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SCHWENCER,A. Licensing Branch 2

500 RPT

SUBJECT: Forwards response to Geosciences Branch 811201 questions. Response include addl question & two amended questions. All answers will be included in Amend 23 to FSAR.

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January 14, 1981
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Docket No. 50-397

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Schwencer:

Subject: NUCLEAR PROJECT NO. 2
GEOSCIENCES BRANCH QUESTIONS

Reference: Letter, A. Schwencer to R.L. Ferguson, "WNP-2 Request for Additional Information", dated December 1, 1981

Enclosed are sixty (60) copies of the responses to the remaining Geosciences Branch questions transmitted to the Supply System by the reference letter. These responses include the additional question and the two amended questions unofficially transmitted to the Supply System.

These responses will be included in Amendment 23 to the WNP-2 FSAR.

Very truly yours,

G D Bouchey

G. D. Bouchey
Deputy Director, Safety and Security

CDT/jca
Enclosure

cc: R Auluck - NRC
WS Chin - BPA
R Feil - NRC Site

B001
S1/00

b. At Finley Quarry:

Provide a further discussion of the faults in Finley Quarry including the criteria used to determine the non-tectonic origin of the irregularity at the base of the capping gravels over the Center fault, their capability in view of the evidence for repeated movement and the abstract by M.P. Cochran (Pac. NW. AGU, Sept. 1981) suggesting a 2.5-3.5 km extension of the Finley Quarry fault.

RESPONSE

Three faults were exposed during trenching at Finley Quarry. The faults strike, on average N60W to N70W. The north fault dips from approximately 40 to 70 degrees to the southwest; the center fault dips 60 to 89 degress to the southwest; and the south fault is nearly vertical. Striae directions range from plunges that are nearly vertical to those that plunge gently northwestward. All three faults show an up-to-the-southwest sense of stratigraphic displacement. Contacts between post-basalt sedimentary units within Finley Quarry are typically highly irregular. This is primarily the result of abundant cut and fill structures that exist between different stratigraphic units. Irregularities similar to the one mentioned in Question 360.15b are produced by cutting and filling and are present at a number of locations. Some examples are:

- On the contact between units m-3 and m-4 at approximately station 76.

- The contact between units m-5 and u-1 at approximately station 84.

- o The contact between units m-1 and m-3 and the overlying unit m-4 at approximately station 94.
- o The contact between unit u-1 and the enclosing unit u-2 (station 66-70).

Criteria used to distinguish irregular sedimentary contacts from tectonic displacements include:

- o The absence of displacements in underlying units
- o The absence of aligned clasts
- o The absence of thin fractures

The upper part of the center fault strikes N57-86W and dips 63 to 89 degrees to the south and southwest. The sense of displacement is up to the southwest. The irregularity mentioned in Question 360.15b consist of two steps in the unit u-1/unit m-1 contact. The steps lie between 10 inches and 2 feet northeast of the point where the center fault intersects unit u-1/unit m-1 contact. Both of these steps place the base of unit u-1 lower to the northeast, but neither puts unit m-1 above unit u-1. In addition, there is an absence of aligned clasts and fractures in unit m-1 adjacent to the two steps.

Color changes were locally present in the upper part of unit m-1 between stations 41 and 42. The boundaries are very discontinuous and they parallel the unit m-1/unit u-1 contact. Because of their discontinuous nature, these color boundaries are interpreted to be the result of oxidation of unit m-1 adjacent to the contact uith unit u-1.

The irregularities between stations 42 and 44 are interpreted to be the result of erosion that occurred prior to the deposition of unit u-1, but after deposition of unit m-1. This interpretation is based on the following observations:

- Unit m-1 does not rest on top of unit u-1

- There is an absence of fault related features within unit m-1 adjacent to the step

- Irregular sedimentary contacts are abundant within the sediments of Finley Quarry

The north and center faults are capped by unit u-1. This unit is at least 75,000 years old and may have formed during oxygen isotope stage 7, which lasted from 195,000 to 250,000 years B.P. (see response to Question 360.14). The south fault is only overlain by Holocene colluvium and Loess units.

The investigation of the Finley Quaryy fault by Cochran (1981; personal communication, 1982) provides no new information regarding the capability of this fault. Cochran ran magnetic and gravity profiles to trace the geologic structure and his data provide no information regarding the age of faulting in the post-basalt sediments.

Cochran (personal communication, 1982) states that his data suggest the top of basalt is displaced down to the northeast, as is the case in Finley Quarry. He is not sure of the total displacement, but believes it is less than 200 feet. The significance of the data from Finley Quarry to the capability assessment of faults along the Rattlesnake-Wallula alignment is discussed in the response to Question 360.14.

REFERENCES

Cochran, M.P., 1981, Abstracts for the Pacific Northwest Section, American Geophysical Union, September, 1981.

Woodward-Clyde Consultants, 1981, Logs of Trenches at Finley Quarry: Logs prepared for Washington Public Power Supply System Richland, WA.

360.19

Can a case for segmentation similar to that made for Umtanum-Gable Mountain (Golder Associates Inc., 1981) be made regarding other folds near the Pasco Basin, such as the Yakima Ridge fold? Discuss the bases for your response.

RESPONSE

The available data suggest that the folds of the Yakima fold belt are segmented. Evidence regarding the segmentation of each of the folds of potential significance to the site is presented in Section 3 of Appendix 2.5K.

Toppenish Ridge is the only Yakima fold that exhibits evidence of recent (late Quaternary) surface rupture. The relationship between the recent scarps and the geology of the folds was used to assess the significance of the geologically determined structural segments along the Toppenish Ridge anticlinal trend. The criteria for segmentation and the segmentation of Toppenish Ridge, which was not described in Appendix 2.5K because it is more than 50 km from the WNP-2 and WNP-1/4 site, are described below.

CRITERIA FOR SEGMENTATION

Segments are defined as portions of a structural zone that exhibit evidence of relatively uniform past behavior. Therefore, the recognition of segments allows the assessment of the style and location of future deformation.

Several criteria are used to segment the fold structures of the Yakima fold belt; these include:

1. Fold orientation. In some cases, abrupt changes in fold orientation may coincide with segment boundaries. In addition, the axail trace of some segments of the folds are convex northward in the direction of tectonic transport. In places, these arcuate parts are interpreted to represent individual segments.

2. Fold vergence. Many folds exhibit abrupt reversals in the direction of fold vergence along the strike of the anticline. This is commonly reflected in the topography by changes in the asymetry of the topographic expression of the folds. These changes in fold vergence coincide with segment boundaries.

3. Fold amplitude and character. Abrupt changes in fold amplitude and fold width may mark segment boundaries. Boundaries may also be characterized by a virtual absence of fold deformation, such as where two fold segments plunge and die out toward each other.

4. Age of folding. Segment boundaries are inferred where stratigraphic and geomorphic data may show marked differences in the age of the youngest folded geologic unit along the strike anticlinal trend.

5. Boundary faults. In places, segments are bounded by faults that strike at high angles to the anticlinal trend.

6. Geophysical signature. Along some of the folds, changes in the geophysical signature (e.g. gravity, aeromagnetics) along the strike of the anticline or anomalies along the anticline are interpreted to coincide with either changes in character of the folding or the absence of folding at the segment boundaries.

7. <u>Fault characteristics</u>. Where faults are associated with the folds, the characteristics of the faults are used to provide a basis for segmentation. These characteristics include:

- Changes along strike in fault dip direction
- Changes along strike in the amount and/or sense of fault displacement
- Continuity of faults along strike
- Stratigraphic and geomorphic evidence for changes along strike in the age of the most recent displacement

SEGMENTATION OF TOPPENISH RIDGE

Toppenish Ridge is a 95 km-long anticlinal structure that can be segmented on the basis of structural geology, stratigraphy and geomorphology. It is not characterized by a continuous fault along its entire length.

In general, Toppenish Ridge is a continuous anticlinal structure and the topography is directly related to structure (Bentley and others, 1980). Overall, the anticline plunges east and west from Satus Peak. Three distinct segments are defined on the basis of abrupt changes in the fold geometry. These changes coincide with the locations of mapped northwest-trending strike-slip faults that cut across Toppenish Ridge (Bentley and others, 1980; Campbell and Bentley, 1981). From east to west, the three segments of Toppenish Ridge are: the Hembre Mountain anticline, the Satus Peak anticline, and the Peavine anticline. The recent (late Quaternary) scarps investigated by Bentley and others (1980), Campbell and Bentley (1981), and Woodward-Clyde Consultants (1981) only occur along the Satus Peak anticline segment.

Characteristics Defining Each Segment

The Hembre Mountain Anticline is the shortest of the three segments. In general, it is a doubly plunging fold about 15 km long that trends N70E. In detail, it consists of about ten short fold segments that are bounded by north-to-northwest-trending cross faults (Bentley and others, 1980). To the east, it plunges beneath alluvium of the Yakima River; to the west, it is bounded by the northwest-striking right lateral strike-slip faults of the Mule Dry fracture system (Bentley and others, 1980). The Hembre Mountain anticline is also separated from the next segment to the west, the Satus Peak anticline segment, by a distinct bend in the trend of the ridge. The Hembre Mountain anticline has low angle dips compared to the Satus Peak segment. It is slightly asymmetrical having a steeper north flank. The fold is relatively unbreached by erosion and the surface is characterized by broad curving dip slopes.

The south-dipping Mill Creek thrust fault, which is concealed beneath Quaternary alluvium, occurs along the north flank of the Hembre Mountain anticline and the north-dipping Oak Springs thrust fault is mapped in bedrock along the western portion of the south flank (Bentley and others, 1980). The youngest deformation is reported to be pre-Quaternary (Bentley and others, 1980).

The Satus Peak Anticline, which forms the middle segment of Toppenish Ridge, is about 30 km long. Scarps which suggest there has been recent (late Quaternary) surface rupture, occur along this segment for a distance of about 24 km. The segment is arcuate, and convex to the north. The general trend of the segment is about N80E. The fold consists of a single, box-shaped, east-plunging anticline that is somewhat asymmetric having a steeper north flank. The amplitude of the fold increases toward the west. The eastern end of the anticline

plunges steeply eastward. The segment boundary coincides with an abrupt change in the trend of the ridge and with the northwest-trending strike-slip faults of the Mule Dry fracture system. The western end of the anticline is bounded by northwest-trending lineaments near Satus Peak that are interpreted by Bentley and others (1980) and Campbell and Bentley (1981) to be right-lateral strike-slip faults of the Elbow fracture system.

The south dipping Mill Creek thrust fault, which is concealed beneath Quaternary deposits, occurs along most of the north flank. The north-dipping Oak Springs fault is mapped in bedrock along part of the south flank; it dies out to the west. The most recent deformation along Toppenish Ridge is confined to the Satus Peak anticline segment.

The Peavine Anticline is the westernmost segment of Toppenish Ridge. It is the longest segment and has a total length of about 50 km. The anticline trends from N70E to east-west. The anticline is asymmetric having a steeper northern limb. The western end of the segment is defined by a sharp southerly bend in the axis where the fold dies out. The eastern boundary is defined by the northwest-trending faults of the Elbow fracture system at Satus Peak.

The Mill Creek thrust fault is mapped along the eastern part of the segment. There are no thrust faults mapped along the south flank. The most recent deformation along this segment appears to predate the Pliocene Simcoe volcanics.

CONCLUSIONS

Toppenish Ridge can be divided into segments on the basis of bedrock structure, stratigraphy and geomorphology. These segments appear to be structurally distinct and the Quaternary deformation of Toppenish Ridge appears to be confined to the Satus Peak anticline segment. The segment boundaries coincide with the north-

west-trending strike-slip faults that crosscut the anticlines and intervening basins of the southwestern Yakima fold belt (Bentley and others, 1980; Campbell and Bentley, 1981). Campbell and Bentley (1981) suggest that confinement of the recent scarps to the Satus Peak segment is controlled by movement on the bounding northwest-trending strike-slip faults.

Sufficient data are available to segment Toppenish Ridge. The evidence of recent surface rupture is confined to the well-defined Status Peak Anticline segment of the Toppenish Ridge anticlinal trend. Although the Umtanum Ridge-Gable Mountain structural trend and other Yakima folds of potential significance to the site do not show evidence of recent surface rupture, these folds can be segmented (Appendix 2.5K) based on the criteria presented above. The relationship between the recent scarps along Toppenish Ridge to the geologically-defined structural segments of the ridge indicates that geologically defined structural segments of the Yakima folds can be used to assess the style and location of future deformation.

REFERENCES

Bentley, R.D., Anderson, J.L., Campbell, N.P., and Swanson, D.A., 1980, Stratigraphy and structure of the Yakima Indian Reservation with emphasis on the Columbia River Basalt Group: U.S. Geological Survey Open-File Report 80-200, 79 p.

Bentley, R.D., 1981, Magnitude of Neogene horizontal shortening in the western Columbia Plateau Washington - Oregon: Abstracts, EOS, v. 62, n. 6, p. 60.

Campbell, N.P., and Bentley, R.D., 1981, Late Quaternary deformation of the Toppenish Ridge uplift in south-central Washington: Geology, v. 9, p. 519-524.

Woodward-Clyde Consultants, 1981, Task D5 Toppenish Ridge Study: report prepared for Washington Public Power Supply System, Richland, WA, 33 p.

360.20(b)

Discuss the possibility that the fault identified on the southwest flank of the S.E. anticline (Pg. 2.5K-39 of Amendment 18) is a continuation of the north-dipping reverse fault identified at Gable Mountain, including in your discussion the bases for concluding that the S.E. anticline is not a continuation of Gable Mountain.

Response

An extensive set of data applicable to the southeast anticline and Gable Butte-Gable Mountain segments of the Umtanum Ridge-Gable Mountain structural trend is available from the many geologic and geophysical studies done in support of the WNP 1, 2, and 4, S/HNP, FFTF, and the basalt waste isolation project (see attached figure). It includes geologic maps; more than 50 borings; photogeologic, gravity, ground magnetic, seismic and aeromagnetic surveys; and more than 20 trenches.

The Gable Butte-Gable Mountain segments is distinguished from the southeast anticline segment on the basis of both geological and geophysical data. Gravity, magnetic, and surface mapping show that the Gable Butte-Gable Mountain segment trends approximately east-west. Gravity, aeromagnetic, and drilling data indicate a significantly different trend (N50^{o}W) for the southeast anticline. Gravity data also indicate that the southeast anticline extends about 1 mile to the northwest past the eastern end of the Gable Butte-Gable Mountain segment and is separated from the latter by a saddle in the gravity field which is interpreted to represent a structural depression in the top of basalt (see S/HNP PSAR Amendment 23, figure 2K-13).

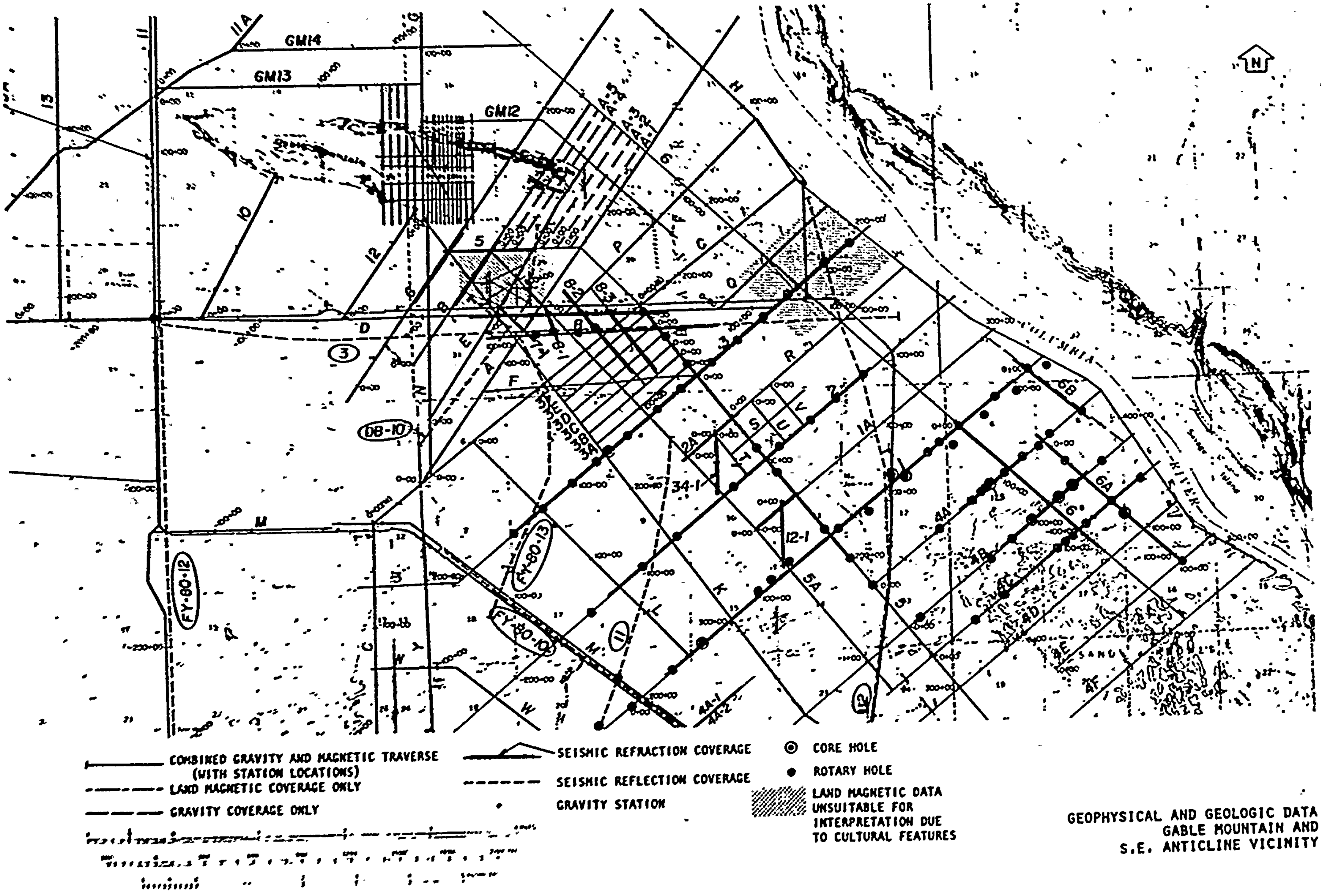
In addition, the two segments differ in structural style. The Gable Butte-Gable Mountain segment is a complex structure composed of an asymmetrical first order fold with superimposed asymmetrical second order folds of differing vergence. In contrast, the southeast anticline is a simple symmetrical fold with structural relief approximately 800 feet less than that of the Gable Butte-Gable Mountain segment.

Like other faults along the Umtanum Ridge-Gable Mountain structural trend, the north-dipping reverse fault on the south flank of the west anticline at Gable Mountain is considered to be associated with the formation of that fold. Therefore, the fault cannot be expected to extend beyond the length of the west anticline (see S/HNP PSAR Amendment 23, Appendix 2-O). The fault on the southwest flank of the southeast anticline has been positively identified only in boring 125 on Line 4A. There are some geologic and geophysical indications that the fault could extend along the flank of the anticline from Line 3 to Line 4B (see S/HNP PSAR, Amendment 23, Appendix 2-R, Section 5.3 and Appendix 2.K, Section 6.2.1). There is no basis for inferring the continuation of this fault to the northwest of Line 3.

The convergence of existing geologic and geophysical data lead to the conclusion that the north-dipping fault at Gable Mountain and the fault on the southwest flank of the southeast anticline are separate faults related to two distinct and separate segments of the Umtanum Ridge-Gable Mountain structural trend. On this basis and the basis of detailed geophysical data between the two segments, a fault between the southwest flank of the southeast anticline and Gable Mountain cannot be either directly interpreted or inferred.

References

Puget Sound Power and Light, 1981, Skagit/Hanford Nuclear Project, Preliminary Safety Report, Amendment 23, Puget Sound Power and Light, Bellevue, Washington.



GEOPHYSICAL AND GEOLOGIC DATA
GABLE MOUNTAIN AND
S.E. ANTICLINE VICINITY

360.22

Provide a complete discussion of the linear feature located at about the 900 foot contour of Rattlesnake Hill (R. 25, T11N, Walla Walla 2° sheet), the extent of mapping in the area (provide map on topographic base), an assessment of its capability and, if applicable, maximum earthquake potential, including bases for conclusions.

REPSONSE

The linear feature described in question 360.22 was reported by D.B. Slemmons during an aerial reconnaissance in early December, 1981. Dr. Slemmons described the feature as a series of back-facing scarps ranging from 1 to 3 feet in height trending from north-south to N20 - 30°W. The location was stated to be approximately one mile out from the range front on the alluvial fan whose apex lies approximately 5 km east of Snively Ranch (Section 11, R25E, T11N, Corral Canyon 15 minute quadrangle). The lineament occurs within sections 1 and 12 of R25E, T11N.

Detailed geologic mapping of the area that includes the lineament, was done by Shannon & Wilson (WNP-1/4 PSAR, Appendix 2R H, October 1977) but no such lineament is reported (op. cit., Figure 2RH.6-1). C.E. Glass undertook a remote sensing analysis (WNP-1/4 PSAR, Appendix 2RK, October 1977), but reported no lineaments within the alluvial fan described in Question 360.22.

Detailed geologic mapping of the area by Rockwell Hanford (1979) revealed no lineaments in the position described by Slemmons. In addition, the lineament is not expressed in the geophysics data (gravity and aeromagnetics), within the resolution of the geophysical techniques.

The feature can be identified on color aerial photographs (BPA-PSLG 6E-B-16 and -17; September 11-19, 1973) and on black and

white photographs (C.E.G. line 15A R-2, nos. 103 and 104; July 23, 1977) as a series of short discontinuous lineaments. The lineaments consist of an apparent alignment of short, relatively straight reaches of intermittent channels on, and adjacent to, the alluvial fan (see Figure 360.22-1). The trend of the lineaments is approximately N40W, approximately parallel to the axis of the Rattlesnake Mountain anticline. The overall length of the lineament defined by the aligned drainages is approximately 1.1 km. To the south, there is a linear tonal (vegetational) contrast on the color photographs that is about 0.5 km-long. If this is related to the aligned drainages, the total length of the lineament is approximately 1.6 km.

Similar alignments of drainage channels can be seen in many places along the northeast slope of Rattlesnake Mountain, but they are not generally as long as the one described above. There does not appear to be any displacement across either the vegetational tonal contrast or the linear elements defined by the aligned drainages. Because of the slope of the alluvial fan, the drainages that traverse this slope have asymetrical cross valley profiles and the eastern (downslope) sides of the channels are steeper than the western (upslope) sides. The one to three feet high scarps described by Slemmons are the steeper west-facing sides of these erosional channels.

The alignment of the erosional channels may be coincidental, or it may be along an old track, trail, or other man-made feature, which are common to the area. The lineament occurs in an area underlain by eolian silt and fine sand, Touchet deposits (about 13,000 years old), and Quaternary alluvial fan deposits. There are no bedrock outcrops mapped along any of the deeper drainages in the vicinity of the lineament. It is unlikely that the position of the lineament is controlled by the bedrock structure beneath the thick surficial deposits. Similar linear features in the vicinity of Warm Springs Canyon (Bingham's lineament) and on Umtanum Ridge have been investigated by Woodward-Clyde

Consultants (1981) and Golder Associates (1981) respectively. These investigations, which included trenching across these lineaments, showed that lineaments in similar deposits were produced by surficial erosion along man-made trails. Based on these observations, the lineament is not interpreted to be tectonic in origin.

If the lineament is assumed to be the result of faulting, the implications to the assessment of the maximum earthquake magnitude depend on assumptions regarding the association of the lineament with the Rattlesnake Mountain fault. If the lineament is assumed to be a seperate fault, its limited dimensions (total length 1.6 km) would indicate a maximum magnitude of less than 5-1/2 and is, therefore, insignificant to the site. If the lineament is assumed to be associated with the Rattlesnake Mountain fault the maximum magnitude assessment that was presented in response to Question 360.14 would apply. In that assessment, the Rattlesnake Mountain fault, is assumed to have a total length of 10 to 20 km, which significantly exceeds the length of the lineament. Therefore, the assumptions that the lineament is either a seperate fault or a part of the Rattlesnake Mountain fault has no effect on the estimate of the maximum earthquake magnitude on Rattlesnake Mountain structure.

REFERENCES

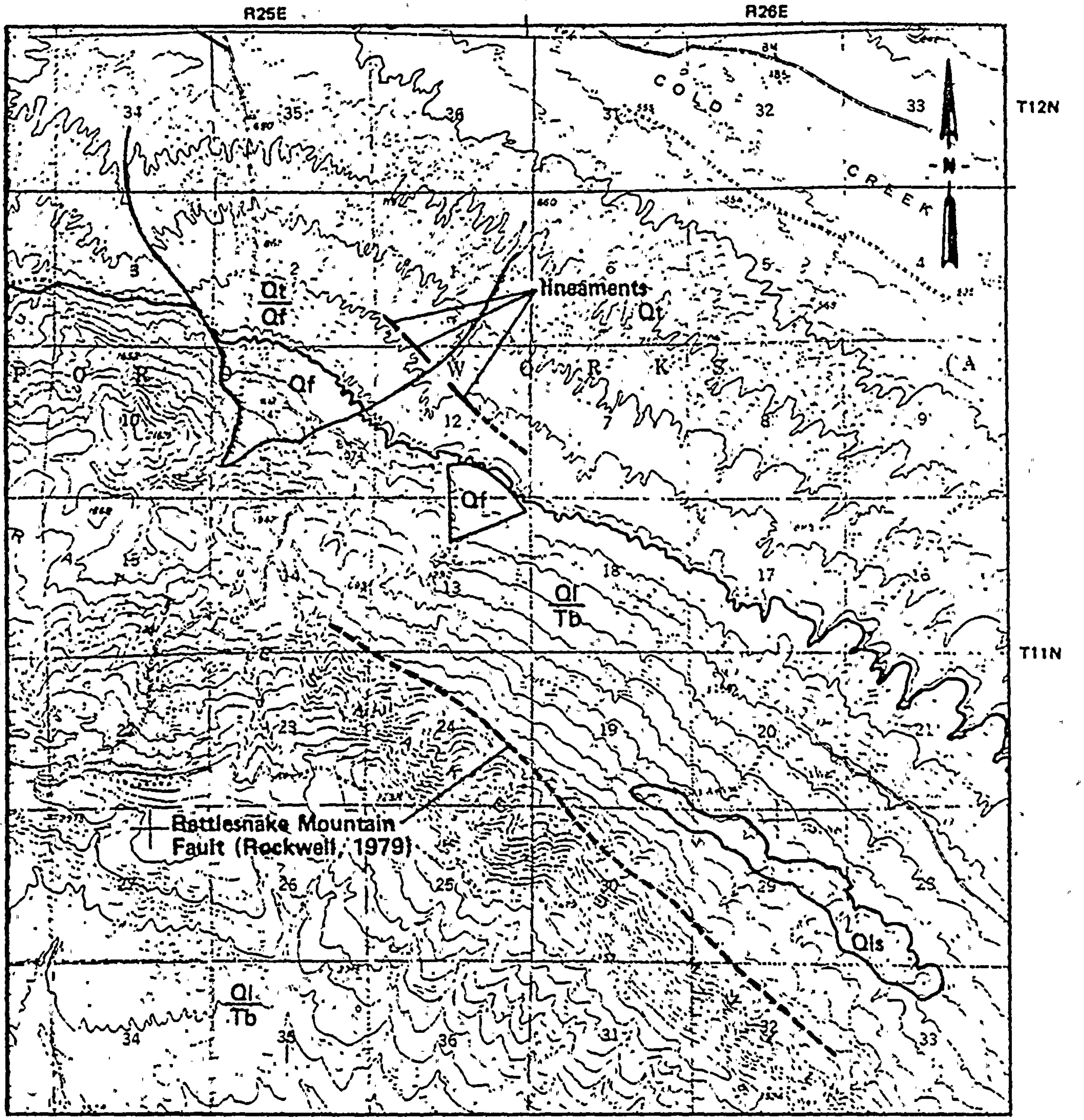
Kienle, C.F., 1977; in WNP-1/4 PSAR, Appendix 2R H, Chapter 6.

Glass, C.E., 1977; in WNP-1/4 PSAR, Appendix 2R K.

Puget Sound Power and Light, 1981, Skagit/Hanford Nuclear Project, Preliminary Safety Analysis Report, Amendment 23, Puget Sound Power and Light, Bellevue, WA.

Rockwell Hanford, 1979; Geologic Studies of the Columbia Plateau - A Status Report: Rockwell Hanford Operations, Richland, WA, RHO-BWI-ST-4, Geologic map sheet 7.

Woodward-Clyde Consultants, 1981, Wallula Fault Trenching and Mapping: Draft report prepared for Washington Public Power Supply System, Richland, WA.



LEGEND

Ql	Quaternary loess
Qt	Quaternary Touchet beds
Qf	Quaternary fan deposits
Qls	Quaternary landslide deposits
Tb	Tertiary basalt

(Base map taken from U.S.G.S. Corral Canyon 15 minute sheet, 2076 I)

For detailed geologic map see Rockwell, 1979, sheet 7

0 1 2
km

Project No. 14940	Hanford FSAR	LOCATION OF SLEMMONS' LINEAMENTS ON RATTLESNAKE HILLS, R25E, T11N	Figure 360.22-1
Woodward-Clyde Consultants			

361.16

Estimate the ground motion (including high frequencies) assuming a magnitude M_L = 4.0 (largest swarm event in the Columbia Plateau) occurred at a distance of 3 to 5 kilometers from the site. Compare the response spectra from this event to the SSE response spectra. Also, state your position on how large and close a potential swarm earthquake could come to the site.

RESPONSE

Until recently there has been a lack of recorded strong ground motions from small magnitude earthquakes at very close distances (3 to 5 km). Consequently, estimation of near field motions for small magnitude events by scaling recorded ground motions at greater distances has not been well documented. The large number of small magnitude strong motion recordings obtained during the recent aftershock sequences of the Imperial Valley, 1979, and Mammoth Lakes, 1980, earthquakes should aid in documenting estimation methods for near field motions. The Supply System is currently gathering and analyzing the newly available data in order to develope an estimate for the ground motions from a magnitude M_L 4.0 earthquake occurring at a distance of 3 to 5 km.

A preliminary estimate can be made for a distance of 10 km using recordings obtained during the Oroville, 1975 aftershock sequence.

Table 361.16-1 lists the 12 available accelerograms for magnitude M_L 4.0 to 4.1 Oroville aftershocks in the distance range 8 to 13 km on soil sites. Two of the recordings were obtained at the Johnson's Ranch station, which has been shown to exhibit a significant "ringing" at a frequency of 6 Hz due to a 10-meter thick layer of alluvium overlying bedrock. Figure 361.16-1 show the median, mean and 84th percentile response spectra computed using the twelve recorded motions. Also shown is the 0.25 g SSE design spectra (Regulatory Guide 1.60 spectra anchored to 0.25 g). (The WNP-2 plant has been analyzed and found to be adequate for the RG 1.60 spectra anchored to 0.25 g.) The statistical spectra are generally well below the design spectra, approaching the SSE only at high frequencies.

As can be seen in Figure 361.16-1, there is a large peak in the statistical spectra at a period of 0.17 seconds (frequency 6 Hz). The source of the peak is the recordings obtained at Johnson's Ranch. Figure 361.16-2 shows the effect of removing the four accelerograms obtained at Johnson's Ranch from the data set. The large peak at 6 Hz is removed and the over-all level of spectral acceleration is reduced.

The median and 84th percentile peak accelerations for the two data sets are tabulated below.

Data Set	Peak Accelerations (g) median	Peak Accelerations (g) 84th percentile
12 records (with Johnson's Ranch)	.10	.18
8 records (without Johnson's Ranch)	.07	.12

The severity of the ground motions from small magnitude earthquakes can be evaluated by comparing their frequency and energy content and significant duration with the frequency and energy content and significant duration of motions recorded during the 1971 M_L 6.4 San Fernando earthquake.

Figure 361.16-3 shows a plot of peak acceleration vs. total energy content (measured by the square of the acceleration integrated over the duration of shaking) for the M_L 4.0 - 4.1 Oroville recordings at 8-13 km and soil site recordings from the M_L 6.4 San Fernando earthquake at distances of 24-27 km. For comparable levels of peak acceleration, the energy content of the Oroville recordings is an order of magnitude lower than the San Fernando recordings. This is due in large part to the short duration of shaking. The significant duration (defined as the time required to transmit 90% of the energy content of the accelerogram) ranges from 1 to 3 is seconds for the Oroville recordings as compared to from 15 to 25 seconds for the San Fernando recordings.

The frequency content of the recordings can be examined by passing the accelerograms through a band pass filter having corners at 1 Hz and 9 Hz. The effect of filtering on peak acceleration and energy content is tabulated below.

Recordings	Average Percent Reduction In: Peak Acceleration	Average Percent Reduction In: Total Energy Content
M_L 4.0 - 4.1 Oroville	35%	45%
M_L 6.4 San Fernando	5%	30%

These results indicate that nearly half of the energy content of the small magnitude recordings is at frequencies greater than 9 Hz.

The maximum magnitude associated with shallow seismicity that can be expected to occur within the Columbia River Basalts in close proximity to the site is approximately M_C 3.0 (Appendix 2.5J).

