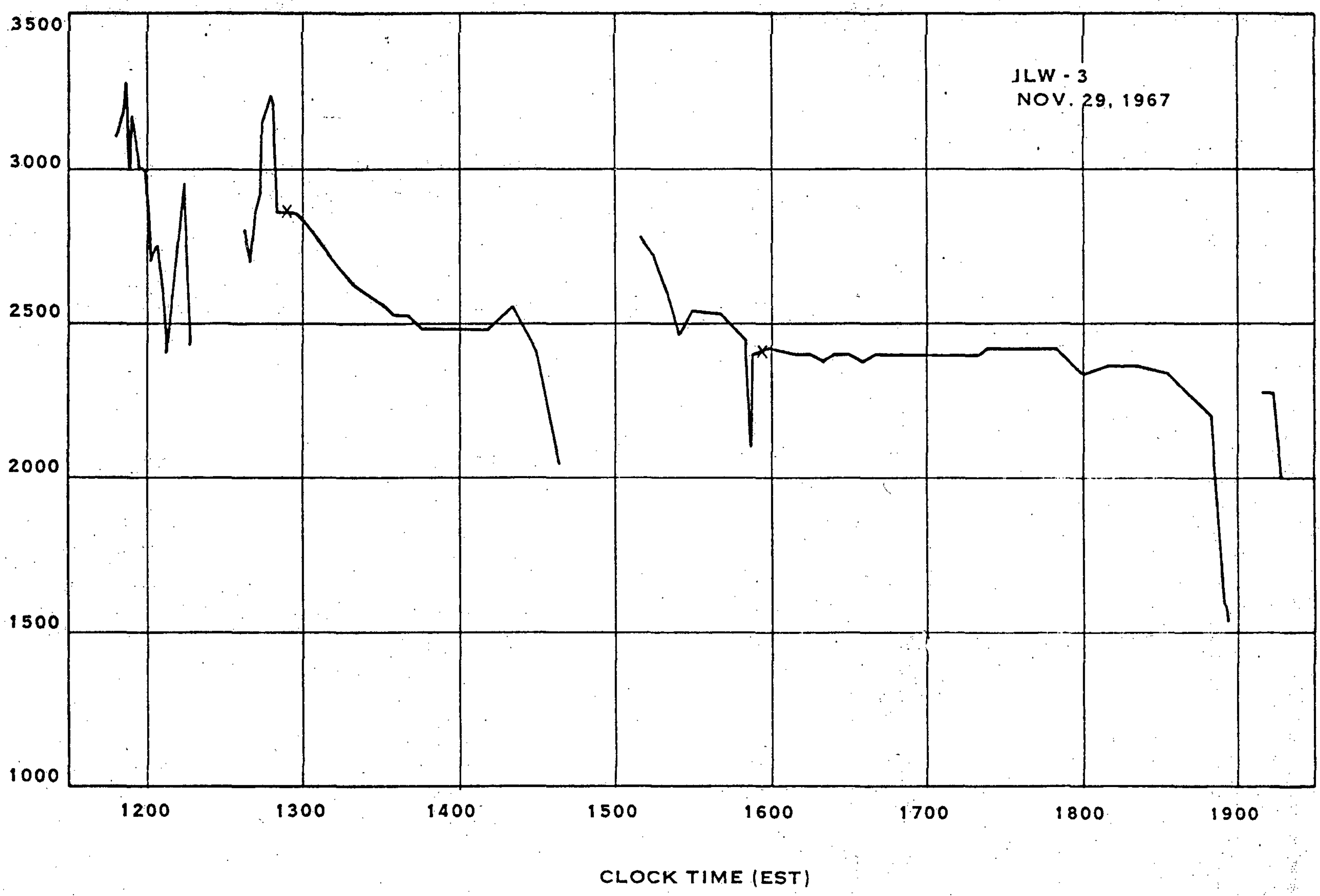
FIGURE Q323.43-1
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975



NOTE - X INDICATES SIGNAL OCCURRENCE
REFERRED TO IN THE RESPONSE

FIGURE 0323.43-2

SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975



NOTE - X INDICATES SIGNAL OCCURRENCE REFERRED TO IN THE RESPONSE

FIGURE Q323.43-3
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

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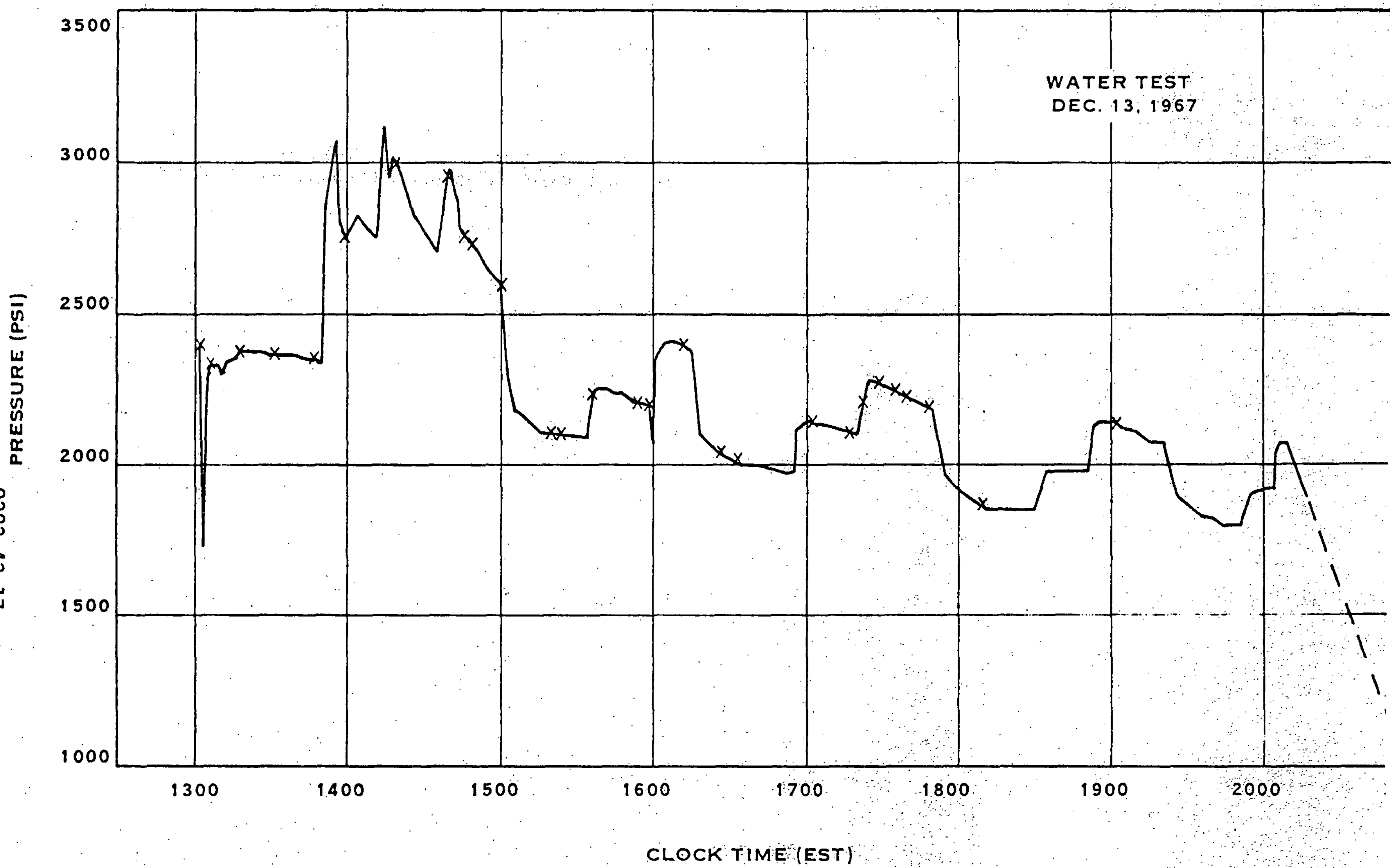
FORWARDED UNDER SEPARATE COVER

Figure Q323.43-24 - Seismograph Record for ILW-5 North Seismometer
10-29-68 1330 GMT to 2100 GMT

Figure Q323.43-25 - Seismograph Record for ILW-5 North Seismometer
10-30-68 1430 GMT tO 2305 GMT

Figure Q323.43-26 - Seismograph Record for ILW-5 North Seismometer
10-31-68 1252 GMT to 2109 GMT

Figure Q323.43-27 - Seismograph Record for ILW-5 North Seismometer
10-31-68 2113 GMT to 2400 GMT and
11- 1-68 0000 GMT to 0605 GMT



NOTE - X INDICATES SIGNAL OCCURRENCE REFERRED TO IN THE RESPONSE

FIGURE 0323.43-7

SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO
JULY 1975

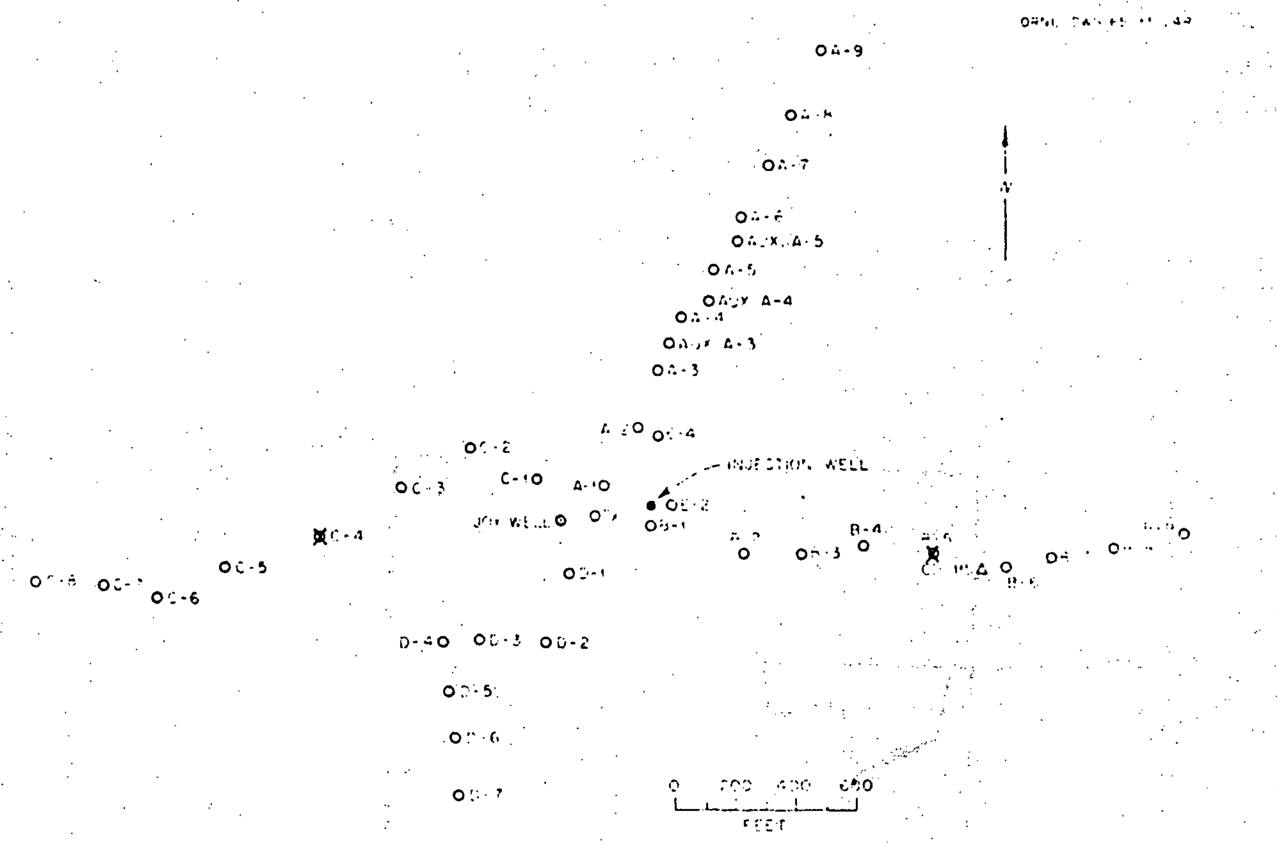


Fig. 11. Layout of leveling bench marks at the hydraulic fracturing plant.

NOTE - X INDICATES SEISMOMETER LOCATIONS FOR INJECTION ILW-4. (REFERENCE 188)

FIGURE Q323.43-8

SOURCE: REFERENCE 136, P.

LAW ENGINEERING TESTING

JULY 1975

Amend. 3
Aug. 1975
Amend. 3

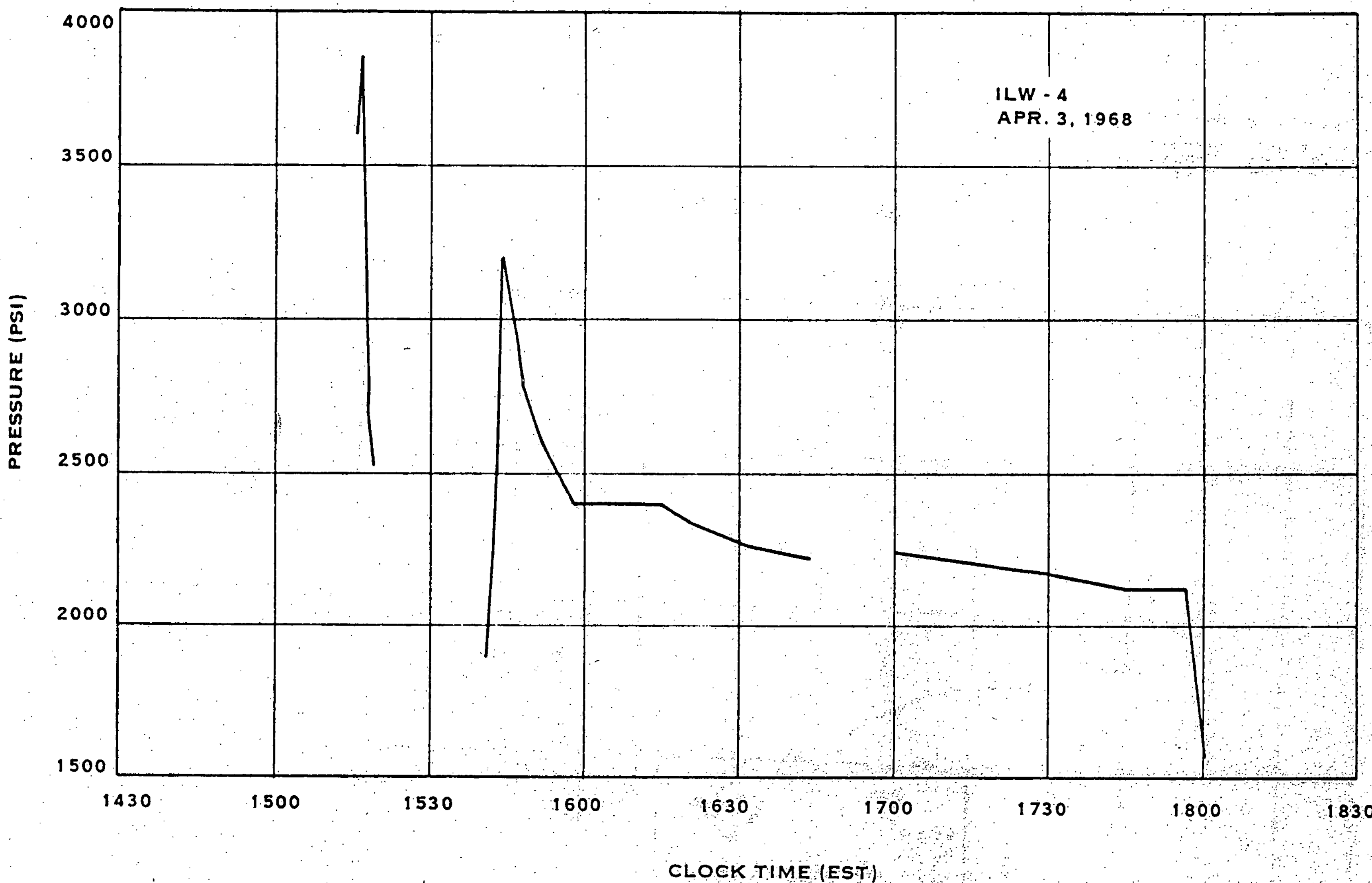


FIGURE Q323.43-9
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO
JULY 1975

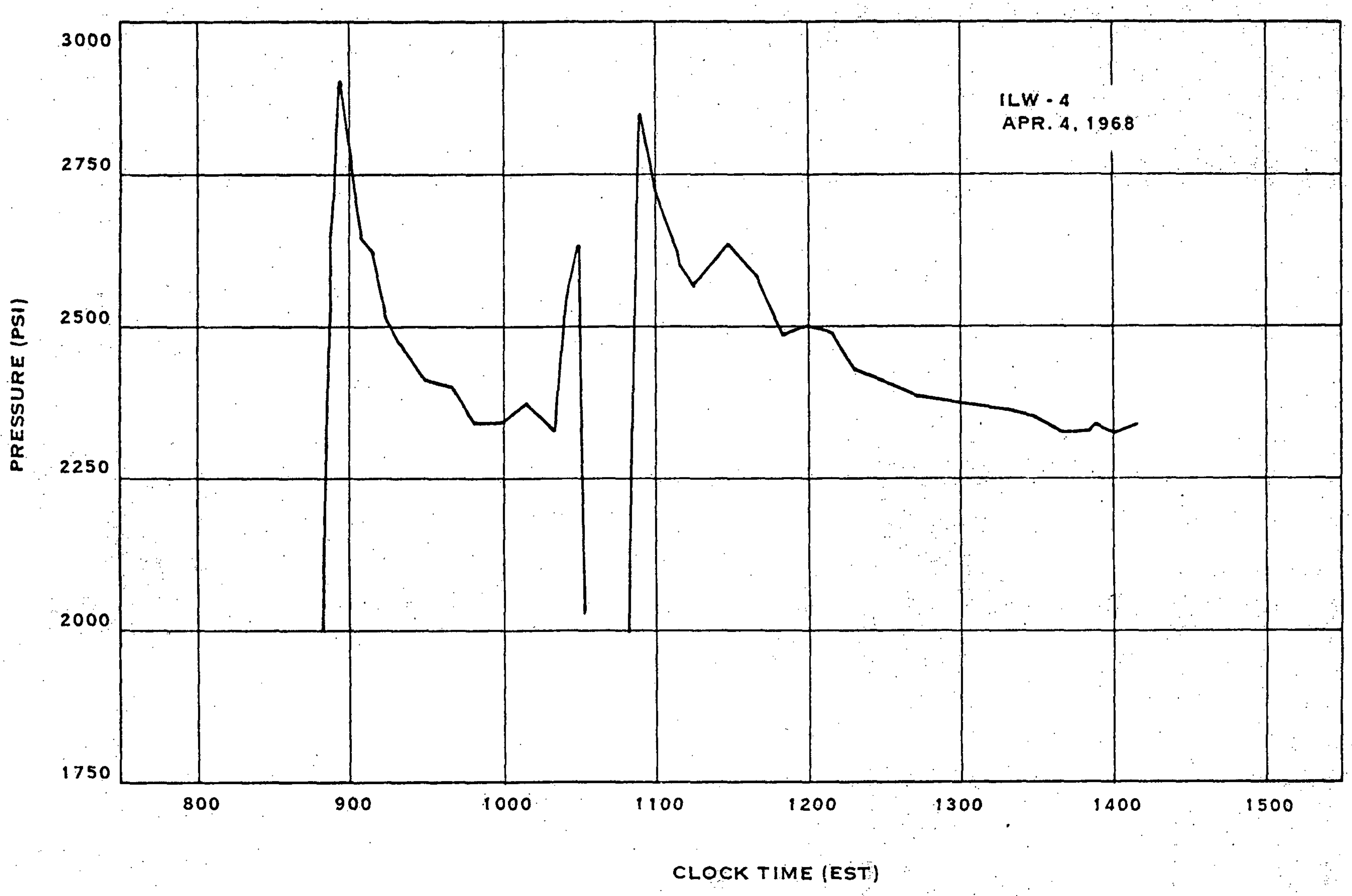


FIGURE Q323.43-10
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING C(
JULY 1975

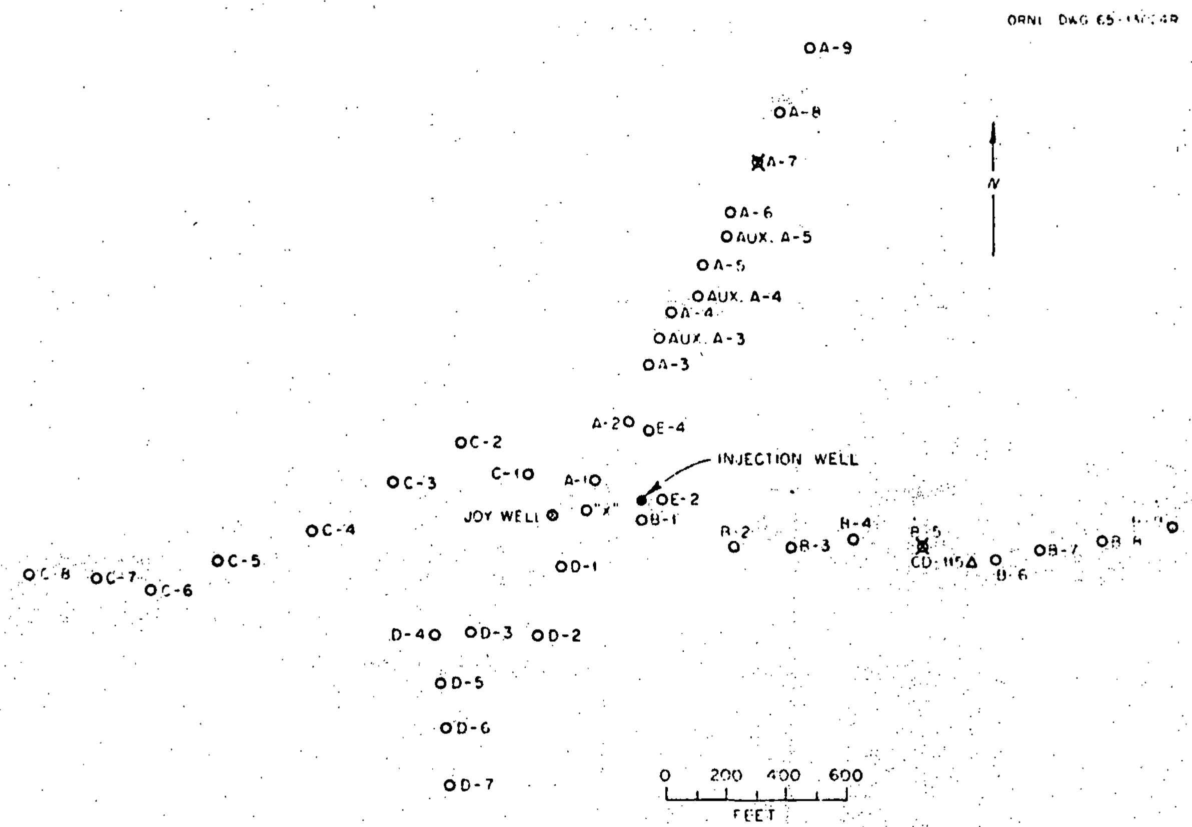
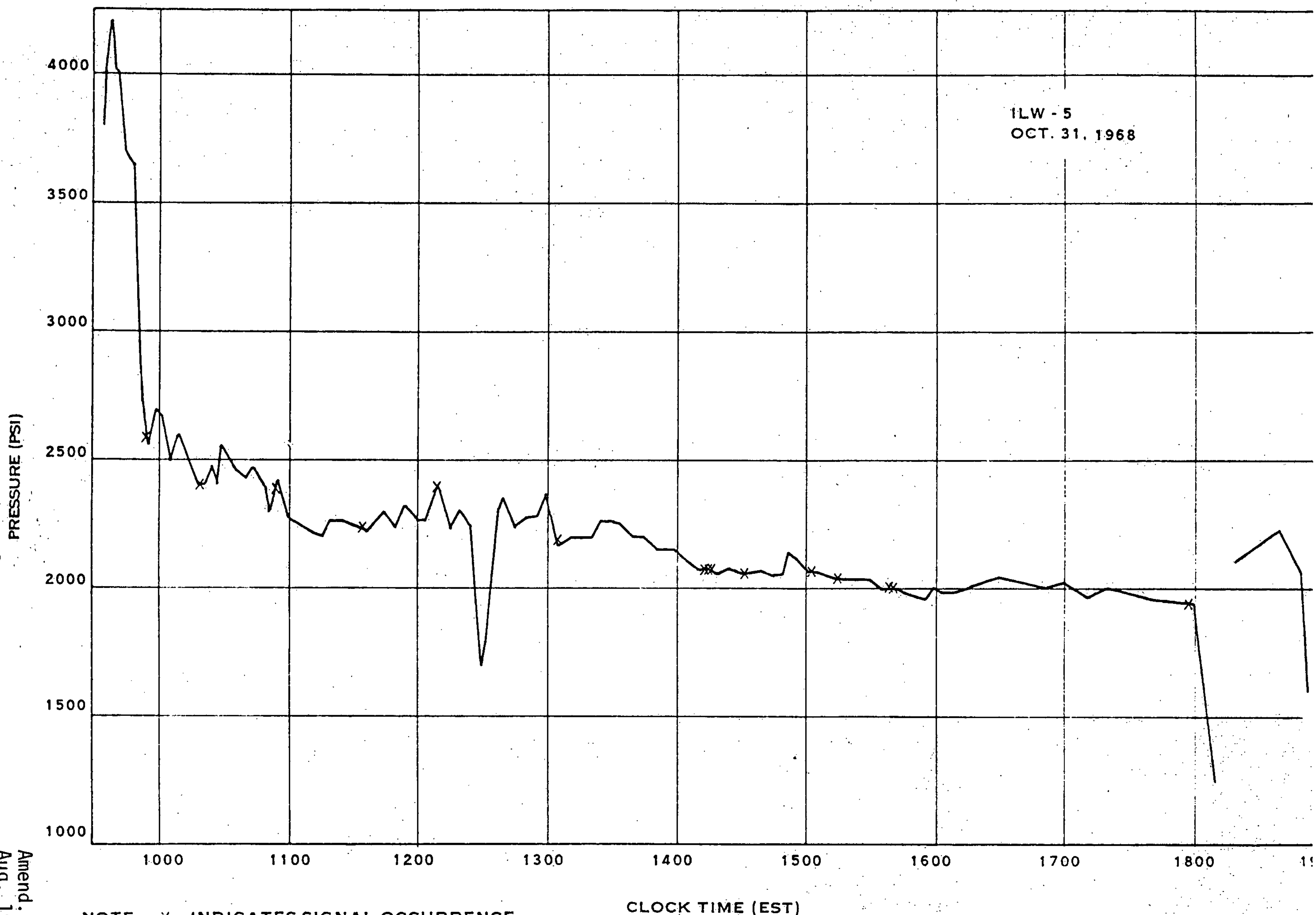


Fig. 11. Layout of leveling bench marks at the hydraulic fracturing plant.

NOTE - X INDICATES SEISMOMETER LOCATIONS FOR INJECTION ILW-5. (REFERENCE 188)

FIGURE Q323.43-17

SOURCE: REFERENCE 136, PA(
LAW ENGINEERING TESTING C
JULY 1975



NOTE - X INDICATES SIGNAL OCCURRENCE REFERRED TO IN THE RESPONSE

FIGURE Q323.43-18

SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.

JULY 1975

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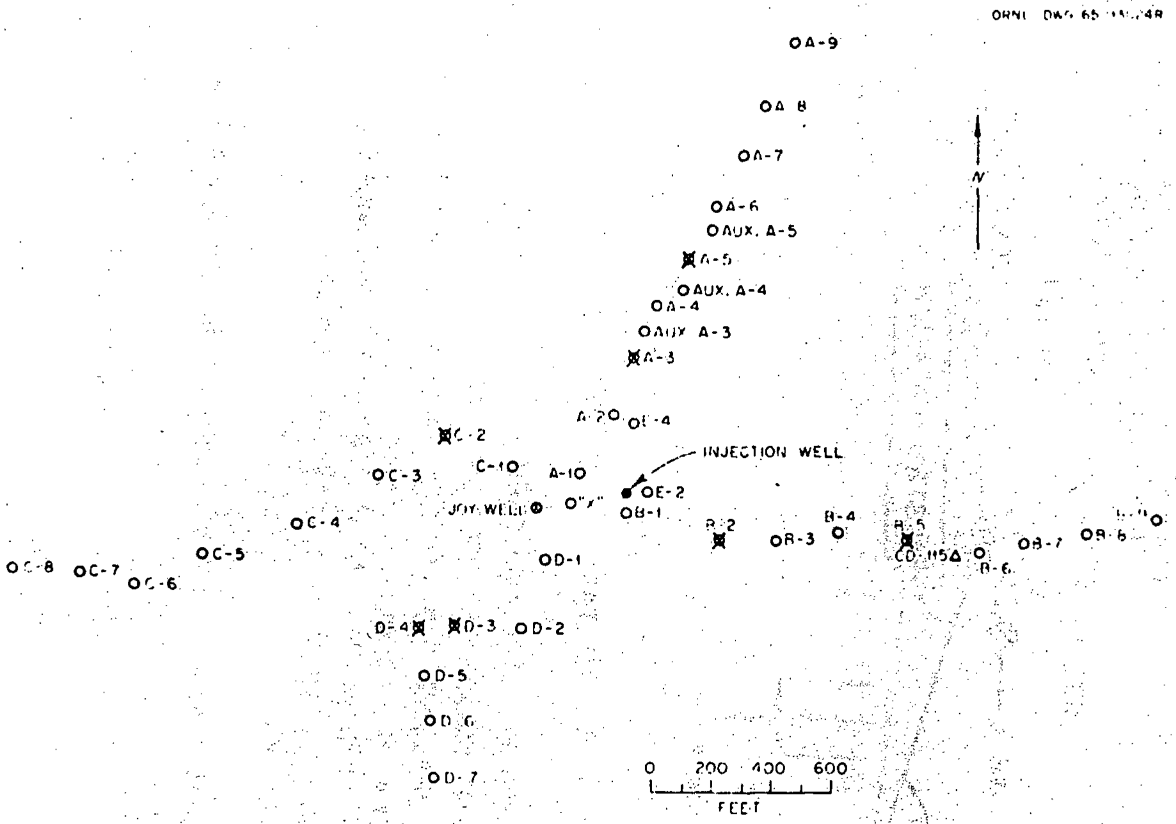
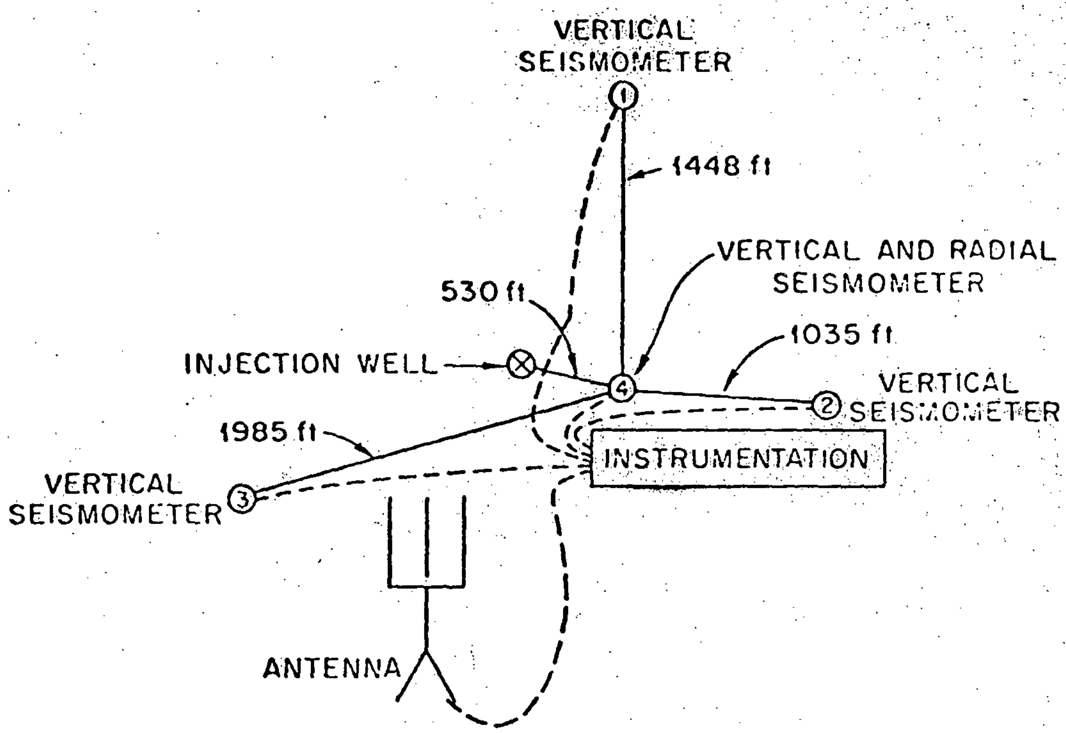


Fig. 11. Layout of leveling bench marks at the hydraulic fracturing plant.

NOTE - X INDICATES SEISMOMETER LOCATIONS FOR INJECTION ILW- 6.(REFERENCE 188)

FIGURE Q323.43-28
SOURCE: REFERENCE 136, PAG
LAW ENGINEERING TESTING CO
JULY 1975

ORNL-DWG 71-5812



1 15/16 ips FM/DIRECT MAGNETIC TAPE RECORDER
7200 ft 1-mil TAPE ON 14-in. REEL

5 0.5 sec NATURAL-PERIOD SEISMOMETERS

5 115-db DUAL-OUTPUT SOLID STATE AMPLIFIERS

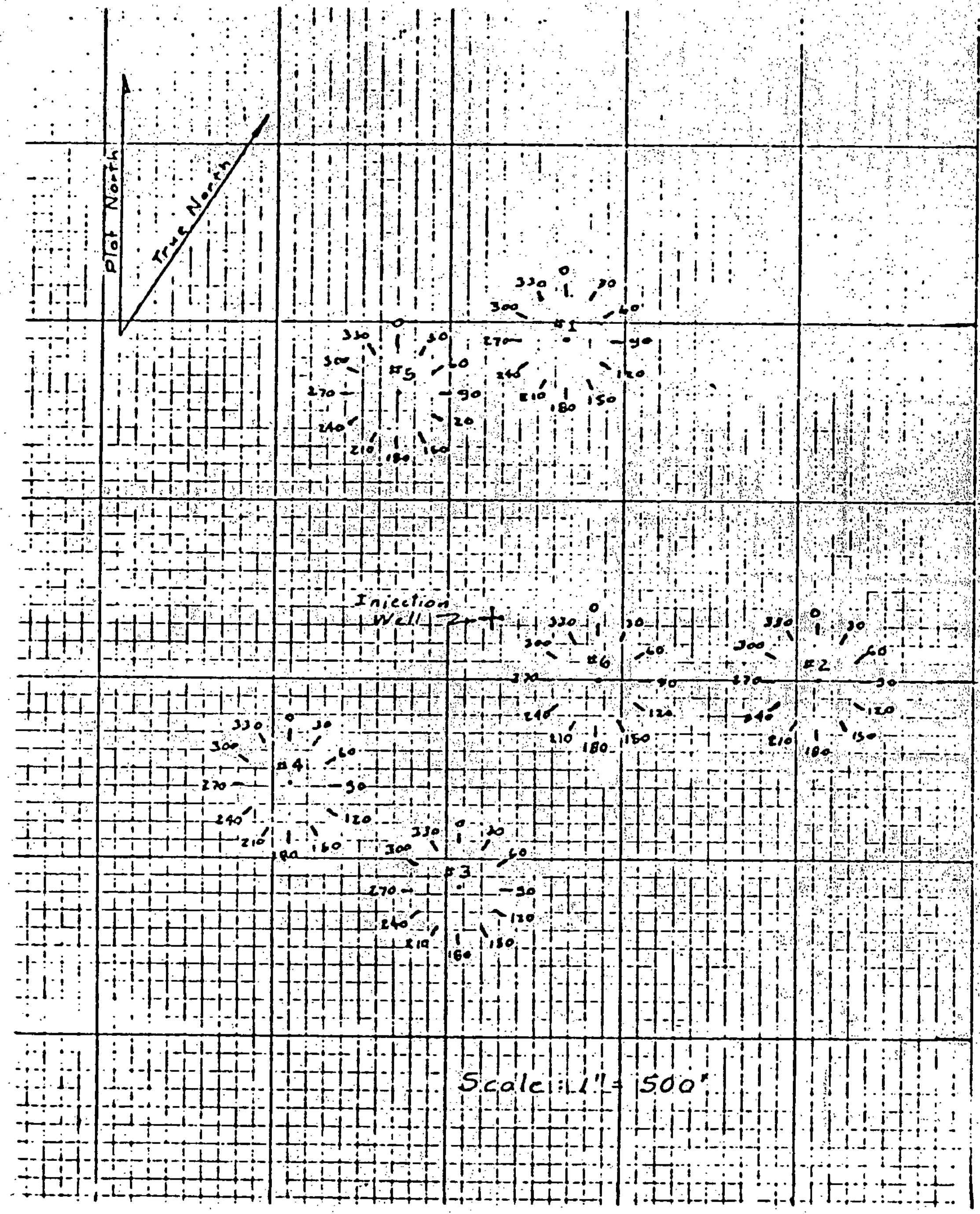
1 WWV RADIO (BCD PRESENTATION OF day, hour, minute, and second)

1 LOCAL TIME GENERATOR, RESOLVING 1 msec
LIGHTNING PROTECTION EQUIPMENT AND CALIBRATION GEAR

1 POWER SUPPLY (BATTERIES NOT GENERATOR) REQUIRES
26 watts FOR OPERATION

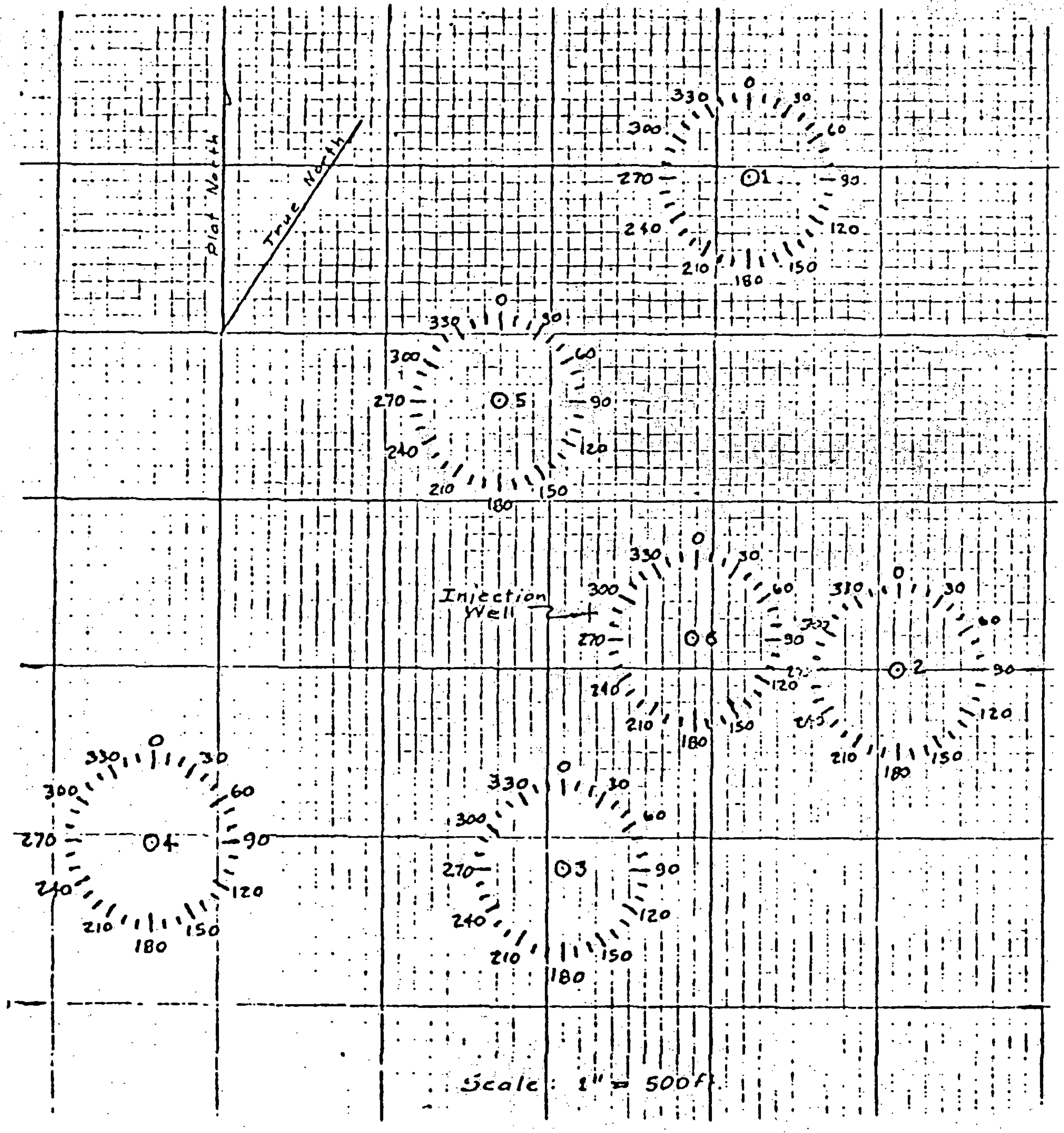
Fig. 7. Seismometer Array and Instrumentation Configuration (Century Geophysical Test).