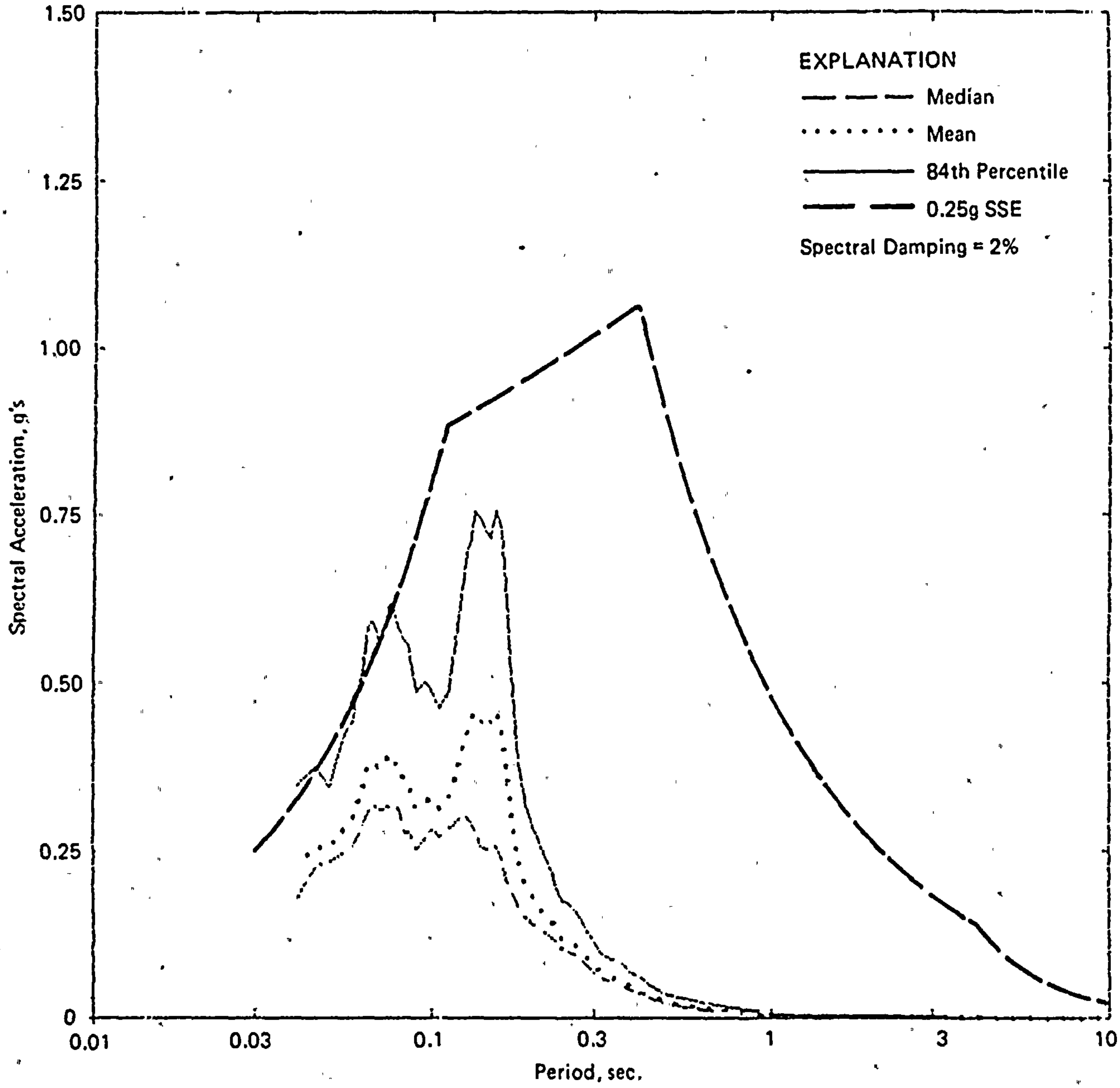
TABLE 361.16-1

Oroville Accelerograms M_L 4.0 to 4.1, R = 8 to 13 kilometers

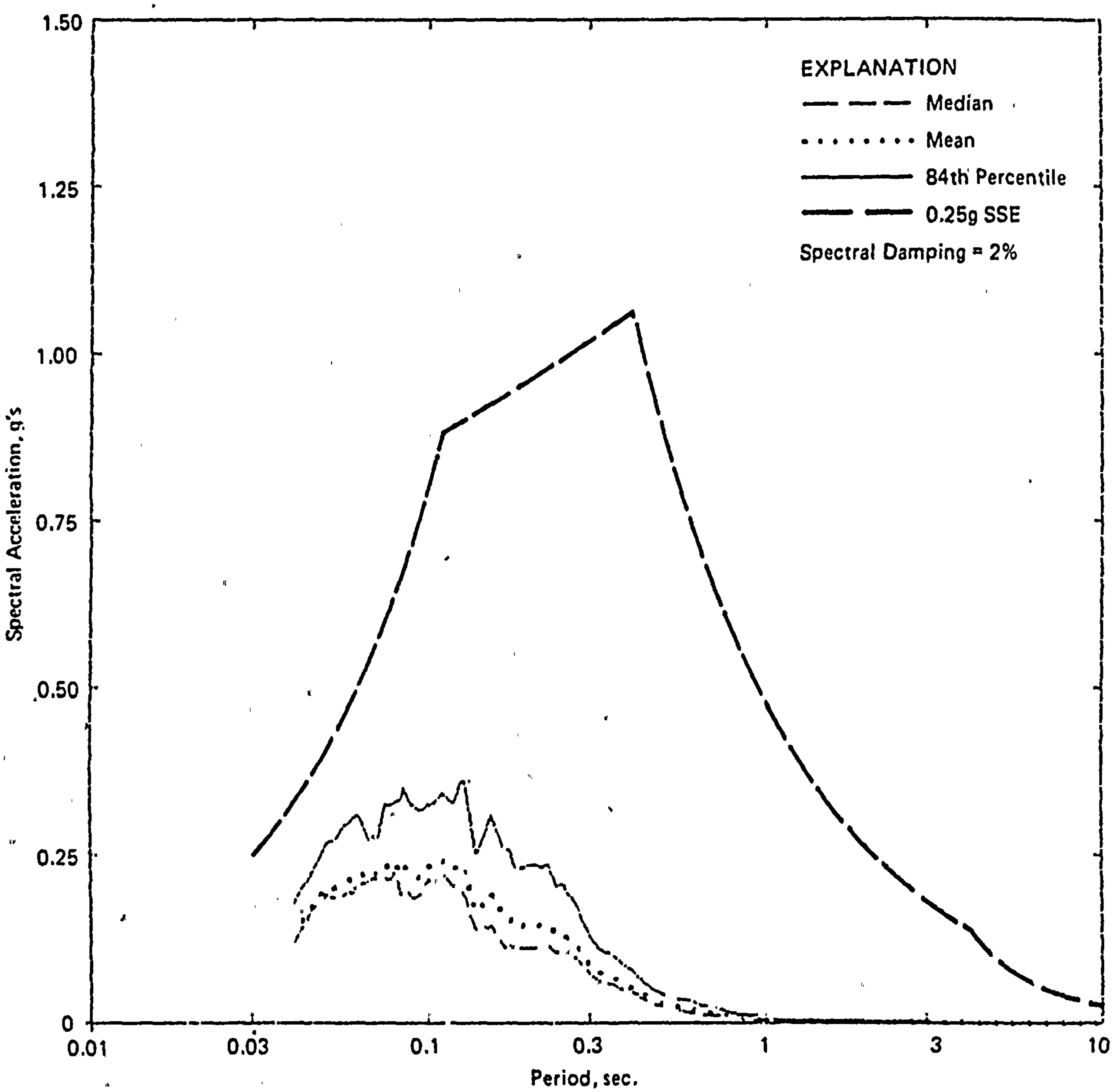
Stiff Soil Sites

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	MAGNITUDE ML	MAGNITUDE MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	DISTANCE TO: EPIC (KM)	DISTANCE TO: RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
OROVILLE AFTERS ROCK B	75 8 3	247 9		4.1		6.8	DWR OROVILLE MEDICAL CENTER TEMP STAT	10	ABB	8.3	4.7		B10	N24W	.086
													B10	S66W	.148
OROVILLE AFTERS ROCK P	75 816	548 9		4.0		8.8	CDMG7 CDMG TEMP STAT 7 AT OROVILLE CA	7	ABB	9.0	1.7		P07	N70W	.070
													P07	S00W	.060
							IUR D. JOHNSON RANCH TEMP STAT OROVILLE	9	AAB	10.2	5.2		P09	N70E	.159
													P09	N00E	.222
							DWR OROVILLE MEDICAL CENTER TEMP STAT	10	ABB	9.8	4.4		P10	N24W	.100
													P10	S66W	.030
OROVILLE AFTERS ROCK I	75 926	231 7		4.0		9.4	IUR D. JOHNSON RANCH TEMP STAT OROVILLE	9	AAB	12.0	7.5		T09	N90E	.242
													T09	N00E	.163
							DWR OROVILLE MEDICAL CENTER TEMP STAT	10	ABB	9.8	2.8		T10	N24W	.081
													T10	S66W	.086

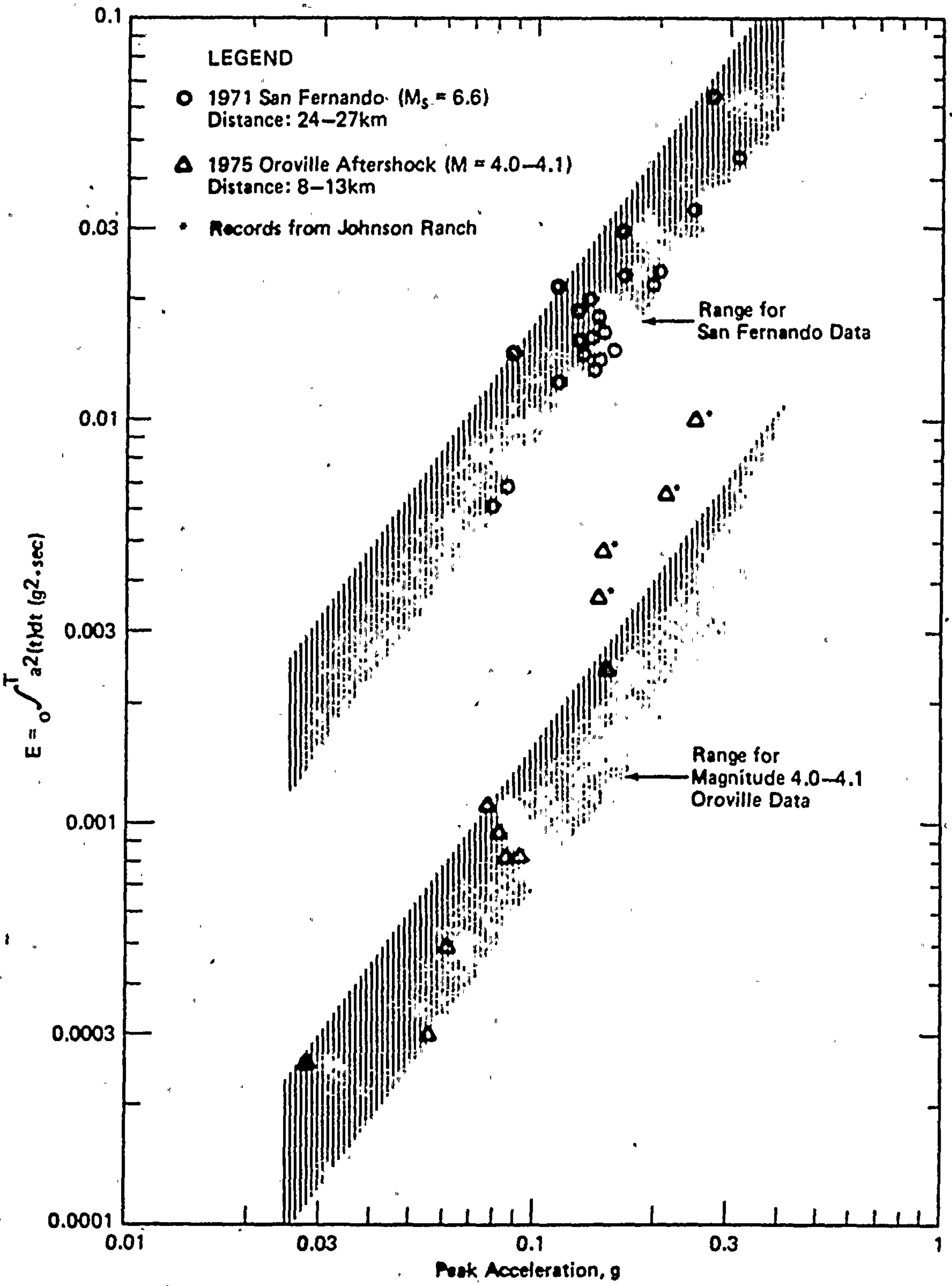
NUMBER OF DATA POINTS = 12



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	STATISTICAL SPECTRA FOR 12 OROVILLE M_L 4.0–4.1, R = 8–13 km ACCELERORGAMS	Figure 361.16-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	STATISTICAL SPECTRA FOR 8 OROVILLE M_L 4.0–4.1, R = 8–13 km ACCELEROGRAMS	Figure 361.16-2



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	PEAK ACCELERATION VERSUS TOTAL ENERGY CONTANT FOR OROVILLE AND SAN FERNANDO ACCELEROGRAMS	Figure 361.16-3

361.17

Estimate the ground motion (both peaks and response spectra) from an M_L 6.1 (July 16, 1936) earthquake occuring close to the WNP 2 site. Compute the median, mean and mean plus one standard deviation from this data set and compare them with the SSE response spectra. Also provide the staff with a comparison of the site conditions of the chosen strong motion recordings and the WNP-2 site.

RESPONSE

The 16 July 1936 Milton-Freewater earthquake (M_S 5 3/4, M_L 6.1) is considered to be associated with a northeast-trending fault that is parallel to, and likely an element of, the Hite fault system of eastern Washington. The area of maximum intensity for the event was in the vicinity of Milton-Freewater, while the instrumental epicenter was located on the basis of 25 regional and teleseismic readings, about 30 km to the northeast near Waitsburg (Woodward-Clyde Consultants, 1980). The aftershocks were first felt near Waitsburg and Walla Walla, but after several days reports were primarily from the Milton-Freewater area (WPPSS, 1974). The pattern of aftershocks suggests a northeast-southwest aftershock zone that initiated near Waitsburg and extended to the southwest. The available focal mechanism data are consistent with the faulting on a northeast-southwest striking plane, but the sense of movement is not well constrained. The focal depth appears to have been shallow (about 5 km), which indicates that although surface fault rupture was not observed in this particular event, the causative fault should be evident at the surface. These features of the 1936 earthquake are compatible with the data on the Hite fault system, which consists of steeply-dipping en echelon group of faults that strike north-northeast. The system is part of and lies along the flank of the Blue Mountains. Mapping indicates that the fault system extends westward and occurs in the basement beneath the Walla Walla basin.

The source area of the 1936 earthquake appears to be distinct from the seismic environment of the interior of the Columbia Plateau. The level of earthquake activity along the Blue Mountains is higher than that to the west-northwest (Woodward-Clyde Consultants, 1981). Also, the direction of maximum compressive stress appears to be generally north-south in the Plateau, but is generally east-west near the 1936 earthquake area.

Shallow earthquakes having magnitudes of about 6 or larger only occur on geologic structures and they should not be considered to be random events. The only fault within 25 km of the site that is large enough to generate an earthquake of the size of the Milton-Freewater earthquake is the Rattlesnake Mountain fault at a distance of 20 km. No other structures within 25 km distance are judged to be capable of generating a magnitude M_L 6.1 event. Consequently, a hypothesis that such an event can occur randomly in the vicinity of the site is considered not be valid. At the request of the NRC, the following methodology was used to estimate site ground motions assuming that the 1936 Milton-Freewater earthquake was a random event and that a similar event could occur close to the site.

The site dependent response spectrum for a magnitude M_L 6.1 earthquake occurring near the site was evaluated by averaging the response spectra computed from accelerograms recorded during earthquakes of magnitude M_L 6.1 ± 0.3 within an approximate distance range of 0 to 25 km. As presented subsequently in this response, the results of this analysis indicate that the SSE design spectra envelope the statistical site specific response spectra, except in the narrow period range of 0.13 to 0.22 seconds, where it is slightly exceeded for only some of the cases analyzed.

DATA SELECTION

Table 361.17-1 lists the currently available accelerograms recorded during earthquakes of magnitude M_L 6.1 ± 0.3 within a distance range of 0 to 27 km. The distance criteria used was the closest distance to fault rupture where known; otherwise, hypocentral distance was used.

A group of records was selected from those listed in Table 361.17-1 on the basis of similar site conditions to the WNP-2 plant site. The plant site is underlain by approximately 500 feet of granular alluvial soils underlain by Columbia River basalts. The top 100 feet of soil consists of medium dense to very dense sands and sand gravel mixtures. The soils between a depth of 100 feet to 200 feet consists of very dense cemented sand and gravel mixtures. Below 200 feet, the soils consists of very dense or hard interbedded sand, silt, clay, and gravel of the lower unit of the Ringold formation. These soils extend down to the basalt. Figure 361.17-1 shows the shear wave velocities measured to a depth of 400 feet at the WNP-2 and WNP-1/4 site. The soil profile is characterized by a large increase in shear wave velocity at a depth of about 100 feet and large drecreases in shear wave velocity below a depth of about 250 feet.

Figures 361.17-2 through 361.17-4 shows a comparison of the shear wave velocity profiles at the WNP-2 and WNP-1/4 site with reported ranges of shear wave velocities for granular alluvium in California (Campbell and Duke, 1976; Funel, 1978; Shannon & Wilson, 1980). As can be seen, with the exception of the high velocity layer between 100 and 250 feet in depth, the WNP-2 and WNP-1/4 site can be characterized as a deep alluvial site. The presence of the high velocity layer is expected to give the site some of the characteristics of a shallow stiff site, and the the low-velocity layers between a depth of 200 to 500 feet give the site some of the characteristics of a deep soil site.

Thus the WNP-2 and WNP-1/4 site can be considered to possess characteristics of both shallow and deep soil sites. Therefore, recordings obtained on either shallow or deep soil deposits were selected for analysis. Table 361.17-2 lists the selected accelerograms. The data set consists of 70 accelerograms recorded during 12 earthquakes: 30 accelerograms from the 1971 San Fernando earthquake, M_L 6.4; two from the 1972 Managua, Nicargua earthquake, M_L 6.0; 14 from the 1976 Friuli, Italy earthquake sequence, M_L 5.9 to 6.1; 12 from the 1979 Coyote Lake earthquake, M_L 5.7; 2 from the 1980 Livermore earthquake, M_L 5.9; and 10 from the 1980 Mammoth Lakes sequence, M_L 5.7 to 6.2.

The accelerograms in the data set were recorded at 26 different recording stations. The site conditions at each of the recording stations are described in Appendix 361.17-A. Figure 361.17-5 shows a composite of all of the site shear wave velocity profiles compared with the velocity profiles measured at the plant sites.

RECORD PROCESSING

The sources of the accelerograms listed in Table 361.17-2 are the California Institute of Technology (CIT), the United States Geological Survey (USGS), the California Division of Mines and Geology (CDMG), and the Comitato Nazionale per l'Enorgia Nucleare, Italy (CNEN). All of the records except those from CNEN were obtained in corrected form. The Friuli data set was obtained in uncorrected form from CNEN. The Friuli accelerograms were then corrected using the processing techniques employed by the other agencies. The general procedure is described by Trifunic (1970) and Trifunic and Lee (1973). The choice of long period filter values was based on the recommendations of Basili and Brady (1978). Based on recent experience with near source recordings, an interpolation time step of 0.01 seconds was used. It should be noted that the records obtained from CDMG for the Mammoth Lakes sequence are in preliminary form.

DATA ANALYSIS

The statistical analysis of the data set was performed on the log of spectral acceleration. Studies (Esteva, 1969; Donovan, 1973; McGuire, 1974) have shown that the variability in recorded ground motions are best modeled by a lognormal distribution. The median, mean and 84th percentile spectral accelerations are computed using the expressions

$$S_a \text{ med} = e^{(\ln Sa)}$$

$$S_a \text{ mean} = e^{(\ln Sa + S(\ln Sa)^2/2)}$$

$$S_a \text{ 84\%} = e^{(\ln Sa + S(\ln Sa))}$$

where lnSa is the mean of the natural log of the data set and S(lnSa) is the standard error of the log of the data set.

In developing the statistical spectra at longer periods, not all records were used as many of the accelerograms were processed with a long period motion filter corner frequency of greater than 0.1 H_z. The number of spectra averaged to various periods is tabulated below.

Period Range	Number of Spectra
0.04 - 1.4 sec.	70
1.4 - 2.0 sec.	66
2.0 - 3.0 sec.	60
3.0 - 4.0 sec.	48
4.0 - 5.0 sec.	32

RESULTS AND DISCUSSION

Figure 361-17.6 shows the distribution of the data set with respect to magnitude and distance to rupture surface. The mean magnitude is M_L 6.15 and the mean distance is 17.8 km. However,

for several of the earthquakes; the location and size of the rupture surface is not known. For these earthquakes, hypocentral distance is plotted on Figure 361.17-6. Using the relationship published by Wyss (1979), a magnitude 6.1 earthquake can be expected to have a rupture area of 89 km^2. Thus, the shortest distance to the rupture surface may be several kilometers less than the hypocentral distance. Figure 361.17-7 shows the distributions of the data set with magnitude and distance when epicentral distance is used for the unknown distance to rupture. The mean distance for this plot is 16 km. The actual mean closest distance to rupture should be somewhere between 16.0 and 17.8 km.

Figures 361.17-8 through 361.17-10 show an overplot of the 70 response spectra for 2%, 5%, and 7% spectral damping, respectively. The peak accelerations range from 0.08 g to 0.44 g. The large scatter in the peak accelerations and response spectra is due partly to the inherent variability in earthquake ground motion, and partly to the range in magnitudes and distances for the individual recordings.

Table 361.17-3 lists the median, mean and 84th percentile peak accelerations for the data set. The log-normal median, mean and 84th percentile spectra computed from the data set are compared with the SSE design response spectra (Regulatory Guide 1.60 spectra anchored to 0.25 g) in Figures 361.17-11 through 361.17-13 for 2%, 5%, and 7% damping, respectively. (The WNP-s plant has been analyzed and found to be adequate for the RG 1.60 spectra anchored to 0.25 g.) The SSE design spectrum is well above the statistical spectra except in the period range 0.13 to 0.22 seconds where it is slightly exceeded.

The affect of removal of the extremes of the data is illustrated in Figure 361.17-14. Shown are log-normal median and 84th percentile spectra for the data set; and for the data set with the highest and lowest value removed, the 2 highest and 2 lowest removed, the 3 highest and 3 lowest removed and the 4 highest and

4 lowest removed. The removal of the highest and lowest points result in a significant drop in the 84th percentile spectrum and a slight decrease in the median spectrum.

Removal of additional extreme data points result in small reductions in the 84th percentile spectra and virtually no change in the median value.

Examination of the data set indicates that for most of the frequency range, the highest spectral accelerations are from the recording obtained during the 5.7 aftershock in the Mammoth Lakes sequence. The recording was obtained at a hypocentral distance of 3.6 km. Since the acceleration from this recording represented the extreme acceleration throughout the period range, the effect of the removal of this record from the data set was evaluated and is shown in Figures 361.17-15 through 361.17-17. The SSE design spectrum completely envelopes the statistical response spectra in this case.

In the above analyses, each individual response spectrum was given equal weight in the calculations of the statistical spectra. The analysis is attempting to model the random occurrence of an earthquake near the site. Given that an earthquake has occurred randomly within a 25 km radius of the site, the probability of the earthquake occurring within a distance band is equal to the ratio of area within the distance band to the total area. These probabilities are compared below with the percentage of the data set which lies in each distance band.

Distance Range	Probability of Random Event In Distance Band	Portion of Data Set In Distance Band
0 - 5 km	.040	.086
5 - 10 km	.120	.114
10 - 15 km	.200	.086
15 - 20 km	.280	.286
20 - 25 km	.360	.428

This suggests that there are too many records in the data set at the extremes of the distance range and not enough in the middle. A weighted statistical average was performed, with the records in each distance band assigned a weight such that their contributions to the total is equal to the probability of a random event occurring in their distance band. Figures 361.17-18 through 361.17-20 shows the weighted statistical spectra for 2%, 5% an 7% damping, respectively., As can be seen, the SSE design spectra envelope the statistical spectra except for a slight exceedance in the narrow period range of 0.15 to 0.18 seconds.

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TABLE 361.17-3

Statistical Magnitude, Distance and Peak Accelerations

For Analysis Data Sets

Data Set	Number of Records	Mean Magnitude (M_L)	Mean Distance (km)		Peak Acceleration (g)		
			Rupture-Hypocentral	Rupture-Epicentral	Median	mean	84th percentile
Complete set	70	6.12	17.6	16.1	.174	.191	.270
Complete set with highest and lowest value removed	68	6.13	17.8	16.2	.174	.189	.264
Complete set with Mammoth Lakes M_L 5.7 record removed	68	6.14	18.0	16.4	.170	.185	.258
Complete set weighted by area	70	6.11	17.1	15.3	.170	.186	.261

TABLE 361.17-1

Accelerograms from Magnitude M_L 5.7 to 6.4 Earthquake in the Distance Range 0 to 27 kilometers

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACELL (G)
IMPERIAL VALLEY, CA	40 518	203640		6.4	7.1	16.0	EL CENTRO ARRAY # 09: IMP VALLEY IRR DIS	117	CDD	19.7	11.5	10.0	A001 A001	S00E S90W	.359 .224
SANTA BARBARA, CA	41 630	235055		5.9		16.0	SANTA BARBARA: COUNTY COURTHOUSE	283	CBB	20.4	12.6		U299 U299	N45E S45E	.239 .190
KOYNA INDIA	651210	225117		6.0	6.5	4.4	KOYNA DAM SEISMOGRAPH STAT INDIA		DAA	10.0	7.0		K101 K101	LONG TRAN	.631 .490
SAN FERNANDO, CA	71 2 9	6 042	6.2	6.4	6.6	8.4	PACOIMA DAM ABUTMENT CA	279	AAA	12.1	8.7	2.8	C041 C041	S14W N76W	.730 .730
							8244 ORION BLVD	241	DBD	23.7	22.1	7.4	C048 C048	N00W S90W	.258 .140
							LA: 250 E FIRST ST	151	EBB	43.5	42.7	26.3	C051 C051	N36E N54W	.100 .133
							LA: 445 FIGUEROA ST	157	EBB	42.7	41.9	25.8	C054 C054	N52W S38W	.150 .130
							CASTAIC: OLD RIDGE ROUTE, COUR SITE	110	ABB	29.7	28.5	24.9	D056 D056	N21E N69W	.315 .289
							LA: HOLLYWOOD STORAGE BLDG, 1025 N HIGHLAND	133	EBD	37.9	36.9	21.2	D057 D057	S00W N90E	.115 .153
							LA: HOLLYWOOD STORAGE PE LOT	135	ABD	37.9	36.9	21.2	D058 D058	S00W N90E	.187 .217
							LA: 1901 AVE OF THE STARS	187	EBD	40.1	39.2	25.3	D059 D059	N46W S44W	.152 .164
							LA: 1640 MARENGO	181	DCC	43.5	42.7	26.5	D062 D062	N38W S52W	.139 .147
							LA: 3710 WILSHIRE BLVD	217	EBD	40.7	39.9	24.4	D065 D065	S00W S90W	.154 .163
							7080 HOLLYWOOD BLVD LA	238	EAB	35.8	34.8	20.3	D068 D068	N00E N90E	.087 .102
							LA: 4680 WILSHIRE BLVD	223	EBC	40.3	39.4	24.6	E072 E072	N75W N15E	.088 .125
							LA: 3470 WILSHIRE BLVD	208	EBB	40.9	40.0	24.6	E075 E075	N00E S90W	.142 .117
							LA: WATER & POWER BLDG, 111 N HOPE	137	EBB	42.4	41.6	25.5	E078 E078	N50W S40W	.137 .188

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
SAN FERNANDO, CA	71 2 9	6 0 42	6.2	6.4	6.6	8.4	LA: 3407 W SIXTH ST	199	DBB	40.6	39.7	24.1	E083 E083	S00W N90E	.168 .182
							GLENDALE: 633 E BROADWAY, MUNICIPAL SERV	122	CBD	33.7	32.7	16.7	F088 F088	S70E S20W	.274 .227
							LA: 808 S OLIVE ST	175	DBC	43.7	42.8	26.0	F089 F089	S53E S37W	.141 .152
							LA: 2011 ZONAL AVE	190	EBB	43.8	43.0	25.8	F092 F092	S62E S28W	.071 .083
							LA: 120 N ROBERTSON	142	ECB	38.3	37.3	23.2	F095 F095	S88E S02W	.100 .091
							LA: 646 S OLIVE ST	166	EBC	43.4	42.6	26.5	F098 F098	S53E S37W	.252 .206
							LA: UCLA REACTOR LAB	140	EBB	39.4	38.4	24.8	F105 F105	S00W N90E	.095 .089
							OLD SEISM LAB CIT	266	CAA	37.1	36.1	19.1	G106 G106	S00W S90W	.096 .204
							PASADENA: CIT ATHENAEUM	475	CAB	40.8	39.9	23.2	G107 G107	N00E N90E	.103 .114
							MILLIKAN LIBRARY, CIT PASADENA CA	264	EAB	40.5	39.6	22.4	G108 G108	N00E N90E	.206 .189
							JPL CIT PASADENA CA	267	EAB	32.5	31.3	14.3	G110 G110	S82E S08W	.215 .160
							LA: 611 W SIXTH ST	163	FBB	43.2	42.4	26.3	G112 G112	N38E N52W	.106 .088
							PALMDALE FIRE STATION	262	AAB	33.3	32.2	25.4	G114 G114	S60E S30W	.118 .150
							LA: 15250 VENTURA BLVD	466	DBB	30.5	29.3	15.5	H115 H115	N11E N79W	.225 .152
							900 S FREMONT AVE ALHAMBRA	482	EBB	43.8	43.0	25.5	H121 H121	S90W S00W	.121 .117
							435 N OAKHURST BEVERLY HILLS	452	EBB	38.0	37.0	23.4	I128 I128	N00E S90W	.062 .099
							450 ROXBURY BEVERLY HILLS	455	DBB	39.0	38.1	24.4	I131 I131	N50E N40W	.202 .170

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
SAN FERNANDO, CA	71 2 9	6 042	6.2	6.4	6.6	8.4	1800 CENTURY PARK E L A	425	EBB	39.7	38.8	25.3	I134	N54E	.103
													I134	S36E	.090
							15910 VENTURA BLVD L A	461	EBB	30.5	29.3	15.0	I137	S81E	.148
													I137	S09W	.135
							LAKE HUGHES ARRAY #1	125	AAB	30.4	29.2	25.8	J141	N21E	.152
													J141	S69E	.115
							LAKE HUGHES ARRAY #4	126	AAA	28.5	27.3	24.2	J142	S69E	.200
													J142	S21W	.159
							LAKE HUGHES ARRAY #9: WARM SPRINGS	127	AAA	27.6	26.3	23.5	J143	N21E	.147
													J143	N69W	.131
							LAKE HUGHES ARRAY #12: ELIZABETH LAKE	128	ABA	24.5	23.0	20.3	J144	N21E	.374
													J144	N69W	.288
							15107 VANOWEN ST L A	458	EBB	25.5	24.1	13.1	J145	S00W	.118
													J145	S90W	.111
							616 S NORMANDY AVE L A	431	EBB	40.7	39.8	24.1	J148	N00E	.116
													J148	S90W	.117
							LA: 3838 LANKERSHIM BLVD	220	EBA	31.7	30.6	15.3	L166	N00E	.181
													L166	S90W	.154
							1880 CENTURY PARK EAST L A	440	GBB	39.7	38.8	25.3	N188	N54E	.117
													N188	N36W	.129
							2500 WILSHIRE BLVD L A	449	EBB	41.4	40.6	25.1	N192	N29E	.104
													N192	N61W	.107
							LA: GRIFFITH PARK OBSERVATORY	141	AAA	34.9	33.8	17.4	O198	S00W	.188
													O198	S90W	.180
							1625 OLYMPIC BLVD L A	469	DBB	42.7	41.8	25.8	O199	N28E	.144
													O199	N62W	.259
							4867 SUNSET BLVD L A	226	EBB	37.0	36.0	20.3	P214	S89W	.162
													P214	S01E	.167
							LA: 3345 WILSHIRE BLVD	196	GBB	40.8	39.9	24.1	P217	S00W	.122
													P217	N90E	.097
							SANTA ANITA RESERVOIR, ARCADIA	104	AAA	44.0	43.2	27.0	P221	N03E	.172
													P221	N87W	.223
							14724 VENTURA BLVD L A	253	DBB	30.5	29.3	15.5	Q233	S12W	.263
													Q233	N78W	.207

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
SAN FERNANDO, CA	71 2 9	6 042	6.2	6.4	6.6	8.4	1760 ORCHID ST L. A	446	DAB	35.5	34.5	19.6	O236 O236	EAST SOUT	.172 .130
							9100 WILSHIRE BLVD BEVERLY HILLS	416	EBD	39.2	38.3	24.6	O239 O239	SOUT EAST	.126 .171
							LA: 800 W FIRST ST	172	DBB	42.6	41.8	25.5	O241 O241	N37E N53W	.096 .143
							LA: 222 FIGUEROA ST	145	DBB	42.6	41.7	25.5	R244 R244	N53W S37W	.156 .132
							6464 SUNSET BLVD L A	235	EAB	36.4	35.5	20.3	R246 R246	SOUT EAST	.119 .110
							6430 SUNSET BLVD L A	232	EAB	36.5	35.5	20.3	R248 R248	SOUT EAST	.192 .230
							LA: 1900 AVE OF THE STARS	184	EBD	39.9	39.0	25.3	R249 R249	N44E S46E	.084 .093
							LA: 234 FIGUEROA ST	148	EBB	42.7	41.8	25.5	R251 R251	N37E S53E	.200 .189
							LA: 533 S FREMONT AVE	160	EBB	42.8	41.9	25.9	R253 R253	N30W S60W	.256 .232
							6200 WILSHIRE BLVD L A	443	DBD	39.7	38.8	24.8	S255 S255	N08E N82W	.129 .131
							1177 BEVERLY DR L A	413	EBD	40.4	39.5	25.8	S261 S261	N59E N31W	.102 .111
							LA: 3411 WILSHIRE BLVD	202	EBB	40.7	39.9	24.6	S265 S265	SOUT WEST	.111 .132
							LA: 3550 WILSHIRE BLVD	211	EBD	40.8	39.9	24.1	S266 S266	NORT WEST	.167 .135
MANAGUA NICARAGUA (MAIN SHOCK)	721223	029 0	5.6	6.1	6.2	5.0	ESSO REFINERY MANAGUA NICARGUA	3501	ABB	7.5	7.0	5.0	MN05 MN05	SOUT EAST	.330 .390
POINT MUGU	73 0 0	0 0 0		6.0	.5	.2	NAVAL RESRCH & EVAL LAB PORT HUENEME, CA	272	BDD	25.0	18.0		PM01 PM01	LONG TRAN	.130 .080
OROVILLE CA MAIN SHOCK	75 8 1	122013	5.9	5.7	5.6	8.0	OROVILLE SEISMOGRAPH STATION	1051	AAA	14.9	12.6		OS5A OS5A	N53W N37E	.103 .100
FRIULI SEQUENCE	76 911	1635 0		5.9		6.0	FORGARIA-CORN., ITALY		ABB	15.7	14.5		F138 F138	NORT EAST	.133 .235

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
FRIULI SEQUENCE	76 911	1635 0		5.9		6.0	SOMPLAGO D., ITALY - UNDERGROUND		FBA	8.5	6.0		F142 F142	NORT EAST	.063 .062
							BUIA, ITALY		ABC	15.2	14.0		F143 F143	NORT EAST	.234 .114
							S. ROCCO, ITALY		ABA	15.7	14.5		F139 F139	NORT EAST	.092 .091
FRIULI SEQUENCE	76 915	31519		6.1		9.0	S. ROCCO, ITALY		ABA	12.7	9.0		F153 F153	NORT EAST	.069 .119
							BUIA, ITALY		ABC	10.8	6.0		F156 F156	NORT EAST	.110 .102
							FORGARIA-CORN., ITALY		ABB	13.5	10.0		F152 F152	NORT EAST	.263 .218
FRIULI SEQUENCE	76 915	92118		6.0		12.0	TARCENTO, ITALY		ABB	22.5	19.0		F172 F172	NORT EAST	.139 .110
							FORGARIA-CORN., ITALY		ABB	23.3	20.0		F168 F168	NORT EAST	.353 .336
							S. ROCCO, ITALY		ABA	22.5	19.0		F169 F169	NORT EAST	.145 .228
							BUIA, ITALY		ABC	22.5	19.0		F177 F177	NORT EAST	.085 .101
COYOTE LAKE, CA	79 8 6	10 522	5.3	5.7	5.6	9.6	COYOTE CREEK (C217)	1445	ABA	9.8	1.8	3.2	CL01 CL01	N70E N20W	.230 .160
							GILROY ARRAY STA #1	1408	ABA	18.4	15.7	9.3	CL02 CL02	S40E N50E	.130 .100
							GILROY ARRAY STA #2	1409	ABB	17.0	14.0	7.5	CL03 CL03	N40W S50W	.260 .200
							GILROY ARRAY STA #3	1410	ABB	16.7	13.6	6.0	CL04 CL04	N40W S50W	.270 .260
							GILROY ARRAY STA #4	1411	ABB	15.5	12.2	4.5	CL05 CL05	S00E S90E	.260 .240
							GILROY ARRAY # 6: SAN YSIDRO	1413	ABA	14.1	10.3	3.1	CL06 CL06	S40E N50E	.340 .420
							SAN JUAN BAUTISTA 101/156 OVERPASS (C	1492	BBC	29.4	27.8	17.2	CL07 CL07	S67E S23W	.117 .082

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
COYOTE LAKE, CA	79 8 6	10 522	5.3	5.7	5.6	9.6	SAN JUAN BAUTISTA= 101/156 OVERPASS CC	1492	BBC	29.4	27.8	17.2	CL08	S67W	.120
													CL08	S23W	.110
							SAN JUAN BAUTISTA (C126)	1377	ABB	29.4	27.8	15.6	CL10	S57E	.090
													CL10	N33E	.110
LIVERMORE SEQUENCE = SHOCK A	80 124	11 0 9		5.9		5.9	SAN RAMON= EASTMAN KODAK BLDG CC	1418	ABB	17.7	16.7	17.6	LA01	S00E	.148
													LA01	S90W	.063
							SAN RAMON FIRE STATION (C134)	1383	ABB	18.2	17.2	21.7	LA02	N70E	.042
													LA02	N20W	.053
							ANTIOCH	1308	ACD	20.3	19.5	28.5	LA03	N00E	.010
													LA03	N90W	.040
							WALNUT CREEK=FIDELITY SAVINGS (C364)		BBA	25.2	24.2	33.1	LA04	S00E	.027
													LA04	S90E	.031
							PLEASANT HILL= CITIZENS SAVINGS (C348)		BBB	26.4	25.7	35.6	LA05	N70E	.038
													LA05	N00E	.028
							DELTA PUMPING PLANT (CDWR)	1030		17.5	16.5	9.9	LA22	LONG	
													LA22	TRAN	
							DEL VALLE DAM	1265	ABB	25.9	25.2	12.9	LA23	S66W	.249
													LA23	S24E	.140
							LIVERMORE VA HOSPITAL, BUILDING 62	1226	BBB	24.8	24.1	12.9	LA24	S52E	.120
													LA24	N38E	.180
MAMMOTH LAKES SHOCK A	80 525	93345		6.1		8.9	CONVICT CREEK	1529	ACD	9.0	1.5		ML01	S00E	.454
													ML01	N90E	.428
							MAMMOTH LAKES HIGH SCHOOL GYM CC	1490	BAB	14.0	10.8		ML02	S74W	.327
													ML02	N16W	.262
							LONG VALLEY DAM	1444	AAA	15.6	12.8		ML03	N90E	.225
													ML03	N00E	.432
							LONG VALLEY DAM	1444	AAA	15.6	12.8		ML04	N90E	.069
													ML04	N00E	.110
MAMMOTH LAKES SHOCK B	80 525	94927		6.0		13.8	CONVICT CREEK	1529	ACD	16.3	8.6		ML11	S00E	.200
													ML11	N90E	.170
							MAMMOTH LAKES HIGH SCHOOL GYM CC	1490	BAB	14.2	4.5		ML12	S74W	.470
													ML12	N16W	.430
							LONG VALLEY DAM	1444	AAA	24.4	20.1		ML13	N90E	.070
													ML13	N00E	.190

TABLE 361.17-1 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
MAMMOTH LAKES SHOCK B	80 525	94927		6.0		13.8	LONG VALLEY DAM	1444	AAA	24.4	20.1		ML14 ML14	N90E N00E	.010 .040
MAMMOTH LAKES SHOCK C	80 525	124451		6.1		16.4	CONVICT CREEK	1324	ACD	17.0	6.1		ML21 ML21	S00E N90E	.193 .239
							LONG VALLEY DAM	1444	AAA	19.9	11.9		ML22 ML22	N90E N00E	.190 .494
							LONG VALLEY DAM	1444	AAA	19.9	11.9		ML23 ML23	N90E N00E	.062 .110
MAMMOTH LAKES AFTERSHOCK	80 525	1336 0		5.7		2.3	CONVICT CREEK	1324	ACD	3.6	2.8		ML41 ML41	SOUT EAST	.440 .370
MAMMOTH LAKES SHOCK D	80 527	75057		6.2		14.2	CONVICT CREEK	1324	ACD	18.6	12.0		ML31 ML31	S00E N90E	.331 .267
							LONG VALLEY DAM	1444	AAA	20.0	14.0		ML32 ML32	N90E N00E	.412 .994
							LONG VALLEY DAM	1444	AAA	20.0	14.0		ML33 ML33	N90E N00E	.172 .243
							CDMG TEMP STAT AT PARADISE LODGE	19	AAA	24.5	20.0		ML34 ML34	S30E N60E	.119 .090

NUMBER OF DATA POINTS = 222

MRK2.N

TABLE 361.17-2

Accelerograms Recorded at Selected Recording Stations from Magnitude M_L 5.7 to 6.4 Earthquake in the Distance Range 0 to 27 kilometers