FIGURE Q323.43-29
SOURCE: REFERENCE 143, PAGE 21
LAW ENGINEERING TESTING CO.
JULY 1975



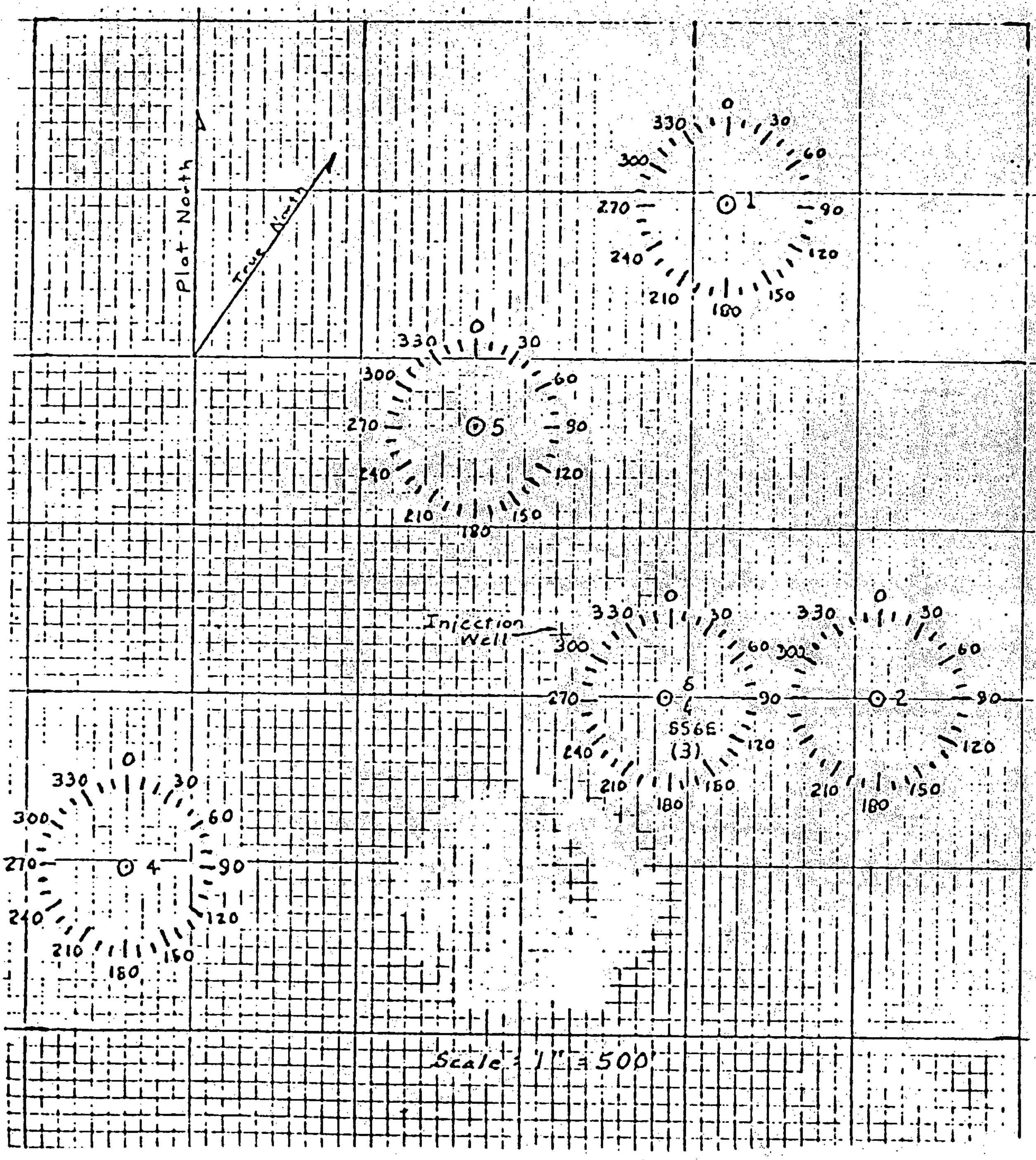
INJECTIONS ILW-8 & ILW-9

FIGURE Q323.43-30
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975



INJECTION ILW-10

FIGURE Q323.43-31
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975



INJECTION ILW-11

FIGURE Q323.43-32

SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

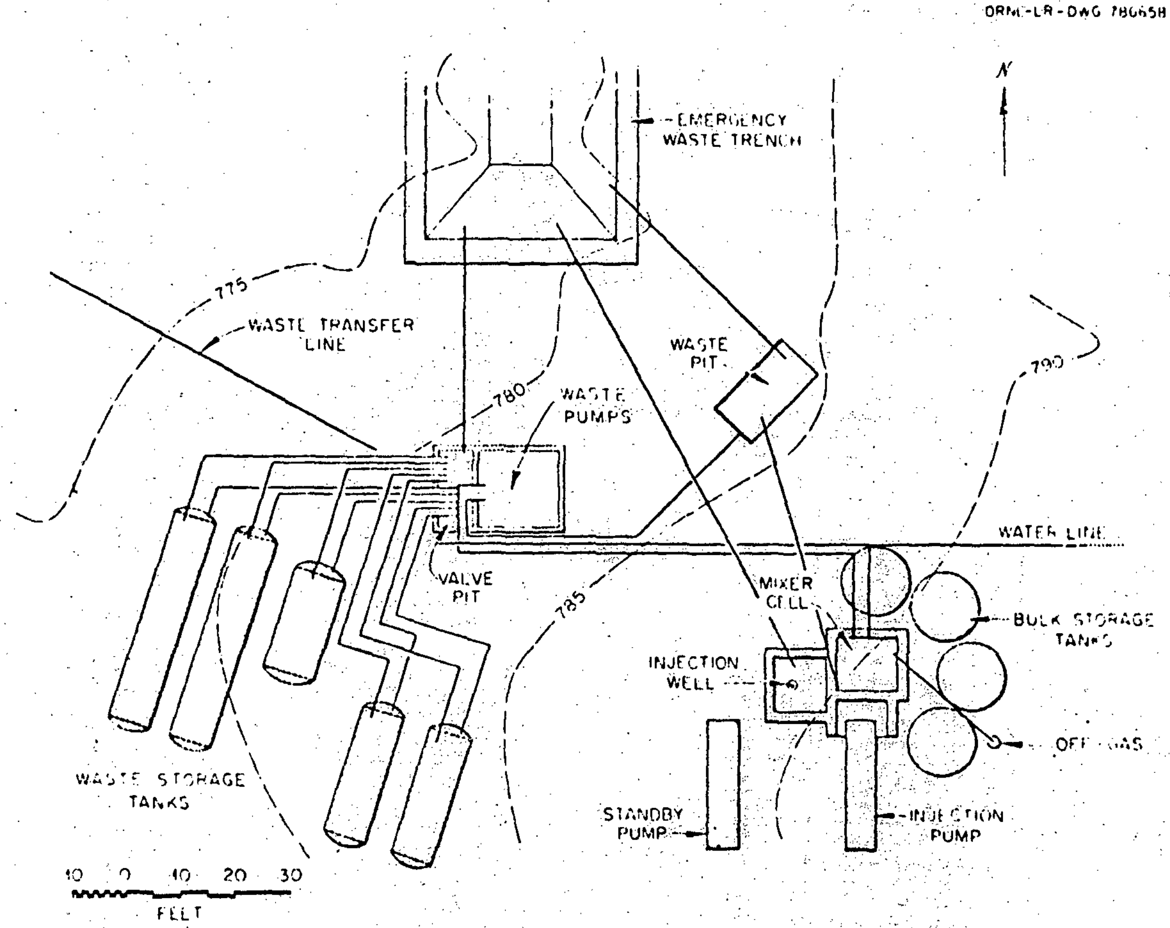
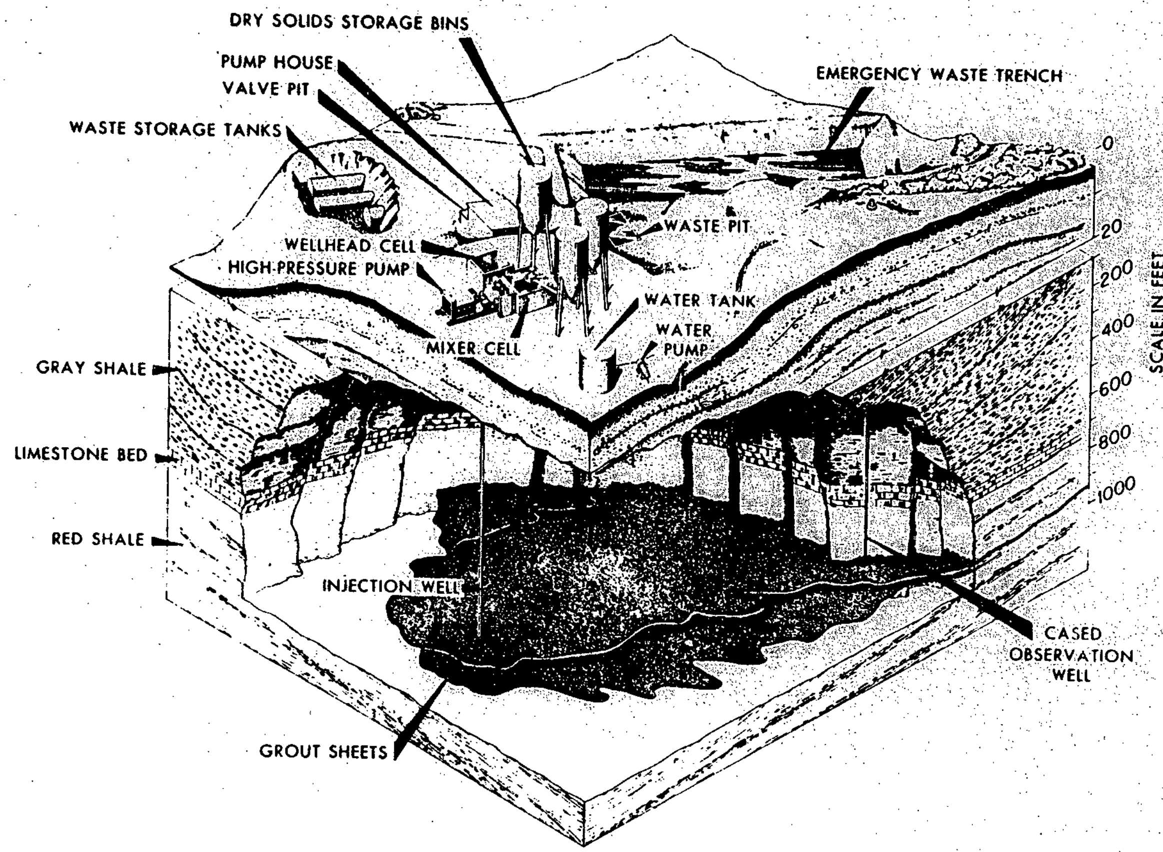


Fig. 7. Layout of the hydraulic fracturing plant.

FIGURE Q323.43-33
SOURCE: REFERENCE 136, PAGE 10
LAW ENGINEERING TESTING CO.
JULY 1975

ORNL-DWG 63-3830



ORNL Fracturing Facility.

FIGURE Q323.43-34
SOURCE: REFERENCE 147, PAGE 7
LAW ENGINEERING TESTING CO.
JULY 1975

Amend. 3
Aug. 1975

Question 323.44 (2.5.1.1.4.2)

Provide complete information on the sensitivity of the short period seismograph sation (ORT) located at ORNL (Oak Ridge National Laboratories).

Response: (References are identified in response to Q323.43)

Seismograph station ORT was operated from July, 1967 to May, 1973 with a single component short period seismometer. This station, or components of the station, were used for seismic monitoring operations during many of the injections made in this time period. Table Q323.44-1 lists the available information about the station (Ref. 188).

Station ORT was reopened with enlarged capability on February 9, 1975. Table Q323.44-2 lists the available information about the reopened station (Ref. 188). Figure Q323.44-1 and 2 are the frequency response characteristics of the seismometer at the new station (Ref. 188).

The reopened station is located at a different site than the prior station. Figure Q323.44-3 shows the location of the stations.

STATION: Oak Ridge, Tennessee

ABBREVIATION: ORT

OPERATED BY: Holifield National Laborat
(formerly Oak Ridge National Laboratory
ADDRESS: P. O. Box Y, Bldg. 9104-3
Oak Ridge, Tennessee 37830

DATE OPEN: July 1967
DATE CLOSE: May 1973

GEOGRAPHIC COORDINATES:

LATITUDE: 35° 55' 24.7" N

LONGITUDE: 84° 18' 42.5" W

FOUNDATION:
FORMATION: Limestone ledge in Conasauga shale

ELEVATION: 262 meters

GEOLOGIC AGE: Cambrian

INSTRUMENTATION:

TYPE	SEISMOMETER COMP.	SEISMOMETER T_o	GALVO T_g	TYPE OF RECORDING	MAGNIFICATION
Moving Coil (Geotech-18300)	Z	1.0	-	Visible Heated Pen	~100,000 @ 1.0 sec

TIMING SYSTEM: Geotech Model TF-110 with quartz crystal frequency controlled power to all instruments.

RESPONSE CURVES: None available

SHORT HISTORY OF STATION: Station opened using almost entirely used and cast off equipment. Closed of exhaustion.

REMARKS: Records available upon request.

TABLE Q323.44-1
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

Amend. 3
Aug. 1975

STATION: Oak Ridge, Tennessee

ABBREVIATION: ORT

OPERATED BY: Holifield National Laborat (formerly Oak Ridge National Laboratory)
ADDRESS: P. O. Box Y, Bldg. 9104-3
Oak Ridge, Tennessee 37830

DATE OPEN: February 9, 1975

GEOGRAPHIC COORDINATES:

LATITUDE: 35° 54' 34.2" N

LONGITUDE: 84° 18' 17.4" W

FOUNDATION:
FORMATION: Knox Dolomite

ELEVATION: 370 meters

GEOLOGIC AGE: Ordovician

INSTRUMENTATION:

TYPE	SEISMOMETER COMP.	T_o	GALVO T_g	TYPE OF RECORDING	MAGNIFICATION
Moving Coil (Geotech-18300)	Z	1.0	-	Visible-Heated Pen	60,000 - 120,000[1] @ 1.0 sec
Moving Coil (Geotech-18300)	N,E	1.0	-	Visible-Heated Pen	40,000 - 100,000[1] @ 1.0 sec
Moving Coil (Geotech-28280)	Z		-	Visible-Heated Pen	

TIMING SYSTEM: Geotech Model TG-110 with quartz crystal frequency controlled power to all instruments.

RESPONSE CURVES: See enclosure

SHORT HISTORY OF STATION: Station operated July 1967-May 1973 with single component (SP-Z). Reopened with enlarged capability.

REMARKS: [1]Maximum convenient magnification not yet determined, but will vary with seasonal background noise levels within estimated range.

[2]Long-Period not yet installed. Estimated March 1, 1975. Will submit supplement sheet.

TABLE Q323.44-2
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

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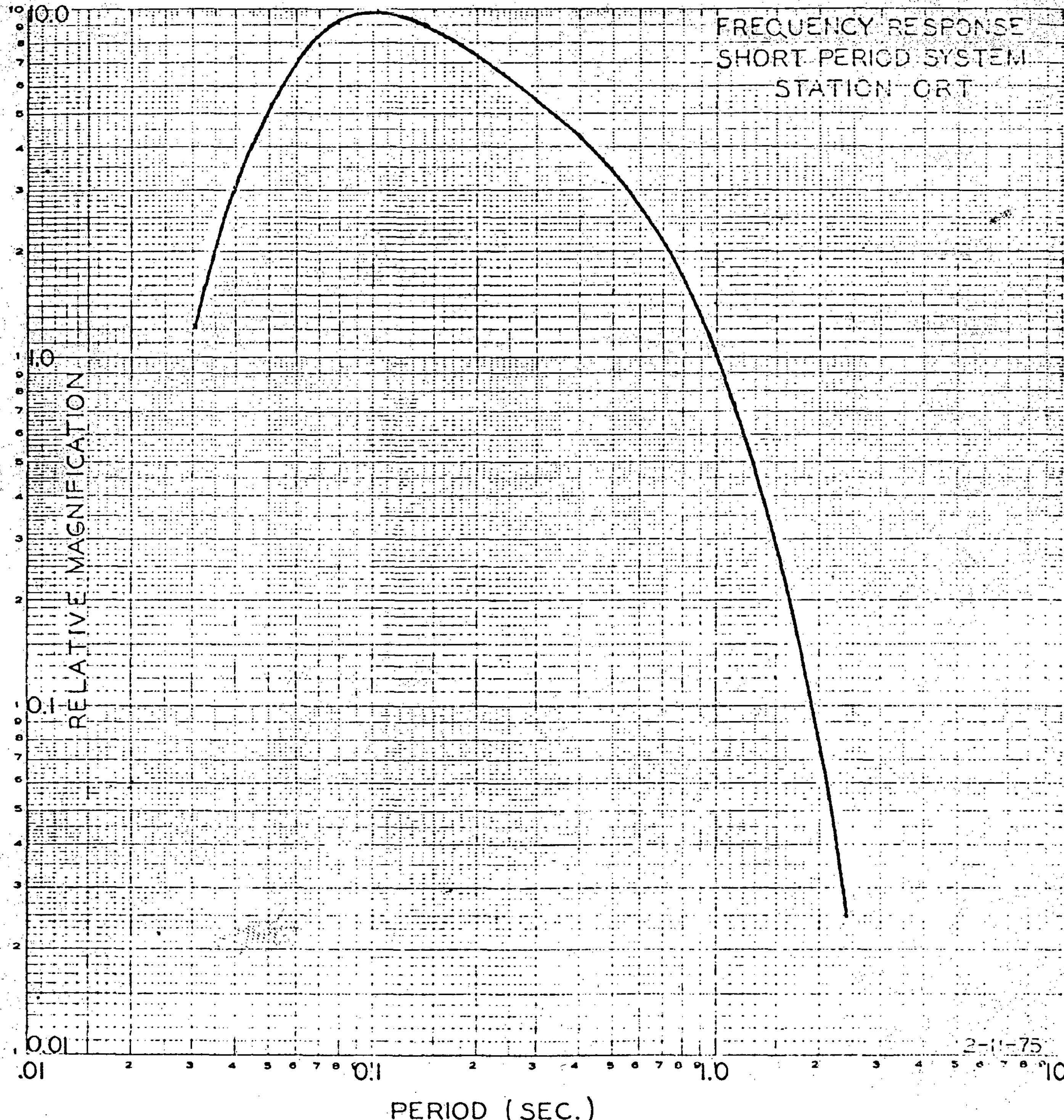
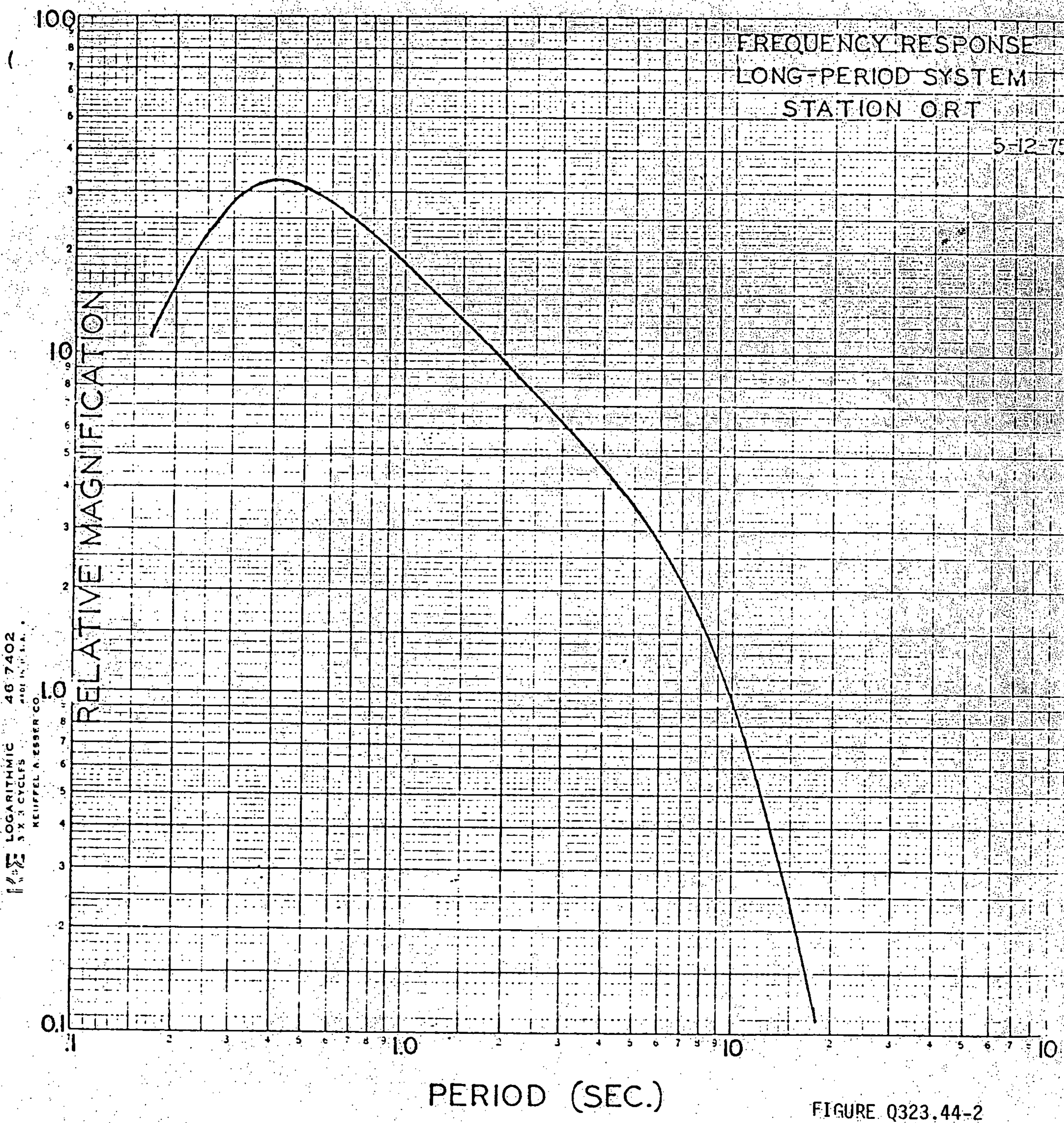


FIGURE Q323.44-1
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

Amend. 3
Aug. 1975



Q323.44-5

FIGURE Q323.44-2
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

Amend. 3
Aug. 1975

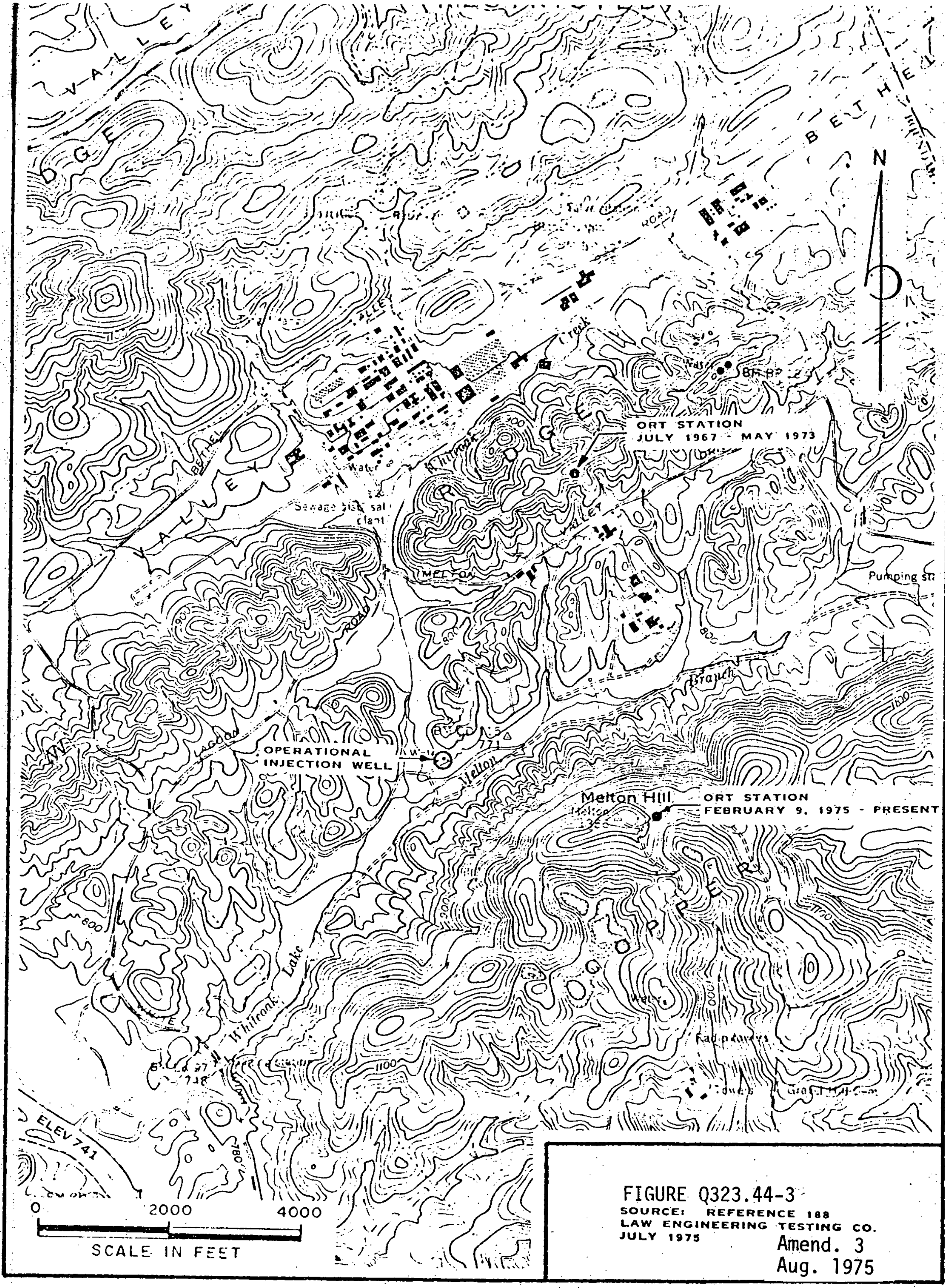


FIGURE Q323.44-3
SOURCE: REFERENCE 188
LAW ENGINEERING TESTING CO.
JULY 1975

Amend. 3
Aug. 1975

Question 323.45 (2.5.2.2.3)

Provide all available data used to develop radiometric dates for mylonites along the Copper Creek Fault. This information should include mineral analyses, number of samples tested, radiogenic argon and the name of the laboratory that accomplished these tasks. A discussion of the validity of utilizing the potassium-argon dating method in these rock types should be provided for evaluation.

Response:

The response to this question has been incorporated in revised Section 2.5.2.2.3. 27

Question 323.46

The SSE intensity at the Clinch River site is an intensity VIII (MM). The applicant has used the empirical relationship between intensity and acceleration developed by Gutenberg and Richter (Bulletin of the Seismological Society of America, 1956) to determine the appropriate acceleration for seismic design for the SSE intensity. A recent reevaluation of this relationship by Trifunac and Brady (Bulletin of the Seismological Society of American, 1975) used the extensive additional data that has been obtained since the Gutenberg-Richter study. Because the Trifunac and Brady study is based on a much larger data base and since the result is significantly different from that previously obtained by Gutenberg and Richter, the SSE acceleration for the Clinch River site should be reevaluated, using the Trifunac and Brady curve. The value obtained from this reevaluation should be used as the acceleration for seismic design unless a demonstration of why it is not appropriate can be given.

Response:

Before a reply is provided to the above question, one correction should be noted. The applicant did not use the Gutenberg and Richter relationship to determine the appropriate acceleration for seismic design for the Safe Shutdown Earthquake (SSE) as stated in the question. The Coulter, Waldron and Devine intensity/acceleration relationship was used for the CRBRP because it was the prevailing relationship acceptable to NRC, considers site characteristics, and results in a more conservative acceleration than Gutenberg and Richter.