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL (G)
SAN FERNANDO,	71 2 9	6 042	6.2	6.4	6.6	8.4	8244 ORION BLVD	241	DDD	23.7	22.1	7.4	C048	N00W	.253
CA													C048	S90W	.140
							CASTAIC OLD RIDGE	110	ABB	29.7	28.5	24.9	D056	N21E	.335
							ROUTE, CHUR SITE						D056	N69W	.289
							LA: HOLLYWOOD STORAGE	135	ABB	37.9	36.9	21.2	D058	S00W	.187
							PE LOT						D058	N90E	.217
							LA: 1640 MARENGO	181	DCC	43.5	42.7	26.5	D062	N38W	.139
													D062	S52W	.147
							LA: 3407 W SIXTH	199	DBB	40.6	39.7	24.1	E083	S00W	.168
							ST						E083	N90E	.182
							LA: 808 S OLIVE	175	DBC	43.7	42.8	26.0	F089	S53E	.141
							ST						F089	S37W	.152
							PALMDALE FIRE STATION	262	AAD	33.3	32.2	25.4	G114	S60E	.118
													G114	S30W	.150
							450 ROXBURY BEVERLY	455	DBD	39.0	38.1	24.4	I131	N50E	.202
							HILLS						I131	N40W	.170
							LAKE HUGHES ARRAY	125	AAB	30.4	29.2	25.8	J141	N21E	.152
							#1						J141	S69E	.115
							1625 OLYMPIC BLVD	469	DBB	42.7	41.8	25.8	O199	N28E	.144
							L A						O199	N62W	.259
							14724 VENTURA BLVD	253	DBD	30.5	29.3	15.5	Q233	S12W	.263
							L A						Q233	N78W	.207
							1760 ORCHID ST L	446	DAB	35.5	34.5	19.6	Q236	EAST	.172
							A						Q236	SOUT	.130
							LA: 800 W FIRST	172	DBD	42.6	41.8	25.5	Q241	N37E	.096
							ST						Q241	N53W	.143
							LA: 222 FIGUEROA	145	DDB	42.6	41.7	25.5	R244	N53W	.156
							ST						R244	S37W	.132
							6200 WILSHIRE BLVD	443	DBD	39.7	38.8	24.8	S255	N08E	.129
							L A						S255	N82W	.131
MANAGUA NICARAG	721223	029 0	5.6	6.1	6.2	5.0	ESSO REFINERY MANAGUA	3501	ADB	7.5	7.0	5.0	MN05	SOUT	.330
UA (MAIN SHOCK)							NICARAGUA						MN05	EAST	.390
FRIULI SEQUENCE	76 911	1635 0		5.9		6.0	FORGARIA-CORN.,		ADB	15.7	14.5		F138	NORT	.143
							ITALY						F138	EAST	.235

TABLE 361.17-2 (Continued)

EARTHQUAKE	DATE Y M D	TIME H M S	MAGNITUDE MB	ML	MS	DEPTH (KM)	RECORDING STATION	USGS STAT NO	SITE CLASS	DISTANCE TO: HYPOC (KM)	EPIC (KM)	RUPTURE (KM)	RECORD	COMP	PEAK ACCEL. (G)
FRIULI SEQUENCE	76 911	1635 0		5.9		6.0	BUIA, ITALY		ABC	15.2	14.0		F143	NORT	.234
													F143	EAST	.114
FRIULI SEQUENCE	76 915	31519		6.1		9.0	BUIA, ITALY		ABC	10.8	6.0		F156	NORT	.110
													F156	EAST	.102
							FORGARIA-CORN.,		ABB	13.5	10.0		F152	NORT	.263
							ITALY						F152	EAST	.218
FRIULI SEQUENCE	76 915	92118		6.0		12.0	TARCENTO, ITALY		ABB	22.5,	19.0		F172	NORT	.139
													F172	EAST	.110
							FORGARIA-CORN.,		ABB	23.3	20.0		F168	NORT	.353
							ITALY						F168	EAST	.336
							BUIA, ITALY		ABC	22.5	19.0		F177	NORT	.066
													F177	EAST	.101
COYOTE LAKE,	79 8 6	10 522	5.3	5.7	5.6	9.6	GILROY ARRAY STA	1409	ABD	17.0	14.0	7.5	CL03	N40W	.260
CA							#2						CL03	S50W	.200
							GILROY ARRAY STA	1410	ABD	16.7	13.6	6.0	CL04	N40W	.270
							#3						CL04	S50W	.260
							GILROY ARRAY STA	1411	ABD	15.5	12.2	4.5	CL05	S00E	.260
							#4						CL05	S90E	.240
							SAN JUAN BAUTISTA:	1492	DAC	29.4	27.8	17.2	CL07	S67E	.117
							101/156 OVERPASS (C						CL07	S23W	.082
							SAN JUAN BAUTISTA:	1492	DAC	29.4	27.8	17.2	CL08	S67E	.120
							101/156 OVERPASS (C						CL08	S23W	.110
							SAN JUAN BAUTISTA	1377	ABB	29.4	27.8	15.6	CL10	S57E	.090
							(C126)						CL10	N33E	.110
LIVERMORE SEQUE	80 124	11 0 9		5.9		5.9	DEL VALLE DAM	1265	ABD	25.9	25.2	12.9	LA23	S66W	.240
NCE : SHOCK A													LA23	S24E	.140
MAMMOTH LAKES	80 525	93345		6.1		8.9	CONVICT CREEK	1324	ACD	9.0	1.5		ML01	S00E	.464
SHOCK A													ML01	N90E	.428
MAMMOTH LAKES	80 525	94927		6.0		13.8	CONVICT CREEK	1324	ACD	16.3	8.6		ML11	S00E	.200
SHOCK B													ML11	N90E	.170
MAMMOTH LAKES	80 525	124451		6.1		16.4	CONVICT CREEK	1324	ACD	17.0	6.1		ML21	S00E	.193
SHOCK C													ML21	N90E	.239
MAMMOTH LAKES	80 525	1336 0		5.7		2.3	CONVICT CREEK	1324	ACD	3.6	2.8		ML41	SOUT	.440
AFTERSHOCK													ML41	EAST	.370
MAMMOTH LAKES	80 527	75057		6.2		14.2	CONVICT CREEK	1324	ACD	18.6	12.0		ML31	S00E	.331
SHOCK D													ML31	N90E	.267

NUMBER OF DATA POINTS = 70

THREE-LETTER CLASSIFICATION CODE FOR TABLES 361.17-1 AND 361.17-2

FIRST LETTER: Structure Type and Instrument Location

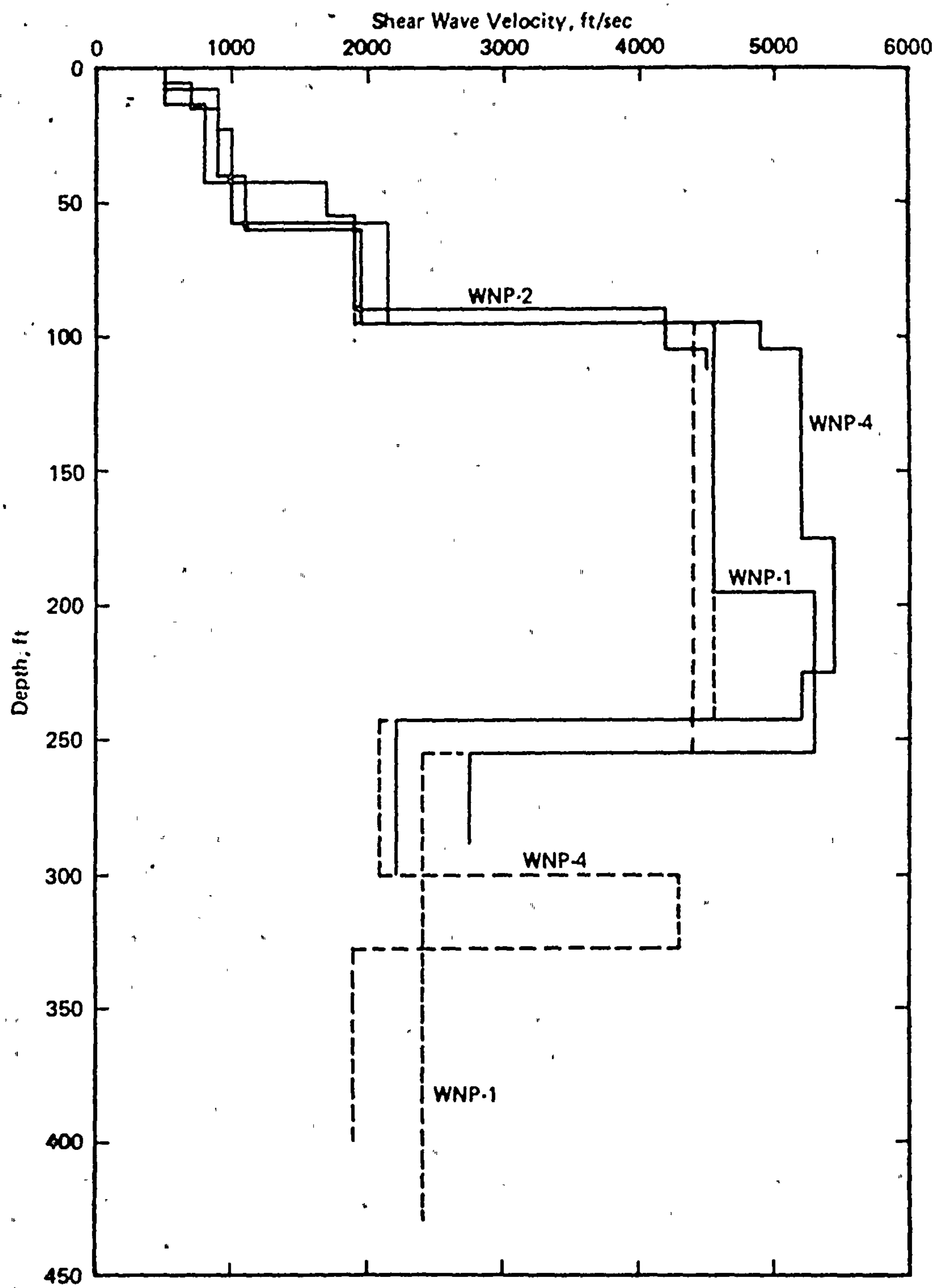
Designation	Description
A	Free-field instrument or one-story structure; the instrument is located at the lowest level of the structure and within ± several feet of the ground surface.
B	Two to four-story structure of light construction; the instrument is located at the lowest level of the structure and within ± several feet of the ground surface.
C	Two to four-story structure of light construction; the instrument is located below the ground surface at the lowest level of the structure.
D	Structure of heavy construction; the instrument is located at the lowest level of the structure and within ± several feet of the ground surface.
E	Structure of heavy construction; the instrument is located below the ground surface at the lowest level of the structure.
F	Structure housing instrument is buried below the ground surface.
G	Structure of light or heavy construction; the instrument is located at the ground surface or below, but is not at the lowest level of the structure.

SECOND LETTER: Deep Local Geology

Designation	Description
A	Hard Rock; competent, typically with $V_s \geq 4000$ fps; generally includes metamorphic and intrusive igneous rocks.
B	Soft Rock; less competent, typically with $2000 \leq V_s \leq 4000$ fps; generally includes sedimentary and extrusive igneous rocks.
C	Old Alluvium; unconsolidated sediments of Miocene age or older; typically may have some "soft rock" characteristics, i.e. $V_s \geq 2000$ fps.
D	Recent Alluvium; unconsolidated sediments of Pliocene age or younger.

THREE LETTER: Near-Surface Geology

Designation	Description
A	Rock; the insturment is founded on rock material or a very thin (less than 10 to 15 feet) of soil over rock; typically is on a ridge or hillside.
B	Shallow Soil; the instrument is founded in or on soil up to 150 to 200 feet thick over rock material ;tyepically is in a narrow canyon, near the edge of a valley or on a hillslide.
C	Deep Narrow Soil; the instrument is founded in or on soil at least 200 to 300 feet thick over rock material in a narrow canyon or valley not more than several kilometers wide.
D	Deep Broad Soil; the instrument is founded in or on soil at least 200 to 300 feet thick over rock material in a broad canyon or valley.

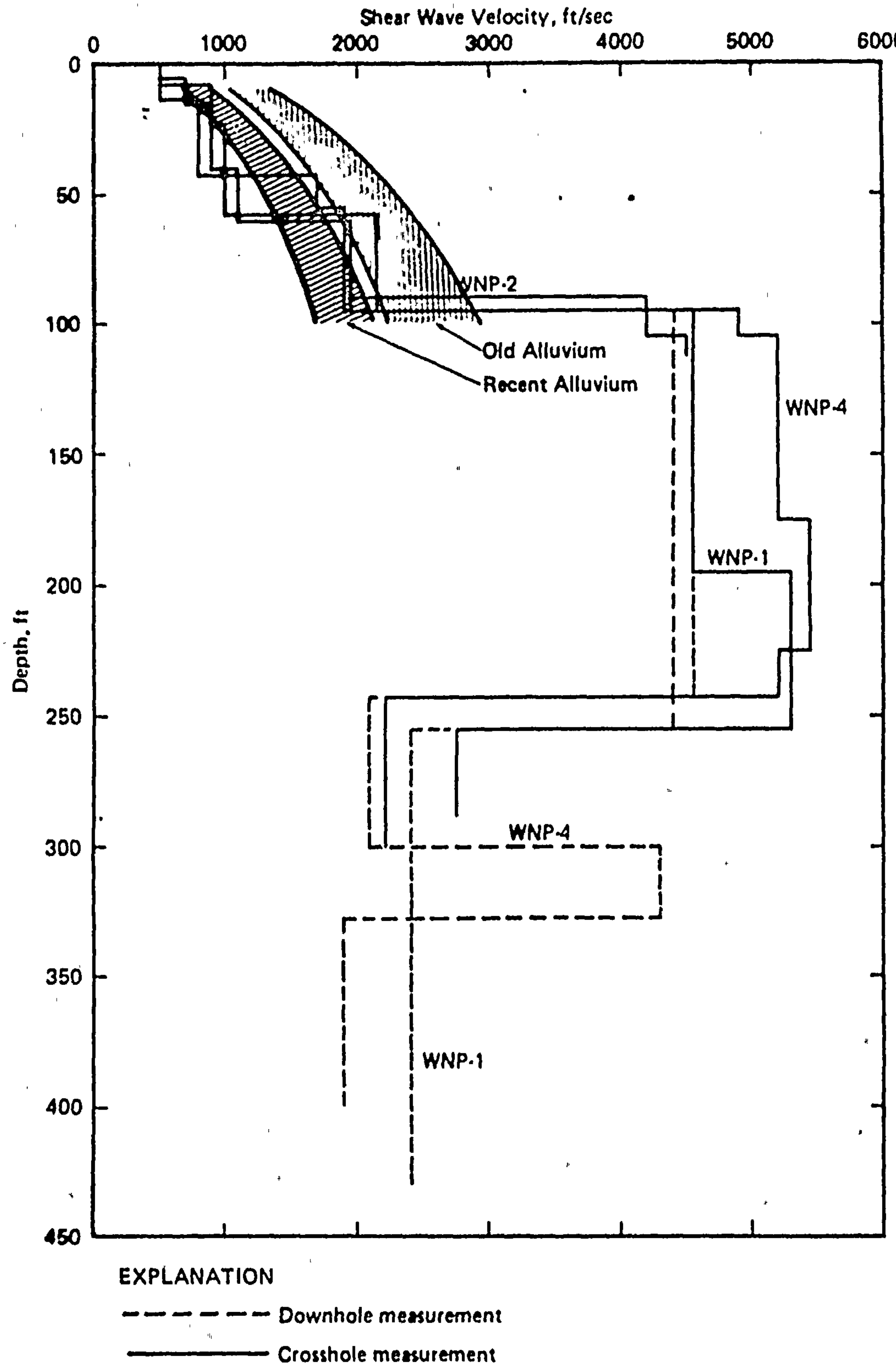


EXPLANATION

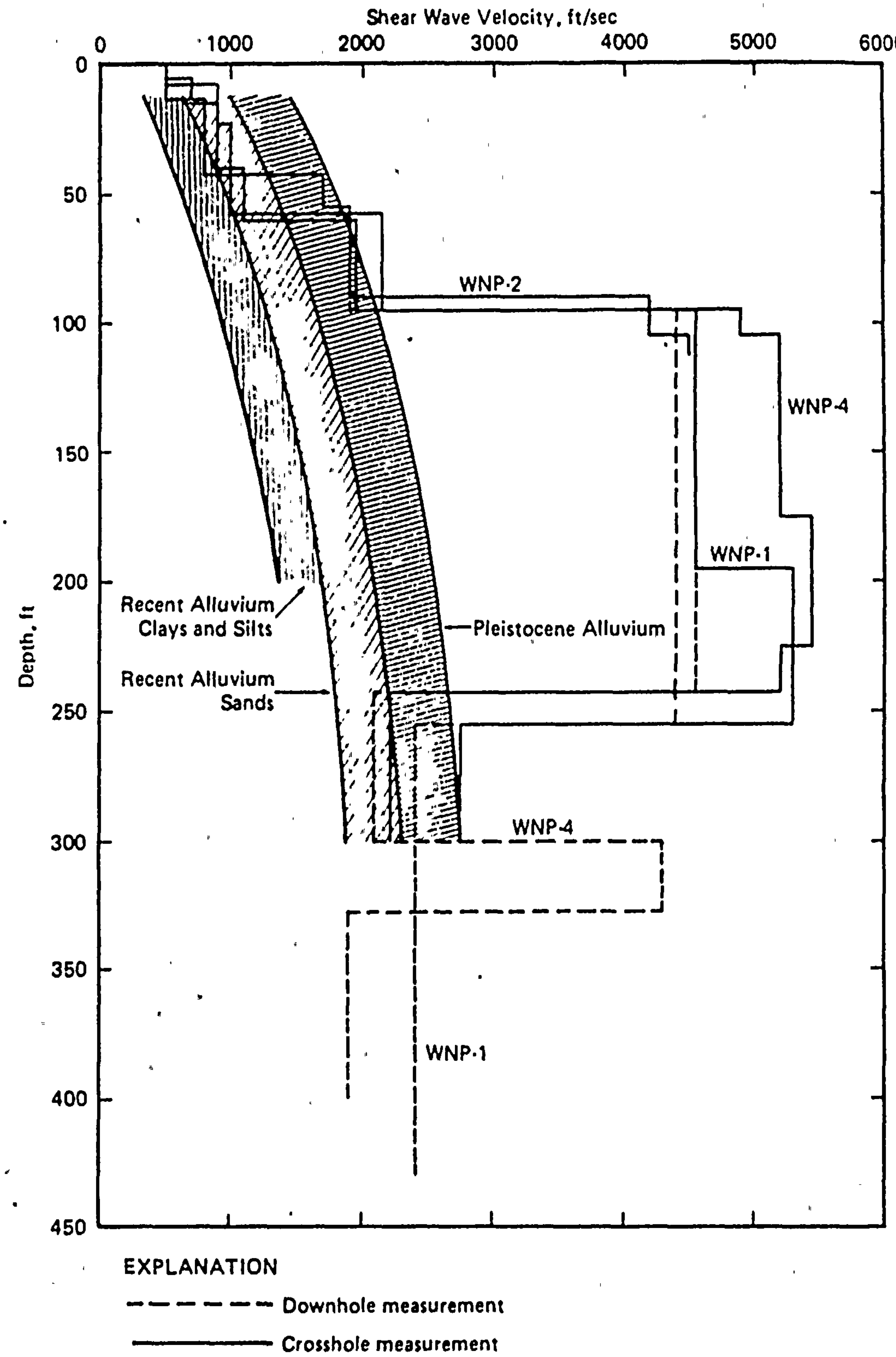
- - - - - - Downhole measurement

———— Crosshole measurement

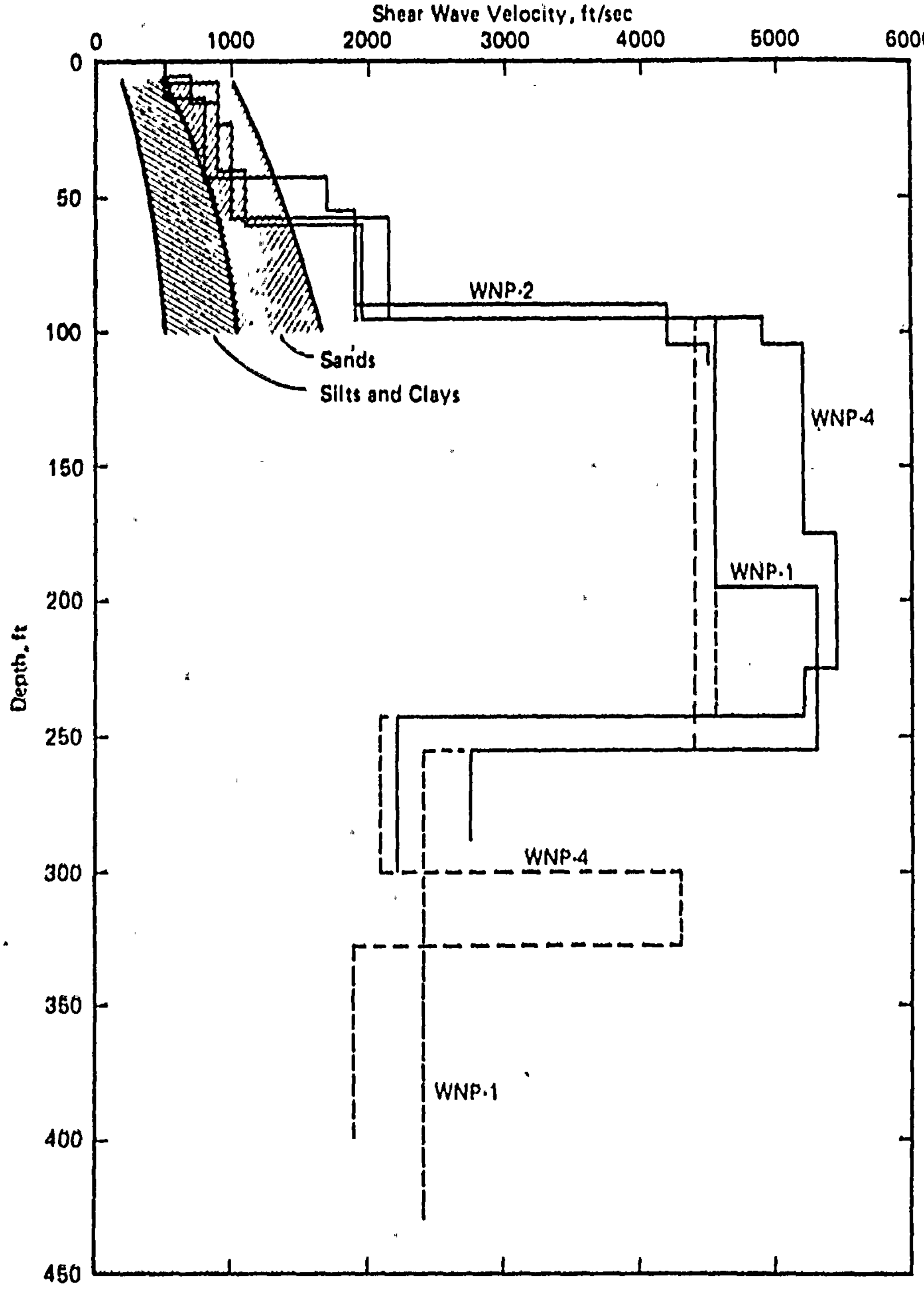
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	SHEAR WAVE VELOCITY PROFILES AT WNP 1,2 & 4 SITES	Figure 361.17-1



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: ALLUVIAL SOILS (CAMPBELL AND DUKE, 1976) VERSUS WNP 1,2 & 4	Figure 361.17-2



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: ALLUVIAL SOILS (SHANNON AND WILSON, 1980) VERSUS WNP 1,2 & 4	Figure 361.17-3

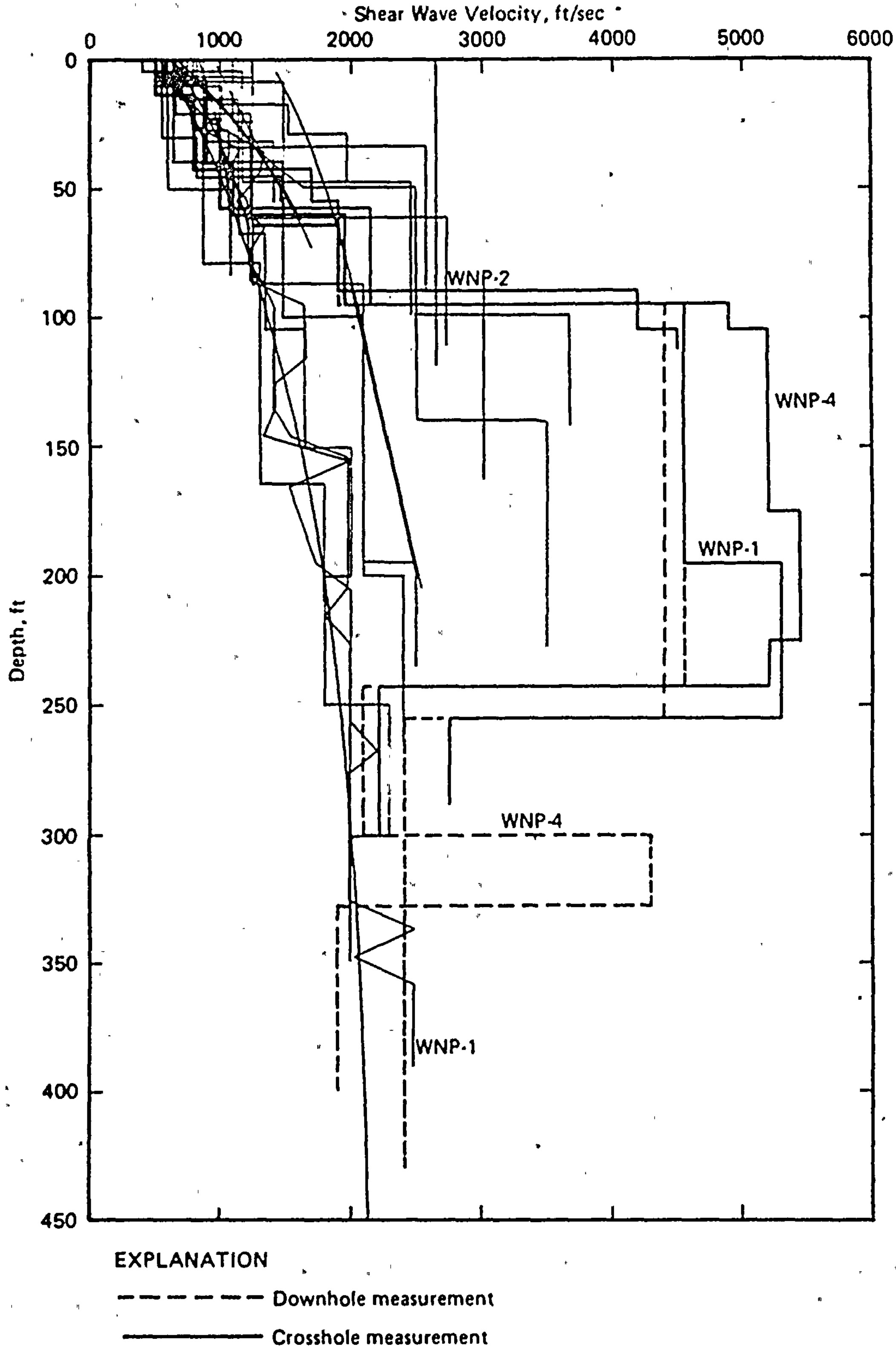


EXPLANATION

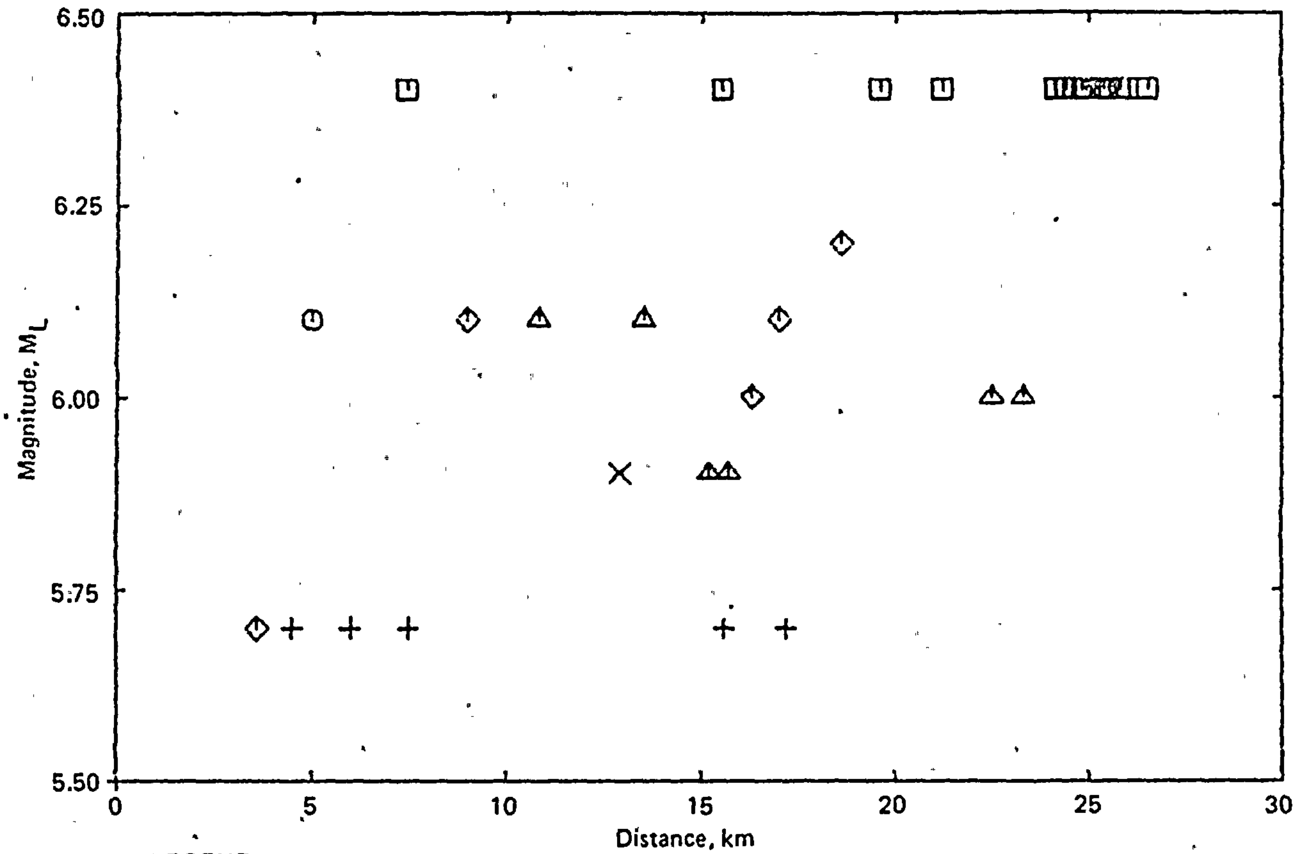
— — — — Downhole measurement

———— Crosshole measurement

WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: ALLUVIAL SOILS (FUMAL, 1978) VERSUS WNP 1,2 & 4	Figure 361.17-4



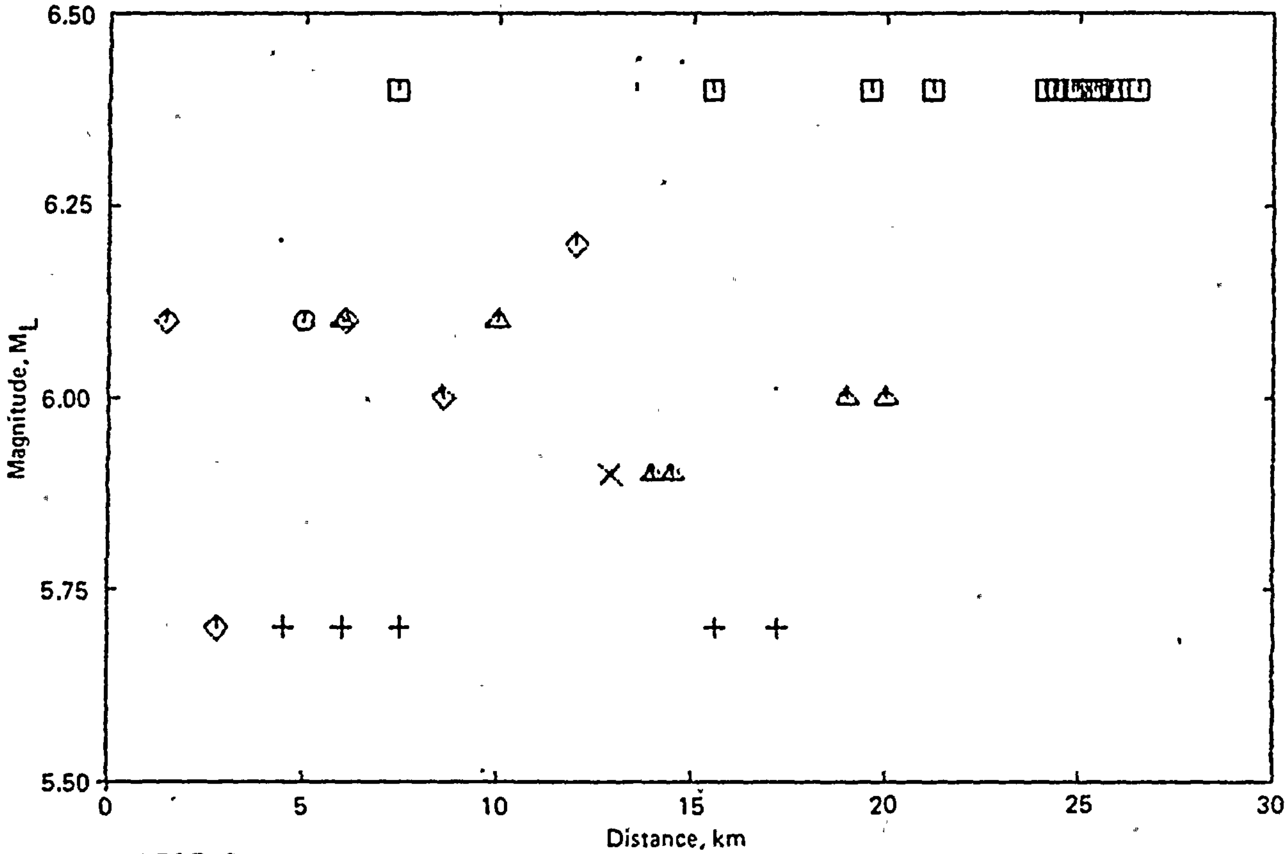
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	OVERPLOT OF SHEAR WAVE VELOCITY PROFILES FOR SELECTED RECORDING STATIONS	Figure 361.17-5



LEGEND

- San Fernando Earthquake, 1971
- Managua, Nicaragua Earthquake, 1972
- Friuli, Italy Earthquakes, 1976
- Coyote Lake Earthquake, 1979
- Livermore Earthquake, 1980
- Mammoth Lakes Earthquakes, 1980

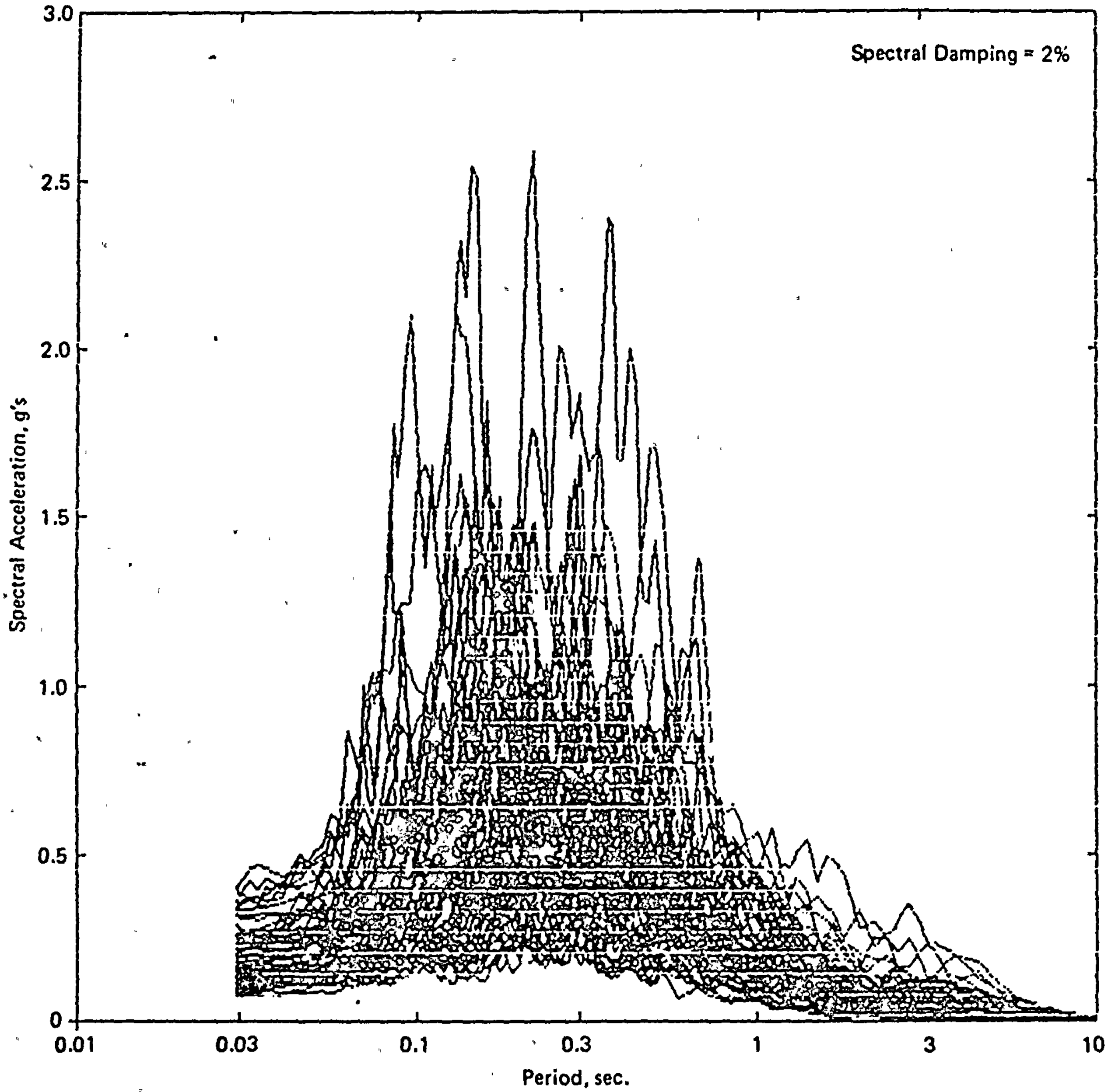
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	SCATERGRAM OF MAGNITUDES AND DISTANCE FOR DATA SET USED IN ANALYSIS (HYPOCENTRAL DISTANCE USED WHEN RUPTURE DISTANCE NOT KNOWN)	Figure 361.17-6



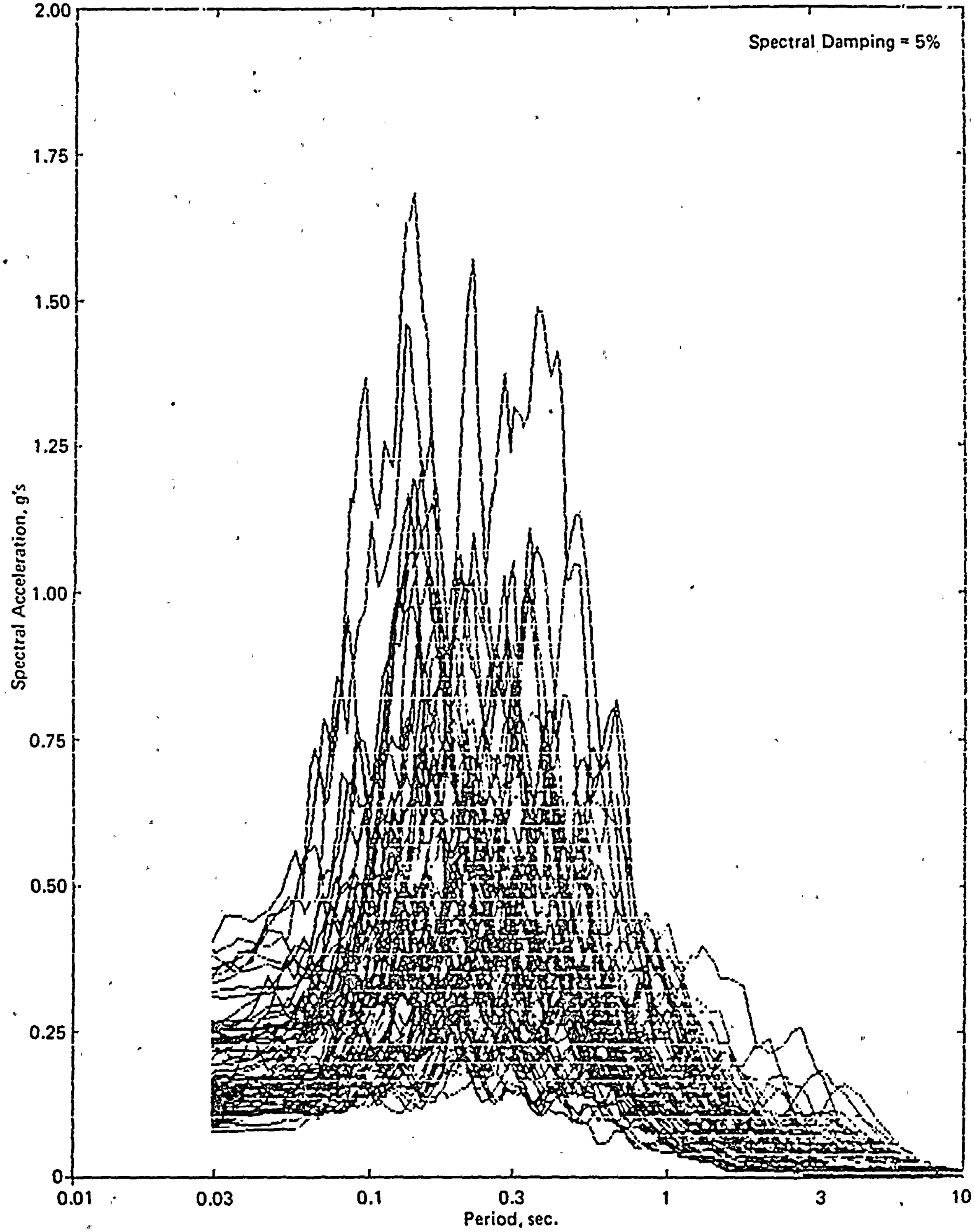
LEGEND

- San Fernando Earthquake, 1971
- Managua, Nicaragua Earthquake, 1972
- Friuli, Italy Earthquakes, 1976
- Coyote Lake Earthquake, 1979
- Livermore Earthquake, 1980
- Mammoth Lakes Earthquakes, 1980

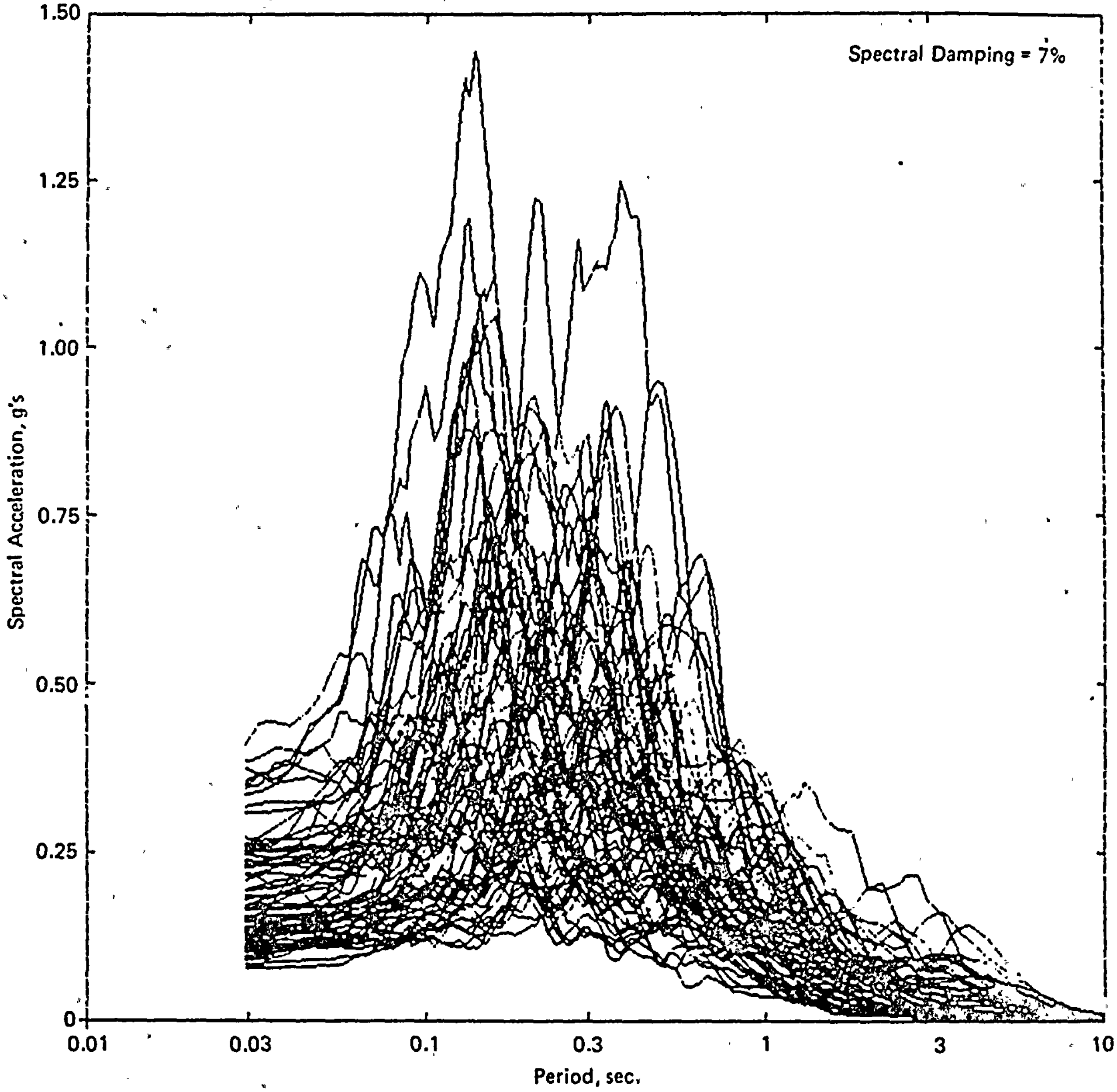
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	SCATTERGRAM OF MAGNITUDES AND DISTANCE FOR DATA SET USED IN ANALYSIS (EPICENTRAL DISTANCE USED WHEN RUPTURE DISTANCE NOT KNOWN)	Figure 361.17-7



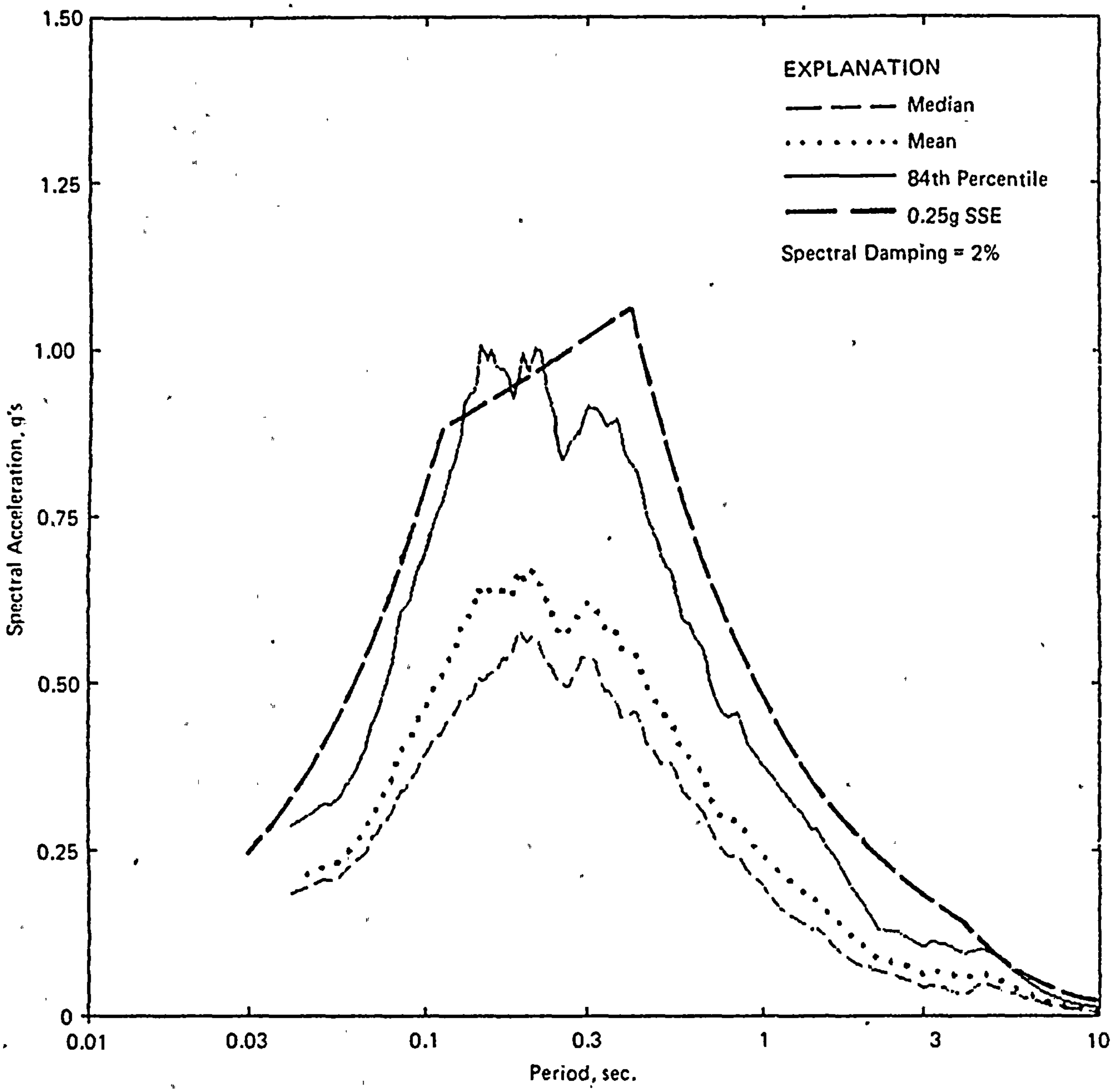
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	OVER PLOT OF 70 RESPONSE SPECTRA USED IN ANALYSIS FOR 2% SPECTRAL DAMPING	Figure 361.17-8



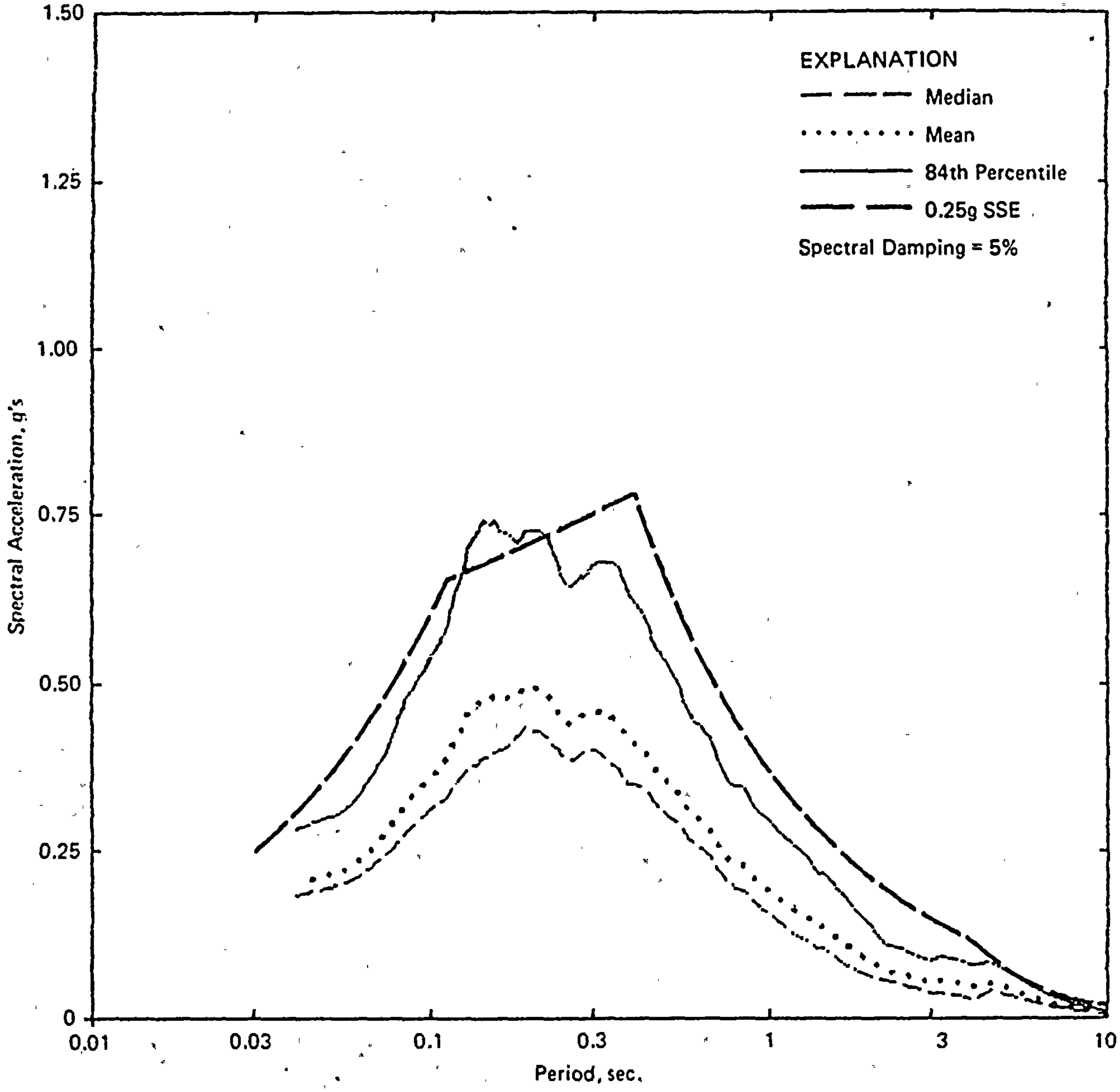
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	OVER PLOT OF 70 RESPONSE SPECTRA USED IN ANALYSIS FOR 5% SPECTRAL DAMPING	Figure 361.17-9



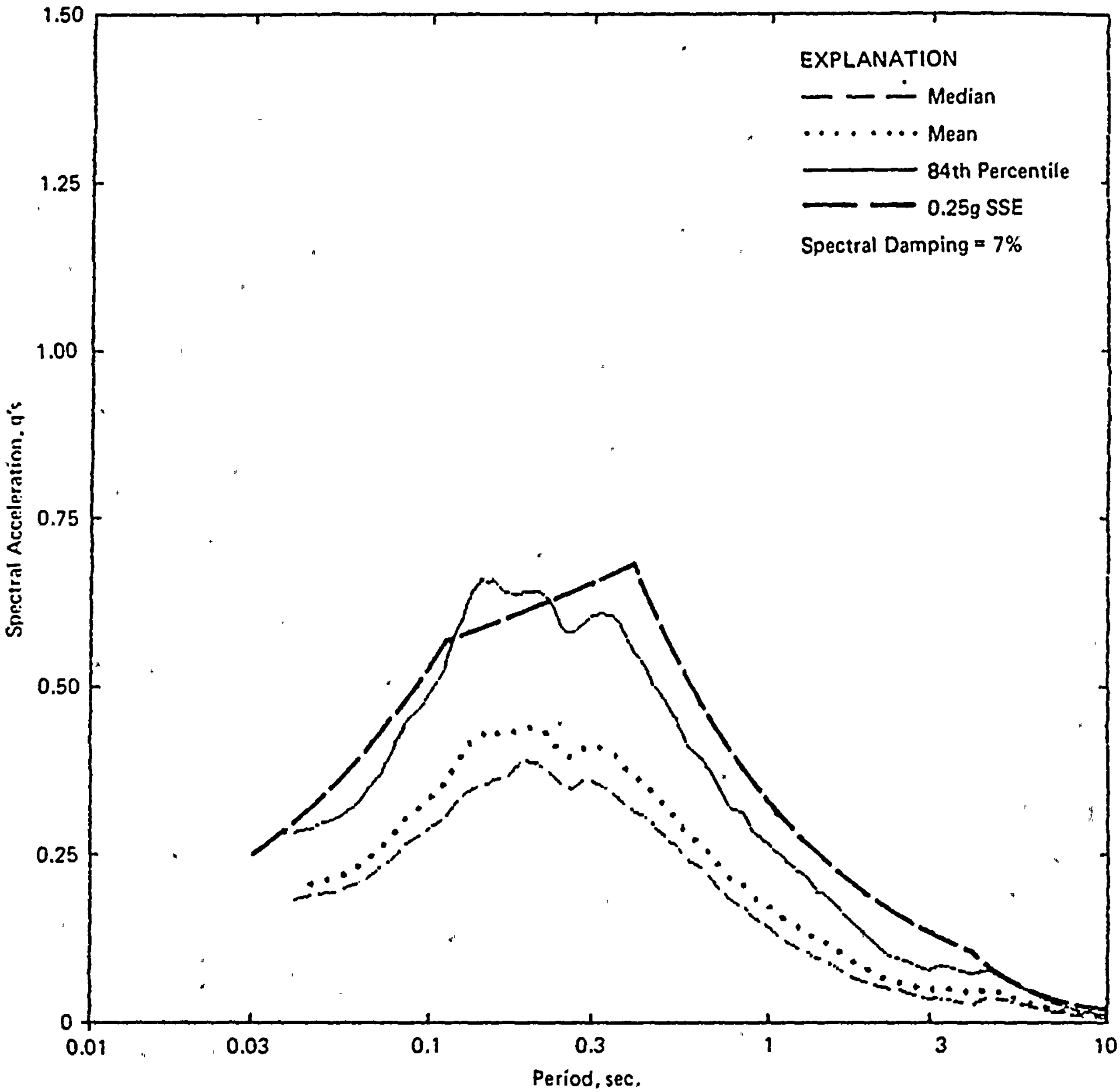
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	OVER PLOT OF 70 RESPONSE SPECTRA USED IN ANALYSIS FOR 7% SPECTRAL DAMPING	Figure 361.17-10



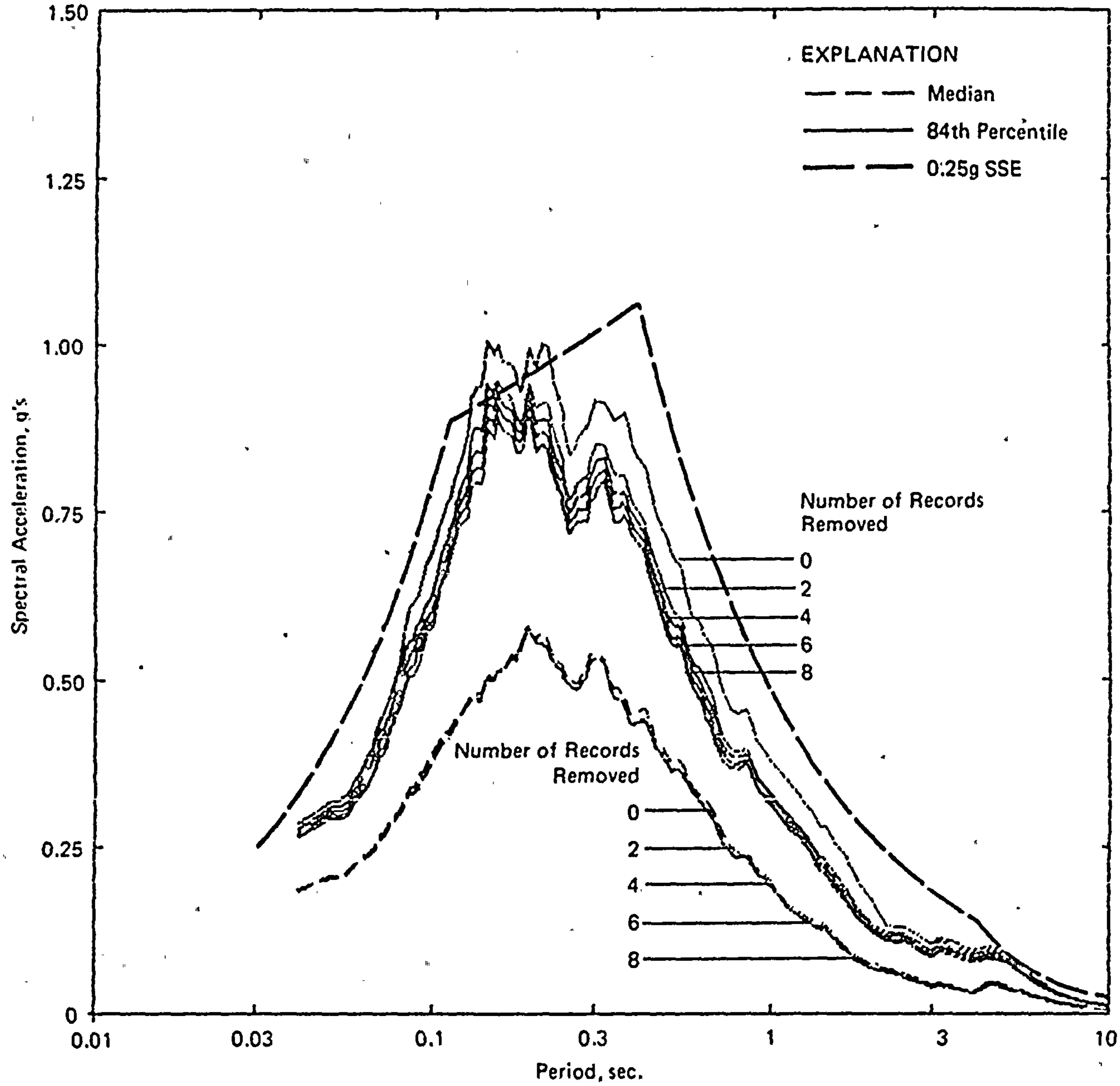
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH SSE DESIGN SPECTRUM: 2% SPECTRAL DAMPING	Figure 361.17-11



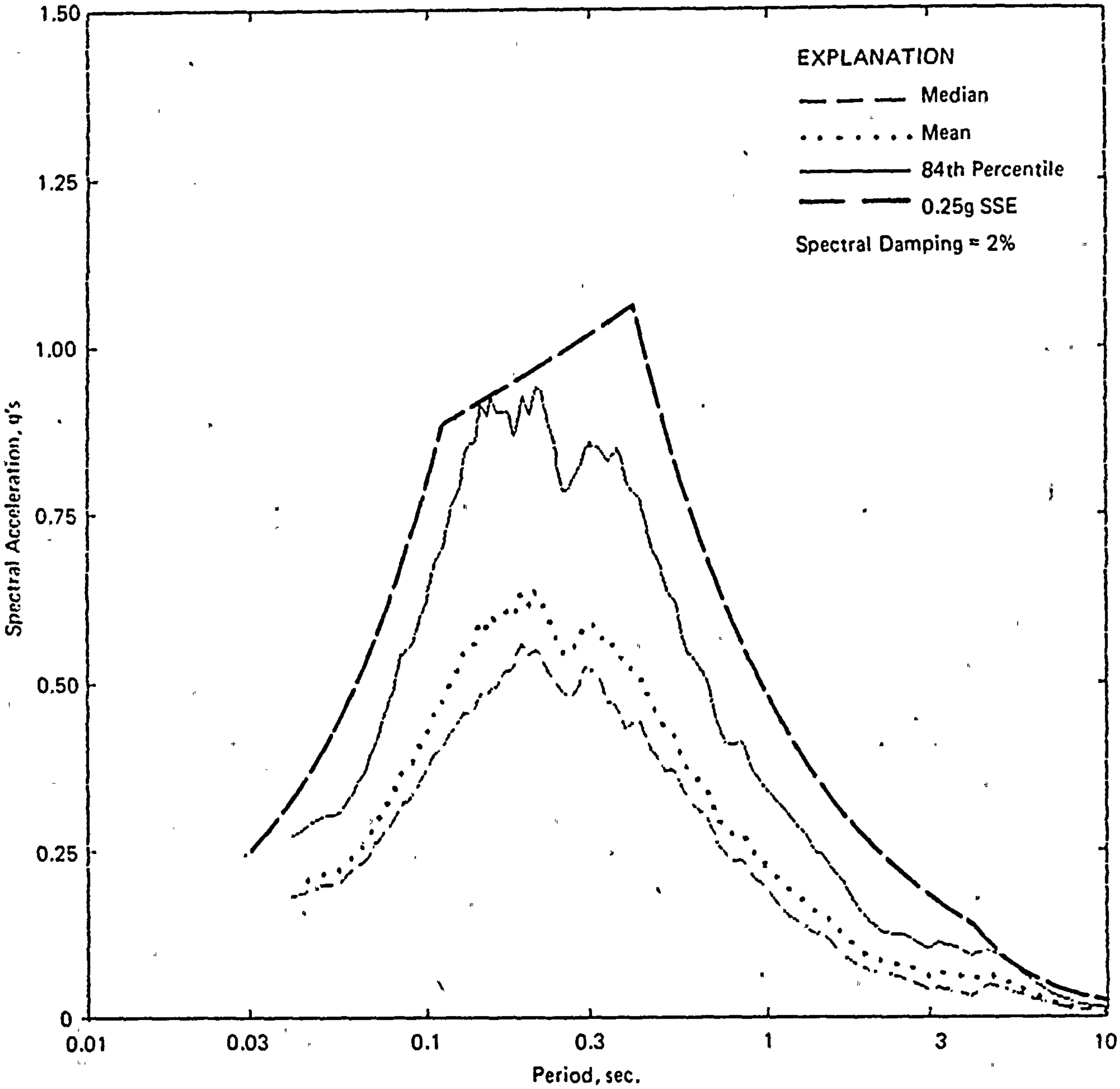
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH SSE DESIGN SPECTRUM: 5% SPECTRAL DAMPING	Figure 361.17-12



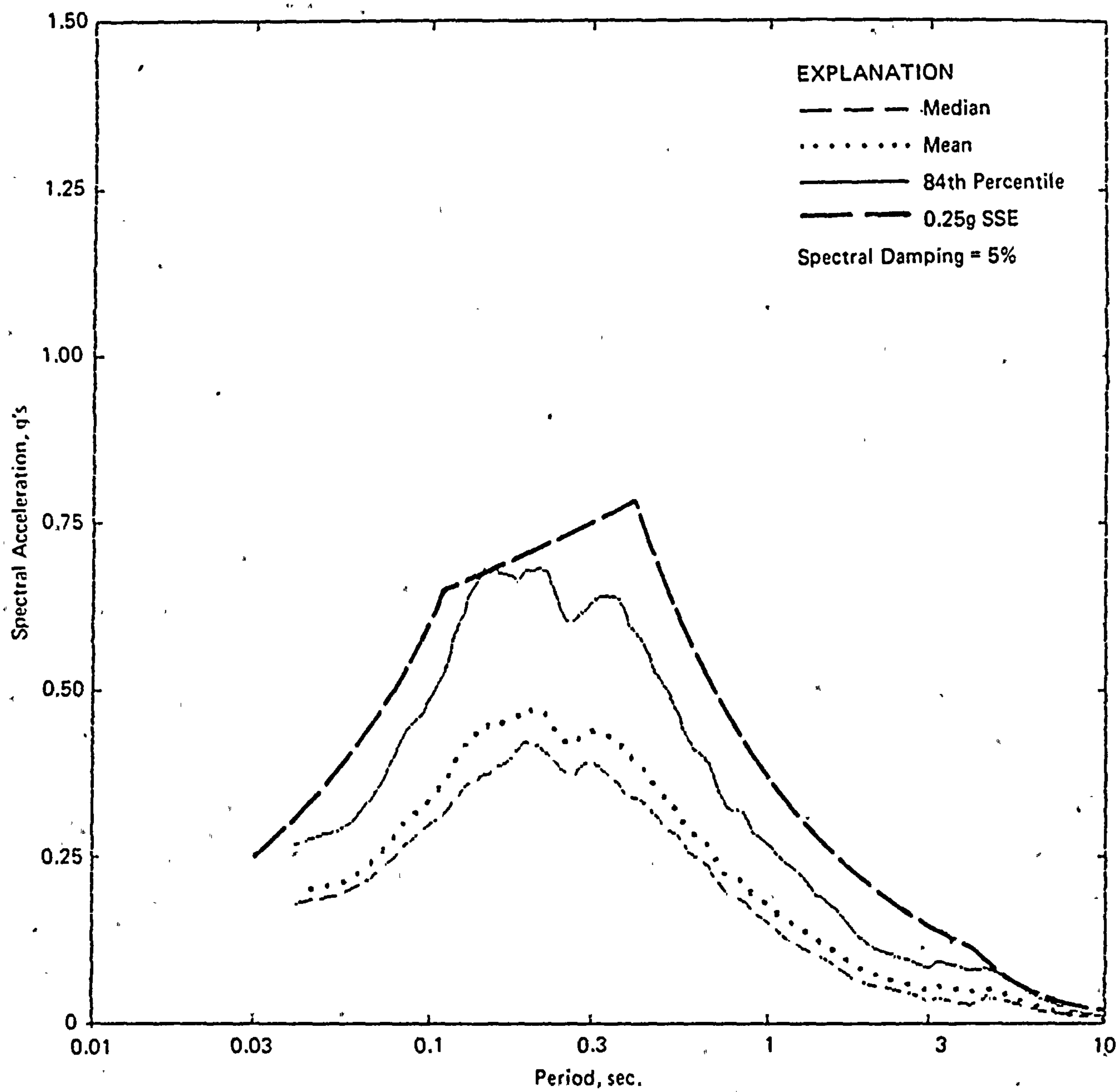
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH SSE DESIGN SPECTRUM: 7% SPECTRAL DAMPING	Figure 361.17-13



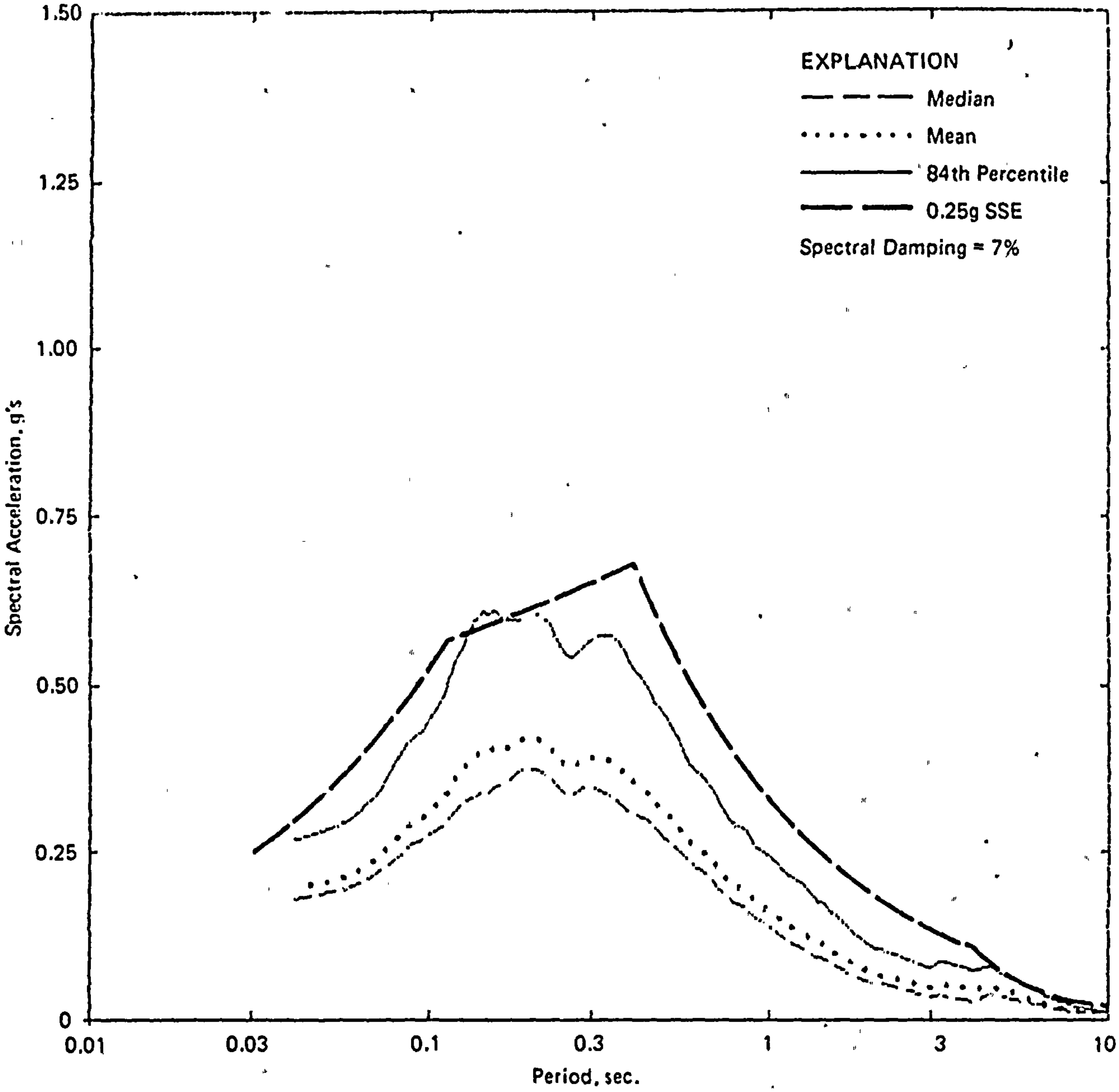
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	EFFECT OF REMOVAL OF EXTREME DATA POINTS ON STATISTICAL RESPONSE SPECTRA	Figure 361.17-14