Introduction

The Modified Mercalli intensity scale purports to distinguish clearly discerable differences in earthquake damage for each progressively higher rating on the scale. As such, each rating includes a range of damage criteria, many of which overlap with adjacent intensity ratings on the scale. This concept is integral to intensity-acceleration relationships such as the Trifunac-Brady relationship where acceleration is related to intensity by a straight line function on a semi-log plot. The Trifunac-Brady correlation was arrived at by plotting all intensity data at the mid-range value and developing a least squares analysis of the data resulting in a straight line relationship as shown on Figure 3 of the Trifunac-Brady paper (Reference Q323.46-1). A study of Table 3 and Figure 4 of this paper indicates that the scatter of accelerations at a particular intensity is partially due to the inability to account for the continuity, or overlap, of intensities.

In order to utilize intensity-acceleration relationships such as Trifunac-Brady or Neumann, it is necessary to understand that a given intensity covers a spectrum of damage. Therefore, in order to determine accelerations which are appropriate to intensities at either the high or low ranges of this spectrum, it is necessary to either utilize the function at points intermediate of the intensity scale or to ignore the function and consult the spread of accelerations at a given intensity and select the acceleration appropriate to the high or low intensity. The second of these alternatives is the more consistent with the concept of intensity. Further, it avoids the confusion associated with the validity of sparse data at very low and very high intensities and avoids the lack of agreement among practitioners concerning the shape of the function at very low and very high intensities. However, in keeping with the NRC staff position that the straight line function be utilized, the applicant has conservatively applied the former alternative.

In assessing damage reports and assigning a Modified Mercalli Intensity rating that is to be utilized to select an acceleration ("g" value) for seismic analysis of structures and equipment, it is necessary to recognize that the intensity rating covers a range of damage and that it is therefore necessary to establish the point in the range of a given intensity that best describes the damage from that earthquake.

It is clear from the above that an earthquake rated, for example, as VIII (MM) can be anywhere within the range indicated by Fig. Q323.46-1A.

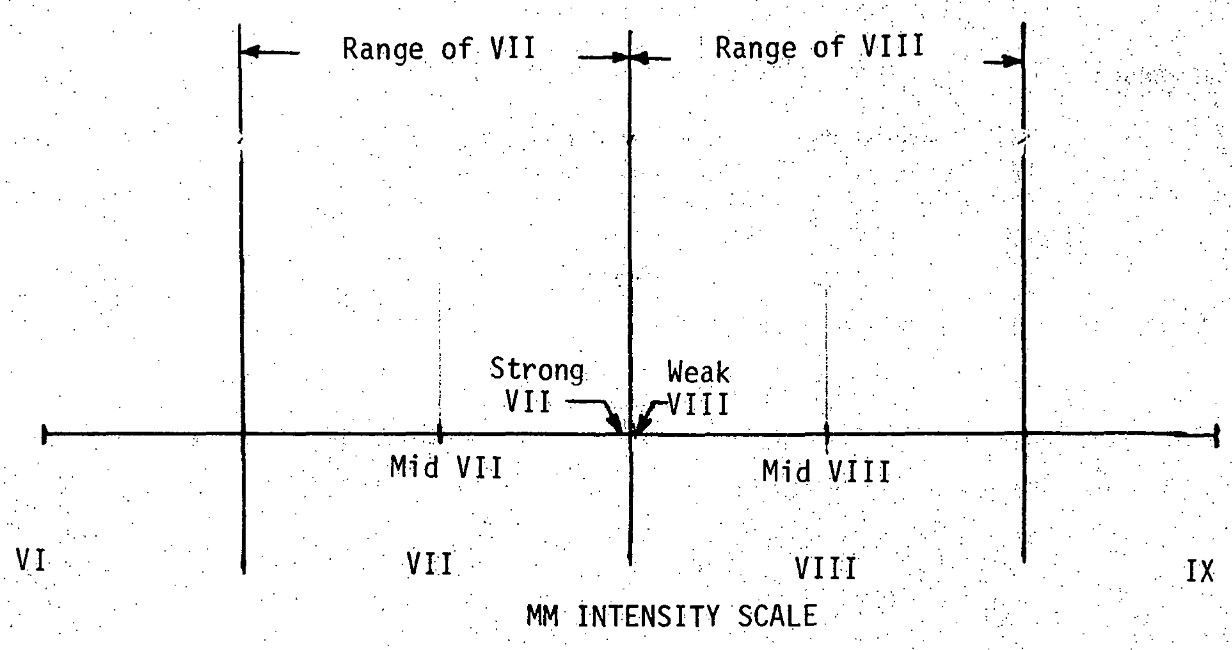


Figure Q323.46-1A

From this figure it is also seen that an earthquake with an intensity at the top end of the VII (MM) range is coincident with one at the bottom end of the VIII (MM) range. For the purpose of the PSAR and the applicant's report evaluating the intensity of the Giles County earthquake (Ref. Q323.46-2) this intensity has been called VII-VIII (MM)

An alternate approach resulting in the same conclusion is to enter an acceptable acceleration correlation at the conservative unit intensity VIII (MM) and select a point in the envelope of data applicable to the range in acceleration values appropriate for that intensity. These values are considered to vary with the range in engineering site characteristics determined for the foundation strata, and number of Modified Mercalli indicators applicable to the site conditions representative of the epicentral region where the maximum historical earthquake has occurred. This approach is shown in Figure Q323.46-1B.

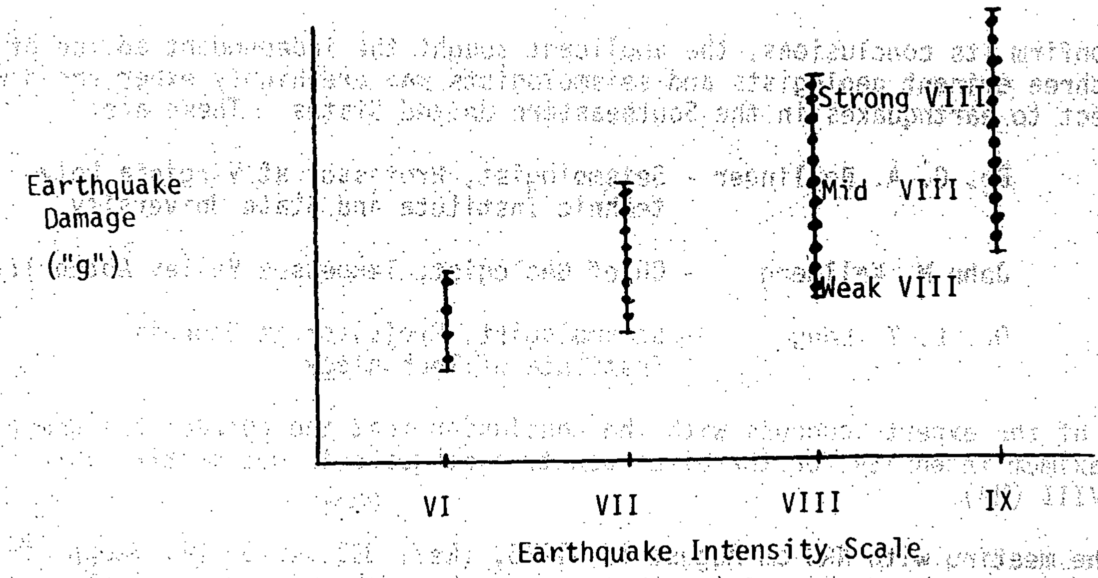


Figure Q323.46-1B

The following discusses first the appropriate part of the MM range to use for the SSE for the CRBRP in order to enter an intensity/acceleration relationship. Next, two procedures are described to determine the applicable 'g' value, and it is shown that the same results are obtained utilizing the applicant's original approach presented in the PSAR or the approach suggested by the NRC Standard Review Plan on Vibratory Ground Motion (which was issued subsequent to submittal of the PSAR).

Finally, the response discusses the precedent for using the resulting acceleration value of 0.18g and concludes that this value is appropriately conservative.

Earthquake Intensity

The maximum historical earthquake in the Southern Appalachian Tectonic Province is the Giles County, Virginia earthquake, which occurred on May 31, 1897. This earthquake is, in the opinion of the applicant, a maximum intensity VII-VIII (MM) (PSAR Section 2.5.2.9), or a weak VIII (MM). The National Oceanographic and Atmospheric Administration (NOAA) document "Earthquake History of the United States" lists the Giles County earthquake as intensity VII (MM), although the applicant understands that this listing of VII (MM) is a typographical error, and that NOAA officially classifies this earthquake as VIII (MM).

The applicant conducted an independent investigation of the Giles County earthquake which showed that all of the Modified Mercalli Intensity indicators lead to the conclusion that the Giles County earthquake was an intensity VII (MM) except one item, which was not verifiable. The report of that investigation (Reference Q323.46-2), prepared by Law Engineering Testing Company in conjunction with Burns and Roe, showed that there were only 12 out of 18 intensity VII (MM) indicators found (excluding the indicator related to motor cars). However, in order to apply a degree of conservatism commensurate with nuclear power plant practice, the applicant concluded that, for the purposes of plant design, the Giles County earthquake would be considered as VII-VIII (MM) or a weak VIII (MM).

To confirm its conclusions, the applicant sought the independent advice of the three eminent geologists and seismologists who are highly experienced with respect to earthquakes in the Southeastern United States. These are:

Dr. G. A. Bollinger	- Seismologist, Professor at Virginia Polytechnic Institute and State University
John M. Kellberg	- Chief Geologist, Tennessee Valley Authority
Dr. L. T. Long	- Seismologist, Professor at Georgia Institute of Technology

Each of the experts concurs with the conclusion that the correct assignment of maximum intensity for the Giles County earthquake is not greater than VII-VIII (MM).

In the meeting with NRC on August 15, 1975, (Ref. Q323.46-3) Dr. Stepp of the NRC staff expressed the opinion that a more thorough evaluation of the observed damage may result in the lower rating, but that the applicant needs to provide the data and justification. The NRC staff stated that a final decision on this matter would not be made by NRC prior to consultation with NOAA. The data and justification requested by NRC was submitted to NOAA by the applicant on October 2, 1975 (an earlier revision of Reference Q323.46-2).

A meeting between CRBRP Project and NOAA representatives was held on November 13, 1975 to discuss Ref. Q323.46-2. General agreement was reached between the applicant and the NOAA representatives and was documented (Ref. Q323.46-4) that the Giles County earthquake is a weak VIII (MM) and should be considered to be at the low end of the range indicated in Figure Q323.46-1A above for an intensity VIII (MM) earthquake.

Subsequent to the November 13, 1975 meeting with NOAA representatives, but before NOAA issued an official letter of confirmation, it was determined that it would not be NOAA but rather the United States Geological Survey (USGS) that would be the determining body for the Giles County earthquake classification. The applicant then submitted its report (Ref. Q323.46-2) to USGS on December 17, 1975.

The USGS reply (Ref. Q323.46-5) concludes that the assigned maximum intensity for the Giles County earthquake of VIII (MM) should not be revised. This conclusion was based on 1) the data reviewed by USGS which shows two attributes of an intensity VIII (MM), and 2) USGS does not intend to classify eqrthquakes with split intensities, i.e., VII-VIII (MM). However, the NOAA evaluation which is made part of the USGS report, states "It seems obvious now that the MM scale needs to be reconsidered and potentially revised to treat intensity or acceleration in finer steps or to improve the definition of the steps."

The USGS report forwarded by Ref. Q323.46-5 recognizes that there is a degree of earthquake intensity within each intensity range. However, since the current Modified Mercalli scale does not account for this variation, the reporters were constrained to assign a single intensity classification to the earthquake. In using this approach of assigning only whole number earthquake intensities, the location in the range of earthquake damage must be accommodated by selecting an appropriate acceleration within the intensity VIII (MM) range as shown on Figure Q323.46-1B.

A number of intensity-acceleration relationships have been plotted as linear functions which do not provide for a variation in accelerations at a given intensity as indicated on Figure Q323.46-1B. However, an equivalent method of accomplishing the objective of accounting for a range of accelerations associated with an intensity is to enter the intensity scale at a higher or lower value than the whole number intensity. The applicant concludes that for the SSE earthquake the appropriate ordinate in an intensity-acceleration plot is that ordinate corresponding to a weak VIII (MM) as described in Figure Q323.46-1A and applied in the following discussion of correlation of intensity with accelerations.

Correlation

The method the applicant originally used to determine ground acceleration as discussed in the PSAR was the Coulter, Waldron, and Devine intensity/acceleration correlation. In using this correlation the applicant added further conservatism by entering the Coulter, Waldron and Devine relationship at one-half intensity above VII-VIII (MM), and reading up to the midrange curve which is appropriate for the Clinch River foundation strata (siltstone). This yielded an acceleration of 0.18g whereas the actual intensity of the Giles County earthquake would have yielded a value of 0.13g; clearly 0.18g is therefore a conservative value. Figure Q323.46-2 below illustrates this point:

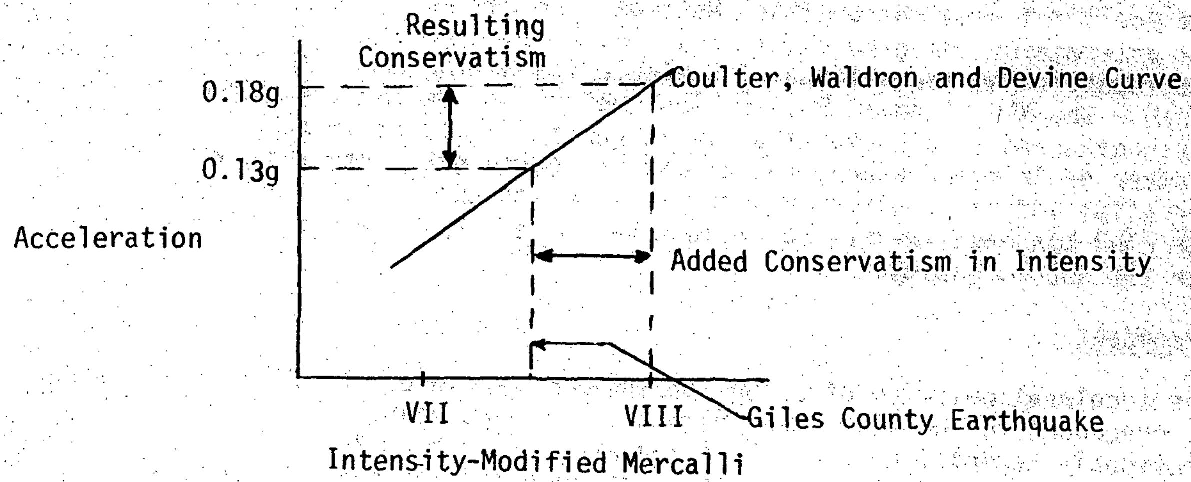


Figure Q323.46-2

The NRC Standard Review Plan on Vibratory Ground Motion issued in June, 1975 indicates that it is acceptable to use the maximum historical earthquake intensity for design purposes, if a conservative correlation such as Trifunac-Brady or Neuman is employed. Figure Q323.46-3 below illustrates the conservatism included in the Neumann (or Trifunac-Brady) correlation compared to Coulter, Waldron, and Devine, and shows that use of the Neumann correlation results in increasing the design acceleration from 0.13g to 0.18g for a weak VIII (MM). Thus, an appropriately conservative design acceleration of 0.18g can be obtained by providing added conservatism in either the SSE intensity or the acceleration correlation. However, the compounding of conservatism by applying both of these methods need not and should not be accomplished.

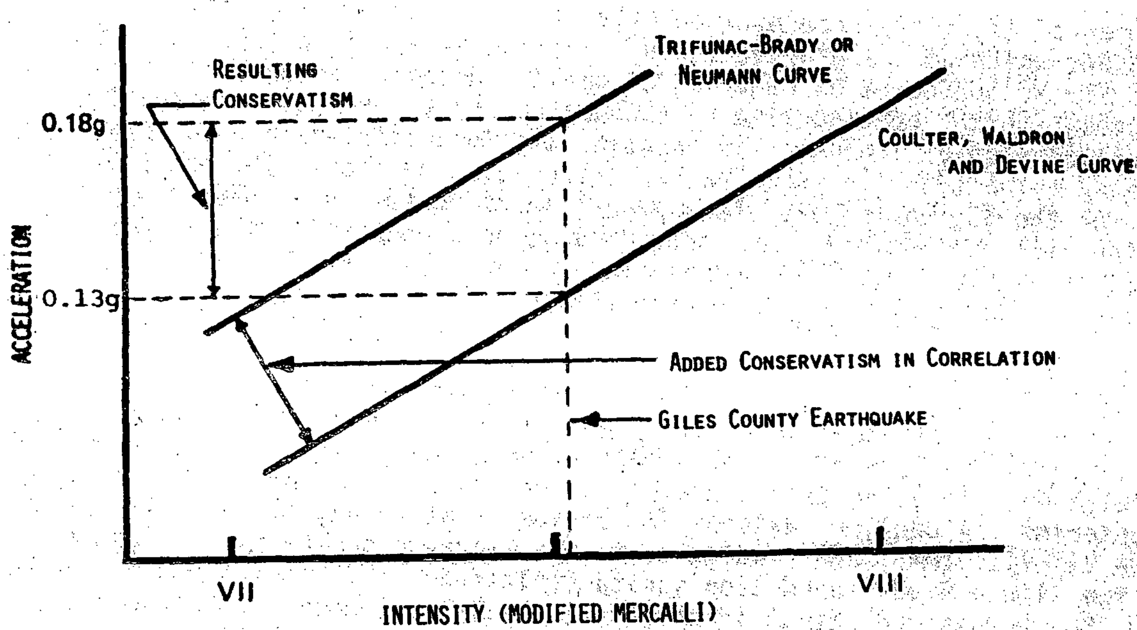


FIGURE Q323.46-3

The applicant used the Coulter, Waldron, and Devine correlation as its basis for determining the ground acceleration, because of its general acceptance in the industry and recognition of variable foundation characteristics. However, because the NRC Standard Review Plan prefers the use of the maximum historical earthquake and a more conservative intensity/acceleration relationship such as Neumann or Trifunac-Brady, rather than an earthquake intensity with added conservatism and the Coulter, Waldron, and Devine curve, Section 2.5.2.10 of the PSAR has been revised to include NRC's new method, using a weak VIII (MM) for the SSE intensity.

Precedent

The acceleration value of 0.18g for seismic design of the CRBRP is supported by precedent for nuclear power plants located at nearby similar sites and previously accepted by USGS, NOAA and AEC. Specifically, this acceleration coincides with the SSE acceleration approved for the TVA Sequoyah, Watts Bar and Bellefonte nuclear stations in 1970 through 1974. The acceleration for these plants was based on the Giles County, Virginia earthquake. Figure Q323.46-4 shows other plants in the area and the design accelerations used.

Summary and Conclusion

In summary, the applicant considers that a ground acceleration of 0.18g is a proper, conservative value for the SSE because:

(1) Our investigation into the Giles County, Virginia earthquake of 1897 (Ref. Q323.46-2) supports a maximum intensity rating for this earthquake of VII-VIII (MM) or a weak VIII (MM) as shown in Figure Q323.46-1A. This research is the most extensive performed to date on this earthquake.

(2) To obtain the ground acceleration, we have complied with the NRC Standard Review Plan and used a conservative (Neumann) correlation between earthquake intensity and ground acceleration as well as our original method, which gave the same value. The applicant has revised the PSAR to include the use of the method contained in the NRC Standard Review Plan.

(3) The SSE acceleration proposed for CRBRP is consistent with ground accelerations already approved by NRC for other nuclear power plants in the same tectonic province.

References:

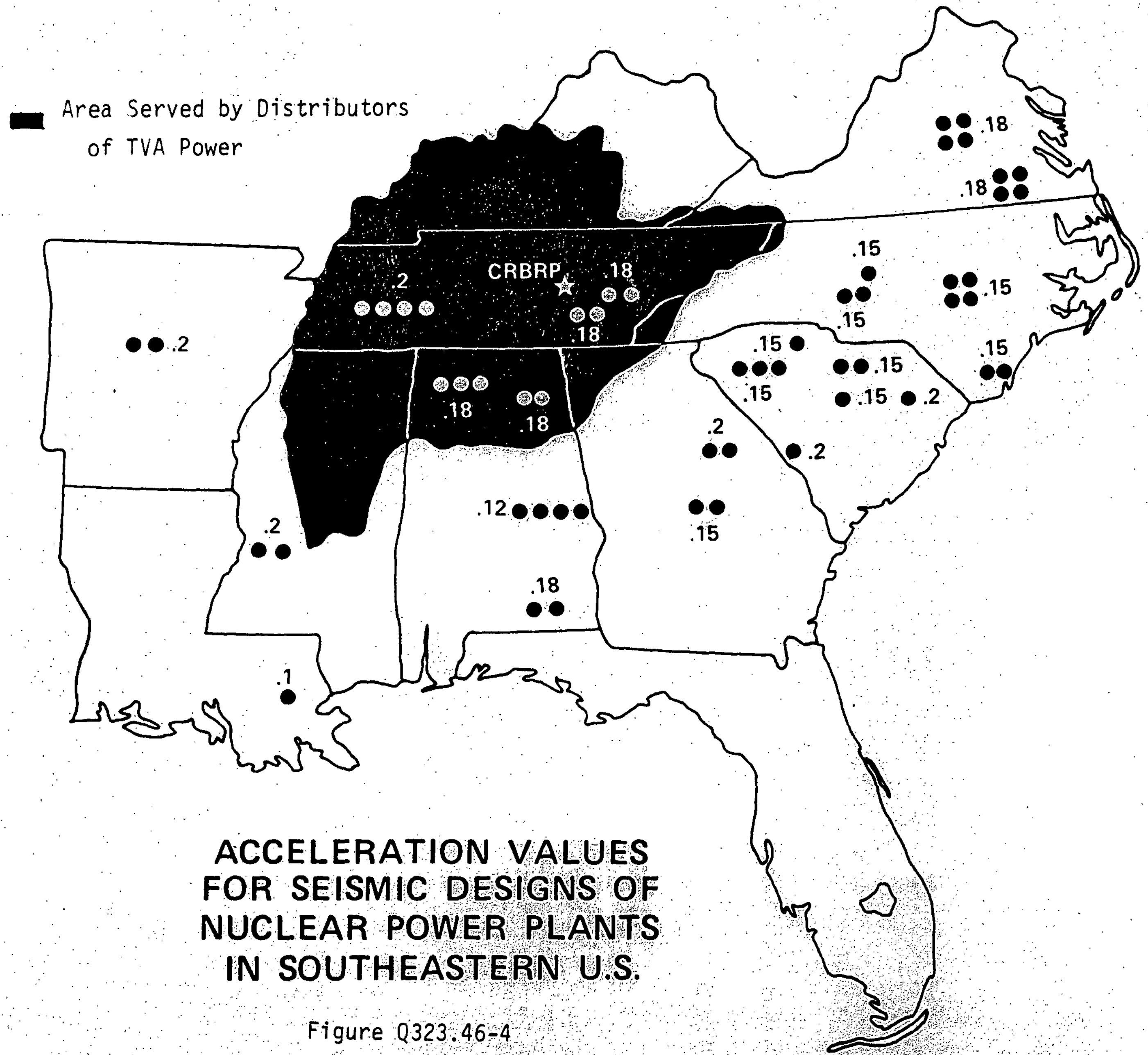
Q323.46-1 Trifunac, M.D. and Brady, A.G., "On the Correlation of Seismic Intensity Scales with Peaks of Recorded Strong Ground Motion", Bulletin Seismological Society of America, Vol. 65 (1975)

Q323.46-2 Law Engineering Testing Co., "Report on Evaluation of Intensity of Giles County, Virginia, Earthquake, May 31, 1897", November 1975.

Q323.46-3 Nuclear Regulatory Commission, "Summary of Meeting Held on August 15, 1975 to Discuss the Design Basis Safe Shutdown Earthquake and Associated Accelerations", September 5, 1975.