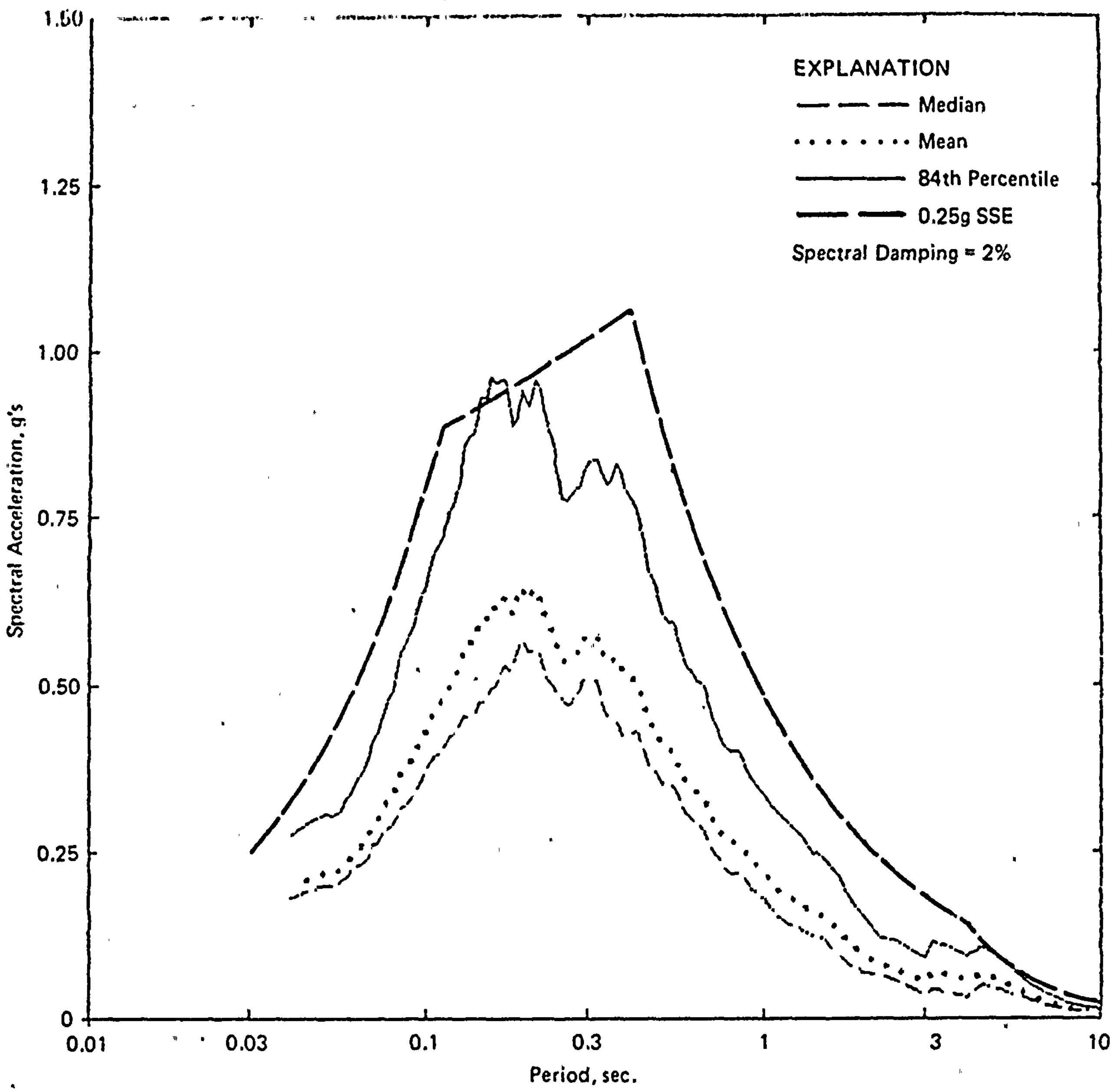
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH MAMMOTH LAKES M_L 5.7 RECORD REMOVED: 2% SPECTRAL DAMPING	Figure 361.17-15



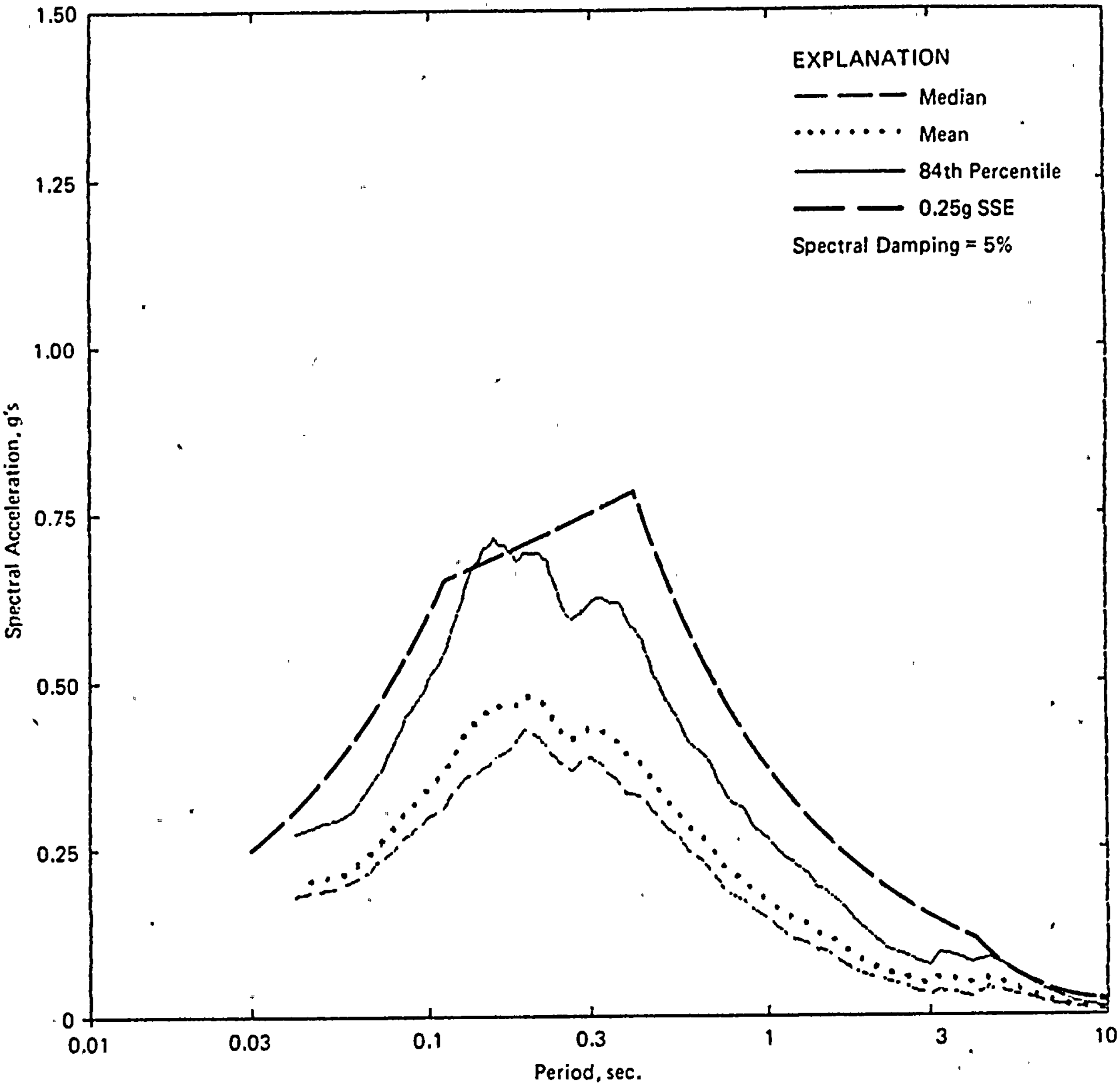
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH MAMMOTH LAKES M_L 5.7 RECORD REMOVED: 5% SPECTRAL DAMPING	Figure 361.17-16



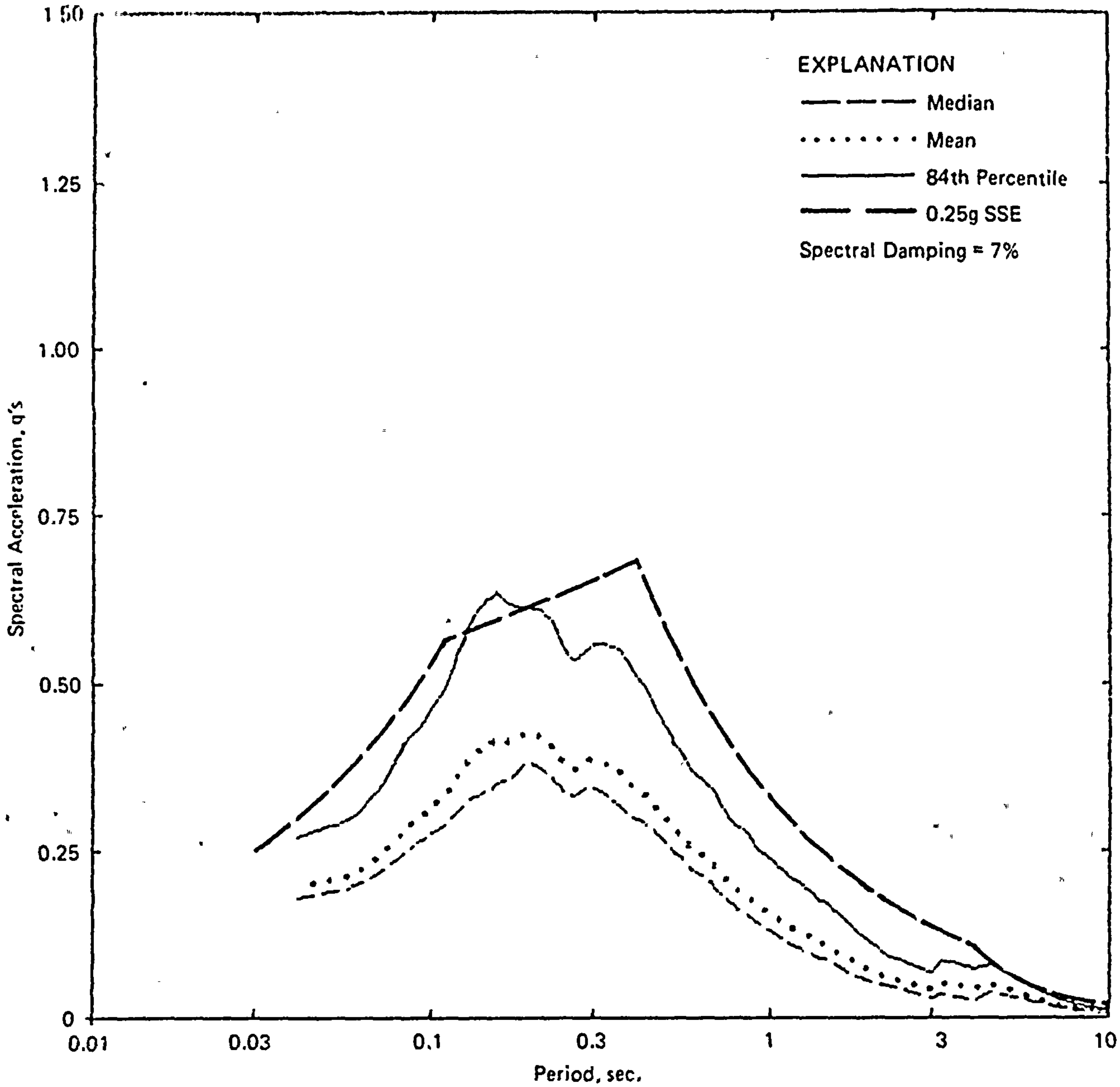
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WITH MAMMOTH LAKES M_L 5.7 RECORD REMOVED: 7% SPECTRAL DAMPING	Figure 361.17-17



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WEIGHTED BY AREA WITH SSE DESIGN SPECTRUM: 2% SPECTRAL DAMPING	Figure 361.17-18



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATE SET WEIGHTED BY AREA WITH SSE DESIGN SPECTRUM: 5% SPECTRAL DAMPING	Figure 361.17-19



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF STATISTICAL RESPONSE SPECTRA FOR ENTIRE DATA SET WEIGHTED BY AREA WITH SSE DESIGN SPECTRUM: 7% SPECTRAL DAMPING	Figure 361.17-20

APPENDIX A

The site descriptions and shear wave velocity profiles presented in this appendix are compiled from two primary sources of data, the Shannon & Wilson reports (1976a, 1976b, 1977, 1979a, 1979b, 1980) and the work by Duke and Leeds (1972), Duke et. al. (1971) and Eguchi et. al. (1976). Where specific information was not available about the site geology, the site conditions were estimated from geologic maps and the shear wave velocities were estimated from published data for similar soils.

A-1 8244 Orion Avenue (Holiday Inn)

The former recording station at 8244 Orion Avenue is designated USGS Station No. 241. The instrument is located on the ground floor of a seven-story building. the site is underlain by an estimated 1000 feet of recent aluvium and pleistocene sediments overlying Miocene sedimentary rocks (Duke et al, 1971). The shearwave velocity profile published by Duke et al. (1971) for the site is shown in Figure 361.17-A1.

A-2 Old R: Route, Castaic

The Old Ridge Route Recording Station at Castaic is designated USGS Station No. 110. The instrument is housed in a sheet-metal prefabricated instrument shelter on the crest of a small ridge. The instrument is underlain by weathered sedimentary rock, grading into fresh rock at depth. The measured shear wave profile is shown in Figure 361.17-A2 (Duke, et al, 1971; and Shannon & Wilson, Inc., 1977). The measured shear wave velocities indicate the subsurface material becomes rock-like at a depth of 100 feet.

A-3 Hollywood Storage PE Lot

The recording station at the Hollywood Storage Building 5 Parking Lot is designated USGS Station No. 135. The instrument was located in a metal shed 112 feet west of the Hollywood Storage Building. Data from a boring drilled at the site (Shannon & Wilson, 1979a) indicates that the accelerograph is underlain by 146 feet of alluvium overlying silts and clays of the Repetto Formation. Figure 361.17-A3 shows the downhole shear wave measurements obtained in the boring. Also shown are shear wave velocities measured by Duke, et al (1971) using surface refraction techniques.

A-4 1640 Marengo Street

The former recording station at 1640 Marengo Street is designated USGS Station No. 181. The instrument is located on the ground floor of a seven-story building. The recording station is within 2000 fett of the USGS Station No. 190 at 2011 Zonal Avenue, which is in an area underlain by a thin alluvial cover overlying Miocene shale and sandstones (Shannon & Wilson, 1976b). The USGS (1981) reports that the station no. 181 is underlain by at least 50 feet of alluvium. The shear wave velocity profile shown in Figure 361.17-A4 is estimated from published data for recent alluvium (Campbell and Duke, 1976) and Miocene Sedimentary Rock (Shannon & Wilson, 1980).

A-5 3407 West Sixth Street

The recording station at 3407 West Sixth Street (Mutual Building) in Los Angeles is designated USGS Station No. 199. The instrument is located on the ground floor of the eight-story office and parking structure. The soil profiles published by Jennings & Strand (1969) indicate the site is underlain by approximately 20 feet of alluvial deposits consisting of Pleistocene clay, silt, sand, and gravel. The shear wave

velocity profile measured by Shannon & Wilson, Inc., (1976b) is shown in Figure 361.17-A5.

A-6 808 South Olive Street

The former recording station at 808 South Olive Street, Los Angeles, is designated USGS Station No. 175. The instrument is located on the ground level of a 8-level garage. the site is located approximately 3000 feet south of the Figueroa Street site investigated by Shannon & Wilson, Inc. (1979b). The area is characterized by recent alluvium overlying Pliocene and Miocene sedimentary rocks. Figure 361.17-A6 shows the estimated shear wave velocity profile for the site. The shear wave velocities assigned to the alluvium are average values reported for similar materials (Campbell and Duke, 1976). The shear wave velocities in the Miocene sedimentary rocks are assumed to be similar to those measured by Shannon & Wilson, Inc. (1979b) at the Figueroa Street site.

A-7 Palmdale Fire Station

The recording station at the Palmdale Fire Station is designated USGS Station No. 262. The instrument is located on the ground floor of a single story building. The site is underlain by an unknown depth of granular alluvium over granitic basement rocks. The shear wave velocity profile shown in Figure 361.17-A7 was estimated from the relationship published by Campbell and Duke (1976) for recent alluvium.

A-8 450 North Roxbury, Beverly Hills

The former recording station at 450 North Roxbury is designated USGS Station No. 455. The instrument was located on the ground floor of a 10-story building. The site is underlain by at least 60 feet of recent alluvium (USGS, 1981). Figure 361.17-A8 shows the shear wave velocities measured at the site by Eguchi et al (1976).

A-9 Lake Hughes Array No. 1

The recording station at the Los Angeles County Fire Station No. 78 is designated USGS Station No. 125. The instrument is located in a one story fire truck garage. The site is underlain by more than 55 feet of alluvial deposits which overlie granitic bedrock at an unknown depth (Dibole, 1961). The alluvial soils between the surface and 55 feet in depth consist of loose to medium dense sands with gravel and cobbles. The shear wave velocity profile reported by Duke et al (1971) is shown in Figure 361.17-A9.

A-10 1625 West Olympic Boulevard, Los Angeles

The former recording staion at 1625 West Olympic Boulevard, is designated USGS Station No. 469. The instrument is located on the ground floor of a 10-story building. The site is approximately 5000 feet southwest of the Figueroa Street site investigated by Shannon & Wilson (1979c) in an area characterized by shallow alluvium overlying Miocene sedimentary rocks. The shear wave velocity profile measured by Duke and Leeds (1972) is shown in Figure 361.17-A10.

A-11 14724 Ventura Boulevard, Los Angeles

The recording station at 14724 Ventura Boulevard, Los Angeles, is designated USGS Station No. 253. The recording instrument is located on the ground floor of a 14-story, reinforced concrete shear wall office tower. The soil profiles published by Jennings & Strand (1969) indicate that the site is underlain by unconsolidated recent alluvium. This material is approximately 60 feet thick, consisting of clay, silt, sand, and gravel. Rocks of the upper Miocene Modelo Formation and the middle Miocene Topanga Formation underlie the alluvium (Duke et al, 1971). The shear wave velocity profile measured by Shannon & Wilson, Inc. (1976b) is shown on Figure 361.17-A11.

A-12 1760 North Orchid Street, Los Angeles

The former recording station at 1760 North Orchid Street is designated USGS Station No. 446. The instrument is located on the ground floor of a 23-story building. The site is approximately 500 feet north of the Hollywood Storage building near the base of the Santa Monica Mountain. The site is underlain by at least 60 feet of alluvium (USGS, 1981) overlying Miocene sedimentary rocks. The shear wave velocity profile shown in Figure 361.17-A12 is based on the velocities measured in the alluvial soils at the Hollywood Storage building (Shannon & Wilson, Inc., 1979a) and velocities measured in Miocene sedimentary rocks (Shannon & Wilson, Inc., 1980).

A-13 800 West First Street

The recording station at 800 West First Street, Los Angeles, is designated USGS Station No. 172. The instrument is located on the ground floor of a 32-story apartment house. The building is situated on a topographic high and is underlain by fractured, weathered shale. The shale is 120 feet below the surface, as determined by foundation engineering borings. The shear wave velocity profile shown in Figure 361.17-A13 was measured at the nearby station at 222 Figueroa Street (Shannon & Wilson, Inc., 1979b).

A-14 222 Figueroa Street, Los Angeles

The recording station at 222 Figueroa Street, Los Angeles, is designated USGS Station No. 145. The instrument is located on the ground floor of a 17-story concrete structure. The site is underlain by 5 to 22 feet of fill overlying a sequence of alluvial sand, silt, and clay. The alluvium extends to between 26 and 33 feet below the surface, where it overlies the shale of the upper Miocene puente formation. Figure 361.17-A14 shows the shear wave velocity measured by Shannon & Wilson, Inc. (1979b).

A-15 6200 Wilshire Boulevard

The recording station at 6200 Wilshire Boulevard, Wilshire Medical Building, is designated USGS Station No. 443. The instrument is located on the ground floor of the 16-story building. The site is underlain by a sequence of Pleistocene older alluvium and terrace deposits. The upper most 130 feet consists of about 49 feet of firm clay, silt, and dense sand overlying 55 feet of asphaltic sand. The lowermost 26 feet consists of firm sandy silt and dense silty sand. The shear wave velocity profile reported by Shannon & Wilson, Inc. (1976a) is shown in Figure 361.17-A15.

A-16 Esso Refinery, Managua, Nicarogua

The recording station at the Esso Refinery is designated USGS Station No. 3501. The instrument is located in a tin shelter next to the main office building. Soil borings indicate that the site is underlain by approximately 150 feet of alluvial deposits of sands, clays and gravels. Below the alluvial deposits fractured basalt and basalt fragments were encountered. The basalt fragments are underlain by a thick sequence of interbedded volcanic and alluvial deposits. The measured shear wave velocity profile reported by Faccioli et al (1973) is shown in Figure 361.17-A16.

A-17 Forgaria - Cornino, Italy

The site of the temporary recording station at Forgaria-Cornino is underlain by approximately 50 feet of alluvial deposits. The alluvial material is underlain by a sloping bedrock consisting of marly sandstone and sandstone (Muzzi and Vallini, 1977). Figure 361.17-A17 shows the shear wave velocity profile for the site estimated from measured velocities in similar materials (Muzzi and Pugilese, 1977; Weston Geophysical, 1981).

A-18 Buia, Italy

The temporary station at Buia, Italy is underlain by a deep alluvial deposit of sand, clay, and gravel, (Basili et. al., 1976). The shear wave velocities in the alluvial soils, shown in Figure 361.17-A18, are assumed to be similar to those reported for Tarcento by Weston Geophysical (1981).

A-19 Tarcento, Italy

The temporary recording station at Tarcento, Italy, was located on approximately 60 feet of alluvial soils overlying marl and sandstone (Busili et. al., 1978). The shear wave profile shown in Figure 361.17-A19 is estimated from velocities measured in similar materials (Weston Geophysical, 1981).

A-20 Gilroy Array Station No. 2

The recording station at the Mission Trails Motel is designated USGS Station No. 1409. The instrument is located on the ground floor of a single story building. The site is underlain by in excess of 500 feet of recent alluvium consisting of medium dense to dense sands (Rogers and Williams, 1974). The shear wave profile shown in Figure 361.17-A20 is estimated from the data presented by Fumal (1978) for similar materials.

A-21 Gilroy Array Station No. 3

The recording station at the Gilroy Sewage Plant is designated USGS Station No. 1410. The instrument is located on the ground floor of a single story building. The site is underlain by approximately 1000 feet of recent alluvium (Rogers and Williams, 1974). The soils are expected to be very similar to Gilroy Array Station No. 2. The estimated shear wave velocity profile is shown in Figure 361.17-A20.

A-22 Gilroy Array Station No. 4

The recording station at San Ysidro School is designated USGS Station No. 1411. The instrument is located on the ground floor of a single story building. The site is underlain by in excess of 500 feet of recent alluvium (Rogers and Williams, 1974). The soils are expected to be very similar to Array Stations 2 and 3. The estimated velocity profile is shown in Figure 361.17-A20.

A-23 San Juan Bautista 101/156 Overpass

The recording station at the Highway 101/156 overpass is designated USGS Station No. 1492. Instruments are located at the ground level on two support columns of a freeway overpass. The site is underlain by an unknown depth of upper Pleistocene terrace gravels (Allen, 1946). The shear wave velocity profile shown in Figure 361.17-21 is estimated from the data published by Fumel (1978) for gravelly soil.

A-24 24 Polk Street, San Juan Bautista

The recording station at 24 Polk Street is designated USGS Station No. 1377. The instrument is located on the ground floor of a single story building. The site is underlain by an unknown depth of upper Pleistocene terrace gravels (Allen, 1946). The shear wave velocity profile is shown in Figure 361.17-A21 is estimated from the data published by Fumel (1978) for gravelly soils.

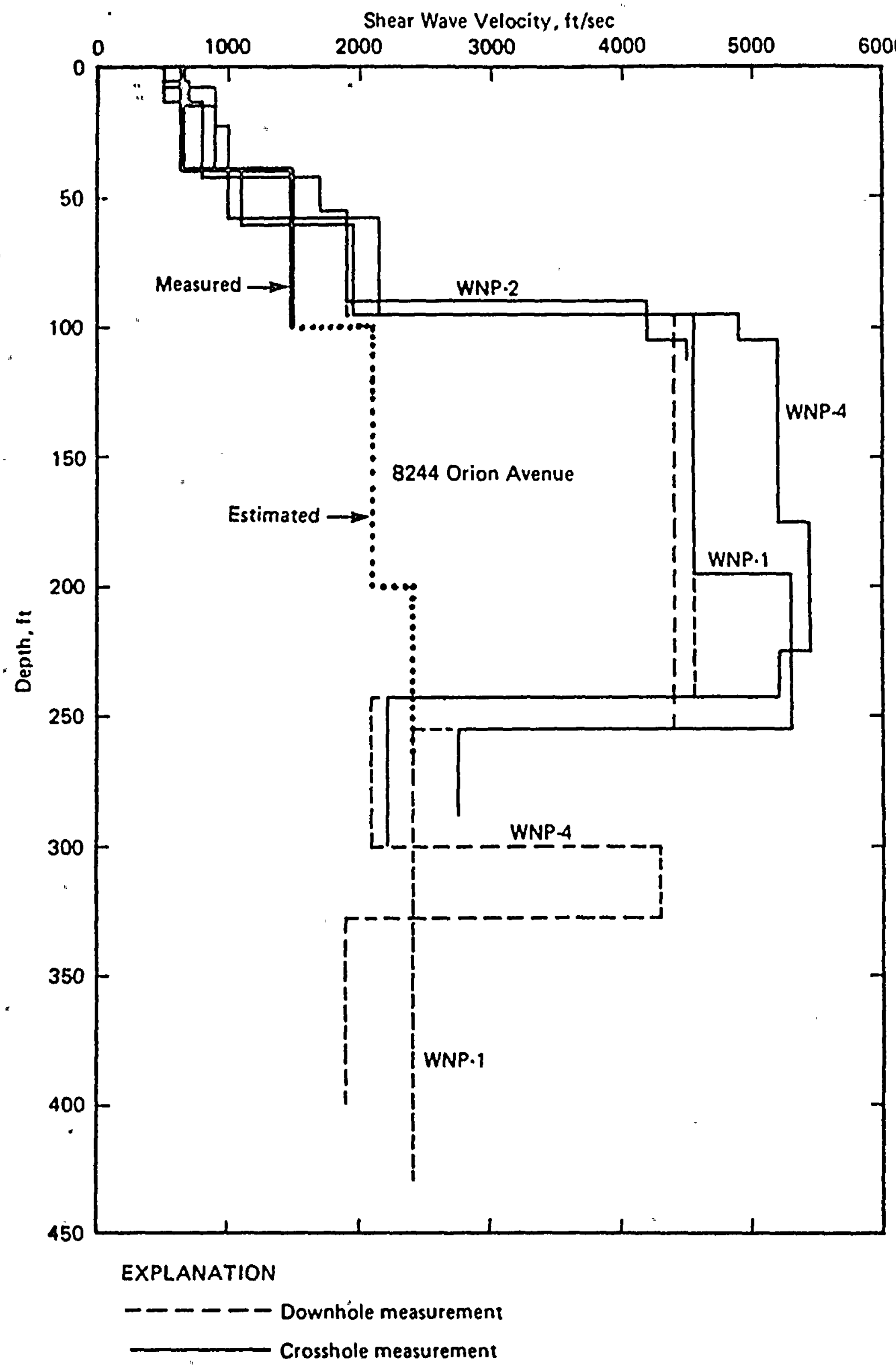
A-25 Del Valle Dam

The recording station at Del Valle Dam is designated USGS Station No. 1265. The instrument is located in an instrument shelter at the downstream toe of an earth dam in a narrow canyon. The site is underlain by shallow alluvium of unknown depth overlying Cretaceous sandstones and shales (Huey, 1948). The velocity

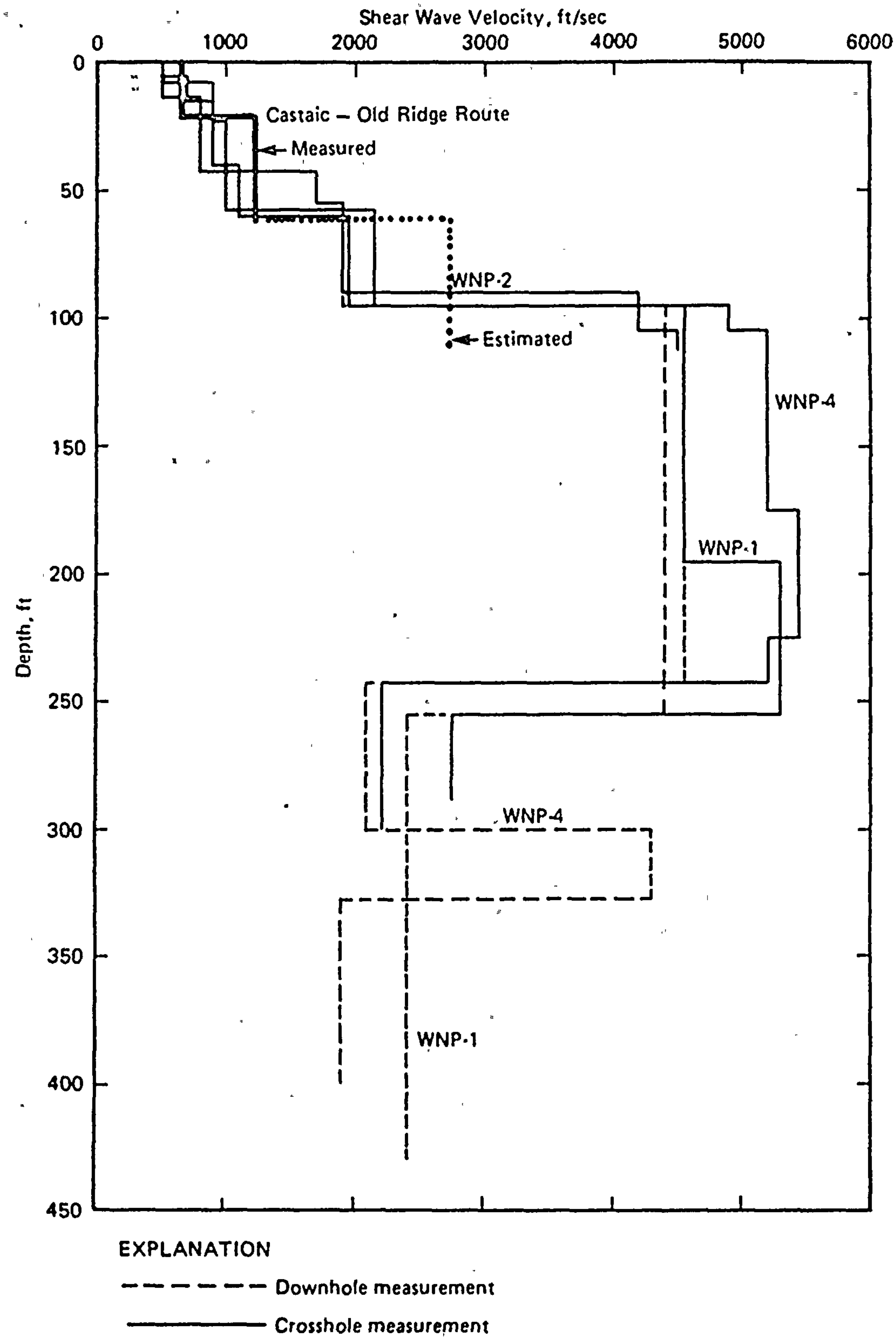
profile shown in Figure 361.17-A22 is estimated from measured velocities in similar materials (Fumel, 1978).

A-26 Convet Creek, Mammoth

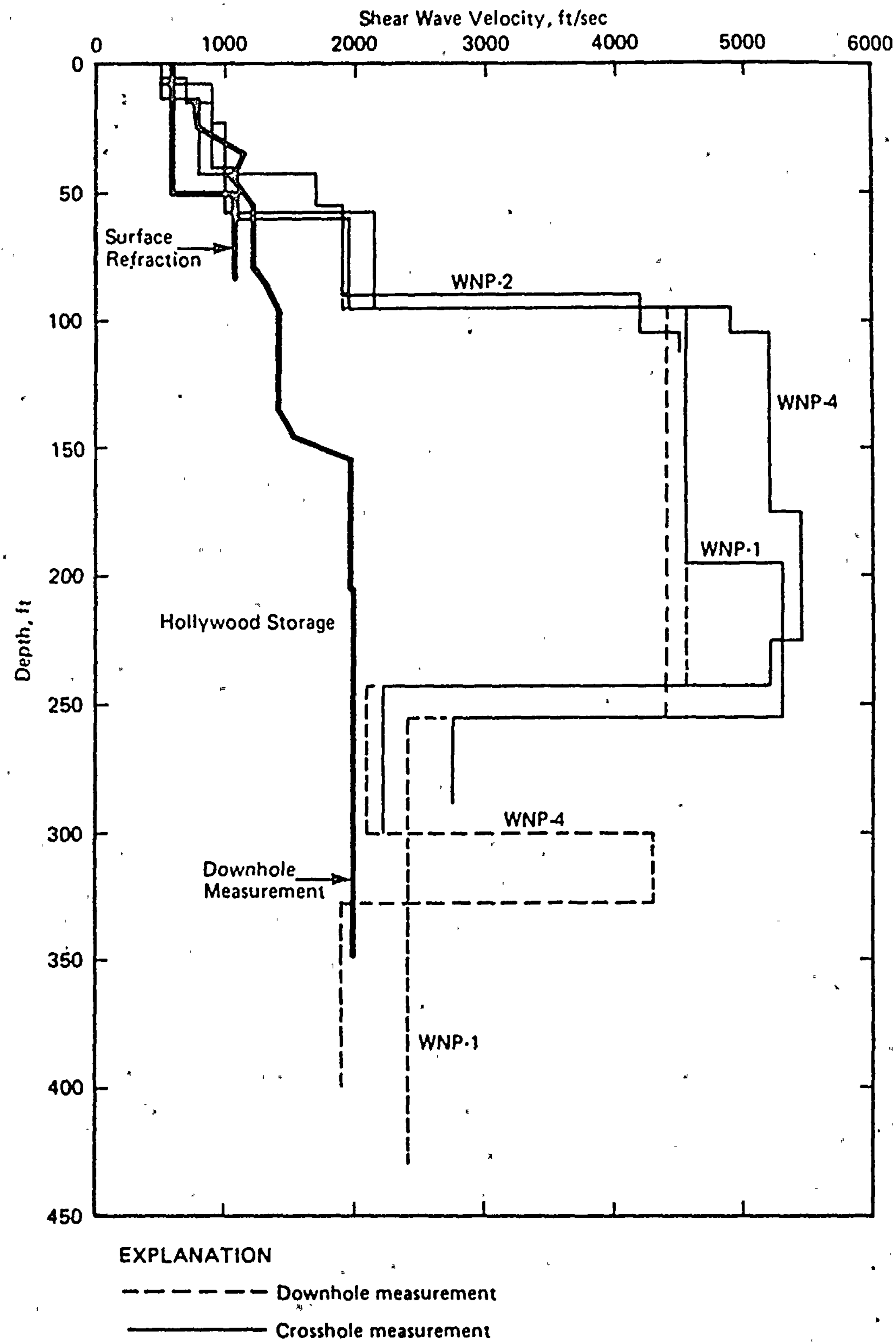
The recording station at the Fish and Game Experimental Station near Mammoth Lakes is designated USGS Station No. 1324. The instrument is located on the ground floor of a single story building. The site is underlain by in excess of 100 feet of alluvium (USGS, 1981). The alluvium is expected to be very coarse grained deposits of sand and gravel. The velocity profile shown in Figure 361.17-23 was estimated from the compression wave velocities measured by Duke and Leeds (1972) for similar soils at Bishop, California.



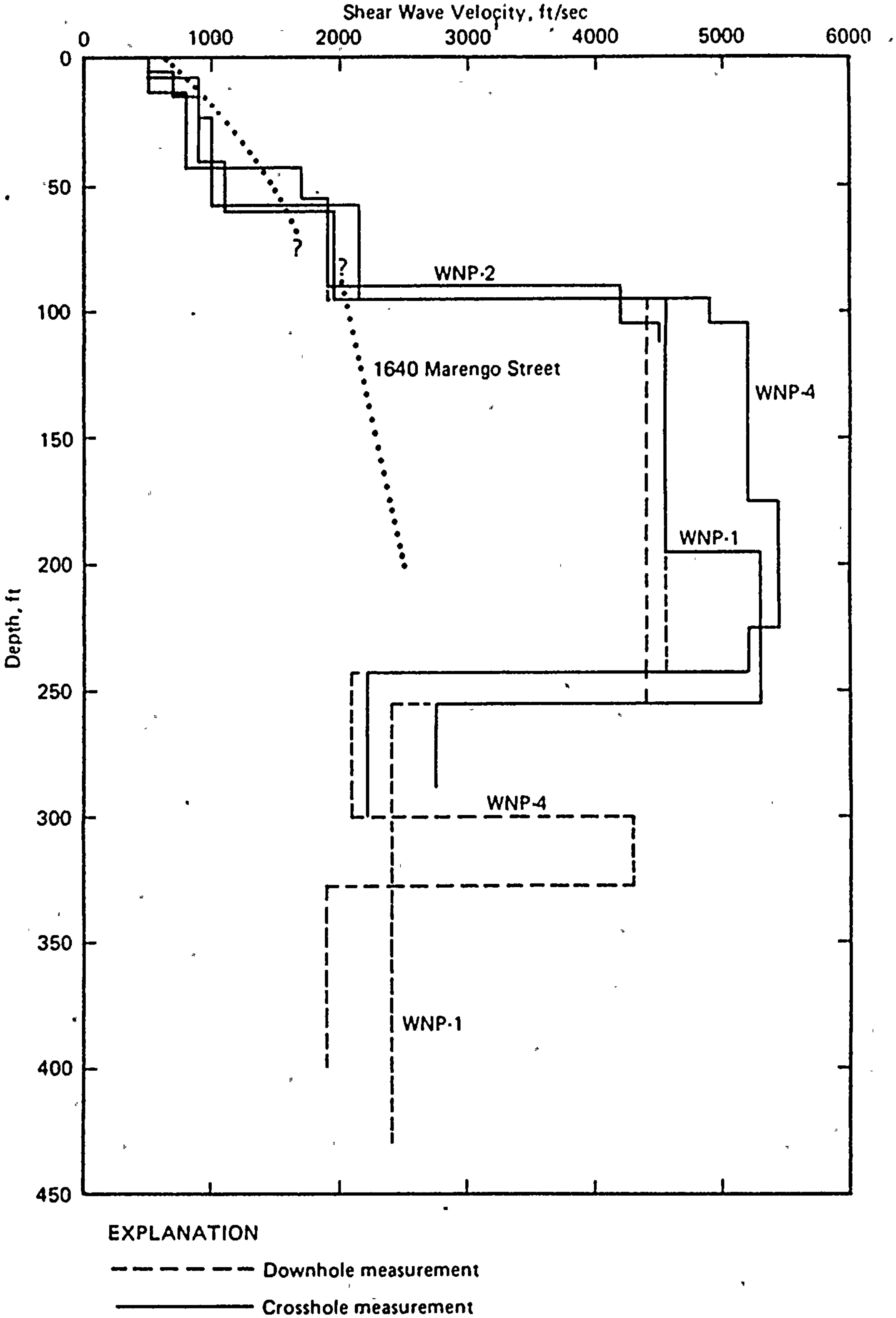
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 8244 ORION AVENUE VERSUS WNP 1,2 & 4	Figure 361.17-A1



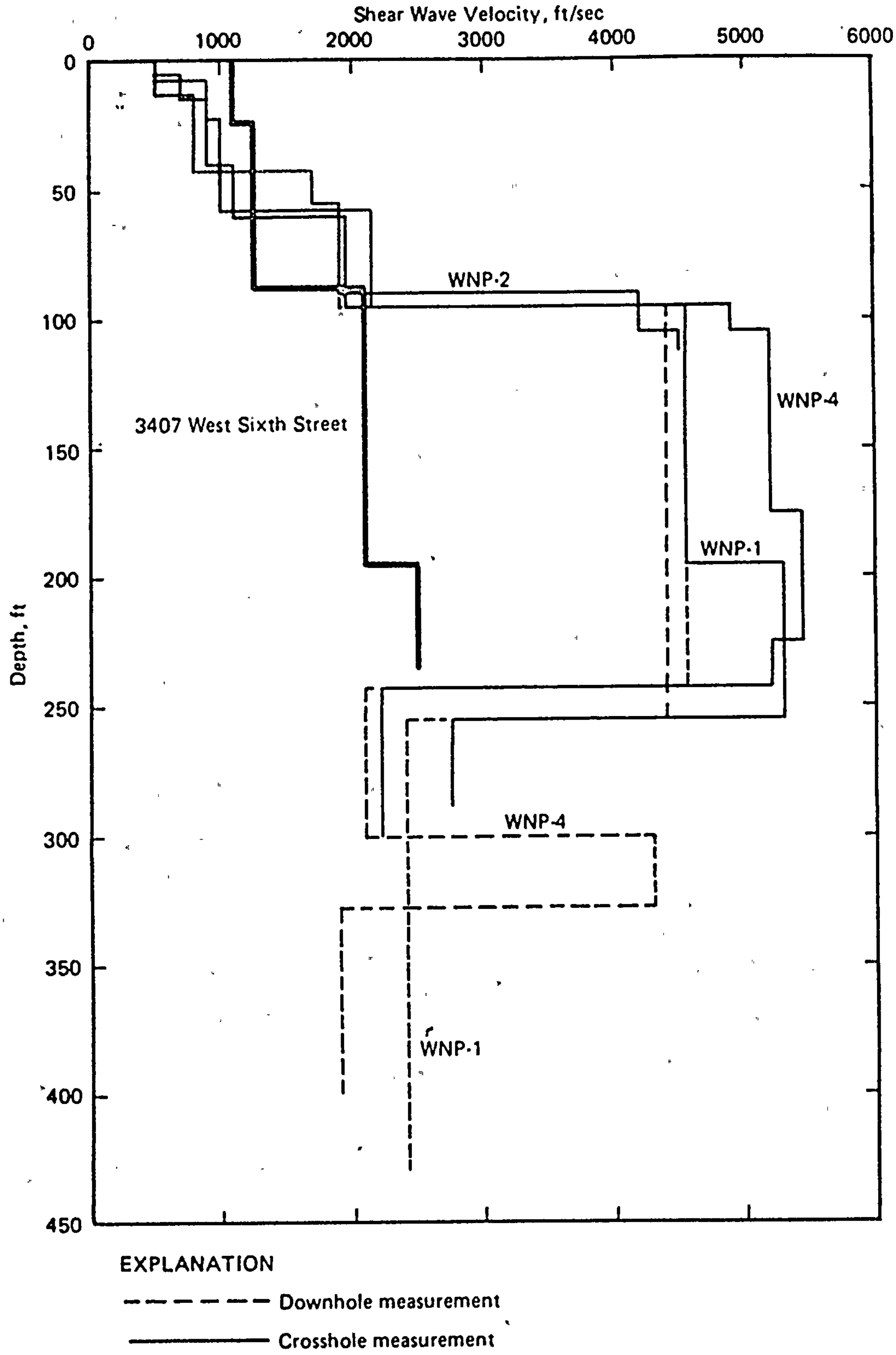
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: CASTAIC – OLD RIDGE ROUTE VERSUS WNP 1,2 & 4	Figure 361.17-A2



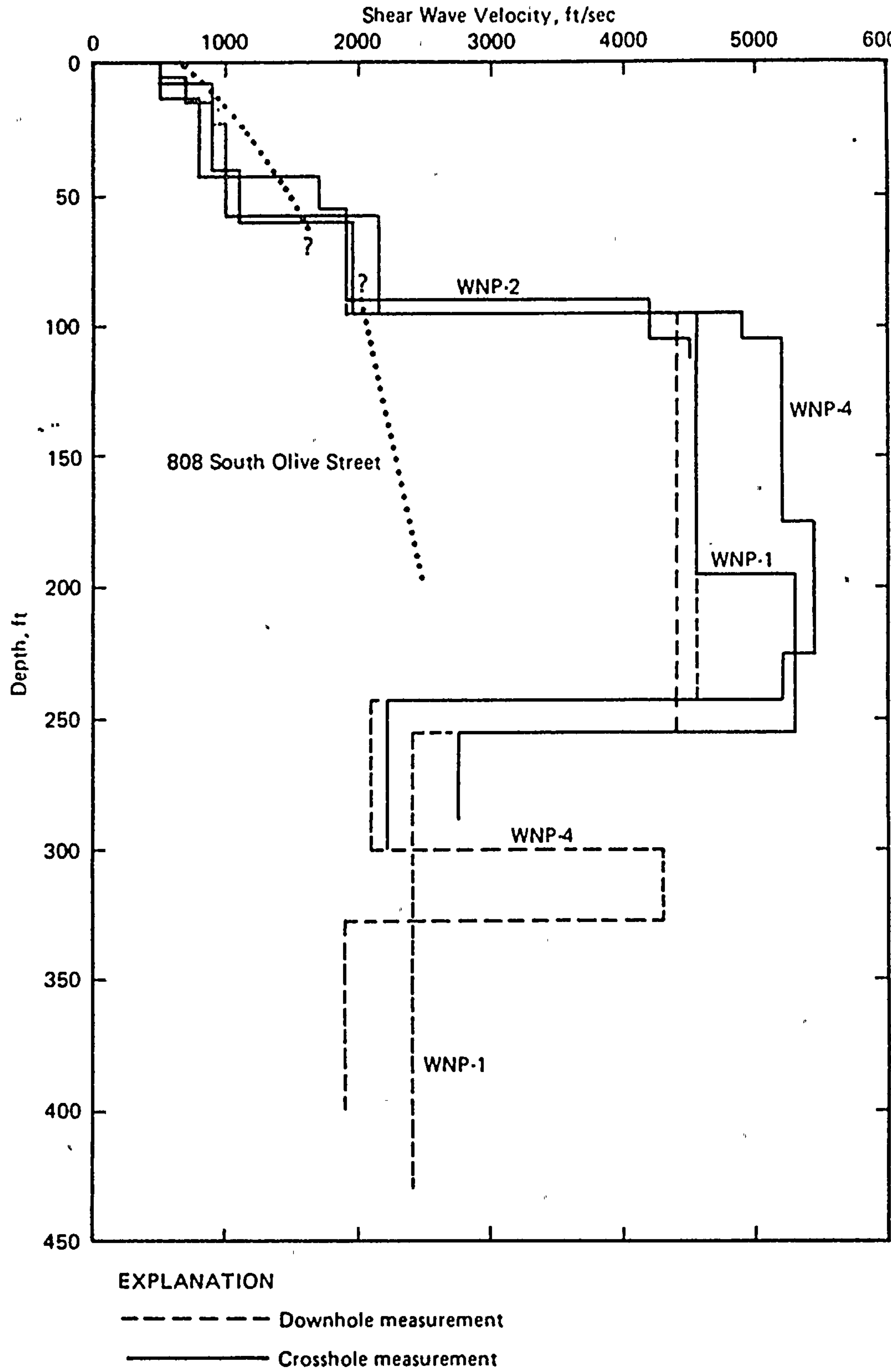
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: HOLLYWOOD STORAGE PE LOT VERSUS WNP 1,2 & 4	Figure 361.17-A3



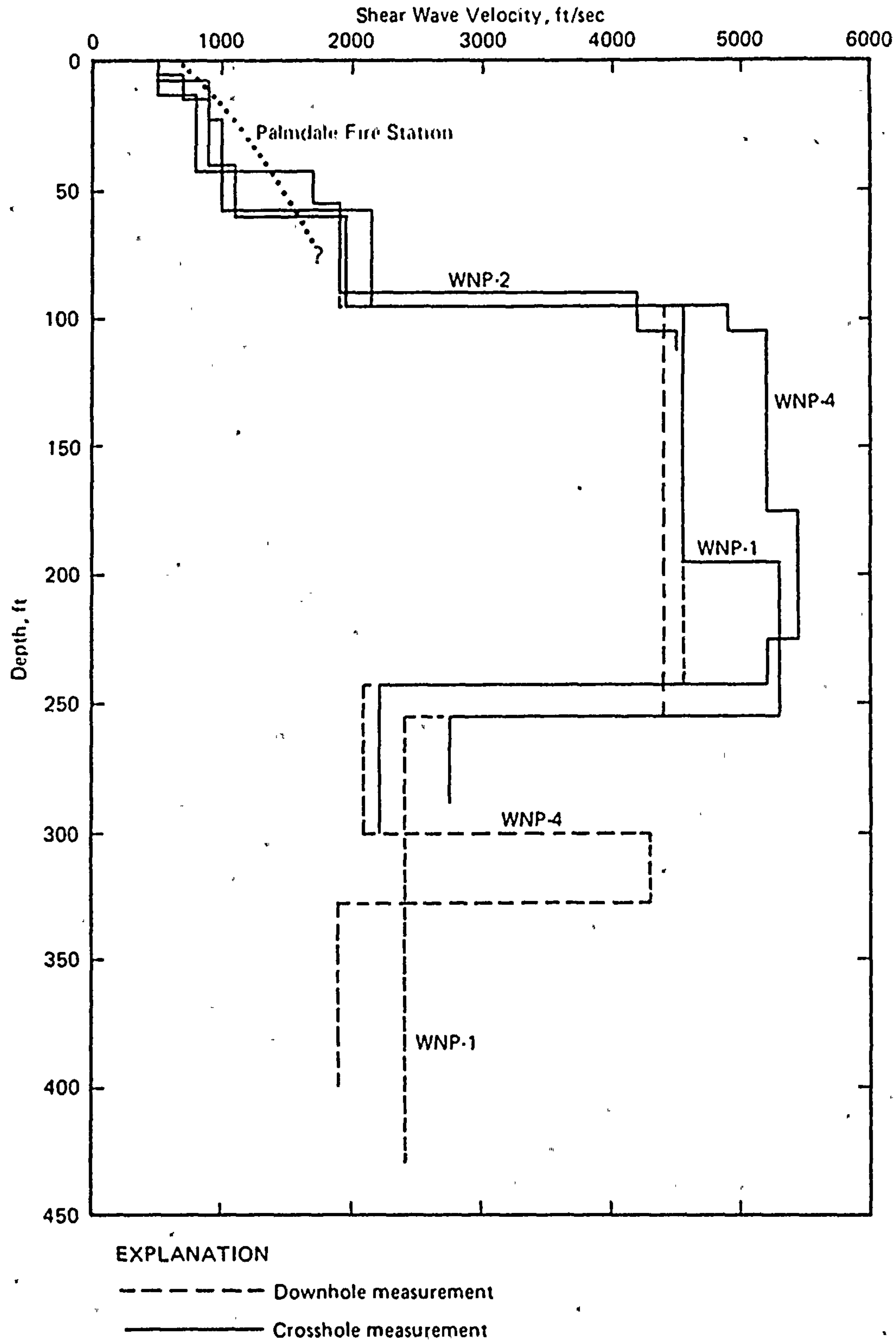
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 1640 MARNGO STREET VERSUS WNP 1,2 & 4	Figure 361.17-A4



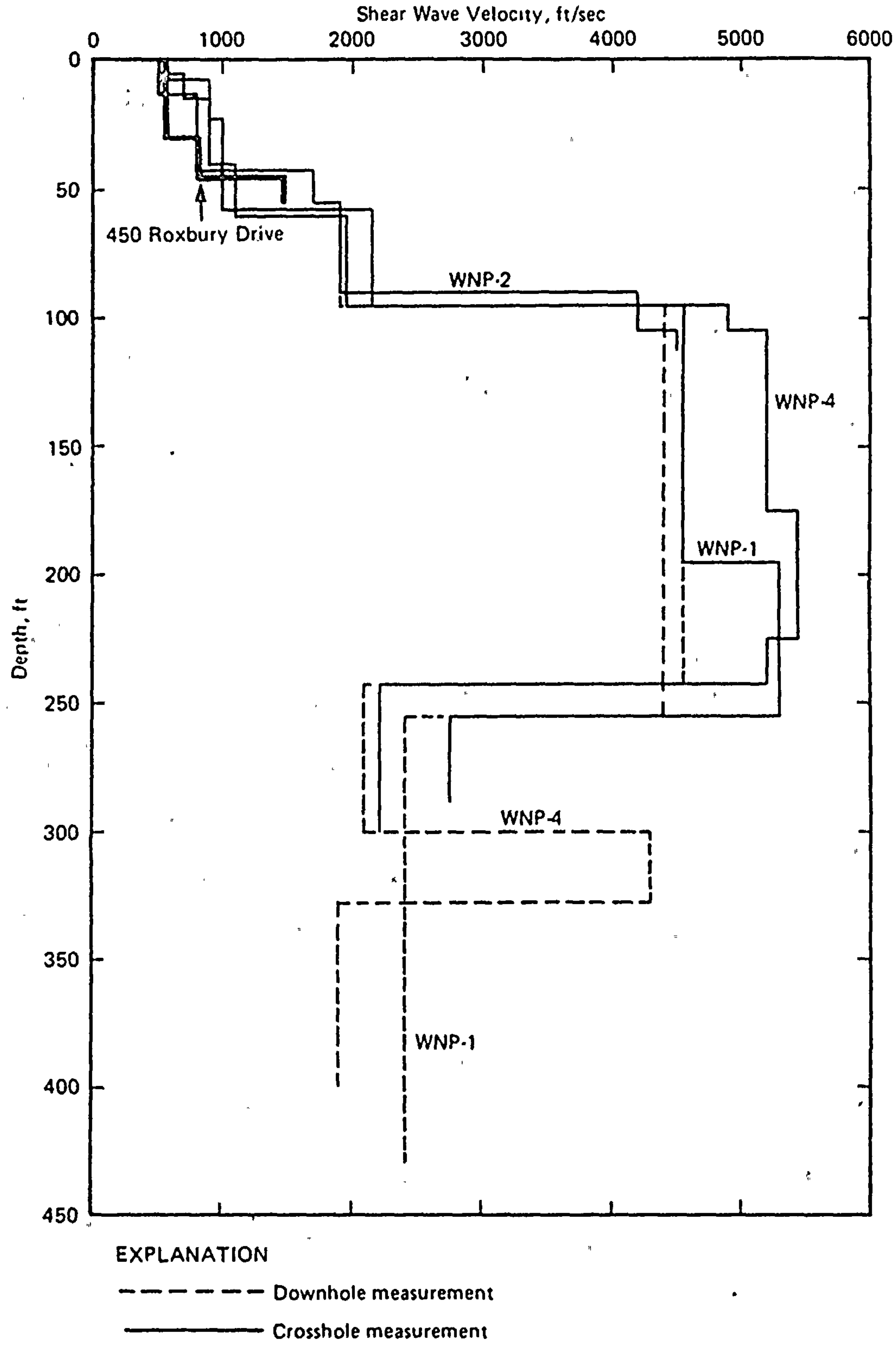
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 3407 WEST SIXTH STREET VERSUS WNP 1,2 & 4	Figure 361.17-A5



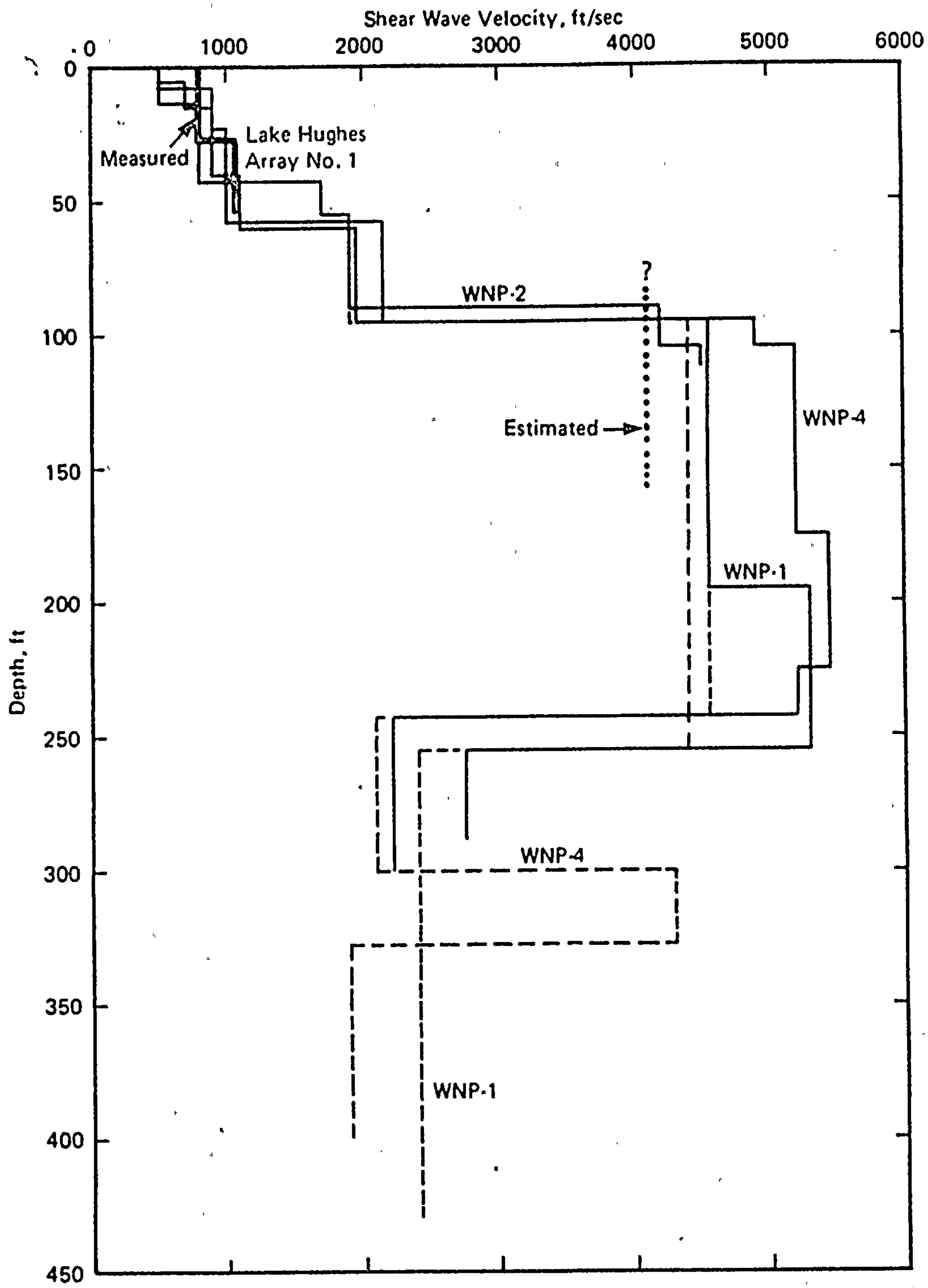
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 808 SOUTH OLIVE STREET VERSUS WNP 1,2 & 4	Figure 361.17-A6



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: PLAMDALE FIRE STATION VERSUS WNP 1,2 & 4	Figure 361.17-A7



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 450 ROXBURY DRIVE VERSUS WNP 1,2 & 4	Figure 361.17-A8

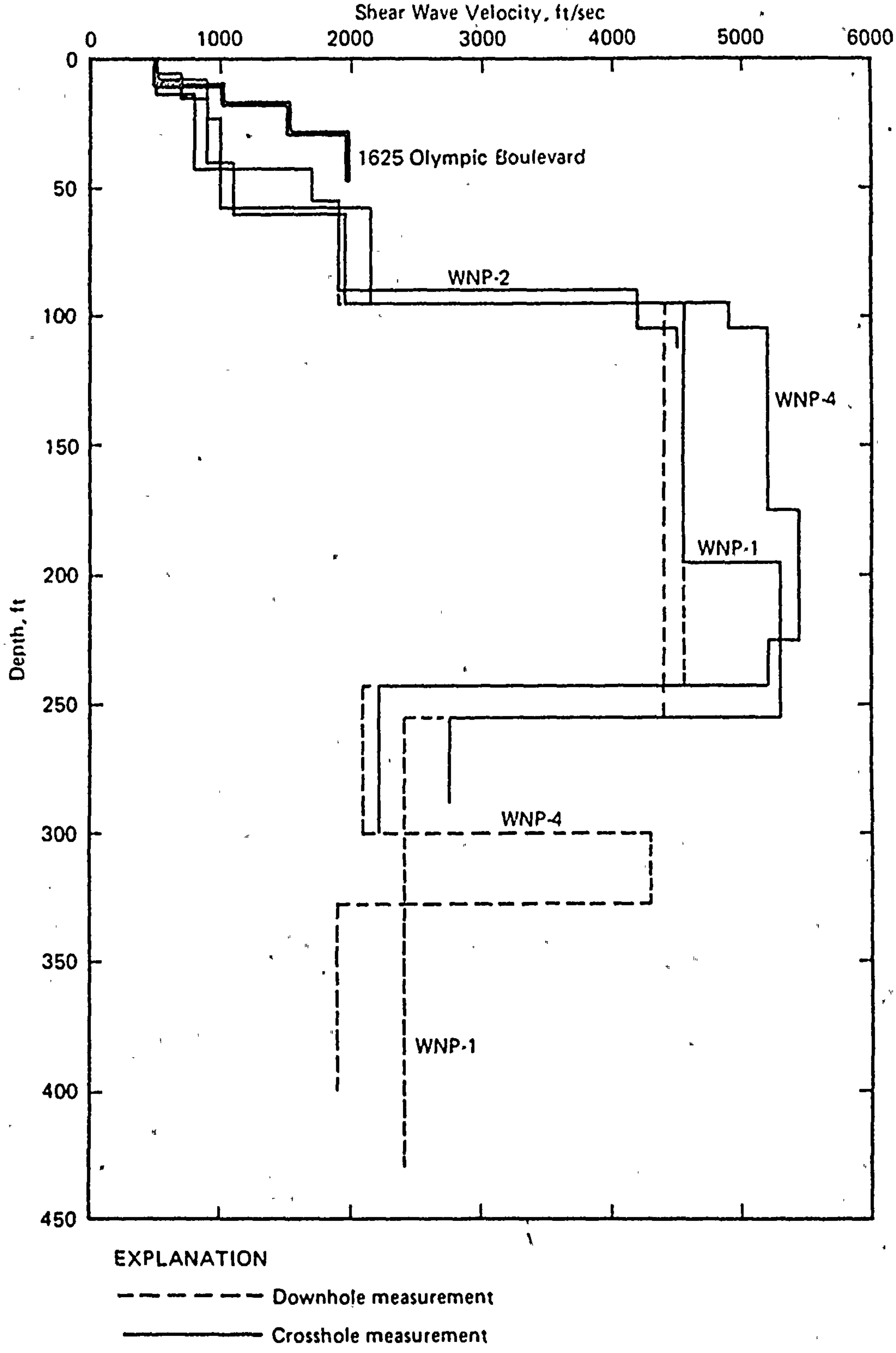


EXPLANATION

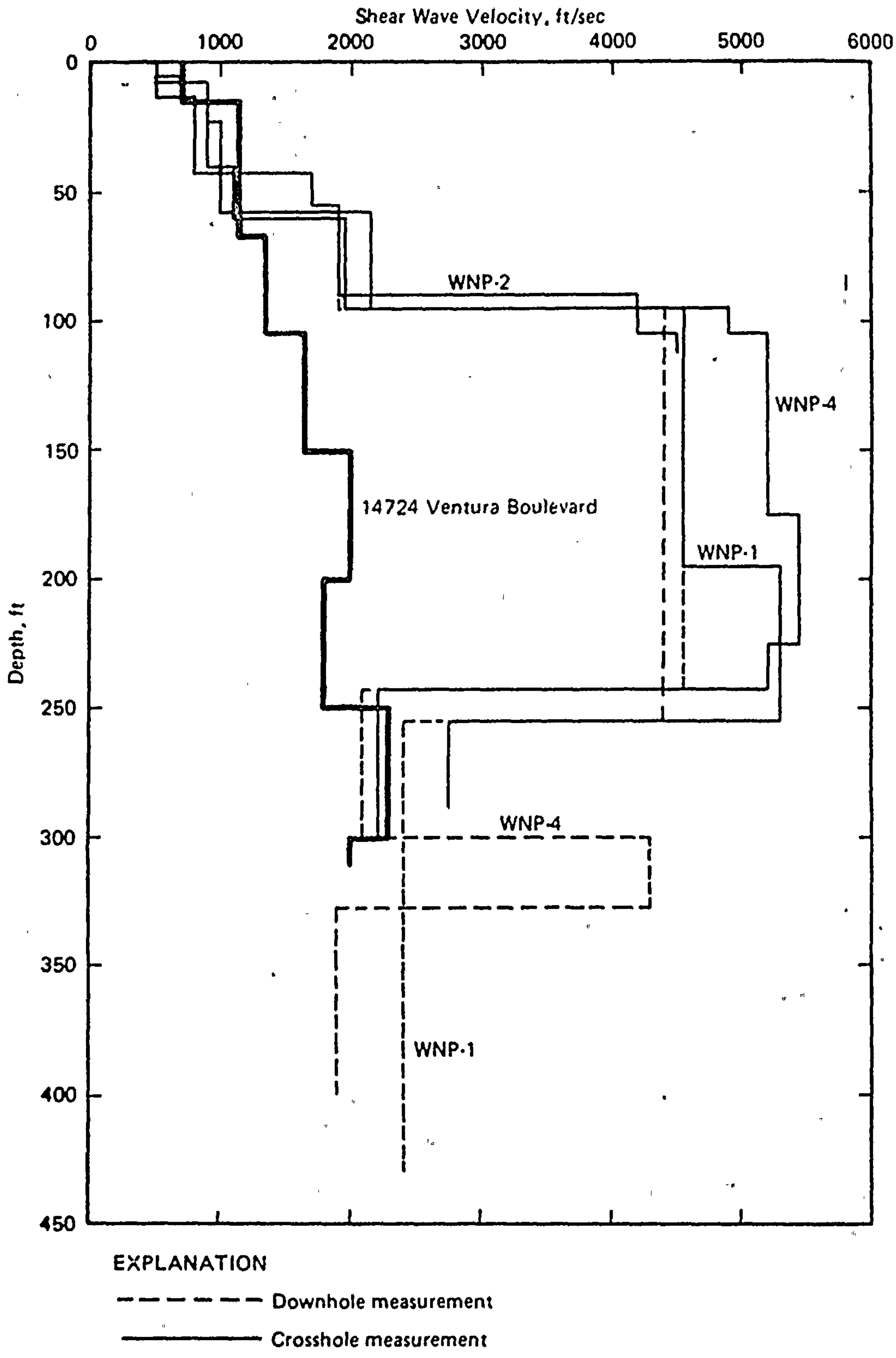
- - - - - - Downhole measurement

———— Crosshole measurement

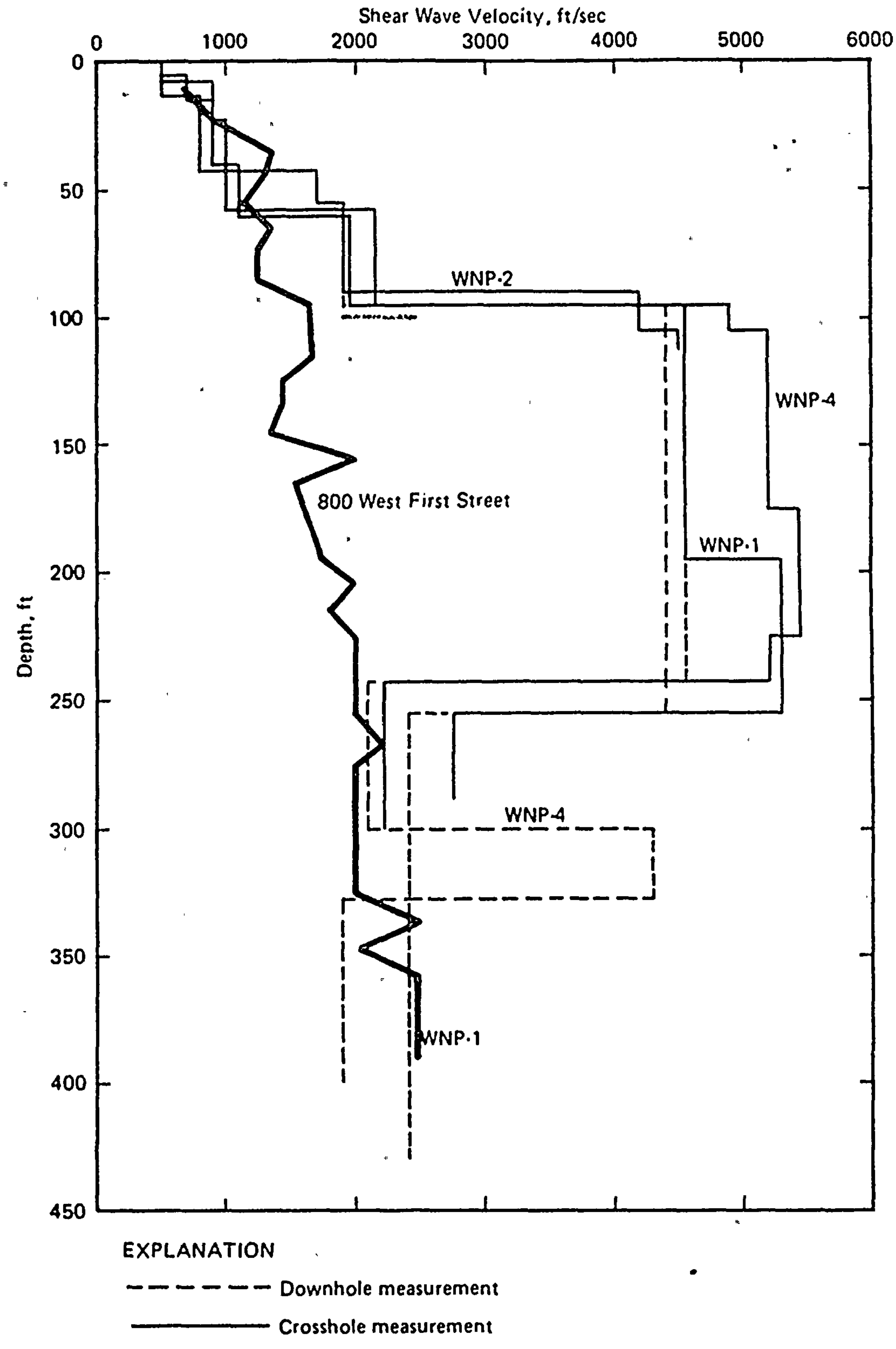
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: LAKE HUGHES ARRAY NO. 1 VERSUS WNP 1,2 & 4	Figure 361.17-A9



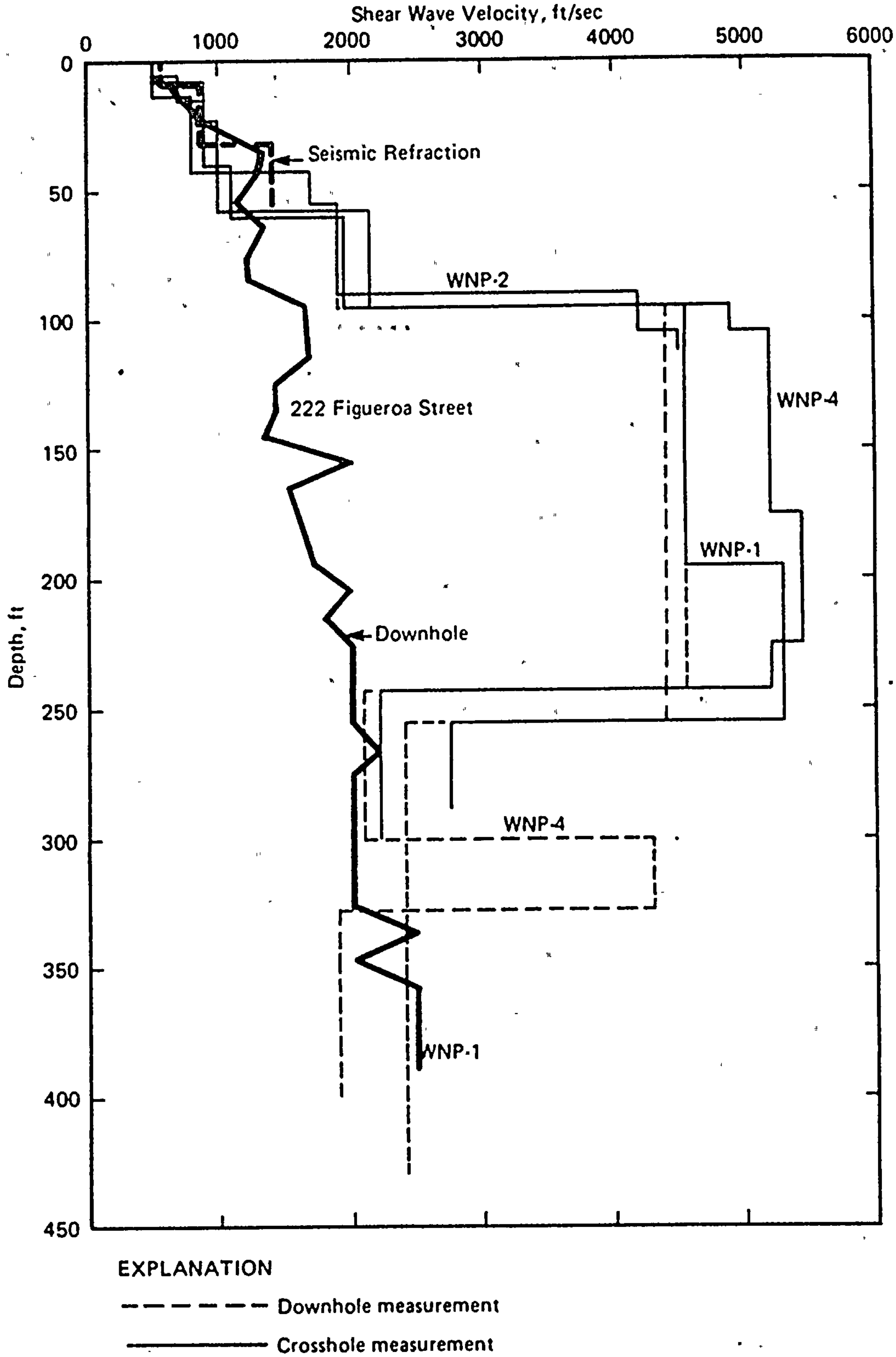
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 1625 OLYMPIC BOULEVARD VERSUS WNP 1,2 & 4	Figure 361.17-A10



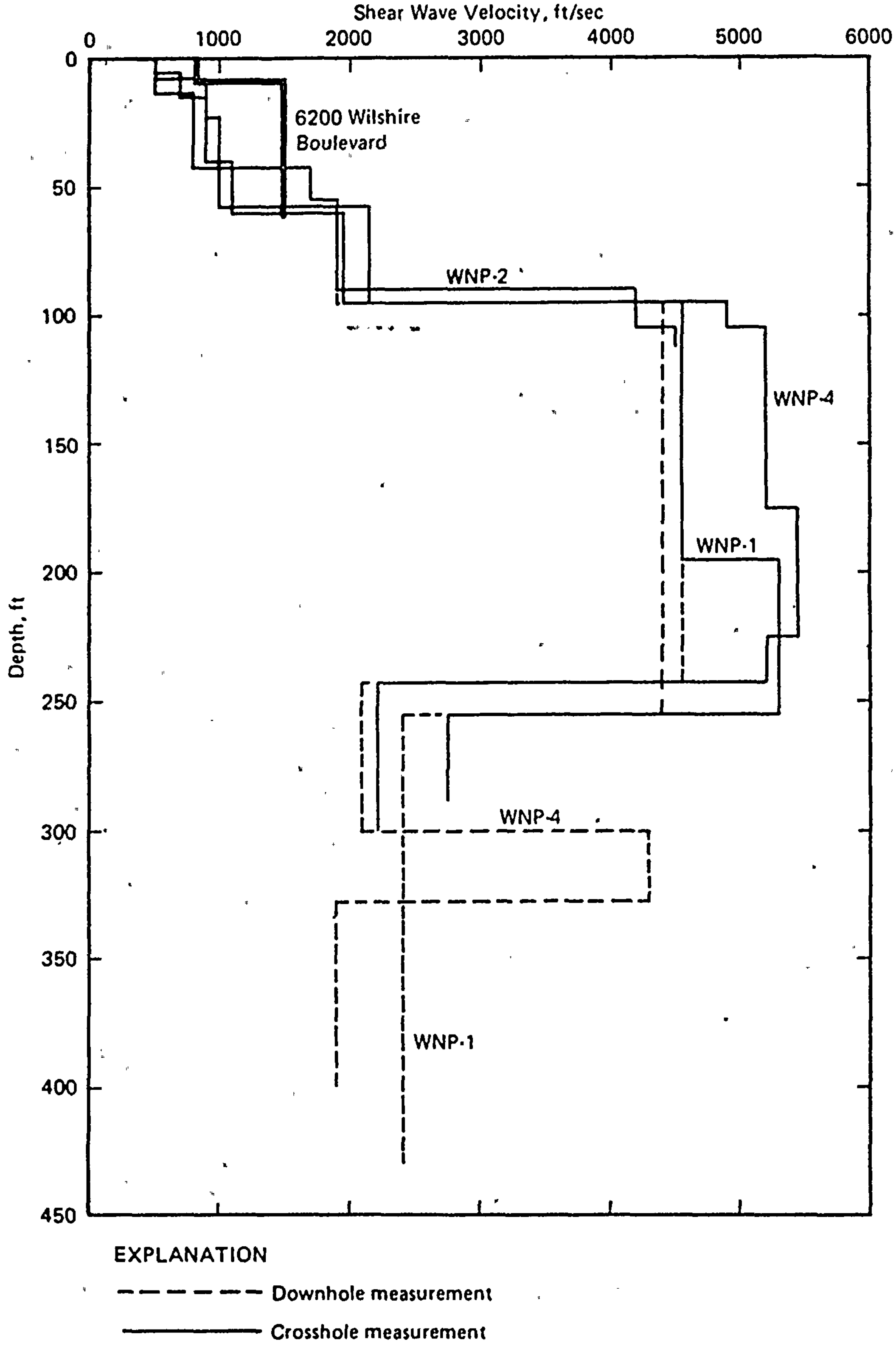
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 14724 VENTURA BOULEVARD VERSUS WNP 1,2 & 4	Figure 361.17-A11