Q323.46-4 Brolin, E.C. (Burns and Roe) and Lander, J. (NOAA), Conference Notes - Evaluation of Giles Co., Virginia Earthquake of 1897, November 13, 1975.

Q323.46-5 USGS Letter, W. A. Radlinski to L. W. Caffey (ERDA), February 12, 1976.



ACCELERATION VALUES FOR SEISMIC DESIGNS OF NUCLEAR POWER PLANTS IN SOUTHEASTERN U.S.

Figure Q323.46-4

323.46-8

Amend. 14
Mar. 1976

The "t" test was used to determine if the observed differences in mean number of occurrences for the various periods were statistically significant. This test was chosen because of its wide usage in statistical hypothesis testing, and because it is asymptotically distribution-free and thus the results obtained from the test are not unduly influenced by assumptions of the character of the population from which the samples were drawn (Ref. Q323.47-1). Procedures for applying the "t" test are given in Reference Q323.47-2.

Results

The interpretation of the seismographs began with an inspection of those portions of the records least influenced by cultural activities. No signals with S-P arrival times of three seconds or less were found in these portions of the seismograph records. Since naturally occurring seismic signals are expected to occur randomly, the lack of signals during the quiet hours of the weeks clearly shows that no local, natural seismic events are occurring in the region.

Figure Q323.47-2 is a histogram of numbers of seismic events occurring during the day for the ninety-five (95) day data base used. Of the 204 events catalogued, all but seven occurred between 8:00 a.m. and 8:00 p.m. Sixty-four events occurred between 5:00 p.m. and 6:00 p.m. For the purpose of this study, we selected the working hours from 8:00 a.m. to 8:00 p.m. local time. Some signals were received at ORT at hours adjacent to this arbitrarily selected interval; however, the signals received have characteristics similar to those induced during working hours.

The statistical tests against non-working periods actually include those signals which border the working interval. The data show that the rate of occurrence during working hours is much larger than the rate of occurrence during non-working hours. However, if the working hours interval could be more accurately defined, the rate of occurrence during non-working hours would be zero.

Using the statistics in Table Q323.47-2, statistical tests were performed to determine if $\mu_N<\mu_S$ and $\mu_N<\mu_{P+S}$, where the symbol μ represents the means for the data sets, N, S, or P+S given in Table Q323.47-2. These tests were made at a 95% confidence level, and in addition, the actual confidence levels of the tests were computed. The actual confidence levels of these tests are indicative of the minimum probability one must accept of falsely concluding that $\mu_N<\mu_S$ or $\mu_N<\mu_{P+S}$ (injection or shut-in increases seismicity) in order to conclude that such an increase has occurred. The results of these analyses are presented in Table Q323.47-3. The actual confidence levels of these tests as presented in Table Q323.47-3 strongly indicate that the mean of the "N" data set is not smaller than the means of the "S" or "P+S" data sets for either working or non-working periods. For example, one must be prepared to falsely state that $\mu_N<\mu_{P+S}$ 84 times out of 100 tests before the present data can be interpreted to support the contention that $\mu_N<\mu_{P+S}$. One must be prepared to falsely state that $\mu_N<\mu_S$ 80 times out of 100 tests before the conclusion $\mu_N<\mu_S$ can be inferred from the present data. Obviously, the data do not support the contention that $\mu_N<\mu_S$ or μ_{P+S}.

17

The likelihood of making a type I error, that is, falsely detecting a difference in means when no such difference exists, has been discussed above. One may also ask the question" What is the likelihood of failing to detect a difference when in fact a difference exists?". A failure to detect a real difference in means is called a type II error. The likelihood of making a type II error is a function not only of the data statistics, but also of the real difference in means and the level of confidence at which the statistical test is conducted. If the likelihood of making a type II error is examined under the assumption that the test is conducted at the actual confidence level of the test, then the likelihood of failing to detect a pre-selected difference in means is equal to the probability of occurrence of the observed difference in sample means. This probability was computed for pre-selected differences in means. The results of these computations are shown in Figure Q323.47-3. The results presented in Figure Q323.47-3 provide further support to the contention that the means of the S and P+S data sets are not greater than the mean of the N data set.

Even though the ORT data indicate beyond question that the signals received at ORT are a result of cultural effects, for the sake of complete conservatism those signals which were identified as being close to the seismograph were analyzed as if they could have a seismic origin. In order to compare the differences in the mean number of events which were received at ORT during injection (P&S) and non-injection (N) periods, a history of earthquakes induced by pressurization was identified. Such a history is documented in the March 1976 issue of Science, "An Experiment in Earthquake Control at Rangely, Colorado," by Raleigh, et. al. This documentation shows that when fluid pressures are of a sufficient nature to induce seismicity, the mean number of earthquakes increased from 2 or 3 per month to as much as 170 per month, an 85 fold increase. When the ORT data is compared for a difference in means equivalent to an 85 fold increase, the probability of failing to detect such a difference in the means is essentially zero. The ORT data clearly indicate a large difference in means, such as that which was found to accompany the induced seismicity at Rangely, has not occurred as a result of the ORNL injection well activity. The Rangely data thus provide further confirmation that the ORNL injection wells are not inducing seismicity in the area.

Conclusions

Records were available to cover all of the injection periods. Therefore, this study encompasses all of the data for injections. The selected sampling of non-injection periods was frequent enough to provide representative results.

The statistical comparison shows that the seismic signals recorded at ORT are independent of breakdown, injection or set up activities at the ORNL injection well. The clear trend for signals to occur during the working hours of the week shows that those signals which are received are associated with man's activities. The pressurization at the injection well continues throughout the non-working period without an increase in frequency of non-working period seismic signals. Therefore, it is concluded that the injection process is not one of the activities which affects the signal frequency. 17

The "t" test was used to determine if the observed differences in mean number of occurrences for the various periods were statistically significant. This test was chosen because of its wide usage in statistical hypothesis testing, and because it is asymptotically distribution-free and thus the results obtained from the test are not unduly influenced by assumptions of the character of the population from which the samples were drawn (Ref. Q323.47-1). Procedures for applying the "t" test are given in Reference Q323.47-2.

Results

The interpretation of the seismographs began with an inspection of those portions of the records least influenced by cultural activities. No signals with S-P arrival times of three seconds or less were found in these portions of the seismograph records. Since naturally occurring seismic signals are expected to occur randomly, the lack of signals during the quiet hours of the weeks clearly shows that no local, natural seismic events are occurring in the region.

Figure Q323.47-2 is a histogram of numbers of seismic events occurring during the day for the ninety-five (95) day data base used. Of the 204 events catalogued, all but seven occurred between 8:00 a.m. and 8:00 p.m. Sixty-four events occurred between 5:00 p.m. and 6:00 p.m. For the purpose of this study, we selected the working hours from 8:00 a.m. to 8:00 p.m. local time. Some signals were received at ORT at hours adjacent to this arbitrarily selected interval; however, the signals received have characteristics similar to those induced during working hours.

The statistical tests against non-working periods actually include those signals which border the working interval. The data show that the rate of occurrence during working hours is much larger than the rate of occurrence during non-working hours. However, if the working hours interval could be more accurately defined, the rate of occurrence during non-working hours would be zero.

Using the statistics in Table Q323.47-2, statistical tests were performed to determine if $\mu_N < \mu_S$ and $\mu_N < \mu_{P+S}$, where the symbol μ represents the means for the data sets, N, S, or P+S given in Table Q323.47-2. These tests were made at a 95% confidence level, and in addition, the actual confidence levels of the tests were computed. The actual confidence levels of these tests are indicative of the minimum probability one must accept of falsely concluding that $\mu_N < \mu_S$ or $\mu_N < \mu_{P+S}$) (injection or shut-in increases seismicity) in order to conclude that such an increase has occurred. The results of these analyses are presented in Table Q323.47-3. The actual confidence levels of these tests as presented in Table Q323.47-3 strongly indicate that the mean of the "N" data set is not smaller than the means of the "S" or "P+S" data sets for either working or non-working periods. For example, one must be prepared to falsely state that $\mu_N < \mu_{P+S}$ 84 times out of 100 tests before the present data can be interpreted to support the contention that $\mu_N < \mu_{P+S}$. One must be prepared to falsely state that $\mu_N < \mu_S$ can be inferred from the present data. Obviously, the data do not support the contention that $\mu_N < \mu_S$ or μ_{P+S}. 17

The likelihood of making a type I error, that is, falsely detecting a difference in means when no such difference exists, has been discussed above. One may also ask the question" What is the likelyhood of failing to detect a difference when in fact a difference exists?". A failure to detect a real difference in means is called a type II error. The likelihood of making a type II error is a function not only of the data statistics, but also of the real difference in means and the level of confidence at which the statistical test is conducted. If the likelihood of making a type II error is examined under the assumption that the test is conducted at the actual confidence level of the test, then the likelihood of failing to detect a pre-selected difference in means is equal to the probability of occurrence of the observed difference in sample means. This probability was computed for pre-selected differences in means. The results of these computations are shown in Figure Q323.47-3. The results presented in Figure Q323.47-3 provide further support to the contention that the means of the S and P+S data sets are not greater than the mean of the N data set.

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Conclusions

Records were available to cover all of the injection periods. Therefore, this study encompasses all of the data for injections. The selected sampling of non-injection periods was frequent enough to provide representative results.

The statistical comparison shows that the seismic signals recorded at ORT are independent of breakdown, injection or set up activities at the ORNL injection well. The clear trend for signals to occur during the working hours of the week shows that those signals which are received are associated with man's activities. The pressurization at the injection well continues throughout the non-working period without an increase in frequency of non-working period seismic signals. Therefore, it is concluded that the injection process is not one of the activities which affects the signal frequency. 17

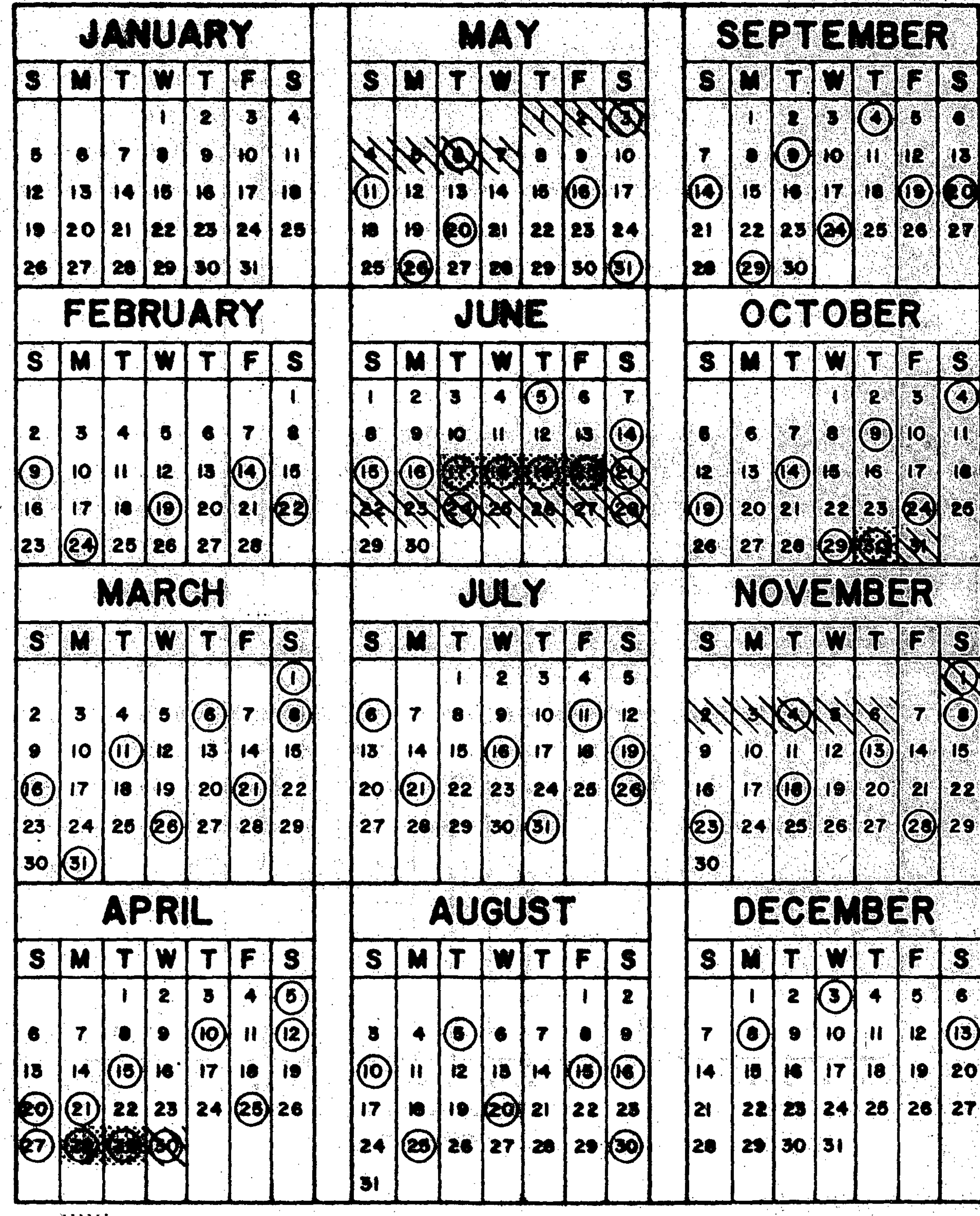
Based on discussions with the NRC staff on April 7, 1976, further assurance was needed that future injection well operations would not invalidate the conclusion drawn above.

This assurance, in the form of a geographical, geological, and operational envelope within which all future well operation would be restricted, is provided in Exhibit A of this response, as well as a commitment to notify NRC prior to any proposed operation outside of this envelope. This envelope also encompasses all injection operations to date. The approximate geographical bounds of the envelope is illustrated on revised Figure Q323.43-1. 17

References:

Q323.47-1. Lehmann, E. L., Non Parametrics: Statistical Methods Based on Ranks, p. 77. Holden-Day, San Francisco, California, 1975.

Q323.47-2. Natrella, M. G., Experimental Statistics, NBS Handbook 91, pages 3-27 and 3-36, U. S. Department of Commerce, 1963.



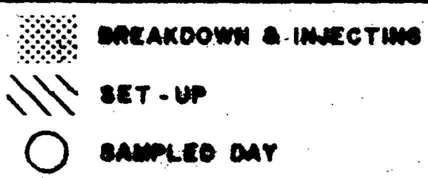


FIGURE Q323.47-1
1975 CALENDAR

CRBRP
STUDY OF ORT STATION
SEISMOGRAMS

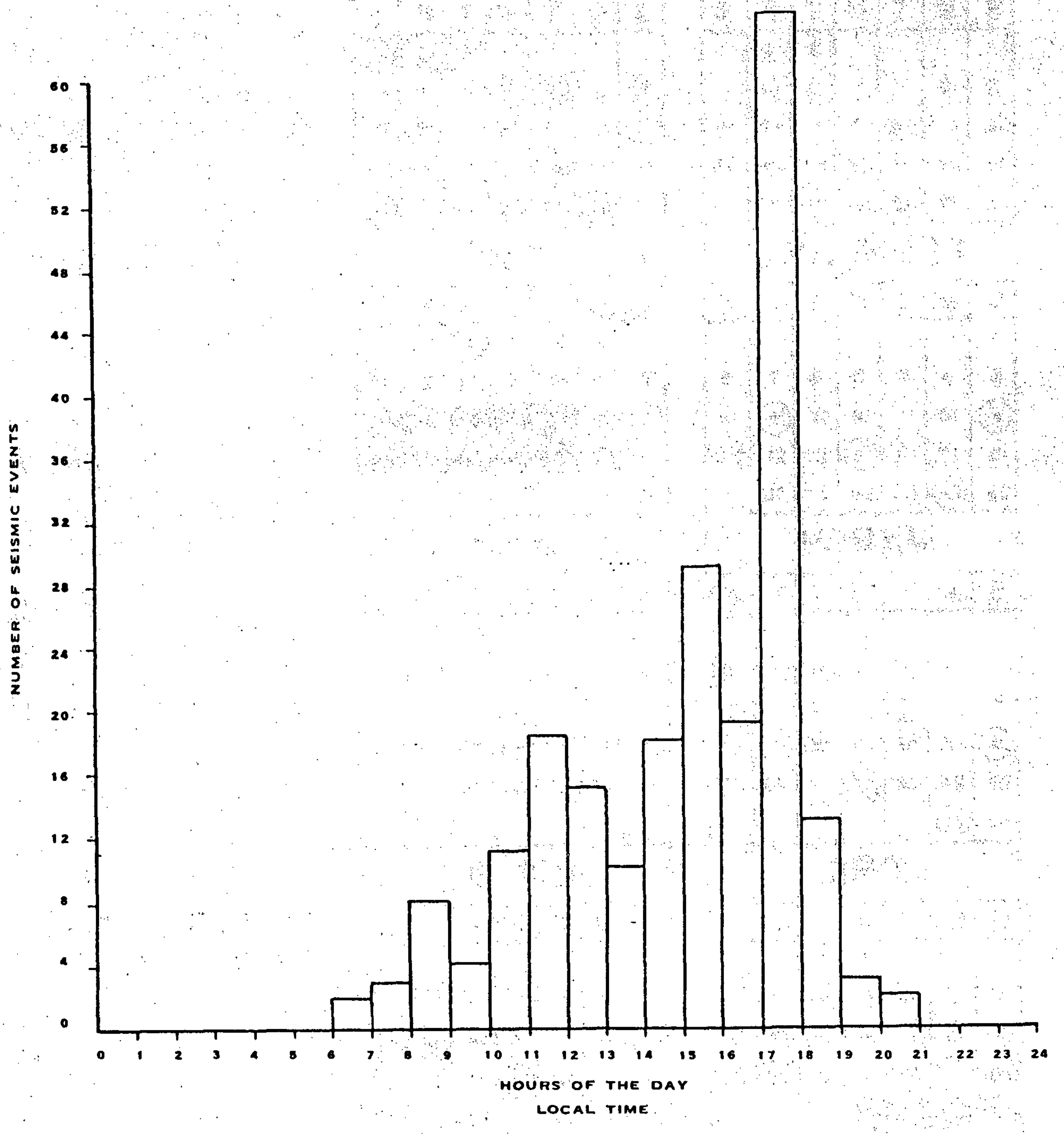


FIGURE Q323.47-2

HISTOGRAM OF SEISMIC EVENTS

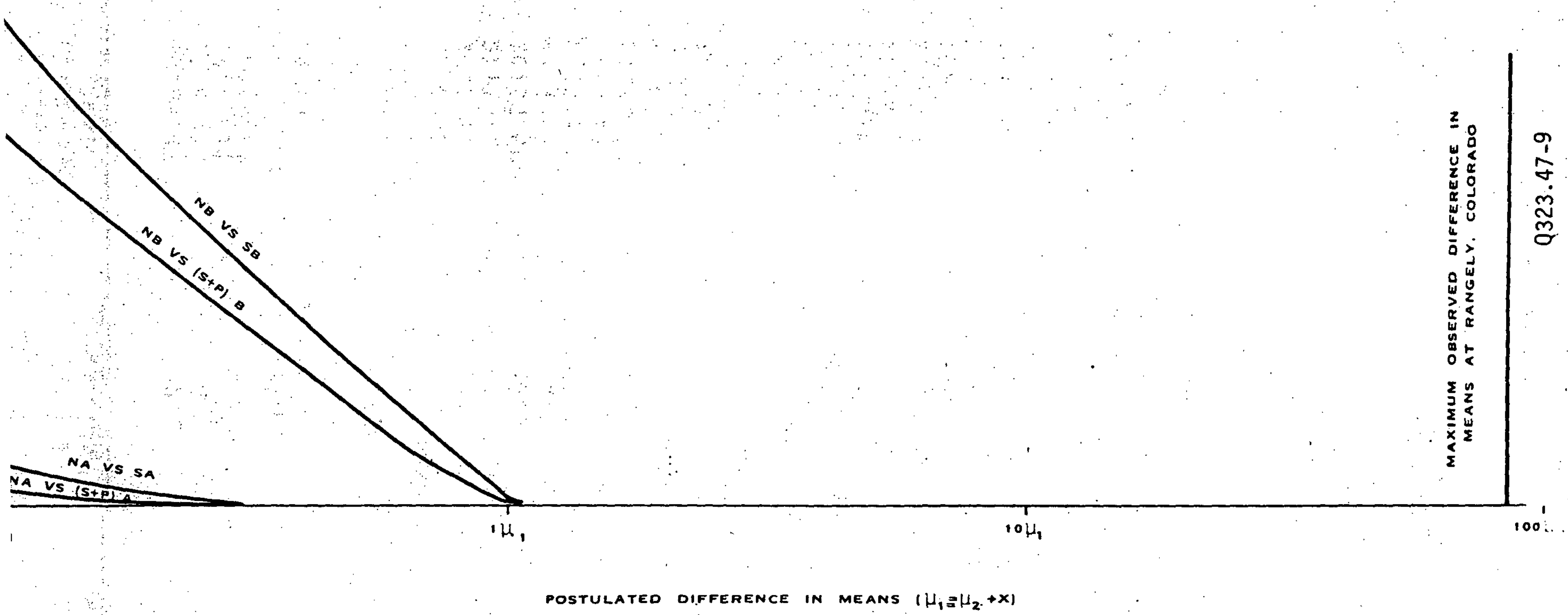


FIGURE Q323.47-3

SYNOPSIS OF TYPE II

ERROR ANALYSES

Date (Universal Time)		Time (Universal Time)	S - P (seconds)	Injection and working status
FEB.	10	13:03:42	2.1	NA
		16:41:53	0.8	NA
	14	16:50:41		NA
		20:12:56		NA
	15	16:07:18	(1.8)	NA
	19	22:19:3(5)		NA
	20	13:39:47	(3.)	NA
		15:11:47	(.8)	NA
	22	20:36:40	2.1	NA
		20:44:35		NA
MARCH	1	19:02:23	2.2	NA
		22:14:31		NA
	6	21:18:19	3.	NA
	12	10:55:58	(3.)	NB
	26	22:43:13	3.	NA
		23:57:07	(2.)	NA
	27	12:03:20		NA
		14:31:30		NA
		15:02:22		NA
	31	21:32:3(1)		NA
		22:36:50	3.	NA
		23:16:41		NA
APRIL	1	15:49:36		NA
		16:01:30	(2.8)	NA
	5	19:14:43		NA
		19:27:26	(3)	NA
		19:30:50		NA
		19:46:03		NA
	12	18:53:36	2.8	NA
	15	19:33:56	(3.)	NA
		21:08:07		NA
		21:55:04		NA
	22	14:50:59	3.	NA
		15:48:16	(3.)	NA
	28	21:28:35		PA
		21:33:11		PA
	29	15:47:41		PA
		21:29:08	3.	SA
	30	21:27:33	3.	SA

LEGEND

N = Non-Injecting Period
P = Breakdown and Injecting Period
S = Set-Up Period
A = Working Period
B = Non-Working Period
( ) = Approximated

TABLE Q323.47-1

LISTING OF SEISMIC EVENTS USED IN STUDY

(Universal Time)		(Universal Time)	S - P (seconds)	Injection and working status
May	1	11:33:59		SB
		18:14:04	1.2	SA
		19:50:08	1.2	SA
		21:29:15	2.5	SA
	2	15:26:42		SA
		16:23:02		SA
		16:26:10	(1.)	SA
		16:27:56	2.2	SA
		21:26:05	2.3	SA
	3	17:55:24	2.8	SA
		19:27:58		SA
		19:36:57		SA
	5	16:26:07	(1.4)	SA
		21:28:42	2.7	SA
	7	22:01:17	2.6	SA
	8	17:43:29	2.5	SA
	12	14:35:17	2.8	NA
	20	20:34:39		NA
	26	15:47:38	1.2	NA
		21:04:24	2.2	NA
June	5	19:34:13	2.4	NA
		22:00:24	(2.3)	NA
	14	19:28:08	2.0	NA
	16	18:34:49	(.8)	NA
		21:38:32	(2.2)	NA
	17	00:36:19	3.	NB
		18:09:23		NA
	19	16:03:32	(3.)	PA
	20	15:16:04		PA
		21:28:55	(2.5)	SA
		21:30:00	3.	SA
	24	21:23:42		SA
	25	19:14:30	1.7	SA
	26	16:03:58	2.	SA
	27	17:47:13	1.8	SA
		19:10:28	1.8	SA
		20:47:30	2.0	SA
	28	18:58:42	(2.5)	SA
JULY	7	15:52:26	3.	NA
	11	17:14:20		NA
		18:02:02	2.2	NA
		20:55:12		NA
		21:59:20		NA
	16	19:34:52	2.5	NA
		20:09:20	2.5	NA
		21:08:49		NA
		21:57:03	(1.5)	NA
	17	12:16:23		NA

TABLE Q323.47-1 (Cont'd.)

Date (Universal Time)		Time (Universal Time)	S - P (seconds)	Injection and working status
JULY	21	16:48:43	(2.5)	NA
		20:42:29	1.	NA
		21:10:33	(1.5)	NA
		21:26:41	(1.5)	NA
		15:21:45	(.8)	NA
	22	16:01:56	(.8)	NA
	26	20:45:32	1.	NA
		21:26:27		NA
		21:46:12	1.	NA
	31	18:40:42	2.5	NA
		18:55:17	2.	NA
		21:04:51	2.	NA
		21:14:52		NA
		21:22:16	2.	NA
		21:22:57		NA
		21:25:46	(2.8)	NA
AUGUST	15	17:20:04		NA
		18:21:11		NA
		19:21:06	2.5	NA
		20:16:15		NA
		21:27:22		NA
	16	12:25:14		NA
	20	18:19:45	2.3	NA
		21:03:49	2.2	NA
		21:36:32		NA
	21	10:49:34		NB
	25	16:02:21	(2.8)	NA
		16:06:38	2.6	NA
		19:16:38	(2.6)	NA
		20:02:29		NA
		21:13:37		NA
		22:05:07	2.7	NA
		22:08:33	3.	NA
	26	13:21:16		NA
		14:22:51		NA
SEPT.	4	18:34:36		NA
		20:20:34		NA
		20:38:25		NA
		20:51:08		NA
		22:08:44	3.	NA
		22:24:29		NA
	9	19:50:08		NA
		20:05:03		NA
		21:10:28		NA
		21:10:54		NA
		21:11:55		NA

TABLE Q323.47-1 (Cont'd.)

Date (Universal Time)		Time (Universal Time)	S - P (seconds)	Injection and working status
SEPT.	15	13:11:56		NA
	19	17:45:15		NA
		20:41:53	(2.5)	NA
		20:48:38		NA
		21:03:59		NA
		21:19:24	(3.)	NA
		21:24:56	(2.5)	NA
		21:29:04	3.	NA
		22:07:39	3.	NA
		22:19:48		NA
	20	00:01:25		NA
		17:23:46	3.	NB
		18:30:50	2.7	NA
	29	16:00:18		NA
		16:38:54	2.9	NA
		21:28:51	2.9	NA
		21:30:56		NA
	30	14:00:37		NA
		14:02:16		NA
OCT.	4	19:30:10		NA
		19:31:03		NA
		20:47:18	(3.)	NA
	10	13:10:56	2.5	NA
	14	14:44:27		NA
		17:51:20		NA
	15	11:30:32		NB
		14:46:18	2.5	NA
	20	15:17:06		NA
	24	16:23:32	2.6	NA
		19:44:28		NA
	29	22:01:54		NA
		22:16:37		NA
		22:17:26		NA
		22:30:40		NA
		22:31:07		NA
	30	19:27:10		PA
		20:22:15	2.4	PA
		20:44:44	(2.6)	PA
		22:46:19	(1.2)	PA
	31	19:33:22	(2.4)	SA
		20:43:02	(2.2)	SA

TABLE Q323.47-1 (Cont'd.)

Date (Universal Time)		Time (Universal Time)	S - P (seconds)	Injection and working status
NOV.	1	20:30:29	3.	SA
		20:38:22		SA
	3	18:46:15	(3.)	SA
		20:50:11		SA
	4	16:00:12	(1.2)	SA
		22:31:34	(2.1)	SA
	5	14:57:08		SA
		16:01:44		SA
		22:27:33		SA
		22:34:00		SA
	6	22:42:31		SA
	13	21:07:59		NA
	14	13:35:30	(1.8)	NA
	18	19:29:06		NA
		22:06:12		NA
		22:12:26		NA
		22:12:44		NA
		22:14:04		NA
		22:26:53		NA
		22:48:26		NA
	19	15:42:39	(3.)	NA
	28	19:44:11	2.4	NA
		22:08:00		NA
		22:32:32	(3.)	NA
DEC.	3	17:00:07	2.6	NA
		18:30:13	3.0	NA
		20:23:43		NA
		21:05:52	(3.)	NA
		23:01:55		NA
	4	00:51:46	3.	NA
		12:25:38	(3.)	NB
		15:12:55		NA
	8	16:10:59	3.	NA
		17:55:29		NA
		18:58:38	3.	NA
		21:01:40		NA
		21:59:48		NA
		22:14:17		NA
		22:15:32		NA
	9	13:04:35	2.8	NA
		13:05:56	2.8	NA
	13	20:28:05	2.8	NA
		20:23:48	(2.4)	NA

TABLE Q323.47-1 (Cont'd.)

TABLE Q323.47-2

MICROSEISMIC SIGNAL FREQUENCY
STATION ORT

		N (Non-Injecting Periods)	P (Periods Under Pressure)	S (Set up Periods)	P & S (Pressure and Set up Periods Combined)
A	MEAN	.2526	.1731	.1802	.1789
	VARIENCE	.4387	.2244	.2389	.2353
	NO. EVENTS	148	9	40	49
	NO. HOURS	586	52	222	274
B	MEAN	.0066	0	.0031	.0027
	VARIANCE	.0066	0	.0031	.0027
	NO. EVENTS	6	0	1	1
	NO. HOURS	909	48	323	371

A = Working Period

B = Non-Working Period

TABLE Q323.47-3

RESULTS OF HYPOTHESIS TESTING ($\mu_1 < \mu_2$)

	$\mu_{NA} < \mu_{SA}$	$\mu_{NB} < \mu_{SB}$	$\mu_{NA} < \mu_{(S+P)A}$	$\mu_{NB} < \mu_{(S+P)B}$
Does difference exist at 95% significance level	No	No	No	No
Actual level of test	.05	.20	.03	.16

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
OAK RIDGE OPERATIONS
P. O. BOX E
OAK RIDGE, TENNESSEE 37830
AREA CODE 615
TELEPHONE 483-8

Lochlin W. Caffey, Director, Clinch River Breeder Reactor
Plant Project Office

PROPOSED RESOLUTION WITH NRC ON ORNL INJECTION WELLS

Reference is made to your memoranda of January 27 and April 6, 1976, as well as our discussions on the above subject. We are pleased to learn that, following discussions with NRC, an acceptable resolution of the seismic issue related to the ORNL injection wells appears imminent.

We are in agreement that NRC needs assurance that future hydrofracture operations will be carried out within a defined envelope of conditions — geologic, geographic, and operations. We believe the following will establish such an envelope of conditions as well as fulfill our commitment in this matter:

> All future ORNL hydraulic fracturing waste disposal operations will be carried out in that portion of Melton Valley enclosed by the following four coordinate points (based on the Tennessee state system of rectangular coordinates -- topographic map of Melton Valley, ORNL D26364): (N 557,800, E 2,498,500); (N 557,800, E 2,499,400); (N 555,500, E 2,497,600); (N 554,900, E 2,498,500). For ready reference this area is roughly sketched on the enclosed copy of a map identified as Figure Q323.43-12 which was supplied by your office. The portion of the Conasauga formation utilized for this purpose will be limited to the approximately 300 ft of red shale occuring between the rome sandstone and the three limestone beds used as stratigraphic markers. Future operations will be restricted to those locations where this particular stratum occurs in the range 500 ft to 1500 ft below the land surface. Furthermore, all operations will be conducted such that the static injection pressure (injection pressure extrapolated to no flow conditions) will not exceed 3000 psig as measured at the wellhead annulus.
>
> In the event ORNL desires to perform operations or experiments outside the above described envelope at some time in the future, NRC will be appropriately notified.

Please do not hesitate to let us know if additional information is desired.

for R. J. Hart
Manager

ORR:EHH

Enclosure:
Cy of Map

cc w/encl:
C. A. Keller
J. A. Lenhard

Question 323.48

If the results developed in response to item 323.47 are not sufficiently complete and conclusive, a microseismic monitoring program will need to be established. This need will be determined by the following:

1. The data are inadequate to permit a decision at the desired level of confidence; or,

2. The rates of activity at the desired level of confidence are significantly different for the differing time periods.

A mircoseismic program will be required, using a very dense network of high gain portable seismographs, to monitor an injection(s) to develop the necessary data at the desired level of confidence. The purpose of the monitoring will be to determine the relationship, if any, between the microearthquakes triggered by the injection activities and the geologic structure(s).

The required monitoring period would have to extend from one month prior to start of injection activities until such time after uncapping the well that the microearthquake activity has returned to its pre-injection level.

If the results of your response to 323.47 indicate a correlation between microseismic events and injection activities, a complete data set (pre-injection through post-injection) would be required. Since injection occurs infrequently, we strongly encourage and recommend that preliminary planning of a monitoring network be initiated without delay. Furthermore, if your response to 323.47 is not complete at the time of the next injection, it is our position that the network be installed in order to monitor that injection. Alternatively, a commitment to terminate injection operations prior to operation of the CRBRP will be sufficient to resolve this issue.

Response:

The results developed in response to item 323.47 indicate completely and conclusively that no correlation exists between ORNL injection activities and microseismic activity in the site vicinity. Consequently, the establishment of a microseismic monitoring program is not necessary.

Question 324.1 (2.4.13, 2.5.1.2.4.4)

The location of the groundwater table is not clear; to aid interpretation, show the water table on the geologic profiles shown in Figures 2.5-7 through 11. On page 2.5-18 it is stated that generally the groundwater elevations coincide with the top of continuous rock, however, the logs of the borings and geologic profiles indicate the water table varies as much as 10 feet above and below the continuous rock line. Provide clarification in the PSAR.

Also, the groundwater data does not reflect groundwater conditions in the alluvium and weathered rock sufficiently to permit an evaluation of the quantity of water that will have to be pumped for construction dewatering. Packer tests were generally conducted below the level of continuous rock and don't provide quantitative data particularly in areas where the rock has weathered quite deep. Other data on groundwater in the upper zones is from the observation wells which only provides water table elevation. Discuss your construction dewatering program and provide an upper limit estimate of the quantity of water to be handled.

Response:

Geologic profiles, Figures 2.5-7 through 11, have been revised to include the groundwater table as recorded on January 6, 1975. Clarification of groundwater level readings has been provided in Section 2.4.13.2.2. A discussion of the construction dewatering program and an upper limit estimate of the quantity of water to be handled has been provided in revised Section 2.5.4.5.1.4 of the PSAR. 25

Question 324.2 (2.5.1.2.4.4)

Weathering. Continuous rock is defined as rock which does not contain any significant weathered or solutioned discontinuities. This definition appears ambiguous. On examination of the boring logs and geologic profiles, we note a considerable variation in relating the lower limits of weathering to the top of continuous rock. The level of weathering in the logs for boring 41, 46, 54 and 55, for example, could be interpreted to be as much as 15 to 25 feet below the top of continuous rock. Discuss more specifically what constitutes continuous rock and discuss what criteria will be used to establish this grade in the field during construction.

Response:

A more specific discussion of what constitutes continuous rock is provided in revised Section 2.5.1.2.4.4. A discussion of the criteria which will be used to establish this grade in the field during construction is provided in Section 2.5.4.5.1.3. 25

Question 324.3 (None)

The depth of weathering in the Unit "A" limestone is highly variable. We are most concerned about the northwest edge of the plant island and emergency cooling tower where the limits of weathering in the Unit A limestone extends very close to foundation grades. Also of concern, is the emergency cooling water tower which will be founded near the limits of weathering in the Unit A siltstone at Elevation 765.

The foundation excavations should be exploratory, recognizing that final grades may locally be considerably lower than what is shown on the drawings. Establish and describe in the PSAR a foundation verification program to be used in the field during construction to determine final foundation grades. Include in this program provisions for additional borings during construction to investigate local weathering features.

Response:

A description of additional borings taken along the northwest edge of the plant island to establish the depth of weathering in that area is provided in revised Section 2.5.1.2.4.4 of the PSAR. The proposed foundation verification program for the Nuclear Plant Island is described in Section 2.5.4.5.1.3 of the PSAR, respectively.

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Question 324.4 (2.5.4.12)

It is stated that the final 18 inches of rock above design grade will be removed by controlled means. Describe how this will be accomplished, particularly if the bottom 18 inches is in hard rock.

Response:

The information requested is provided in revised Section 2.5.4.5.1.3 of the PSAR. 25

Question 324.5 (2.5.4.12)

Describe the program you propose for foundation treatment, including requirements for dental work, grouting, foundation protection, and foundation cleanup.

It is stated that localized solution zones will be treated individually as the excavations proceed. Discuss how these features will be treated.

Response:

The information requested is provided in revised Section 2.5.4.12 of the PSAR. 25

Question 324.6 (None)

Both the Unit A and B limestone contain solution zones within the depth of weathering. We are most concerned about the Unit A formation which dips beneath the Category I structures. Solution features may be very unpredictable and are often found along joints in limestone rocks below the depth of weathering.

The boring program conducted on the northwest edge of the plant island area indicates that solution features are present in the weathered zone. However, the same intensity of investigations were not conducted beneath the Category I structures or in the unweathered zone of rock.

Discuss the supplemental exploration programs planned to be conducted during construction to investigate the presence of solution features beneath Category I structures. Indicate the scope of these investigations, methods to be used and remedial treatment proposed.

Indicate and discuss the scope of investigation completed to evaluate the significance of sink hole depressions shown on Illustration 7 of Supplement 2.

Response:

The information requested is provided in revised Section 2.5.1.2.4.4 and 2.5.4.5.1.5 of the PSAR. 25

Question 324.7 (2.5.4.5)

Structural Fill and Backfill. More testing should be conducted to determine the dynamic and static properties of the granular class A structural fill and backfill. The dynamic testing program should be conducted in conjunction with dynamic analyses to evaluate the effects of the SSE on the class A structural fill and backfill. The dynamic analyses should be conducted to evaluate liquefacation potential, dynamic lateral loads and possible densification of the class A structural fill and backfill. Provide (1) all test data, (2) a description of the analyses used identifying input and assumptions, (3) the results of the studies completed and your conclusions.

Response:

The information requested is provided in revised Section 2.5.4.5.1.5 of the PSAR. 25

Question 324.8 (2.5.4.5)

Paragraph 2.5.4.5.1.5, should define the material to be used for class A structural fill and backfill (gradation and Atterberg limits). Discuss how compacting the class A structural fill and back fill to 95% maximum dry density determined by ASTM Test Designation 1557-70 method will preclude liquefaction and/or excessive settlement of the structural fill and backfill under the SSE loading.

Identify the studies and analyses which were conducted to determine that 95% of the maximum dry density as determined by the above method would be adequate.

Describe the "detailed investigations" being conducted to determine the dynamic properties of the class A structural fill and backfill.

Response:

The information requested is provided in revised Section 2.5.4.5.1.5 of the PSAR. 25

Question 324.10 (3.7.1.6)

(a) Indicate if the effect of the structural soil backfill around Category I structures was considered in the soil structure interaction analysis. What assumptions were made?

(b) The Category I service water piping is to be founded on 50 feet of Class "A" fill. Identify the analyses used to estimate pipe settlements and to evaluate its response to dynamic loading. Specify your design criteria, estimated deflections, displacement, settlement, and margin of safety.

Response:

(a) The information requested is provided in revised PSAR Section 3.7.1.6.

(b) The information requested is provided in revised Section 2.5.4.5.1.5. 25

Question 324.11

During construction, after excavation and before structural concrete is placed, the staff requires that the Project prepare and submit for review, a summary report which describes actual foundation conditions encountered during excavation. This report will be reviewed by the staff to confirm that your estimate of foundation conditions have been actually found and that there are no significant changes that require design modifications. The following information should be included in the report:

(a) Results and logs of additional investigations, including the airtrack exploration holes, geophysical logs, and core borings extending through the Unit "A" limestone on the western boundary of the plant.

Describe and interpret evidence of solutioning, and any other condition which could adversely impact foundation stability.

(b) Details of required foundation treatment including corrective excavations, grouting, dental concrete and leveling concrete. Information should be provided regarding actual treatment of excavation walls and the foundation.

(c) Geologic mapping of the excavation.

(d) "As constructed" excavation plans, sections and profiles. Include contour maps of excavations.

Response:

The Project will prepare and submit for review before structural concrete is placed, a summary report describing actual foundation conditions encountered during excavation. The report will include the information requested by the NRC Staff as described in the above question.

Question 324.12 (2.5.4.5)

Describe in detail the quality control and quality assurance programs to be enforced during the placement of Class "A" structural fill and backfill. The description should include testing methods and frequency of testing.

Response:

The quality assurance program to be implemented during placement of structural fill and backfill is described in Appendix F, "A Description of the Constructor Quality Assurance Program", Chapter 17-Quality Assurance.

The specifications will provide requirements for the test methods and test frequencies during the placement of structural fill and backfill. These requirements will be designed to provide assurance that required in-place densities are achieved and verified and will be in accordance with recognized codes and standards which are appropriate for the areas being filled or backfilled.

Question 324.13 (2.5.4.5)

Because backfill is being specified to be compacted to the Modified ASTM Standard (ASTM Designation 1557-70), the staff requires that the at rest lateral earth pressure coefficient (Ko) be assumed to be 0.7 to account for pressures generated by this heavy compaction effort.

Response:

The at rest lateral earth pressure coefficient (Ko) will be assumed to be 0.7 as required.

Question 331.1 (12.1.1.2, 12.2.1, 12.3.1)

Provide, as a primary design and program objective, a management commitment that radiation exposures to plant personnel will be kept as far below regulatory limits as practicable, as recommended in Regulatory Guides 8.8 and 20.1(c) of 10CFR20.

Response:

49 Detailed ALARA objectives and commitments are provided in Appendix 12A.

Question 331.2 (12.1)

Describe in detail the specific steps to be taken to follow the guidance given in Regulatory Guides 8.8, 8.10, and 1.8 (except that which has been superceded by Guide 8.10), to the extent that provisions of those guides apply to the proposed plant, or provide descriptions of specific alternative approaches to be used. Discuss relevant radiation protection design aspects of refueling, fuel handling and storage, radioactive material handling, processing use, storage and disposal, maintenance, routine operational surveillance, inservice inspection, and calibration, as well as response to and cleanup following postulated accidents. Reference may be made to material in other chapters of the PSAR. This discussion should describe the design features of the systems related to the listed activities that assure that radiation exposures will be ALAP during the activities.

Response:

The management of the CRBRP Project is committed to designing and operating the plant such that every reasonable effort shall be made to keep radiation exposures to plant personnel as far below regulatory limits as is reasonably achievable. This commitment and ALARA measures are stated in PSAR Section 12A. Expected man-rem exposures to plant personnel are discussed in PSAR Section 12.1.5.

Additional details of CRBRP design and project management regarding ALARA considerations and Regulatory Guides 8.8, 8.10, 8.19, and 1.8 are provided in responses to NRC Question 331.17 and PSAR Section 12. Information on ALARA considerations in system design are provided in the
49 response to Question 331.4.

Question 331.3 (12.1)

Describe the following policy and design considerations as each relates to assuring that occupational radiation exposures will be ALAP: management policy and organizational structure, and facility and equipment design considerations. Give illustrative examples of how the design is directed toward reducing the need for maintenance and reducing the radiation levels and time spent where maintenance is required. Describe proposed procedures to assure that preliminary and periodic design reviews will be conducted by comparing health physicists (with the support of other specialists) before and during construction specifically to ensure that occupational exposures will be ALAP. State the manner by which these reviews will be conducted.

Response:

Information regarding the ALARA policy and Project ALARA reviews is provided in revised PSAR Section 12A and NRC Question/Response 331.15. Information on ALARA considerations in systems design is provided in
49 response to Question 331.4.

Question 331.4 (12.1)

In the course of designing facilities and equipment and developing plans and procedures, it is necessary to think through each process with regard to maintaining occupational radiation exposures as far below regulatory limits as practicable. Normally this process will result in changes in designs that had been prepared without regard to these considerations.

Describe illustrative developmental design changes resulting from your ALAP review which have resulted in reduction of projected exposures for the following operations:

1. operation of the liquid radwaste system, including flushing resin beds, draining tanks and sumps and replacing filters.

2. maintenance of radwaste system, including welding, inspections, calibrations, leak repairs, valve repair, and replacement of components.

3. maintenance on gaseous radwaste system including work on RAPS, CAPS, and vapor traps.

4. solid radwaste handling, including hauling, pushing, moving and loading of radwaste drums, filters, resins, and contaminated parts of various systems.

5. closure head operations, removing the moisture separator , steam dryer, core instrumentation, decoupling the control rods, reassembly of instrumentation and control rod drives, bolt tensioning, and upper cavity decontamination.

6. refueling,including discharging fuel from the core, moving, reloading, inspecting fuel.

7. in-service inspections, including removal of insulation, testing of components, and replacement of insulation.

8. control rod drive maintenance including inspection, removal, overhaul and replacement.

9. maintenance work on large equipment, including items in containment and turbine buildings, such as recirculation and reactor coolant pumps, valves, steam generators, turbines, bypass valves, condensor, condensate demineralizers, etc. Specific activities may include routine maintenance such as changing packings on pumps and valves, inspecting, searching for steam leaks, greasing, changing oil, work on controls, overhauling after removal, checking motors, testing, and disassembling and reassembling.

Response:

The specific questions in 331.4 are answered as follows:

1. Liquid Radwaste System Operations - The design and operation of the liquid waste system is discussed in detail in PSAR, Chapter 11.2. As noted in this chapter, the system is designed to minimize the radiological impact of the plant on the environment and the radiation hazards to plant personnel.

   Specific design features incorporated in the liquid radwaste system to achieve ALARA radiation exposure during operation are as follows:

   a. Routine operations are conducted remotely with the control center located in a Zone 1 radiation area.

   b. Periodic valve manipulation required for operation is done in corridors outside of cells housing the contaminated solutions.

   c. All piping systems have low point drains which allow complete drainage of flush liquids. Shielding is provided for cell pipes transferring high activity.

   d. All cells are provided with floor drains connecting to a sump to allow spilled liquids to be removed from the cell. All cell floors in the radwaste area are painted with epoxy for ease of decontamination after a spill.

   e. Filter cartridges are removed remotely and the cartridge is placed in a concrete-lined 55 gallon drum. This drum is shuttled remotely to a position in the solid radwaste area, and then remotely to the drum storage area. Concrete-lined drums carrying spent filter cartridges are handled in the same way as other solid radwaste drums.

   f. Spent resin is slurried and transported to a decanter in the Solid Radwaste System. The spent resin is concreted with minimum radiation exposure in the same way as concentrated liquid waste in an automatic sequence of operations (see Response 4).