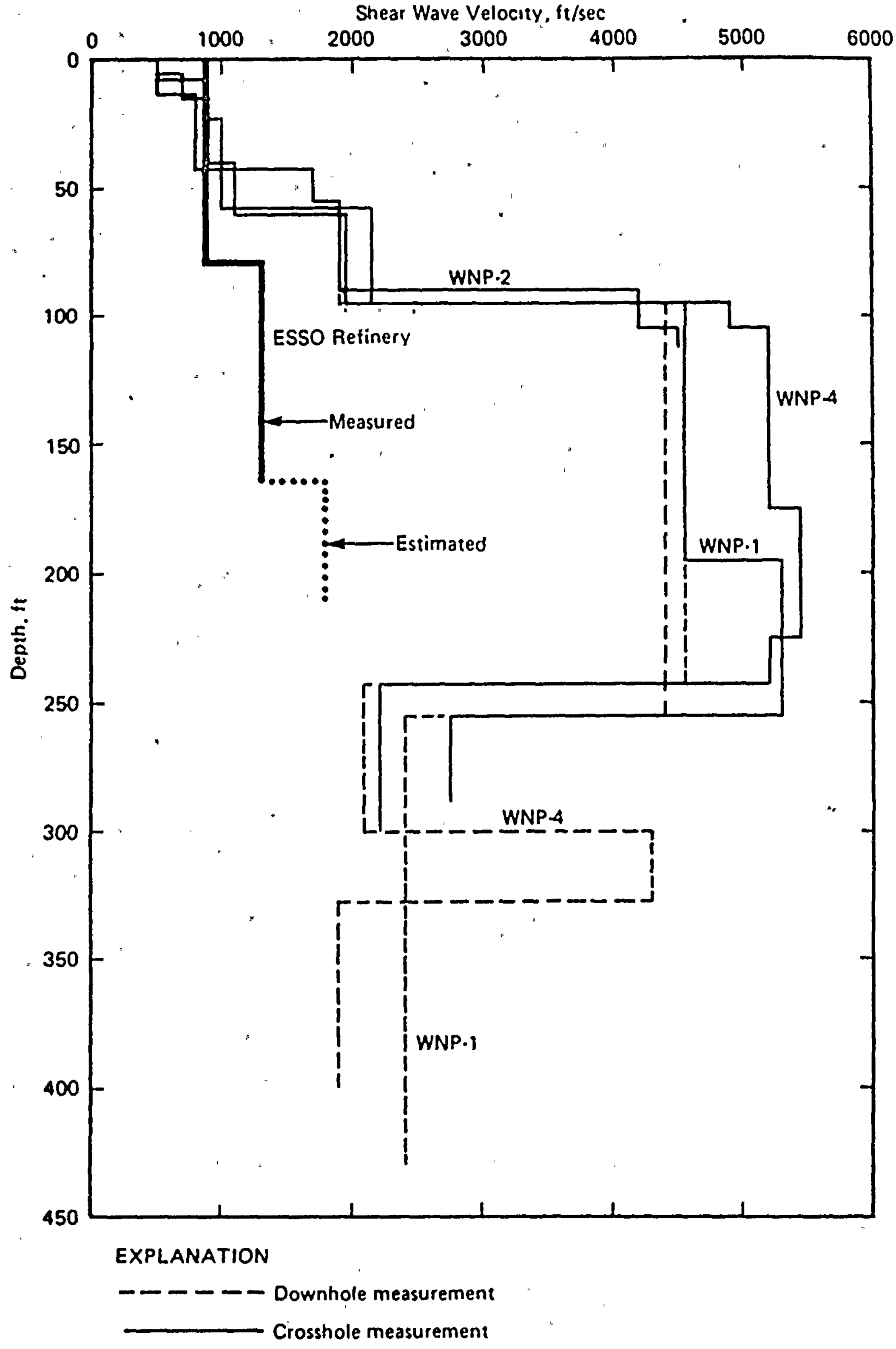
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 800 WEST FIRST STREET VERSUS WNP 1,2 & 4	Figure 361.17-A13



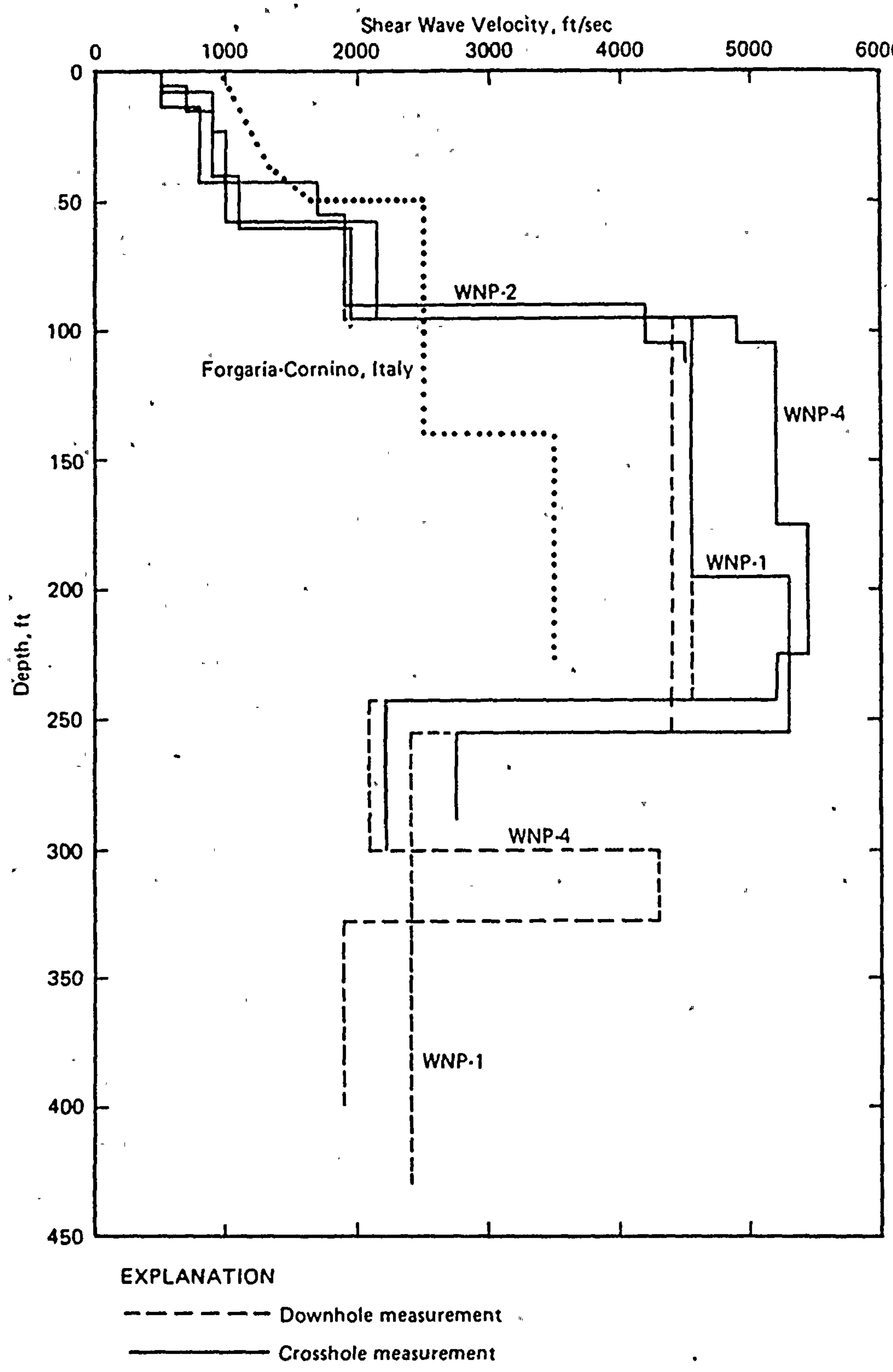
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 222 FIGUEROA STREET VERSUS WNP 1,2 & 4	Figure 361.17-A14



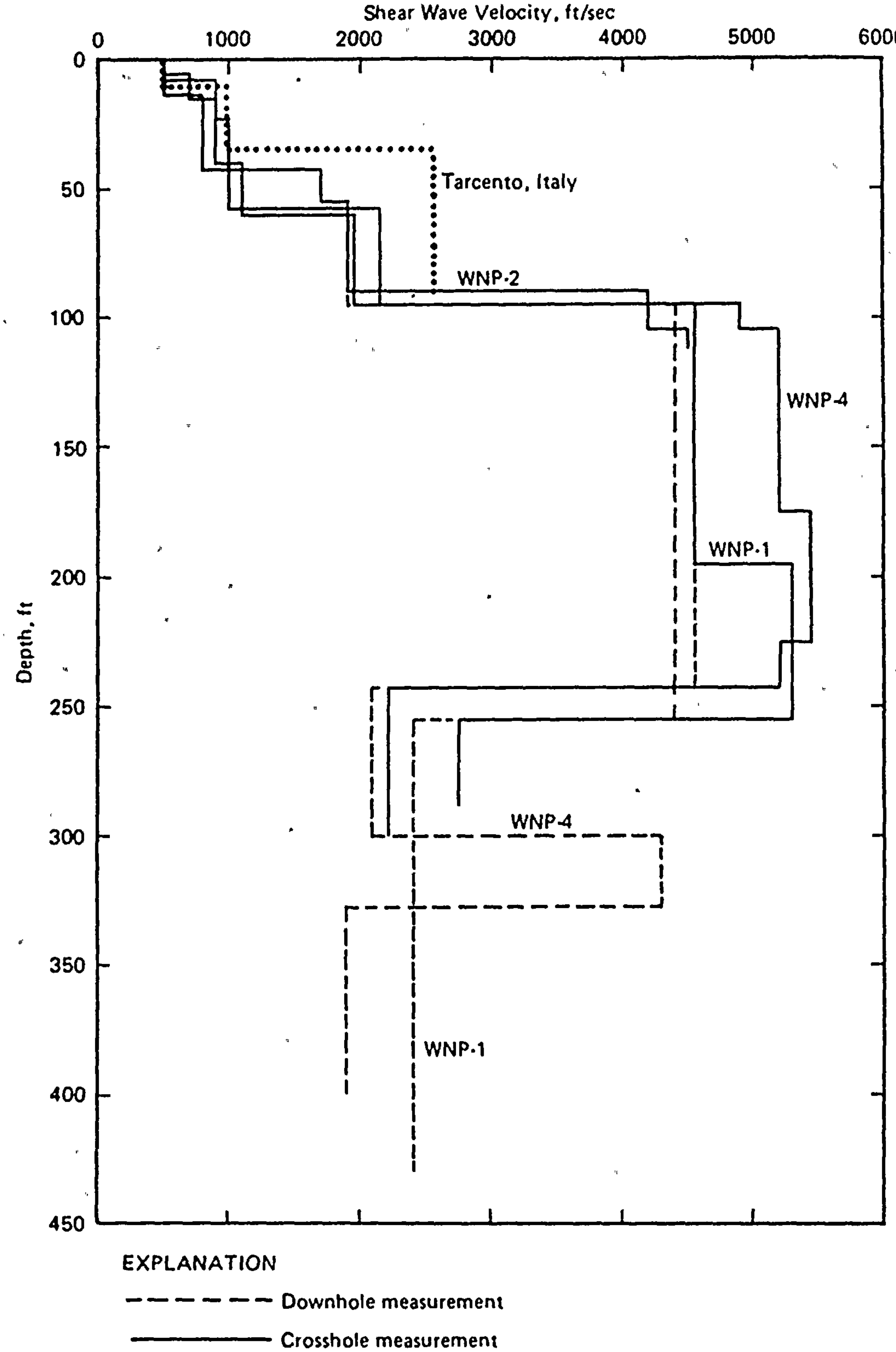
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 6200 WILSHIRE BOULEVARD VERSUS WNP 1,2 & 4	Figure 361.17-A15



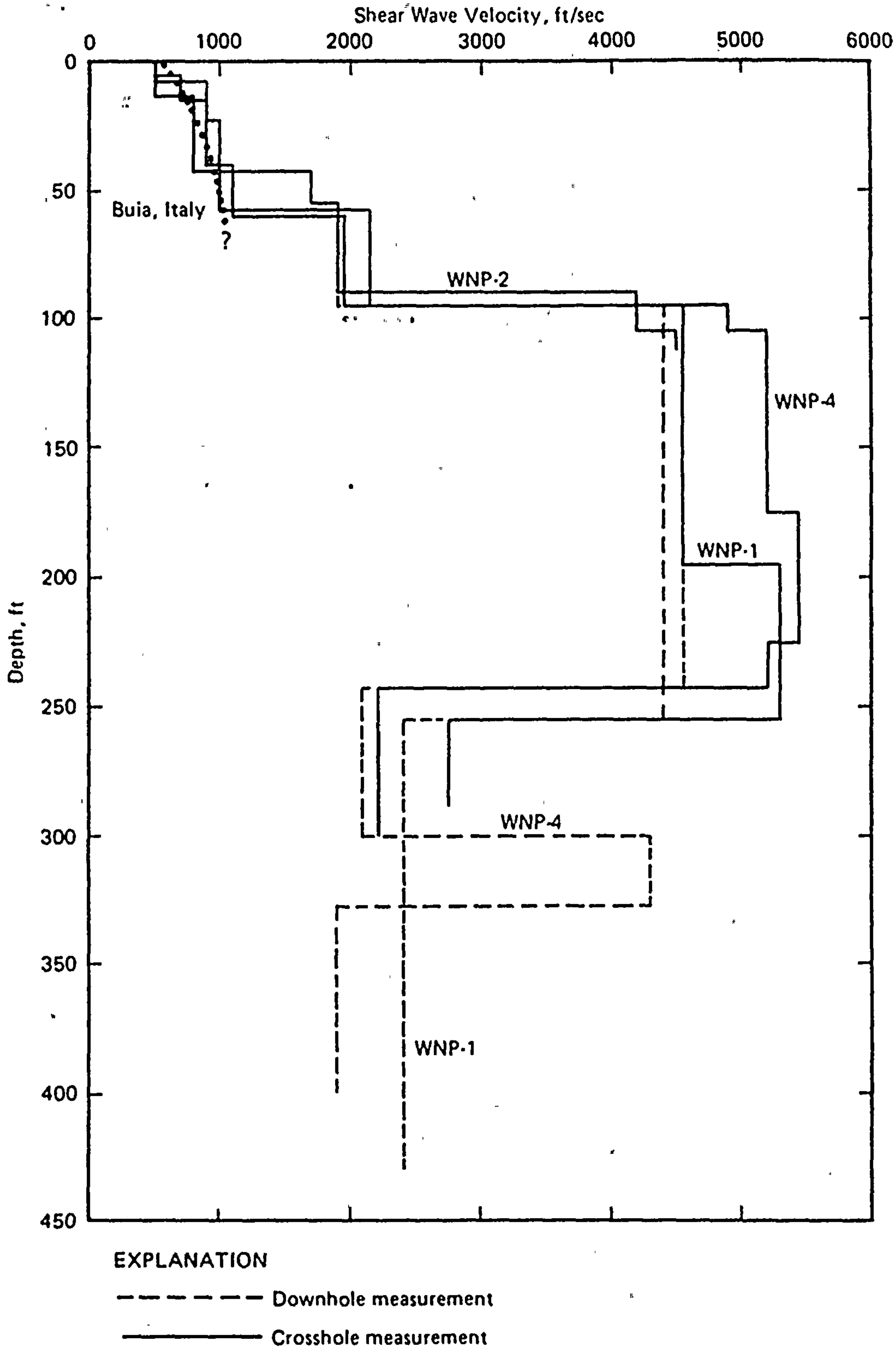
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: ESSO REFINERY VERUS WNP 1,2 & 4	Figure 361.17-A16



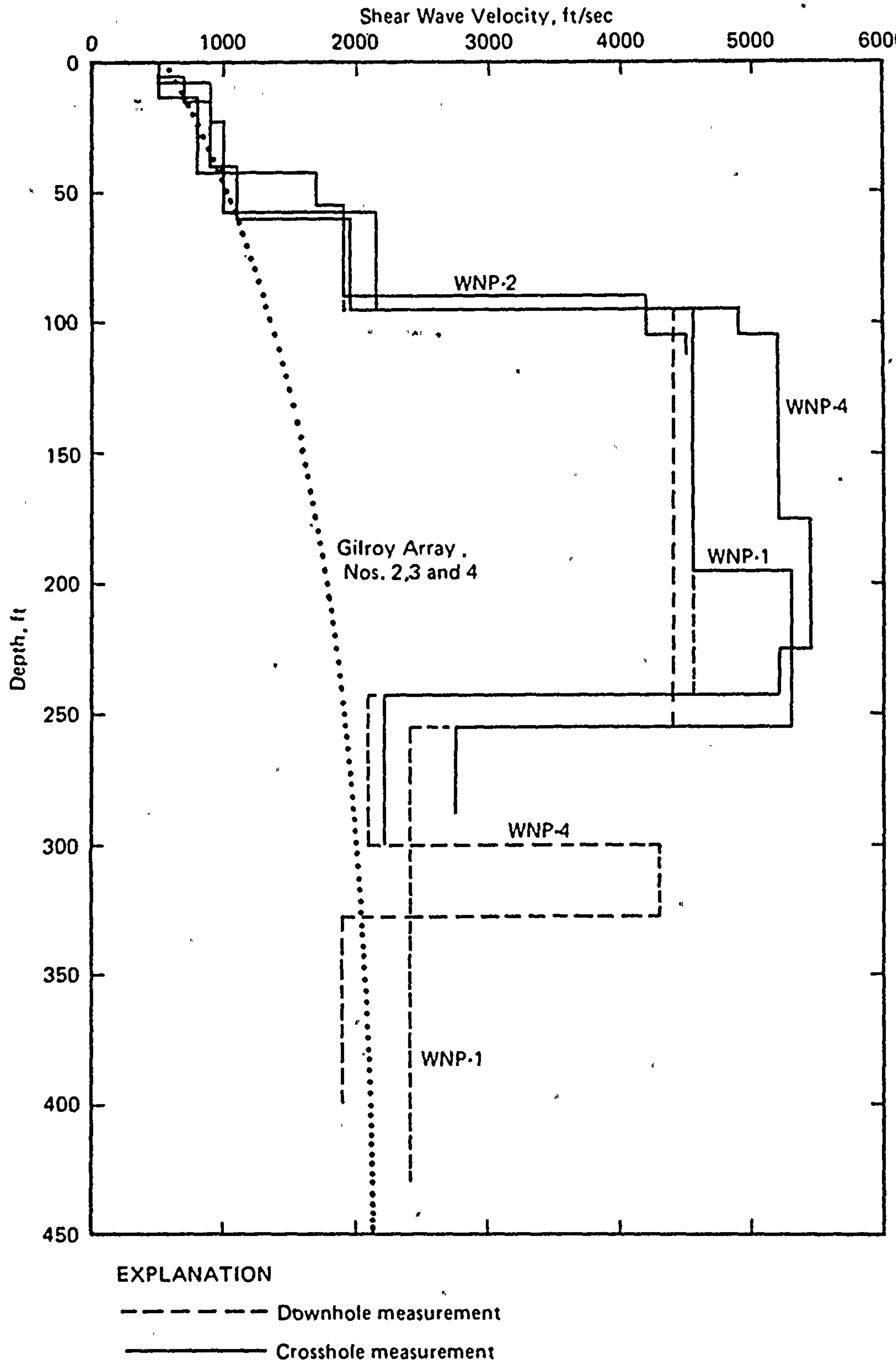
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: FORGARIA–CORNINO, ITALY VERSUS WNP 1,2 & 4	Figure 361.17-A17



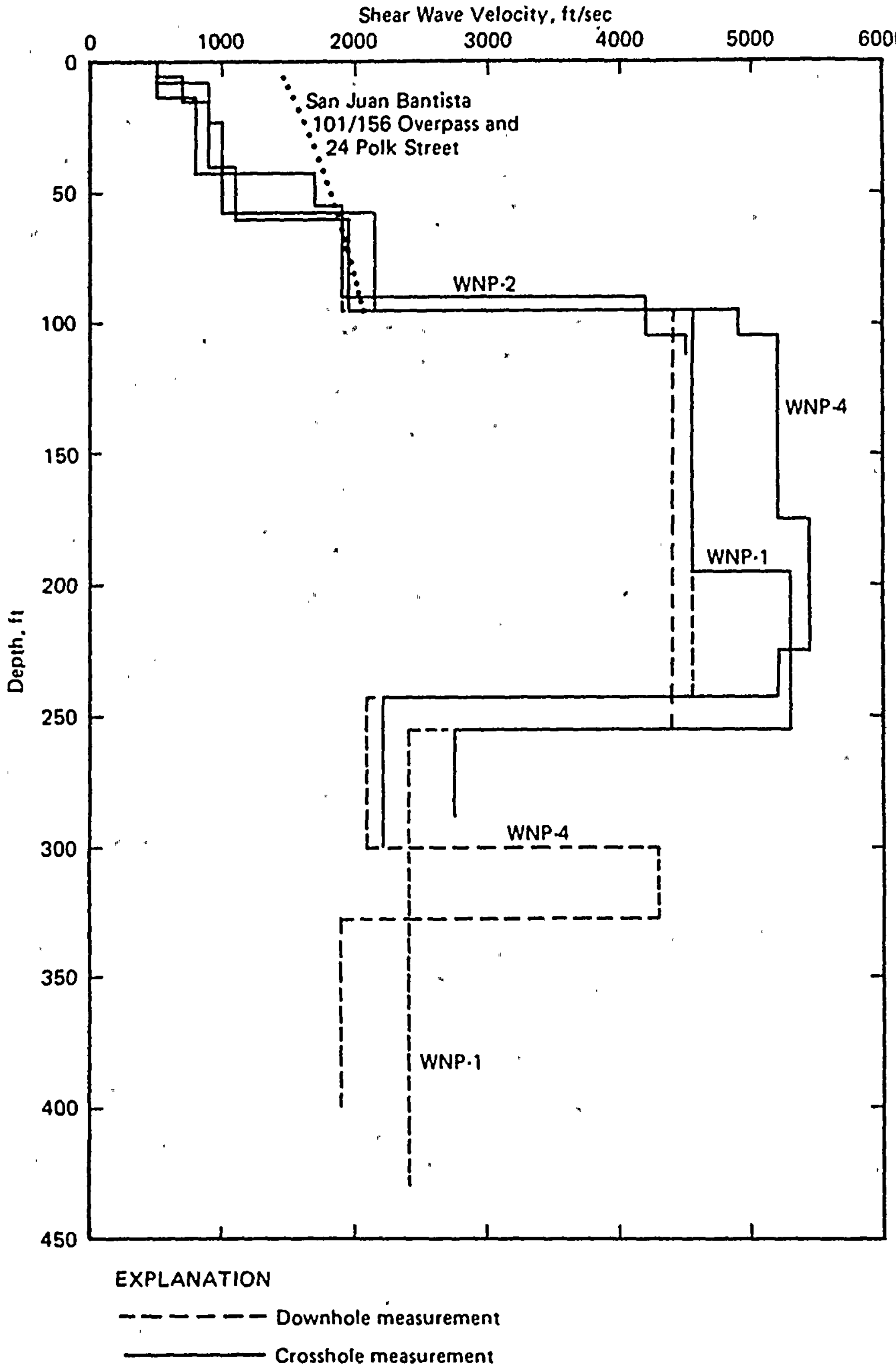
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: TARCENTO, ITALY VERSUS WNP 1,2 & 4	Figure 361.17-A18



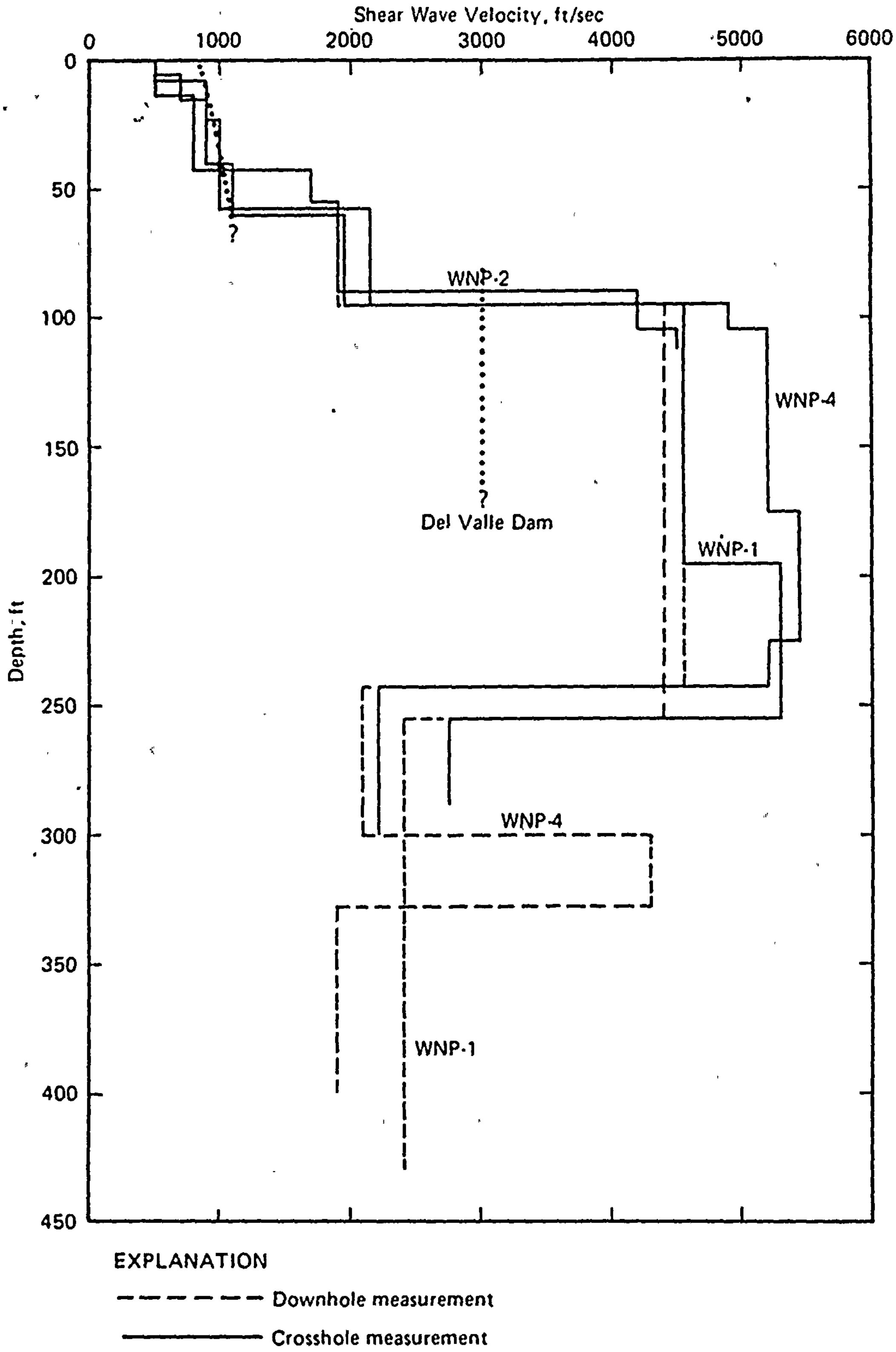
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: BUIA, ITALY VERSUS WNP 1,2 & 4	Figure 361.17-A19



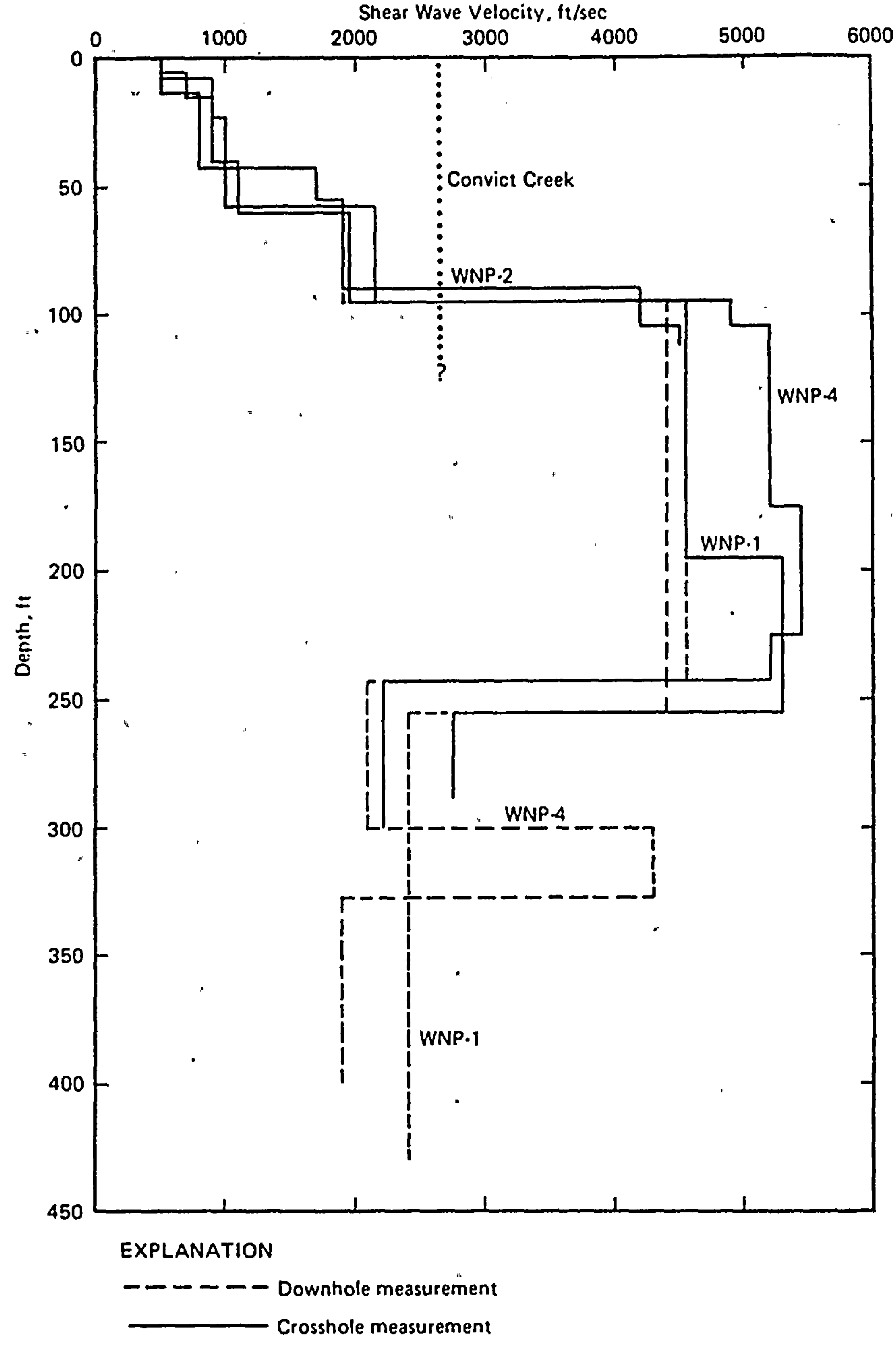
WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: GILROY ARRAY NOS. 2, 3 AND 4 VERSUS WNP 1,2 & 4	Figure 361.17-A20



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: 101/156 OVERPASS AND 24 POLK STREET VERSUS WNP 1,2 & 4	Figure 361.17-A21



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: DEL VALLE DAM VERSUS WNP 1,2 & 4	Figure 361.17-A22



WASHINGTON PUBLIC POWER SUPPLY SYSTEM Nuclear Project No. 2	COMPARISON OF SHEAR WAVE VELOCITY PROFILES: CONVICT CREEK VERSUS WNP 1,2 & 4	Figure 361.17-A23

361.19

Provide the staff with any additional information (if available) on observations and felt effects of the 1872 Earthquake which might not have been communicated as of yet.

RESPONSE

The Supply System's position regarding the December 14, 1872 Earthquake is contained in pages 2.5-115 through 2.5-118 of WNP-2, FSAR, Amendment 18, September, 1981. A summary of that position as stated in teh FSAR, is that a comparison of the data from the December 14, 1872 earthquake with modern data suggests that the 1872 earthquake had a magnitude of M_S 7 to 7-1/2 and probably occurred at a focal depth of about 20 km with a maximum epicentral intensity of MM VIII in terms of structural response. The epicenter for the earthquake is located within a meizoseismal zone that extends from Lake Chelan on the south to southern British Columbia on the north, as defined by Coombs et. al. (1976).

The following discussion includes additional information on observations and felt effects that may not have been communicated as of yet. The discussion is divided into two principal parts; (1) information relative to differences in intensity and location

assignments by the principal investigators; and (2) an explanation of the significance of selected supporting information contained in Appendix D, Coombs et. al. (1976).

Between December 1976 and October 1977 a series of reports were prepared by various utility and utility-sponsored groups that contained all of the known directly relevant information on the 1872 Earthquake as of October 1977. These reports and a summary of their content are as follows:

Coombs, H. A., Milne, W. G., Nuttli, O. W., and Slemmons, D. B., dated 1976, "Report of the Review Panel on the December 14, 1872 Earthquake;" Report prepared for Washington Public Power Supply System, 457 p.

This report contains all of the known information which was collected by the Supply System staff and could in any direct way be related to the December 14, 1872 Earthquake. The review panel (also known as the Coombs' Panel or Coombs et al., 1976) report on the December 14, 1872 Earthquake is contained in the first 31 pages. Appendix A to the review panel report concerns an analysis of landslides that were reported to have ocurred as a result of the 1872 Earthquake. Appendix B of the review panel report contains a complete typewritten transcription of all known newspaper accounts of the 1872 Earthquake. Appendix C of the

review panel report contains selected earthquake catalogs related to the 1872 Earthquake and selected isoseismal maps for other earthquakes of the Pacific Northwest. Appendix D to the review panel report contains selected supporting information related to the 1872 Earthquake or relevant to understanding the historical aspects important to interpreting the reports of the 1872 Earthquake. All of this data and information contained in the review panel report was available to the Washington Public Power Supply System's consultants Woodward-Clyde Consultants and Weston Geophysical Research; and to Puget Sound Power & Light and their consultants Bechtel and their consultants, Nina Scott and Dr. Bruce Bolt at the time their respective reports were prepared. The main report text, Appendix A, parts of Appendix B, parts of Appendix C, and parts of Appendix D, were also submitted as Appendix 2.5 R A, WNP-1/4 PSAR, Amendment 23, dated September 1977 (Docket Numbers 50-460 and 50-413). In addition, Appendix D of the review panel report contains two reports by Shannon and Wilson, Inc.:

1. "Reconnaissance Investigation of the Ribbon Cliff Landslide, Entiat, Chalan County, Washington;"

2. "1872 Earthquake: New Data from Oregon;"

3/5, Appendix 2.5M, WNP-3/5 PSAR, Amendment 37, dated February, 1977 (Docket Numbers 50-508 and 50-509). "Review of the North Cascade Earthquake of Decemer 15, 1972 GMT)

This report was prepared by Dr. Don Tocher and Dr. Tom Turcotte, Woodward-Clyde Consultants. This report contains the principal technical discussion relative to comparison of intensity data from modern earthquakes to the December 14, 1872 Earthquake. Parts of the report were revised and expanded upon and submitted as Appendix 2.5R B, WNP-1/4 PSAR, Amendment 23, dated September, 1977.

Washington Public Power Supply System. Appendix 2.5R B WNP-1/4 PSAR, Amendment 23, dated September 19, 1977 (Docket Numbers 50-460 and 50-513). "Review of the North Cascade Earthquake of December 14, 1872".

This report was prepared by Dr. Don Tocher and Dr. Tom Turcotte, Woodward-Clyde Consultants. This report represents an extended technical analysis and revision of the earlier Woodward-Clyde report (Appendix 2.5M, WNP-3/5 PSAR). The report contains a discussion of the factors which critically affect the evaluation of the felt reports for the determination of epicentral location of this earthquake, its magnitude and focal depth and concludes what value, or range of values, can be assigned these parameters

based on correlations with modern data. Table 2 R B-4 from this report has been attached to the answer to this question and will form the outline for part of the subsequent discussion.

Weston Geophysical Research, Inc., December 1976, "Presentation of Significant Data and Conclusions Concerning the 1872 Earthquake", report prepared for Washington Public Power Supply System under the direction of United Engineers and Constructors, Inc.

This report was prepared to supply information for utilization by the Coombs' Panel in preparing their report of December, 1976. The Weston report was submitted as a reference document along with the Coombs' Panel report in December, 1976. The Weston Geophysical Research report does not appear directly in any of the Supply System's submittals, either on WNP-1/4, WNP-2 or WNP-3/5, except as a reference document. The intensity assignments made by Weston Geophysical are found in Table 2.5R B-4, WNP-1/4 PSAR, attached as part of the answer to this question. The map containing the intensity assignments, Figure 2.5.M.18, Appendix 2.5M, WNP-3/5 PSAR, is also attached as part of the answer to this question.