2. <u>Liquid Radwaste System Maintenance</u> - The following specific design features are included to enhance system maintainability and to reduce personnel radiation exposure:

   a. Tank inspection in individual cells can be accomplished only when tanks are empty. Sprinklers are provided to wash down internal walls in the collection and concentrate tanks prior to maintenance. The washing removes the radioactive surface contaminants and minimizes the radiation exposure during maintenance. The wash water is sent to low activity level sub-systems for collection and further processing.

   b. Major components in the system such as evaporators are skid mounted. Access for their removal is provided by separate hatches in the operating floor.

   c. Small components and tools can be decontaiminated in the Decontamination Facility prior to their repair or use.

3. <u>Gaseous Radwaste System Maintenance</u> - The engineering performance goals in the design and development of the Inert Gas Receiving and Processing (IGRP) System have been to ensure that radioactive gases in the CRBRP are safely contained; release of gaseous radioactivity to the environment is as low as is reasonably achievable and occupational dose of plant personnel is as low as is achievable (ALARA). The system performance goals have led initially to the selection of the chemical and physical processes described in Sections 9.5 and 11.3 of the PSAR. The goal of minimizing occupational dose has been pursued concurrently and is continuing. As a consequence, IGRP components which contain radioactive gases, even in small amounts, are housed in shield-wall cells. Service lives of expendable components (vapor traps) have been considered and redundant components have been provided when necessary to ensure that the minimum replacement-time period will be at least one fuel cycle so that replacement and/or maintenance can be performed during refueling and periods of low radiation.

   Each of the filter vapor traps in the two continuous-flow cover gas circuits are housed in separate cells. Thus, in the event it becomes necessary to replace one or more traps in order to con-
|27 tinue reactor operation, the replacement can be carried out at power operation with one cell shutdown.

   As a part of the selection of the process design of the IGRP System, the piping for these vapor traps and other components in the IGRP are fitted with fresh argon purge connections to permit the displacement of the normal radioactive process gas from IGRP components. This purge gas is treated in the cell atmosphere processing system to remove radioactivity before the gas is released from the plant. This approach is a means of keeping the exposure of maintenance personnel at ALARA conditions. In all cases, the maintenance procedures will include purging of all components and piping prior to inspection, in-place maintenance and/or repair or replacement.

When IGRP components contain activity which cannot be removed by a clean argon purge, an evaluation will be made by the operating staff of the need for the use of portable personnel shielding.

The need for replacement of the diaphragms of the RAPS and CAPS compressors has led to the location of each of these four components in individually shielded cells to permit replacement during power operation.

The RAPS and CAPS cold box blowers annual maintenance operation is another example of the application of the ALARA principle in the design of the IGRP System. These blowers are housed within their respective cold boxes. The maintenance sequence for the routine lubrication and inspection of the blowers and motors will involve the use of a permanently installed iron shadow shield for the blower maintenance work area. The thickness of the shield is to be determined by the application of the ALARA principles for operating personnel, once the detailed configuration and source term is finalized. The CAPS normally contain (under design base conditions) a much lower burden of radioactivity, and a fifferent, less damaging, mixture of isotopes, and permanent shielding is currently not specified.

The IGRP System contains more than 2,000 valves. Most of these are manual and remain open or closed for long periods of time. Some are on-off gas operated units and others are modulating, but self-contained. The remainder are gas operated modulating control valves. While all valves require periodic preventive maintenance, the modulating-type valve maintenance needs are most critical. They require, as a minimum, an annual physical check, and therefore, must be located in areas which permit personnel access on an annual basis and in a manner to ensure ALARA exposure. Judicious placement and shadow shielding, as required, will be used to minimize the radiation exposure of maintenance and repair personnel.

4. Solid Radwaste System - The solid radwaste system is operated remotely from the radwaste control room using a sequence of operations. The operation of the solid radwaste system is based on in-the-drum or ex-drum mixing with cement using 55 gallon drums. In in-the-drum mixing, drums are prefilled with cement in a low radiation level area and are sent to a wet filling area for a sequence of operations. But, in ex-drum mixing

system the waste to be solidified is premixed with cement and sent to a wet filling area for a selected sequence of operations. The sequence includes pumping concentrated liquid waste (i.e., evaporator bottoms), filter sludge or spent resin, into a drum with or without cement, drum weighing, pumping additives, drum capping, drum tumbling, and drum monitoring. All drum movements are carried out remotely. The drums of concentrated waste are loaded remotely onto a trailer for shipment to a burial site. These design features will minimize radiation exposure during drum handling (ALARA).

Relatively small contaminated parts which can be accommodated in 55 gallon drums are accepted in the Solid Radwaste System for temporary storage and disposal. An area is provided for the temporary storage of such parts in the Drum Storage Vaults, pending shipment to a disposal site. Movement and loading of such components is remotely controlled from the Radwaste Control Room.

Consequently, the major design features in the solid radwaste system to achieve as low as reasonably achievable (ALARA) conditions are:

a. Remote operation from the radwaste control room to minimize the radiation exposure during normal operation.

b. The maintenance radiation exposures will be minimized by remote mixing of the radioactive waste with the cement, and allowing the mixture to solidify.

c. Provisions of two drum storage vaults so that either of the vaults could be emptied before entering for maintenance. During normal storage conditions, low level solid storage vault does not need the emptying before entrance for maintenance.

d. Design of shield thicknesses to provide adequate radiation protection during normal operation and maintenance (as described in PSAR Chapter 12.1)

5. <u>Closure Head Operations</u> - The closure head of CRBRP is located in the Head Access Area (HAA) of the Reactor Containment Building. It differs significantly from LWR's in that much of the equipment specifically addressed in the question is not present, i.e., moisture separators and steam dryers. Another significant

difference from LWR technology is that access is expected during reactor full power operation.

Access to the HAA is made possible by controlling the radiation level through shielding and component design. Therefore, maintenance activities associated with the control rod drive mechanisms, head instrumentation and bolt tensioning should result in comparatively small radiological exposures. Similar activities on LWR's often require reactor compartment entries.

The major effort to minimize man rem exposures in the HAA has centered around controlling radiation from cover gas sources. A total of thirty-two penetrations exist in the CRBRP closure head assembly. Structural gaps in these penetrations range from several mils to several inches in size and provide potential leakage paths for radioactive cover gas, as well as paths for radiation streaming.

Several guidelines to keep radiation exposures ALARA were established early in the closure head penetration shield design effort. The most important of these was to limit the impact of radioactive cover gas on personnel exposure. This design objective was accomplished by maintaining radioactive cover gas at elevations below the top of the closure head by hermetically sealing the penetrations, using double buffered seals and sodium dip seals for the rotating plugs. The implementation of this control method (which constitutes the primary seal system) obviated the need for large, expensive and complex bulk shielding structures on the closure head, and provides a radiological environment consistent with ALARA design objectives. As a result, ALARA considerations resulted in only minor design changes e.g., increasing structural steel thickness from 1 inch to 2 inches, minimizing gap sizes (most effective for smaller annular gaps where potential radiation streaming problems existed, and combining shield steps with controlled gap dimensions for large annular gaps such as the rotating plugs. For example, to minimize the impact of radiation streaming on the HAA environment, the rotating plug design configuration provides steps in the annular gaps through the closure head assembly. The use of shield steps is estimated to reduce dose rates in the HAA from ~100 mrem/hr to less than 1 mrem/hr.

In addition to gas purges, sodium dip seals, and mechanical seals located in the closure head assembly, all major penetrations provide a secondary seal system to minimize cover gas leakage into the HAA. For example, bellow seals, elastomer seals and conoseals are used in the CRDM design to complement the gas purge and double-seals are employed as a secondary seal system for each rotating plug to complement the primary seal function of the sodium dip seals. These secondary seals are located in the riser assemblies and include double "O" ring metallic seals at the base of each riser, double inflatable elastomer seals above the closure head, and double elastomer seals at two locations inside the risers. Periodic leak checks are performed on all riser seals to insure seal integrity. Double elastomer seals and swagelok fittings are employed in the upper internals structure and jacking mechanism design. The secondary seal systems provide reasonable conservatism in limiting radioactive gas leakage into the HAA.

In addition, the closure head bulk shield design configuration substantially reduces the general area neutron/gamma levels above the closure head. This reduction is accomplished by a total carbon steel thickness of ~52" above the sodium pool. There is also a B.C. shield collar surrounding the reactor vessel at the base of the support ledge which limits neutron streaming into the HAA from scattering in the reactor cavity concrete, reactor vessel and guard vessel.

In summary, the penetration shield design permits limited access to work locations in the HAA during plant operations and reactor maintenance and satisfied ALARA.

6. Refueling and Fuel Handling Systems - The Reactor Refueling System has been designed to maintain occupational radiation exposures as low as is reasonably achieved (ALARA). A review of the recommended design practices listed in Paragraph C.3 of Regulatory Guide 8.8 shows that essentially all items in the list have been incorporated in System 41 design efforts.

The following design provisions have been made to minimize the radiation exposure to refueling personnel:

a. The equipment is shielded to meet the radiation protection
49 criteria in Section 12.1.

b. Double seals have been provided on all reactor refueling system equipment and facilities which contain radioactive materials.

c. For those facilities containing material which, if released would exceed the limits of 10CFR20, pressurized buffer gas has been provided between the seals, both to minimize the amount of leakage and to detect whether one of the pair of seals has failed. This permits replacement of the failed seal prior to an increase in seal leakage.

In addition to the above items, a survey was conducted prior to the initiation of conceptual design, to review past experience of fuel handling systems on sodium cooled reactors, both fast and thermal. This review indicated that the majority of the radiation exposure from refueling system operation was due to either leakage of radioactive gas through seals or contamination of equipment. Contamination is primarily due to sodium drippage, the making and breaking of connections between the movable machines and access parts, such as in the reactor or spent fuel storage tank. To minimize the amount of radioactive gas leakage, double seals are provided as described previously.

To reduce the potential for radiation exposure due to sodium contamination, a number of design features have been incorporated into the design of the EVTM, core component pot, and floor valves. These features will minimize the amount of sodium drippage, eliminate splashing of dripping sodium, localize the collection of drippage to specified locations, and minimize the potential for release to the outside environment.

The design features to accomplish the above objectives are as follows:

a. A siphon has been added to the core component pot to reduce the level of sodium so that when the pot is lifted into the EVTM, the sodium will not overflow from either thermal expansion or sloshing.

b. The exterior surface of the core component pot has been designed without protuberances which could cause splashing due to sodium run-off from external wetted surfaces.

c. The EVTM design incorporates drip pans to collect any sodium drippage from the core component pot. The capacity of these pans is several times greater than the total drippage expected during one complete refueling.

d. The floor valve port hole is provided with a chamber at its upper surface and has no protuberances. Both features faciliate run-off of potential sodium drops to the liquid sodium containing facility underneath. The potentially contaminated area and volume between floor valve and equipment mating to it are minimized, and the interface purged before decoupling, to dispose of any contaminated gas.

In combination, the above features will reduce, to as low as is reasonably achievable, the amount of contamination reaching the outside environment from the interior of refueling machines and reactor system or storage facility.

7. In-service Inspections - The CRBRP in-service inspection program is discussed in PSAR Section 5.3.2.1.3. The principal emphasis in the program is placed on visual condition inspection. Remote viewing capabilities are being developed to permit viewing the primary coolant boundary in the PHTS cells and pipeways. This will include the ability to view the annuli between an IHX or pump and its respective guard vessel.

The radiation exposure due to visual in-service inspection will be low. This is based on the following information:

a. The optical and cell inspection equipment for visual inspection will be designed for service in an operating PHTS cell. The radiation protection afforded by the system will be consistent with the requirements of 10CFR20 and ALARA.

b. The inservice inspections will normally be scheduled to coincide with refueling periods to allow for decay of the Na^{24} activity.

The outer surface of the reactor vessel and nozzles, and the inner surface of the reactor guard vessel welds will be inspected using surveillance and in-service inspection (SISI) equipment. The in-service inspection equipment for the reactor vessel/guard vessel annulus consists of a TV camera, transporter, and cabling to provide for cooling and appropriate electrical interfaces.

The camera is mounted on a transporter which moves in the annulus between the reactor vessel and guard vessel (See PSAR Section 5.2.4.5). This inspection will be carried out during reactor shutdown.

The personnel radiation exposures associated with a reactor vessel inspection using the SISI will be from shutdown radiation sources present at the operating floor adjacent to the SISI entry ports. The dose rate from these sources are anticipated to be nearly background.

The remote viewing methods being developed to perform in-service inspections will provide features to minimize the radiation exposure.

8. Control Rod Drive Removal Operations - Removal of the control rod drivelines (for inspection, replacement, storage) from the reactor vessel introduces a highly radioactive source into the Head Access Area. Radiation analysis were performed to establish shielding requirements during CRDL maintenance operations and to pinpoint potential problem areas requiring special radiation control procedures.

One analysis was performed to define the radiation environment and shielding requirements for CRDL transit through the HAA. The analysis indicated the HAA would be a high radiation area during CRDL transit, which resulted in the establishment of the HAA as an exclusion area during the transient period. Shield thickness requirements were established for CRDL transit to control general area radiation levels within design limits consistent with the ALARA objective.

An analysis was performed to determine radiation levels during manual disconnect operations at the storage pit locations. These operations require close access to the CRDL and could result in high exposure levels unless appropriate radiation controls are implemented. The assessment of decay time effects and the impact of fission/corrosion product plate out on CRDL surfaces identified potential radiation control problems and established guidelines to minimize radiation exposure levels. A seven day decay time at the storage pits was estimated for CRDL manual disconnect operations in order to minimize personnel exposure levels.

The impact of cover gas on CRDL maintenance operations was also evaluated. To provide ALARA exposures, gas purges inside the CRDMs will be maintained for as long as several days following plant shutdown. The purge will reduce the cover gas leakage to the HAA by maintaining the raw cover gas elevation below the top of the closure head.

9. <u>Maintenance Work on Large Equipment</u> - The plant arrangement for CRBRP has been developed to minimize the need to maintain equipment located within cells containing primary sodium systems. For example, continuous access is provided to the primary pump motors because their cells do not contain any primary sodium. Thus, all normal maintenance activities on primary pumps can be performed in a low radiation field under controlled conditions.

The intermediate heat exchangers (IHX) are accessible for inspection and tube plugging by removal of the circular hatch above the IHX upper dome. Provisions have been made to provide up to 3 inches of lead shielding around the working area adjacent to the IHX. This will effectively attenuate the radiation from the sources in the piping and the pump adjacent to the pit containing the IHX.

The auxiliary liquid metal systems are arranged to minimize radiation exposures during maintenance and normal operational occurrences by the use of the following design features: a) shielding, b) redundancy in key components with each component located in a separate cell, c) by using reach rods or remote actuators on valves for this equipment, and d) locating associated non-radioactive components in low radiation cells.

A typical example of this design approach is in the arrangement of the E.M. makeup pumps of the overflow system. These pumps are located in individual cells with no other equipment, the valves are located in an adjacent valve gallery, the power conditioning equipment is located in a third cell, and the control panels are located in a cell having routine access during normal operations.

Access to cells containing radioactive sodium is required only when equipment has failed. Routine monitoring is conducted remotely. The number of minor failures will be reduced by having redundant instrumentation on highly radioactive components. Another design feature which reduces required access is the tank liquid level instrumentation which is designed to be replaced through a removable plug in the cell wall.

When significant equipment failures do occur, personnel exposure is minimized by allowing the Na^{24} activity to decay to minimal levels before entering the cell, and by isolating and draining equipment in the cell, when possible. Equipment is arranged in cells to provide straight pipe lengths sufficient to expedite cutting and welding. Use of removable modular insulation with heaters is provided to minimize maintenance time.

When a major component (primary pump, primary check valve, certain non-core reactor internals or fuel handling equipment) requires major maintenance, provisions are being provided for the removal and subsequent cleaning in the Nuclear Island General Purpose Maintenance Equipment System. Key facilities in this system contain design provisions which are included for the purpose of keeping man rem exposures ALARA. Provisions for each key facility are:

LARGE MAINTENANCE STAND

a. The stand is designed with a containment bagging cover to control the atmosphere in the work area and with an air lock entrance way to prevent spread of radioactivity from stand.

b. Bagging and packaging capabilities are provided for component handling to minimize hands-on contact and prevent spread of radioactivity.

c. Life support and respirator protection systems are provided for maintenance personnel working within the LMS.

LARGE COMPONENT CLEANING VESSEL

a. System operations are controlled from a Zone I area with access to the vessel and cell; access to a Zone III areas is limited to periods when cleaning operations are not in progress.

b. Entry to the cleaning vessel prior to or following cleaning a component requires a sequence of operations. Prior to entry the vessel walls are cleaned by a rinse solution. The contamination level of the walls will be determined from the specific activity in the rinse solution. This operation will be repeated until sufficient reduction in levels is achieved. The N_2 which may contain airborne radioactivity will be vented to the H&V system and released consistent with plant technique specification. The inert atmosphere will be replaced by air. The in-vessel atmosphere will be checked by suitable monitors to assure ALARA, airborne radioactivity and sufficient oxygen levels for personnel entry.

c. Components introduced into the vessel will be in bags or casks to minimize operator exposure and contamination during handling.

d. Floor valves and adaptors will be used for transfer of components into the vessel when required.

GENERAL PURPOSE HANDLING EQUIPMENT

a. Equipment used for non-routine maintenance operations, e.g., removal of PHTS primary pump internals, check valves, cold traps, EVST cold trap, and reactor internals will include shielded casks, shielded floor valves and floor adaptors, portable auxiliary shielding, and a portable control console to remotely operate floor valves and casks.

DECONTAMINATION FACILITY

a. The facility is divided into three rooms, consisting of an entrance chamber (air lock), a wash vault, and a decontamination bay. Each room can be isolated from the other rooms.

b. The interior of the rooms will be of sheet metal or finished with a smooth non-porous coating to minimize entrapment of contaminated airborne particles.

c. The H&V system provides for isolation of the atmospheres in each of the three rooms. Air filtration and flow patterns are directed away from doors and ceiling access ports to prevent spread of radioactive particles.

d. Floor drains and recessed removable floor rails, with drains in recesses, are provided for decontamination and minimize the potential for spread of radioactivity.

e. Bridge cranes are provided in the wash vault and decontamination bay to minimize hands-on contact during disassembly prior to decontamination.

f. Bagging capabilities are provided for items after decontamination and prior to transporting.

g. Viewing windows are provided to all facility enclosed spaces to provide visual inspection from outside the facility and enhance operational safety.

h. Life support and respiratory protection systems are provided for personnel entry to the facility in the event of a radioactive atmosphere.

Question 331.5

Specify the design basis radiation level in the hot laboratory and in the counting room during normal operation and anticipated operational occurrences. Describe the facilities such as hoods, glove boxes, filters, special handling equipment, and special shields related to the use of sealed and unsealed special nuclear, source and by-product materials.

Response:

The hot laboratory and counting room are located within the radiological restricted area of the plant services building. The radiation zone for these facilities is Zone 1, which limits the radiation level to 0.2 mrem/hr or less. There are no significant sources of radiation in adjacent areas of the plant services or reactor service building during normal operation, which will be detectable in the hot laboratory or counting room facilities. The radiation level will be controlled by the size and nature of the radiochemical sources. The samples will be shielded, allowed to decay, or limited in mass (i.e., source intensity) to control the radiation levels within the facility zoning criteria.

Both the hot laboratory and counting room are approximately 40' x 18' in size and equipped with regulated power, air, gas, and water utilities as required. Air and gases from the vacuum pump will be vented through HEPA filters to the plant ventilation exhaust system. The ventilation exhaust from the hoods and the laboratories will be vented through HEPA filters and a charcoal filter.

Special equipment in the hot laboratory is as follows:

1. Shielded glove box - to be used for radioactive sodium work. The glove box will be connected to a nitrogen gas source for inerting. The shielding should be at least four inches of steel. No water should be allowed into the glove box. The working area inside the glove box will be less than a 4' x 4' area. A Mini-Manip master slave manipulator will be installed in the glove box.

2. Shielded sample storage cave - is used for temporary storage of radioactive samples. The wall thickness will be not less than 12" of steel.

3. Oven - dual purpose vacuum ovens which are used for drying either under vacuum or drying under standard atmosphere conditions. The maximum temperature will be limited to 400°F. The inside dimension of the ovens is at least 12" diameter by 12" deep.

4. Hoods - three hoods are provided (fume, isotope, and safetrol). The exhaust of each hood is filtered by HEPA and charcoal filters to restrict laboratory radioisotopic releases.

Several sources will be required for the calibration of the counting room equipment and other permanently installed monitors in the plant. The gamma sources are anticipated to be small sources requiring only "hand held" portable shields. A portable neutron source cask will be available to transport a neutron source (<5 curie) required to calibrate delayed neutron monitors. This portable shield will be 36" in diameter and contain borated polyetheylene as the shield material.

Question 331.6 (12.1.3)

Describe the review process with regard to approval of field run piping which carries or may carry radioactive materials. One goal of the review should be to assure that occupational radiation exposures will be as low as practicable. In the description of the review, show clearly how this goal is achieved. Assurance should be provided that drawings showing the desired routings will be issued to the field prior to fabrication and installation, and that subsequent changes to the proposed routing by field personnel will require review and approval by the onsite health physicist or shielding engineer or other appropriately qualified individual, to assure that unnecessary or unacceptable radiation exposure will not result.

Response:

Piping carrying radioactive materials will not be field run. A fully staffed field QA program at both the contractor level and owner level will ensure that the piping is run according to the home office drawings. Engineering site personnel are limited, in writing, in the type of changes they are permitted to approve in the field. All other changes, which include piping carrying radioactive materials, must be approved in the home office.

Revisions to this pipe routing will require review and signoff by the A/E Shield Design section.

Question 331.7 (12.1.2)

Indicate on the plan drawings (Fig. 1.2 and/or 12.1) locations of all significant sources, and typical or proposed locations of area monitors, airborne radiation monitors, and fixed particulate sampling stations identified in Tables 12.1-43, 12.2-3 and 12.2-34.

Response:

The plan drawings shown in Figures 12.1-2 through 12.1-19 entitled,
"Plant Radiation Protection" have been updated to illustrate proposed
area and airborne radiation monitors. The new set of "Plant Radiation
49 | Protection" drawings now are number Figures 12.1-1 through 12.1-19d. Note
that the fixed particulate sampling stations have been replaced by portable
air sampling units, as described in the updated Section 12.2.4 writeup.
Since the portable air sampling units will be located by the site Health
Physicist, they are not shown on the revised "Plant Radiation Protection"
drawings. Location of the area monitors and continuous air monitors are
49 | identified on Tables 12.1-48 and 12.2-3. Table 2.2-3A has been deleted
since fixed particulate samplers are no longer being used.

Question 331.8 (12.1.4.3, 12.2.4.3)

Describe the general nature of proposed calibration procedures, and discuss the approximate expected calibration frequencies for the various monitoring devices.

Response:

Descriptions of the proposed calibration procedures and frequencies are given in revised Sections 12.1.4.3 and 12.2.4.3.

Question 331.9 (12.2)

Discuss provisions in the design of the ventialtion system with respect to:

a. How filter housings are designed such that filters can be changed with as low an exposure as practicable and with minimum spread of radioactivity.

b. What provisions will be made for installation of temporary flexible ducting to site of maintenance and repair activities which may result in airborne activity levels.

c. Provisions in the design of the ventilation system arrangement of supply and exhausts with respect to maintaining radioactive airborne contamination concentrations in areas occupied by personnel as low as practicable.

Response (a):

The response to this question is provided in the response to Regulatory Position 2j and 4a, of Regualtory Guide 1.52 given in Table 6.3-1, "Conformance of the Control Room Filtration System With Respect to Each Position of USNRC Regulatory Guide 1.52".

Response (b):

The response to this question is incorporated in revised Sections 9.6.2, "Reactor Containment Building HVAC System" and 9.6.3 "Reactor Service Building HVAC Systems".

Response (c):

The requested discussion is provided in revised Section 12.2.2. 25

Question 331.10 (12.2)

Provide ventilation system diagrams which show the location of the airborne radioactivity monitors with respect to sources of airborne contamination and ventilation system filters. Include identification of all inflow and outflow points on a cubicle-by-cubicle basis. Label all flow rates, rooms, and points of airtransfer from floor-to-floor. Be sure to indicate the location, type, and dilution of all monitors and the flowrates of the normal containment clean-up system.

Response:

The revised HVAC system P&IDs, indicating the ventilation system filters and the airborne radioactivity monitors are presented in Figures 9.6-1
49 through 9.6-15 and in Sections 9.6.1, 9.6.2, 9.6.3, 9.6.5 and 9.6.6.

The plan drawings shown in Figures 12.1-1 through 12.1-19, entitled "Plant Radiation Protection", have been updated to illustrate proposed area and airborne radiation monitors. The new set of "Plant Radiation
49 Protection" drawings are provided in Figures 12.1-1 through 12.1-19d.

The detailed HVAC system air balance, including supply and exhaust flow rates, infiltration and/or exfiltration flow rates and the location of the air transfer points, on a cell by cell basis, will be presented in the FSAR.

Question 331.11 (12.2)

Discuss any relative air pressure gradients between buildings in the complex which may cause airborne radioactivity to flow from one building to another.

Response:

The requested discussion is provided in revised Section 12.2.2. 25

Question 331.12 (12.3)

Discuss the means to be used to monitor airborne radioactivity in each area (fixed ventilation system monitors, portable continuous monitors, routine surveys, grab samples prior to entry, other). Provide the basis, models and assumptions used to establish the adequacy of the monitoring method in each area.

Response:

The airborne radioactivity monitoring provided for the CRBRP is described in detail in revised Section 12.1.4 and Section 12.2.4. The general design criteria and philosophy, as well as specific monitoring/sampling provisions are discussed in that section. 8

Figure 12.1-21 has been modified to indicate data recording by the Plant Data Handling and Display System instead of by strip-chart recording, and to eliminate buffers in the monitor circuitry. Figures 12.2-1 and 12.2-2 have been modified to indicate the revised data recording provisions.

Question 331.13 (12.3)

Describe administrative and physical measures that will be used to control access to radiation zones above level II. Indicate on plant layout diagrams the areas within the plant to which access will be controlled and the points of access. Indicate which areas or cubicles will receive what kinds of barriers (doors, ropes). Describe how workers who are untrained or unescorted, or who have no need to enter controlled areas, will be denied access to those controlled areas.

Response:

Under normal operational conditions all areas with radiation zones greater than level II are located in the Reactor Containment Building, Reactor Service Building including the Radwaste Area and the Intermediate Bay. Access to the Intermediate Bay areas is through floor hatches requiring removal of shield plugs or through locked doors. All access to the Reactor Service Building and Reactor Containment Building is through the door located between lines R4 and R5 on line RA on PSAR figure 1.2-11. All areas exceeding 100mRem/hr (level IV and V) will have access restrictions per 10CFR20 Section 20.203. Access to High Radiation Areas will require Special Work Permits. All level III zones will have access restricted by zoning and barricading per 10CFR20 requirements for Radiation Areas. Level II areas and areas adjacent to level III, IV, and V areas are zoned as Regulated Areas requiring radiological training and a need for entry for unescorted access. Only those personnel requiring unescorted access to the controlled access areas will receive radiological orientation training. The plant security system will control access to all plant areas as discussed in Section 13.7.

Question 331.14 (12.3)

Describe the space available for the necessary office activities (report writing, library work, record-keeping, etc.) of the proposed 6-person health physics staff (Fig. 13.1-1), aside from the one 2-person office shown in Fig. 1.2-32.

Response:

The 6-person health physics staff (Figure 13.1-1) is intended to perform routine functional operations such as expediting work assignments, supplying special protective equipment, performing laboratory work, conducting general and specific plant surveys, and overseeing the safety of personnel working at specific work stations in contaminated areas on special work permits. All routine record-keeping involved in these activities will be handled by the 6-person health physics staff through the use of log books, standard survey forms, simplified recording forms, etc. These records will be maintained by both the 6-person health physics staff and the clerk assigned to both the health physics laboratory and office.

To reduce the necessary record-keeping required of such a staff, only active files will be maintained in the health physics area. Non-active records will be placed in the QA records center (see Figure 1.2-32).

During times of special report writing, temporary use can be made of the Lunch-Assembly room and/or the conference room. A small active library of health physics handbooks and reference material (books, trade journals, etc.) can be accommodated in the health physics office. Support library facilities are available through the central TVA staff located offsite.

Question 331.15 (12.3, 13.1.3.1)

Discuss how the provisions of Regulatory Guide 8.8 and 8.10 are to be met in the selection of health physics personnel, as well as those of Regulatory Guide 1.8 and Section 4 of ANSI N18.1. Identify a position in the plant organization with explicit responsibility and authority for ensuring that exposures are ALAP. The individual in that position should be directly responsible to someone at a high management level and should have significant experience in power reactor health physics.

Response:

Information regarding health physics personnel and the provisions of
49 Regulatory Guides 1.8, 8.8, 8.9, and ANSI N18.1 is provided in Sections
12.3.1 and 12A.3.2.

Question 331.16 (12.3)

Describe the expected personnel traffic pattern through the facility particularly through the health physics, laundry, locker room complex. Describe how the controlled access openings throughout the plant will control personnel flow. Describe what provisions are made to assure that radiation levels from the decontamination room and laundry rooms will not interfere with low level monitoring in the health physics area.

Response:

49 Information regarding personnel traffic is provided in detail in Section 12.3.2.

Question 331.17 (12.3)

Provide estimates of expected man hours of occupancy for the plant radiation areas and for areas with expected airborne radioactivity concentrations during normal operation and anticipated operational occurrences.

Response:

Estimated expected man hours of occupancy for the radiation areas in the plant is incorporated in new Section 12.3.4 and new Tables 12.3-3 and 12.3-4. 25

Question 331.18 (12.3)

Provide the criteria for selection of portable and laboratory technical equipment and instrumentation for performing radiation and contamination surveys, for airborne radioactivity sampling, for area radiation monitoring, and for personnel monitoring during normal operation, anticipated operational occurrences and accident conditions. Describe the instrument storage, calibration, and maintenance facilities. Describe the health physics facilities, laboratory facilities for radioactivity analyses, protective clothing, respiratory protective equipment, decontamination facilities (for equipment and personnel) and other contamination control equipment and areas that will be available. Indicate whether, and if so how, the guidance provided by Regulatory Guides 8.3, 8.4, and 8.9 has been followed or describe the specific alternative methods used. Describe storage locations for respiratory protective equipment protective clothing, and portable and laboratory technical equipment and instrumentation.

Response:

The criteria for selection of monitoring and laboratory equipment is contained in the following Tables:

1. 12.3-1, Typical Portable Health Physics Equipment
2. 12.3-2, Typical Health Physics Laboratory Equipment
3. 12.3-5, Personnel Protection Monitors - Area Monitors
4. 12.3-6, Personnel Protection Monitoring - Continuous Air Monitors

49 Additional information is provided in Section 12.3.

Question 331.19 (12.3, 9.1.3.1.4, 10.4.2.4)

Provide estimates of total man-rem doses expected to result from routine and in-service inspections and from transfer of spent fuel. Identify approximate expected dose rates and annual man-hour requirements.

Response:

The CRBRP in-service inspection program is discussed in PSAR Section 5.3.2.1.3. The principal emphasis in the program is placed on visual condition inspection. Remote viewing capabilities are being developed to permit viewing the primary coolant boundary in the PHTS cells and pipeways. Revised Section 12.1.5 provides the information requested. 25

Question 331.20 (12.3)

Describe in detail procedural and other controls that would prevent the spread of radioactive contamination from the Reactor Service Building to the cold laboratory and counting room (Figure 1.2-46), and the office areas. Justify placement of the hot laboratory adjacent to the counting room, and the existance of a direct corridor to the office area, apparently not requiring passage through the change area.

Response:

Additional information responding to this question is provided in revised sections 12.1 and 12.3. 33

33 | 50

Question 331.21 (12.3)

In addition to the information to be supplied in response to item 331.19, provide estimates of total man-rem doses expected to result from operations, maintenance, and radwaste handling.

Response:

Estimates of man-rem doses for CRBRP from operations, maintenance, and radwaste handling are provided in revised Section 12.1.5. 25

Question 331.22 (12.1, 12.2)

Your answer to item 331.1 is incomplete. Provide a copy of the material in TVA's General Release Manual pertinent to assuring that occupational radiation exposures are low as is reasonably achievable (ALARA). It is not clear that principal responsibility as applicant, and later as licensee and plant operator, will always reside with TVA. Therefore, provide in 12.1.1.2a and 12.2.1a of the PSAR, a statement of management policy to assure that radiation exposures to plant personnel will be kept ALARA. If the provisions of Regulatory Guides 8.8 and 8.10, to the extent that particular provisions apply to the design and operation of CRBRP, will not be followed, describe specific alternative approaches to be used.

Response:

Response to this question has been provided in revisions to Sections 12.1.1.2 and 12.2.1 and in Appendix 12A (new).

Question 331.23 (12.1.3)

Include a discussion of the extent to which you will use high temperature/high flow rate filtration, low Co-59 primary coolant surfaces and reduced stellite in contact with the primary coolant.

Response:

The response to this question is in three parts as follows:

A. Filtration - High temperature/high flow rate filtration of the primary sodium will be accomplished prior to initial core loading. Purification of the primary sodium by filtration is not incorporated into the plant design for use during power operations.

   Core special assemblies will be inserted into normal core, control, and radial blanket assembly positions prior to fuel loading to filter any undetected or fine construction debris from the primary sodium. Filtration will be accomplished at the plant expected mass flow rate and temperatures of 400° - 800°F. The core assemblies will remove particles down to 104 microns.

B. Low Co-59 Materials - Stainless steel materials in the core assemblies, control assemblies, radial blanket assemblies, removable radial shielding, and upper internals have controlled Co-59 content defined in equipment specifications. The Co-59 level is limited by specification in component materials consistent with neutron flux level and expected material temperature. In the high neutron flux regions (core assemblies), the Co-59 limit is 0.05%. It is estimated that having nominal (<0.2%) Co-59 levels in materials outside of the regions designated above will increase the total Co-60 release by less than 0.25%.

C. Reduced Stellite Surfaces - The only Stellite identified for use in contact with the primary coolant is in the Cold Leg Check Valve as indicated in Section 5.3.2.3.3 and Table 5.3-6.

Question 331.24 (12.1.5)

For areas in which significant airborne concentrations of radioactive materials are expected, provide estimates of the concentrations, man-hours of occupancy in each such area, and estimated man-rem doses.

Response:

No area within the plant is an "airborne radioactivity area" as defined by paragraph 20.203(d) of 10CFR20. The head access area of the reactor containment building is the only area of the plant in which continuous (40 hours/week) exposure to the environment would result in a measurable exposure (100 mrem/year) due to airborne radioactivity. Therefore, the head access area is the only area addressed by this response.

The estimated concentrations of airborne radioactivity in the head access area is shown on Table 12.2-2 of the PSAR. The man hours of occupancy in the head area has been estimated as 220 man-hours/quarter. This estimate of occupancy includes head access area activities during periods of reactor operation, reactor shutdown and reactor refueling. (See NRC Question 331.17 for further details).

Based on this information, the upper limit man-rem dose due solely to airborne radioactivity is 0.21 rem/year.

Question 331.25 (12.2.4.1)

Continuous monitors on once-through ventilation (12.2-3) and on effluents (12.2-3a) are discussed in 11.4.2.2. Provide sufficient information about location, shielding, dilution factors from various compartments, background radiation levels, and detector and collector efficiency to demonstrate a capability to detect one MPC-hour (particulate or gas) in any compartment or area for which the monitors apply.

Response:

Section 12.2.4, Airborne Radioactivity Monitoring, describes overall monitoring for airborne radioactivity in the CRBRP. Sub-section 12.2.4.2, Monitoring System Description, provides operational descriptions of the various types of monitors to be used. The capability to detect one MPC-Hour in the applicable compartments and areas will be provided. The additional detailed information to demonstrate this capability is not currently available and will be included in the FSAR.

Question 331.26 (12.3)

The traffic pattern you describe in your answer to item 331.16, for personnel, through the HP laboratory to the locker room to the RSB, appears to apply only to men. Women can enter their locker room directly from the outside corridor, but not from the controlled corridor. Describe how comparable traffic flow control will be maintained for women.

Response:

49 Women traffic flow control will be maintained in the same manner as indicated for men (see Section 12.3.2.)

Question 331.27 (12.1)

Your response to item 331.2 is incomplete. Describe in detail the specific steps to be taken to follow the guidance given in Regulatory Guide 8.8 regarding the following provisions, and provide descriptions of specific alternative approaches to be used, to demonstrate that (Reference may be made to other chapters of the PSAR):

(1) equipment that may require servicing will be designed and located to minimize servicetime;

Response:

General service and access design criteria are included in overall plant design requirements. Features specific to individual systems are included in the system design requirements. Examples of overall plant service and access design criteria are as follows:

a. All components shall be made readily accessible and maintainable with a logical removal path. Provisions shall be included, where practicable, for isolating components to permit continued operation of the plant. Pad-eyes shall be stratigically located in radioactive cells for installation of portable shielding or for mounting pipe restraints or tooling.

b. The plant design shall be such that maintenance can be performed with adequate maintenance access for personnel and for required tools, and with minimization of scaffolding, rigging and portable shielding required to facilitate the work for both scheduled and unscheduled events.

c. Maintenance access for servicing and/or removal or replacement shall be provided for each component that is to be maintained.

d. Clearance shall be provided between adjacent components and structures for personnel access, installation and operation of tooling, and installation of temporary shielding. Overhead room shall be provided for equipment removal and replacement. The following represents specific maintenance envelope requirements:

   1) A nominal 3'-0" maintenance clearance space shall be provided for all major components and piping 24" and larger.

2) For in-service maintenance requiring cutting and re-welding of pipe, access space must be provided for manual and/or automatic cutting and welding equipment. The most restrictive clearance is expected to be for cutting the pipe. Specific access requirements as a function of pipe radial and axial dimensions have been developed for project use.

e. A minimum of 7'-0" clearance from the floor to any overhead obstruction shall be provided for all stairs, walkways and other personnel access ways.

Item 2: equipment and components requiring servicing will be designed to be movable to the lowest practicable radiation fields;

Response:

Wherever possible non-radioactive plant components are located in the lowest practicable radiation field as a part of the overall plant design criteria. The maintenance system design criteria provides for the removal and cleaning of several major components such as the PHTS primary pump and check valves. The response to Q331.4 discusses in detail the accessibility and removability of the following systems:

a. Liquid, Gaseous and Solid Radwaste

b. Closure Head Operations

c. Refueling and Fuel Handling Systems

d. Control Rod Drive Removal Operations

e. Maintenance Work on Large Equipment

Provisions have been made for remote removal of components from high radiation areas (Zones 4 and 5) to restricted areas (Zones 1 and 2). The design requirements for components within the reactor cavity require that all components shall be made as readily accessible and serviceable as practical. Equipment requiring inspection and maintenance shall be arranged to reduce the difficulty which might result from high radiation levels, high temperature sodium, sodium frost, and radioactive gas.

Examples of this design approach are the flux monitor equipment (source, wide range, and high level power detectors) which can be remotely removed from the reactor cavity, the liquid level detectors which can be remotely removed from the reactor vessel and overflow vessel, and the detectors in the failed fuel detection system in the PHTS cells.

Item 3: the best available valves, valve packing, and gaskets will be used to minimize leakage and spillage of radioactive materials;

Response:

The overall plant design criteria recognizes the importance of "best" grade components to minimize radiation exposure. Specifically, design-dictated maintenance will be reduced through application of fail-safe features, designating components which require little or no preventive maintenance and assigning tolerances which allow for use and wear throughout the equipment's useful life. The effects of redundancy requirements on maintenance of essential equipment shall be considered in the design selection process.

The specific problem related to valves is well recognized by all systems and discussed in the response to Question 331.4; parts 3 and 9.

The quality of the sodium valves is considered to be the "best available" because of the design criteria, construction standards, testing and QA requirements. It is a design objective that the valve assemblies require no maintenance for the valve service life.

The valves will be constructed in accordance with the requirements of Section III, Division 1 of the ASME Boiler and Pressure Vessel Code. The design pressure and temperatures are often higher than the actual service conditions. The valves will be tested to verify their design characteristics and to identify any inherent design problems. All valves will be part of a documented quality assurance program in accordance with Article NA-4000 of the Code.

Item 4: shield design specifications will limit void content;

The concrete shields will be constructed to minimize voids. Voids can be classified in two general categories: (a) those constructed in shields to accommodate equipment penetrations and required duct work, and (b) those which occur due to constructability difficulties. The first class is discussed in detail in Chapter 12.1 of the PSAR.

The plant constructability requirements, design, and quality control provisions are comprehensive and will limit the extent of unintentional voids. The following specific requirements reflect the quality control and design standards being used to accomplish this purpose:

a. Regulatory Guide 1.69 "Concrete Radiation Shields for Nuclear Power Plants" is a part of the overall plant design criteria. The guidance provided will be used in the design of the concrete shields.

b. The shield walls shall have the minimum rebar allowed by code.

c. All structural and shielding concrete shall be of high strength (4,000 psi).

d. High density concrete shall not be used unless absolutely required for a specific small area.

Where concrete shield walls are required, their continuous distributions will be assured by vibrating the concrete and by placing the concrete in 6 inch to one foot lifts during placement.

PSAR Section 12.1.3 discusses design basis which has been included in the shield design for possible shield wall irregularities.

Item 5: interior surfaces as well as the layout of ducts and pipes will be designed to minimize buildup of contamination;

Response:

Interior surfaces as well as the layout of ducts and pipes will be designed to minimize the buildup of contamination based on the guidance of Reference Q331.27-1.

Among these considerations for the HVAC design are the following:

Ducts and casings will be designed to minimize the sharp turns, protrusions, and crevices that can collect contaminates. Easily openable access doors will be provided at strategic and accessible locations in the ducts. 31

Casings, filter mounting frames and ducts will be able to withstand anticipated system pressures without distortion, fatigue, or yielding of such magnitude that inleakage or bypassing of the filters results.

Ducts will be sized for transport velocities needed to convey, without settling, particulate contaminates. Ducts and casings will be coated and/or painted with materials consistent with corrosion that can be expected in this particular application and with the size of the duct. Corrosion and radiation resistant paints and coatings, as a minimum will meet the requirements of ANSI N512 for "light exposure".

The following overall plant design requirements have been included to limit the number of undrainable locations:

Liquid-containing systems and/or components shall be designed to facilitate complete drainage. For components that cannot be completely drained by normal means, provisions shall be included in the design of the component to permit use of other liquid removal methods utilizing maintenance equipment. 31

The design of sodium-containing equipment and/or components shall minimize crevices and pockets which would make complete sodium removal difficult.

This requirement to limit sodium-containing pockets also serves to limit potential crevices for solids. It should be noted that LWR type "Crud" cannot exist in sodium mediums.

The ducts used for environmental control of cells having significant radiation sources are part of the Recirculating Gas Cooling System (RGCS). This system cools the cell atmosphere on a recirculating basis. If the cells require atmosphere changes, this venting will be routed through the CAPS system. The ducts for the RGCS are designed to permit the control of contamination. These ducts will not normally be contaminated by any significant radiation source except for noble gases released in the fuel handling cell and EVST. Associated cooling equipment located in unshielded areas can be removed for de-contamination without releasing atmosphere from the cells containing radioactive sources. However, the equipment is designed to be returned to service following the equivalent of a primary sodium spill which is estimated to yield an equilibrium sodium aerosol concentration of 1.0 μci/cc.

Item 6: movable shielding and convenient means for its utilization will be available for use where permanent shielding is needed but impractical;

Response:

The overall plant design criteria requires the following provisions for temporary shielding:

a. Radiation from sources within the cell shall be limited either by removal or by permanent or temporary local shielding as required.

b. As discussed in item (1) all components shall be made readily accessible and maintainable with a logical removal path defined and documented. Provisions shall be included, where practicable, for isolating components to permit continued operation of the plant. Pad-eyes shall be strategically located in radioactive cells for installation of portable shielding or for mounting pipe restraints or tooling.

c. As discussed in item (1) clearance shall be provided between adjacent components and structures for personnel access, installation and operation of tooling, and installation of temporary shielding. Overhead room shall be provided for equipment removal and replacement.

In addition the overall plant design criteria requires that in large areas, such as a primary heat transport system cell, portable or permanently 31
installed work platforms shall be provided as required for maintenance operations. These platforms can be used to support shielding and in special cases may be designed as a permanently installed maintenance shielding.

Item 7: remote handling equipment will be provided where it is needed and practical.

Response:

The overall plant design requires that each system consider the following:

> The logistics of all maintenance operations shall be considered, including; the paths all equipment must follow; the availability capacity, lift, and area coverage of handling devices; port and hatch size and locations; rotating and other special handling requirements; operator stationing with respect to safety and visibility; and requirements for pits or other temporary storage of transfer areas. Special equipment shall be identified as required by each system.

Examples of remote handling equipment are given in response to Question 331.4; Parts 1, 2, 4, and 9.

Reference:

Q331.27-1 ORNL-NSIC-65, "Design, Construction, and Testing of High-Efficiency Air Filtration Systems for Nuclear Application", Pg. 219, dated January, 1970. 33

Question 331.28 (12.1)

Your response to item 331.3 is incomplete. Provide addition information about members of the TVA ALARA Committee, and any other personnel who are responsible for radiation protection design review (item {c}, page 12A-3). Provide a tabulation for these personnel by position title, listing the number of years of health physics training and experience requirements for each. Describe arrangements to assure that such radiation protection reviews are performed throughout the design process and that adequate records are kept to document the completion of each such review.

Response:

The response to these questions are provided in Section 12A.

49

The third level of review is performed at the formal component design reviews and is consistent with the Project QA requirements. The radiation protection/shielding designers at each Reactor Manufacturer and the Architect Engineer participate in the appropriate reviews and must approve the shielding design of the component design before release.

The CRBRP ALARA reviews with the health physicists will be held at least twice a year through construction, and periodic system reviews will be conducted as described above. The first review meeting with the health physicists on the ALARA committee has been held and comments from the health physicists have been provided to the Project. These comments have been evaluated and in specific cases design changes have resulted, in the other cases, a response will be prepared for transmittal to the health physicists. ALARA review documentation will be maintained consistent with the standard Project correspondence and filing system.