Puget Sound Power & Light, 1977, Skagit Nuclear Power Project,

Appendix 2.5J SNP 1/2 PSAR, Amendment 15 (Docket Number 50-514) prepared by Bechtel Corporation, San Francisco, California.

The report by Bechtel submitted as Amendment 15, SNP-1/2 PSAR, is a revised version of Appendix 2.5J dated June, 1975 that was prepared previously in October of 1976 and used by the Coombs' Panel. Appendix 2.5J, SNP-1/2, Amendment 15 contains, in addition, the consultants reports on the 1872 Earthquake by Perry Byerly, Bruce Bolt, and two reports by Nina H. Scott.

The above reference reports with three exceptions, constitute essentially the entire written record of information on observations and felt effects of the 1872 Earthquake. Two of the exceptions constitute new data that became subsequently available after December 1977. These data are as follows:

1. A report by Shannon and Wilson, Inc., dated February, 1978, "Investigation of the Ribbon Cliff Landslide, Entiat, Washington", prepared for the Washington Public Power Supply System. Based on geologic reconnaissance and detailed mapping of the Ribbon Cliff landslide, Shannon and Wilson concluded that the main part of the Ribbon Cliff landslide near Entiat, Washington, did not occur during the 1872 Earthquake and that no significant movement of the debris has taken place in more than 215 years. This report will be

discussed later in answer to this question and is being submitted as a reference with the answer to this question.

2. The geographic location of the felt report for the town of O'Hamet (?) or O'Damet (?) (see Coombs, et. al., 1976, Appendix B, page 103) that-was-previously listed in the Coombs' Panel report as location unknown. The correct spelling for this location is now thought to be the town of Oyama located approximately ten miles to the southwest of Vernon, British Columbia at the northeast end of Okanagan Lake. Further discussion of this location will be found later in the answer to this question.

The third exception is the supporting data on the geography and history of the area that was made available by the Supply System staff to the Coombs' Panel and the Supply System's consultants, Woodward-Clyde and Weston Geophysical, during the course of numerous meetings and which had a signficant influence on the final assignment of intensities and the locations to which these intensities were assigned. The response to this question will an attempt to provide this same information for the more significant locations in a written form.

The subsequent discussions will be in a narrative form and divided into two parts: 1) a discussion alphabetically using Table 2.5 R B-4, WNP-1/4 PSAR (attached) as an outline and the

felt reports contained in the Coombs' Panel report as Appendix B and Attachment B, Appendix 2R B, WNP-1/4 PSAR as a basis and; 2) a discussion of the relevance of Appendix D, Coombs' et. al., 1976, "Selected Supporting Information."

Appendix 2.5R B, WNP-1/4 PSAR, has a detailed discussion of the history and population distribution of the area, available data sources and their reliability, earthquake effects, and aftershocks. It is recommended that this document be referenced prior to reading the answer to this question. Appendix 2.5R B, WNP-1/4 PSAR, points out how the discrepancies among various felt reports are reflected in the conclusions regarding the region of maximum intensity reached by each of the groups evaluating the December 14, 1872 Earthquake. The differences appear to be due in part to different evaluations and weights given to various felt reports but especially to differing opinions of how intensity assignments should be made to locations reporting ground disturbances. In addition, it is pointed out in Appendix 2R B, WNP-1/4 PSAR how some felt reports appear to have been mislocated. It is also pointed out how there appears to have been an influence on the intensity assignments that was due to familiarities or lack of familiarity on the part of the various evaluators with the geology and geography of the region. For example, the Coombs' Panel report in part reflects the familiarity of Dr. Coombs with the geology and geography of Washington State and the knowledge of Dr. Milne with the geology

and geography of British Columbia and also his previous analyis of the reports from British Columbia (Milne, 1956). The effect of this can be seen in Table 2.5R B-4 (attached) as evidence in general by the assignment of higher intensities by the Coombs' Panel to the locations in British Columbia and the assignment of more intensities to various locations throughout the area of Washington and British Columbia and the Northwest versus the reports by Nina Scott and Bechtel. In addition, Table 2.5R B-4 (attached) appears to show evidence of the bias that various investigators have in applying the Modified Mercalli Intensity scale. This impact is most notable for areas where ground disturbances, particulary landslides, were reported. In addition, the contemporaneity of the various reports appears to also have been a factor that influenced the intensity assignments by the various investigators. For example, the Supply System (1977) intensity assignments were primarily based on effects to people and structures as determined from the more contemporaneous reports of the time, with consideration, but not strong influence, of the reports of landslide effects and related ground disturbances. Weston Geophysical appears to have made their intensity assignments using the contemporaneous reports and was influenced, in part, by all the the factors such as the effets on people, strucutres, and ground disturbances. The Coombs' Panel is known to have utilized all of the available data but were influeneced primarily by the contemporaneous reports. The Coombs' Panel application of the Modified Mercalli Intensity

scale followed a similar approach to that of Weston Geophysical. The Nina Scott and Bechtel reports appear to have been influenced more by later reports in newspaper accounts, diaries, and books. It appears that their use of the Modified Mercalli Intensity scale followed a similar approach to that of the Coombs' Panel and Weston Geophysical Research.

The following discussion will cover selected locations as listed in Table 2.5R B-4, WNP-1/4 PSAR (attached). These particular locations were identified on the basis of either inconsistencies in the intensity assignments between investigators or inconsistencies in the location assignments or where some particular piece of supporting information had strong influence on the assignment of intensities for an area. The discussion will be in narrative from and will refer primarily to the Coombs' Panel report, Appendix B and Appendix D.

Baker City (Baker), Oregon (Appendix B, Coombs et. al, 1976, p. 3) - This locality is an example of how one report can infuence the assignment of intensity over a much larger area. As can be noted on the Nina Scott and Bechtel maps, (attached) the Intensity V contour is drawn farther down to the southeast because of this one location. The main point of contention regards the report from the Bedrock Democrat Newspaper in Baker, Oregon. In late 1976, Woodward-Clyde was working on a project in California. As part of that project, Woodward-Clyde also

reviewed much of the historical earthquake data for California. During the course of the work, they came across several reports of older earthquakes that were, in essence, the same as the last three paragraphs of the article on the 1872 earthquake from the Baker Bedrock Democrat. It was their conclusion, as evidenced by the Intensity IV assignment that the last three paragraphs of the article do not represent the December 14, 1872 Earthquake effects at Baker, Oregon, but instead represent some literary license that was taken by the editor in relating the experience in Baker to the experience of someone who have been in one of the California earthquakes. There is some support for this conclusion in the last paragraph of the article, last sentence, which states that "we have not learned at this writing how far from this locality the shock extended but we should not be surprised to hear of a violent shock at some other point on the coast at which this was the only result." The other reviewers (Coombs, et. al, Weston, Bechtel, and Scott) did not accept this position and accordingly assigned Intensity V.

Bozeman, Montana (Appendix B, Coombs, et. al. 1976, p.4) - The Coombs Panel assigned an Intensity III to this location on the basis of a report found on page 41, Appendix B, from the Virginia City Weekly Monatanian, dated December 19, 1872, which states, "A big piece of plaster fell down upon Charley's back and you'd better believe he got out of bed in a hurry." Weston and Woodward-Clyde did not feel that this report was adequate to

assign either a felt report or an intensity value to this location.

Caribou, British Columbia (Appendix B, Coombs et. al. 1976, p. 203) - The single mention of this location can be found in the article on page 203, from the Daily British Colonist, December 17, 1872 which states "From Caribou we have no report." No location for the town of Caribou could be found on any of the maps that covered the area at the time. It was concluded that the use of the term "Caribou" referred to the paper by the same name, The Caribou Sentinel from Barkerville, British Columbia, as shown on page 200, Appendix B, Coombs et. al., 1976.

Cascades, Oregon and Washington (Appendix B, Coombs et. al. 1976, p. 12) - These two locations are probably the same. The maps at the time showed Cascades as being in Washington territory. The present day location of Cascades is on the Oregon side of the Columbia River.

Chelan Falls, (Lake) Chelan, (Lower Lake), Chelan, Washington (Appendix B, Coombs, et. al., 1976, p. 13-19) - These three locations are all considered as one by the Coombs' Panel and Woodward-Clyde Consultants. There were no comtemporary accounts from this local regarding the 1872 earthquake other than the very vague reference by Mr. Covington from Whitestone found on page 234, Appendix B. Many of the later reports, (e.g. the articles

from the Spirit of the West, Walla Walla, Washington Territory dated November 27, 1874 and December 4, 1874) appear to have taken the Covington report at Whitestone out of content and applied it to Lake Chelan. There were probably effects at Lake Chelan and the area at the foot of Lake Chelan known as Chelan Falls or Chelan Landing. Lake Chelan is a unique physiographic fearture that was formed during the late Pleistocene by glacial scouring with the end blocked by a terminal morain. The elevation difference between the surface of Lake Chelan at Chelan Falls and the Columbia River near Chelan Landing is over 350 feet. At Chelan Falls is a well known artesian system named Beebee Springs. It is likely that the reported geysering activity at Beebee Springs, at the time of the December 14, 1872 Earthquake, was caused by fluctuations in the lake level. A detailed field examination of the geology and geomorphology of the lake area and the Columbia River in the vicinity of the lake discharge at Chelan Falls could find no evidence of any type of contemporary deformation (Appendix 2R D, WNP-1/4 PSAR). Pleistocene fine grained silt and sand river terraces occur continuously along this stretch of the Columbia River without any signs of deformation. Further evidence for the actual effects at Lake Chelan or Chelan Falls can be found in the letter from Father Urban Grassi, (pp. 51-62, Appendix D, Coombs et. al., 1976). In this letter, dated November 10, 1874(?), Father Grassi mentions that the Intielikum was the tribe more than any other on the Columbia that for two years had been visited by God with

earthquakes. The Intielikum were located near Entiat. Farther along in the letter, Father Grassi states; "that from the Intielikum, I pass to the Cilan Indians who are the next tribe, The Cilans are situated about 16 miles beyond the last camp of the Intielikum." Father Grassi states that he visited the Cilan three times during 1874 and discusses each one of these visits. In contrast to the more detailed discussion of the earthquakes and its effect on the Intielikum tribe, Father Grassi makes only one mention of the earthquake effect on the Cilan trib, (middle of page 60, Appendix D). It is stated," that it was only since the time of the earthquake that the Cilans had prayed; on feeling the earth move beneath their feet for the first time they were in consternation, and said among themselves: let us pray". It is likely that Father Grassi would have written considerably more if, in fact, the Cilan tribe had suffered, "the death of all the Young Indians...," (Daily British Colonist, August 19, 1873, p. 14, Appendix B) or, "a choking sensation, and so effecting children as to cause the tonsils to swell and with smaller ones, death earned in every instance," (Spirit of the West, December 4, 1872, p. 18, Appendix B).

Chiliwack, British Columbia and Clinton, British Columbia - (Appendix B, Coombs et. al., 1976, pp. 20-21) These two localities and the intensity assignments as shown on Table 2RB-4 (attached) are examples of variations in the way the Modified Mercalli Scale was used by the varous investigators. The Coombs'

Panel, Weston Geophysical, and Woodward-Clyde, all had a tendency to assign higher intensities values to the Canadian reports. This is primarily due to the recognition of Dr. Milne's earlier study (Milne, 1956) of the 1872 Earthquake and the greater degree of familiarity on the part of these three investigators with the history, geography, and geology of the region.

<u>(Fort) Colville and North of Colville, Washington</u> (Appendix B, Coombs et. al., 1976, pp. 25-33) - One of the most significant reports of the effect of the 1872 Earthquake come from Fort Colville. It is contained in a letter from John A. Sims, the Indian Agent, to General Milroy, the Superintendent of Indian Affairs located at Olympia. The reference to this report can be found at the top of page 129, Coombs' Panel Report, Appendix B for the location Okanagan and Osoyoos Lake. The reference that states the report is found under Colville, Washington Territory is in error. The report was inadvertantly omitted. However, in the Colville section starting on page 25 of Appendix B, the report is essentially contained on page 26, Appendix B, in the article from the Puget Sound Daily Courier dated January 20, 1873. There are a couple of minor missing phrases in the introduction and a reference to Osoyoos Lake which should be in the last sentence of the third paragraph. This line should read "the earthquake was particularly severe in the vicinity of Okanagan and Osoyoos Lake." A copy of the original report is attached to the answer to this question. It is our opinion that

this letter is significant because it represents one of the most credible and factual accounts of the earthquake made at the time of the earthquake. This report was frequently used either in reference, copied or plagiarized by others reporting on the 1872 Earthquake. For example, the report by Mr. McBride from the Wenatchee area (page 226, Appendix B) as reported in the Washington Standard, January 11, 1873, starting with approximately the fifth sentences from the end of the article, appears to have been extracted from Sims' letter. This conclusion is based on the fact that the Spokane Indians were known to be confined to an area approximately 60 miles east of Wenatchee where the Spokane River enters into the Columbia River and the area north towards Fort Colville. It is also known that the original letter from Sims was released in the Portland and Olympia areas just prior to the time that McBride arrived in Portland. The Sims letter is the principal source of the report for Okanagan and Osoyoos Lake which states, "a point of land projecting into the lake has disappeared and that the earth has opened from 18 inches to 2 feet in several places." For example, see the reports from the Caribou Sentinel, Barkerville, B.C., page 28, Appendix B; and the Olympia Transcript, Olympia, Washington Territroy, page 28, Appendix B; and the Victoria Daily Standard, January 24, 1873, Victoria, B.C., page 27, Appendix B.

The report for North of Colville can be found in the Oregonian, January 15, 1873, Portland, Oregon article on page 26, Appendix

B. Nina Scott was the only investigator to consider this report to have enough credibility to assign an Intensity VII. The Coombs' Panel and Woodward-Clyde felt that the existence of other similar type buildings in the area with no reports of damage and the survivial of the chimney at the abandoned Hudson Bay post at Fort Shepard just north of Colville was supportive of a lower Intensity VI.

Entiat-Ribbon Cliff, Washington (Appendix B, Coombs et. al., 1976, pp. 44-70) A landslide at Ribbon Cliffs, approximately two miles north of Entiat on the Columbia River, was almost certainly triggered by the 1872 Earthquake, although it is not mentioned explicitly in any of the contemporary reports. An investigation of the Ribbon Clilff landslide by Shannon & Wilson completed in late 1977, concluded that the majority of the landslide developed prior to the 1872 Earthquake. Because of this study, the assignment of an intensity value for this particular area becomes more problematic. The present assingment of intensity should be more realistically based on the amount of damage one would interpret to have occurred to the Wapato John cabin located in Wells Coulee between Entiat and Lake Chelan. The reports regarding the Wapato John cabin, however, are also problematical. These reports are another example of how both eyewitnesses and newspaper accounts can become distorted with time. There are several versions of the Wapato John cabin account which appeared in the Yakima Herald of March 3, 1892,

page 44, Appendix B; and subsequently, in four editions of the Wenatchee Daily World between 1922 and 1932, pages 47, 48, 52, 59, 65, and 66, Appendix B. The Yakima Herald, March 3, 1892 account states that a house was carried away by floodwater. The Wenatchee Daily World, 1922 account by Peter Wapato, John's son, states that the cabin was "torn apart" by the earthquake. The Wenatchee Daily World, 1925 account states that the logs from one side of the cabin caved in. The Wenatchee Daily World, 1932 account, as told by Sylvester and Peter Wapato, makes no mention of damage at all, merely stating that the family was afraid to enter the cabin because of the shaking. The Wenatchee Daily World, 1925 account states that the cabin was destroyed by backwater. The Wenatchee Daily World, 1931 account states that the log house shook so much that all the roof shook down and also makes the statement that the Columbia River was dammed but does not state that the backwater reached the house. The Wenatchee Daily World, 1932 account again states that the Wapato's were afraid to go back in the cabin and spent the rest of the night in the open. Finally, the Wenatchee Daily World, 1972 account states that the water level raised over 50 feet covering his farm and trading post. It is known that the Wapatos did not run the trading post. The trading post was located downstream of the Ribbon Cliffs landslide and remained intact after the earthquake. Records show that the Wapato cabin located in Wells Coulee was at an elevation that was at least 50 feet higher than the maximum elevation that could have existed behind the Ribbon

Cliff's landslide and, therefore, could not have been directly affected by the backwaters of any pool that might have been built up by the damming of the river. The records also show that the Wapatos continued to live in their cabin until 1879 when they were forced to move by the Army to a new Indian Reservation at Lake Chelan.

<u>Fort Shepard, British Columbia</u> (Appendix B, Coombs, et.al., 1976, pp. 72, 234-237) The newspaper articles that refer to a bridge across the Columbia River at, or near, Fort Shepard that resulted from the earthquake, can be found on pages 234 and 235, Appendix B. These reports came from the Walla Walla Union, March 15, 1873, the New Northwest, Deer Lodge, Montana, April 15, 1873, and the Olympia Transcript, Olympia, Washington Territory, March 29, 1873. All three newspaper accounts are identical. The author, Mr. Covington, operated a trading post at Whitestone located near the big bend in the Columbia River just west of Spokane. The location is shown on a 1880-1881 map of the Camp Spokane area. This trading post was on the direct route that the miners took coming from the Similkameen gold fields west of Osoyoos across the Doodney trail to Fort Shepard and then south to Fort Colville and on to Fort Walla Walla. Although this account is not first hand, it does appear to have some basis in present day fact. Fort Shepard was one of two Hudson Bay Company trading posts that were established in the early eighteen hundreds. Fort Shepard was abandoned sometime in the 1860's after the completion of the

49th parallel boundary survey between the United States and Canada. Evidence of the fort can still be found. The main chimney, originally built as part of the fort, is know to have been standing well into the 1900's. Directly opposite Fort Shepard, on the east bank of the Columbia River is a large incipient landslide area which continues to be a problem to the British Columbia Highway Commission in keeping the road open. The landslide scarp face is at least as large, if not larger, than the present day scarp face that can be seen at Ribbon Cliffs in the Entiat area. Bechtel assigned an Intensity VI(?) on the basis that there were reports of houses being shaken down north of Fort Colville and that the chimney at Fort Shepard was still left standing. Nina Scott assigned an Intensity VII(?) to the local, North of Fort colville, most likely on the basis of the same report for Fort Shepard. The Coombs' Panel, Woodward-Clyde Consultants, and Weston Geophysical all lumped their intensity assignments under Fort Colville.

<u>LaGrande, Oregon</u> (Appendix B, Coombs et. al., 1976, pp. 91-92) - The intensity assignments for LaGrande are another example of the influence of the Baker, Oregon report discussed earlier. This influence can be seen in the Woodward-Clyde assignment of Intensity III to IV because of their belief that most of the Baker report was from another area; the Intensity IV to V assignments by Weston Geophysical and the Coombs' Panel because they were uncertain as to the validity of the Baker, Oregon

report; and the Intensity V assignment by Bechtel and Nina Scott because they believed that the Baker report was entirely for Baker, Oregon.

Oyama (O'Hamet or O'Damet), British Columbia (Appendix B, Coombs et. al., 1976, p. 103) - The geographical location for this report has been identified as Oyama, located approximately 10 miles southwest of Vernon, British Columbia at the head of Lake Okanagan. The basis of this identification is the fact that the report is dated December 15, 1872, and was printed in the Victoria Daily Standard on December 16, 1872. Therefore, it is concluded that the report had to be transmitted by telegraph wire. A study of the settlements along the known telegraph lines that existed in British Columbia in 1872 identified only one local, Oyama, as having a similar sounding name. The American Morse Code in use in 1872 for O'Hamet is as follows: •• •••• •– –– • –•. The American Morse Code in use in 1872 for Oyama is as follows: •• •• •• •– –– •–•. Because the sequence of American Morse Code is identical for the two spellings, it is concluded that Oyama is the correct local. In Table 2RB-4 (attached) Weston Geophysical, Nina Scott, and Bechtel show an Intensity IV-V and V assignment, respectively, for Oyama (O'Hamet). Dr. Howard Coombs and Dr. Bill Milne have recently reviewed the report and conclude that the intensity assignment should be VII (letter report to R.A. Chitwood, WPPSS from Dr. Howard Coombs, dated December 18, 1981, copy attached). Dr. Tom

Turcotte, Woodward-Clyde Consultants, has reviewed the report for Oyama and concluded that the intensity assignments should be VII (letter report to R.A. Chitwood, WPPSS from Dr. Tom Turcotte, dated December 23, 1981, copy attached).

Okanagan Lake (Vernon), British Columbia (Appendix B & D, Coombs et. al., 1976, and Appendix 2RB-B, WNP-1/4 PSAR) - The Coombs' Panel assigned an Intensity VII to the Okanagan Lake area and placed it at the town of Vernon. This was based on the first had reports from John Sims, the Indian Agent at Fort Colville; a knowledge that the principal settlement on Okanagan Lake at that time was at Vernon ; and an aticle in the Vernon News, Vernon, British Columbia, April 2, 1936, (Appendix D, Coombs et. al., 1976, pp. 167) that referred to the earthquake. Nina Scott considered the same reports and assigned an Intensity VII. Scott mislocated the reports to the present town site of Okanagan in Washington State at a distance of approximately 125 miles to the south of Vernon. The present town of Okanagan, Washington State was not founded until around the turn of the century. In 1872, it can be demonstrated that the postmark for Okanagan came from a local known as O'Keefe Ranch at the head end of Okanagan Lake, just north of the town of Vernon, British Columbia. Also in 1872, there were no known settlements in Washington State south of Osoyoos, British Columbia until the trading post at Wenatchee was reached. The next settlement south of Wenatchee was in the Kittitas Valley area near the present day town of Ellensburg,

Washington.

Osoyoos Lake, British Columbia (Appendix 2RB-B, WNP-1/4 PSAR; Appendix B, Coombs et. al., 1976, pp. 129-131) - Three additional contemporary reports from the Okanagan Valley Mission located between Osoyoos and Okanagan Lakes in British Columbia were identified in early 1977. These reports are included in Appendix 2R B, WNP-1/4 PSAR. A copy of these reports is attached as part of the answer to this question. These reports and the other reports used by the various investigators (Woodward-Clyde, Weston Geophysical, Coombs' Panel, and Betchel) were not apparently available to Nina Scott at the time of her evaluation. Osoyoos was a well-established settlement on the Similkameen (Doodney) Trail in British Columbia, that ran between Hope, Princeton, Osoyoos, and over to Fort Shepard. The reports all indicate very severe earthquake damage with earth cracking; a chimney thrown down; and cattle that became greatly alarmed. These reports are further corroborated by the letters from the Okanagan Mission (attached).

Oysterville, Washington (Appendix B, Coombs et. al., 1976, pp. 132-133) - There is a difference of opinion between the Coombs' Panel and Woodward-Clyde and Weston Geophysical, Nina Scott and Bechtel as to whether these reports refer to the December 14, 1872 Earthquake, or a seperate local earthquake that occurred on Tuesday, December 10. The dilemma arises because both earth-

quakes appear to have occurred at approximately the same time of day, about 10:30 p.m. The Coombs' Panel and Woodward-Clyde felt that this represented a small local earthquake and not the December 14, 1872 Earthquake.

Port Discovery and Port Townsend, Washington (Appendix B, Coombs et. al., 1976, pp. 145) - These two locations are thought to be identical. Woodward-Clyde assigned a felt report to Quesnel on the basis of an article in the Victoria Daily Standard, Victoria, British Columbia, dated January 10, 1873, found on page 10, Appendix B. The intensity assignments for Quesnellmouth are based on the report from the Caribou Sentinel, Barkerville, British Columbia, found on page 200 of Appendix B.

Rock Island, Washington (Appendix B, Coombs et. al., 1976, pp. 162) - The basis for the Rock Island report is the article from the Oregonian, Portland, Oregon, December 30, 1872, found on page 240, Appendix B. It is considered likely that this report is the same report from White Bluffs found on page 233 of Appendix B. The main trail from both Fort Colville going to the Fort Simcoe area and from the Okanagan country going to Fort Walla Walla joined at White Bluffs where a ferry was being operated by the Army at that time.

Skokomish and Skykomish, Washington (Appendix B, Coombs et. al., 1976, pp. 177) - These two locations are the same and refer to

the one report from Skokomish found on page 177, Appendix B. On the isoseismal map prepared by Nina Scott (attached) an Intensity V is assigned to the present day location for the town of Skykomish. On the Bechtel isoseismal map (attached) the present day location of Skykomish is incorrectly labeled as Skokomish. The correct spelling and location can be found on the Woodward-Clyde Isoseismal map, the Weston Geophysical Isoseismal map and the Coombs' Panel Isoseismal maps (attached).

Race Rocks, British Columbia (Appendix B, Coombs et. al., 1976, pp. 158) - Race Rocks is located off of the southeast end of Vancouver Island and essentiallly represents the same location as Victoria, British Columbia.

Spokane County, Spokane, and Spokane Bridge, Washington (Appendix B, Coombs et. al., 1976, pp. 181-182) - These three locations are considered to be essentially the same as the present town of Spokane.

Vancouver, Washington - The report that references Vancouver can be found on page 119, Appendix B, from the Washington Standard, Olympia, Washington Territory, dated December 21, 1872. This report states, "at Victoria, Port Townsend, Seattle, Steilacoom, on the Puyallup, at Kalama, Vancoucer, and many other points, the description of time and manner is identical to that of this place". It was on the basis of this statement that the Coombs'

Panel and Woodward-Clyde assigned an Intensity VI.

Vernon, British Columbia - This location is the same as Okanagan Lake (Vernon), British Columbia. The assignment of an Intensity VIII by the Coombs Panel appears to be supported by the later reports from the Okanagan Mission, British Columbia, by Father Baudre (attached). In addition, the letter from Father Baudre, dated March 7, 1873, indicates that aftershocks were still being felt up through that time.

Wenatchee, Washington (Appendix B, Coombs et. al., 1976, pp. 226-230) - There is one contemporary report from the Wenatchee area. That report by Jack McBride is reproduced from the Washington Standard, Olympia, Washington, dated January 11, 1873. The Miller-Freer trading post was originally built by McBride and was located on a sandbar just below the mouth of the Wenatchee River. The trading post is still intact and has been moved to a museum in Cashmere, Washington, west of Wenatchee. A photographic print of this building is attached. In addition, a photo of the St. Francis Xazier Mission building that was located in the area of the Ingram/McBride cabin along the Wenatchee River is also attached. There is no mention by the priest who serviced this area at the time (Father Grassi), of any damage to the mission building. The report from McBride states, "arrived at the store, they found everything in confusion. Messrs. Freer Brothers, and one of their partners named Miller, had been

awakened by the shocks and started from their beds. Mr. Miller ran downstairs and found the door blocked. He then imagined that the store had been attacked by Indians and shouted to his partner who came to his aide with shotguns and pistols. In the morning an examination was made when it was discovered that in the store sacks of flour, which had been piled in four feet deep were thrown around in confusion. The two upper logs of the cabin and the roof were misplaced, and the kitchen separated from the main building." An early 1900 photo of the trading post shows a separate structure abutting the trading post but not directly attached. This structure was later lost to unknown causes. The structure of the trading post shown in the attached photo has no evidence of any structure ever being attached to it. On the basis of the location of the trading post on unstable ground and the limited amount of damage that was reported, it was Woodward-Clyde' opinion tnat an Intensity VI would be appropriate for this area. The Coombs' Panel was apparently influenced by the additional reports of landslides in the area and assigned an Intensity VII-VIII.

It should be noted that the contemporary report of aftershocks by McBride has to be limited to two days, according to this report, in the last two sentences in the january 11, 1872 Washington Standard article. This article states, "Mr. McBride says the shocks continued at intervals until the 16th ULT. The entire country was still alarmed and unsettled when he left there, 15

days ago to come to Portland". Although there may have been additional aftershocks, McBride either did not recognize them or had left the Wenatchee area for Portland. It is known from Army records (Appendix D, Coombs et. al., 1976, pp. 7-18) that the trip from Fort Colville to Portland took 10 days.

Whatcom County, Washington - This location is the same as LaConnor, Washington.

Winesap, Washington - This location is the same as Entiat-Ribbon Cliffs.

White Bluffs, Washington (Appendix B, Coombs et. al., 1976, pp. 233) - As discussed earler, this location is probably the same as Rock Island. The location on the Coombs' Panel isoseismal map is correct. The location shown on both the Bechtel map and the Woodward-Clyde map in Appendix 2.5R B, WNP-1/4 PSAR are both in error. There was an army ferry crossing at White Bluffs, located near the northern most point of the Columbia River where it passes through the Hanford reservation. On the north and east side of the Columbia River at this local, the banks are made up of Pliocene lacustine deposits that exhibit incipient land-sliding. Based upon this knowledge, the assignment of an Intensity VI question to the White Bluffs local is considered to be conservative.

Willow Creek and Willow Forks, Oregon (Appendix B, Coombs et. al., 1976, pp. 238-239) - The location for Willow Forks, Oregon as shown on the Coombs' Panel map is correct (45° 32.3' N by 119° 49.0' W). The location was obtained from an Oregon territorial map published in 1878. This is approximately equivalent to the location of the present day town of Ione. The Scott and Bechtel maps both show this location at approximately 45° 15' N by 119° 15' W, a distance of approximately 30 miles to far south.

Supporting Information Discussion

Appendix D of the Coombs' Panel Report, December 1976, contains selected supporting information related to the December 14, 1872 earthquake. Pages 1-3 of Appendix D, list in order, the index of selected supporting information. A comment will be made on each entry contained in Appendix D.

Appendix D, pages 4, 6, are taken from a popularized version of stories about the 1872 earthquake, published by the Wenatchee Daily World, called "The Night The Mountain Fell". This publication, more than any other, is the source of most of the misinformation and mythology that has arisen regarding the 1872 earthquake. For example, in the fourth paragraph, second sentence, on page 4, regarding the Wapato cabin, it states, "that the ground began to shake again as the mountain just north of their cabin lost its footing". In the third paragraph, next to

the last sentence it states. "that the Wapatos scampered outside as the fury and violent rolling motion of a full blown earthquake gripped the land". On page 51, Appendix B, second paragraph, second sentence, it states that the Wapato family were living at the mouth of Wells Coulee two miles above Ribbon Cliffs, and, "The quake was so great that all the dirt on their log cabin was shaken down and the logs from one side caved in." On page 52, Appendix B, in the second papagraph, third sentence, it states that, "Wapato John, an Indian who had a small farm and a trading post a few miles above where the mountain slid into the river, had it destroyed by backwater." On the bottom of page 53, and the top of page 54, Appendix B, it states, "that the Wapato cabin was a log house with dirt rooms, near the cliff, but it shook so much that all the roof shook down. The shake filled up the Columbia River and all one night the Columbia River was dammed." Other variations of this story can be found in later accounts, all contained in the same Wenatchee Daily World that's responsible for the "Night The Mountain Fell" publication. All historical records indicate that the Wapato cabin was north of the Ribbon Cliff slide area by several miles and survived the earthquake without significant damage. Also on page 4, Appendix D, starting with paragraph 9, is an article regarding Henry Livingstone and a party of 32 Indians who were camped at Lake Wenatchee when the quake struck. They are reported to have been packing in supplies for a railroad survey party sent in by a Jay Cook of New York City. It is stated that, "when the earth began

to shake huge rocks tumbled down the face of Dirty Face Mountain and plunged into Lake Wenatchee." Later on in this discussion of Appendix D, it will be shown that Henry Livingstone did not work for the railroad. That he was most likely not camped at Lake Wenatchee. That he did not work packing in supplies for the railroads during 1872. That the railroad crews were not in the area during the winter of 1872.

Paragraph 10, Page 4, Appendix D discusses Captain Ben Ingalls, U.S. Calvary, who is reported to have become separated from his scouting party near Mt. Stewart. The article implies that Captain Ingalls had discovered gold and that the gold claim was later covered by the landslides. Later in this discussion of supporting information it will be shown that Captain Ben Ingalls was not a captain; he was a blacksmith, Indian scout, and a prospector, and that the nickname "captain" was given to him by admiring soldiers when he guided them over the mountain trails while they were surveying in the 1850's. It will also be shown that Ingalls was discharged from the army in the late 1850's and was shot and died trying to recover the location of some gold that he had identified during the 1850's. He was buried in 1860 between Yakima and Ellensburg.

Page 6, Appendix D also contains an article from the publication "The Night The Mountain Fell" that deals with the Ribbon Cliffs. It was the purpose of this information to try to support

the premise that Ribbon Cliffs was an unstable land mass that had been undercut by the river and that very little vibration, if any, would be required to cause the mountain mass to come down. It has now been shown by field geologic studies (Shannon & Wilson, 1978) that the main body of the landslide at Ribbon Cliffs developed prior to 1872.

Pages 7-18, Appendix D are taken directly from the original army post surgeon's journal for Fort Colville, Washington Territory, found in the National Archives. The main purpose of including this information is to give the reader a feel for the type of structures that were in existance at the time of the 1872 earthquake and also a feeling for the geography of the area as understood by the people at that time. Fort Colville, being the only settlement of consequence for the area, makes this information important in trying to assign appropriate intensity value for the Colville and North of Colville locations (pp. 25-33, Appendix B). For example, an article from the Portland Oregonian on page 26, Appendix B, indicates that two houses north of Colville were shaken down and that the mountain had sunk out of sight. The indications are from the post records that , "the fort was constructed on a small valley fill area of logs, not hewed, but filled between with mortar composed of lime and sand". The records show that there was no damage to the Fort from the earthquake. The report of the landslide to the north could refer to Fort Shepard where an incipient landslide can still be seen.

Additional information contained in the Fort Colville article worth noting can be found on page 17, Appendix D, where under the means of communication discussion, it states that it requires ten days for a letter to reach department headquarters at Portland and one month to Washington. This information is relevent when one considers the authenticity of the McBride report for the area around Wenatchee given to the Potland papers on or about December 25th, 1872. (See article from Washington Standard, dated January 11, 1873, pp. 226-227, Appendix B.) If in fact, it had taken McBride eight to ten days to travel from the Wenatchee area to Portland or Vancouver, then he could not have been in the Wenatchee area much past the 16th or 17th of December, 1872. In addition, there is little possibility that McBride could have received reports of the Spokane Indians, as stated in the same article, and their reaction to the earthquake, but instead, must have picked up the information from someone else in Portland after he had arrived. Paragraph W on page 17, Appendix D, in of the article from Fort Colville describes the Indians attached to the Colville Agency. Again, it should be noted that the Spokane Indians, as mentioned by McBride at Wenatachee, were located southeast, a distance from Fort Colville of approximately 65 miles and nowhere near to Wenatchee. It should also be noted that the Methows are shown as located to the southwest of Fort Colville. The Methows were the farthest south tribe attached to the Colville Agency. The Okanogans which reported many of the

more spectacular effects from the 1872 earthquake were then located to the west and northwest of the Fort Colville area around Okanogan and Osoyoos Lakes.

Pages 19-25, Appendix D contain an early report by Shannon and Wilson, dated August 1976, "Reconnaissance Investigation of the Ribbon Cliff Landslide, Entiat, Chilan County, Washington". This was the first attempt to describe the landslide and try to establish whether any pre-existing geologic conditions could have been responsible for the effects reported during the 1872 earthquake. A more detailed study by Shannon & Wilson (1978) concludes that the major part of the landslide occurred prior to 1872.

Pages 26-29, Appendix D is taken from another popularized version of the history of the Wenatchee area called, "Passes to the North, History of the Wenatchee Mountains". The part of this article included, deals with the discussion of the 1872 earthquake. As can be seen on pages 27-28, the same stories as told by others, are given different twists with some exaggerations in addition. For example, consider the paragraph dealing with Captain Ben Ingalls. One interesting piece of new information that was reported in this article can be found on the last page (page 29) where an upheavel near the center of Lake Chelan on September 9, 1899 is mentioned. This report was taken from a newspaper article in the Chelan Leader, September 14, 1899

(page 19, Appendix B). No other reports could be found that indicate an earthquake occurred in the area during this period of time. One explanation for this upheavel would be overturning of the lake, a fairly common phenomena. This overturning is thought to be due to gas build up from the decay of organic matter at the bottom of the lake. When sufficient volume has accumulated, a bubble will rise. In some cases, bubbles of considerable size are thought to develop. This same type of phenomena could have been responsible for the black smelly material reported from Lake Chelan at the time of the December 14, 1872 earthquake.

Page 30, Appendix D is a later report found in another historical publication, "Spokane and the Inland Empire". This book covers the area of Spokane and the immediately surrounding counties as known by present-day maps. The report of the 1872 earthquake effects at Hangman's Creek is found in the middle of the last paragraph on page 30. Hangman's Creek runs southeast out of the present-day town of Spokane. This location would be in the same general vicinity as the contemporary reports from Spokane Bridge, Spokane, and Pine Grave.

Page 31-32, Appendix D contain the principal piece of information that places the reports from Okanogan and Okanogan Lake at the head of Okanogan Lake, British Columbia. In paragraph 2, in the second sentence, a Messrs. O'Keefe and Greenhow, head of Okanogan Lake B.C. are described. O'Keefe and Greenhow are again

described in paragraph 4, where it indicates that the person responsible for this report was at their house at the time of the earthquake. The O'Keefe ranch can still be seen standing at the head of Okanogan Lake, just north of Vernon, British Columbia. In the last paragraph of the article on page 32, the location of the Okanogan Mission is described as being east of Lake Okanogan and O'Keefe's ranch. Additional reports from the Okanogan Mission are found in Appendix 2R B-B, WNP 1/4 PSAR (attached).

Page 33, Appendix D has a statement of an Indian account of the settlement of Spokane County. In the third paragraph, the big earthquake is discussed (assumed to be the 1872 earthquake although the note #23 indicates that the earthquake was in 1874). This article lends additional support for earlier reported effects in the area around the vicinity of the present day town of Spokane.

Pages 34-37, Appendix D are taken from the Lewis and Clark journals. The principal purpose of this information is to provide some insight into the physical conditions of the Ribbon Cliffs area prior to the 1872 earthquake. On page 35, beginning with the second paragraph, in the second column, a discussion of the Pisscow's River can be seen. This is known to be an early 1800's name for the present-day Wenatchee River. In paragraph 4, second column on page 36, the Intycyook River at the foot of a steep crag is discussed. This is thought to be the present-day

site of Entiat Creek. Oak Point is thought to be located at the base of the present-day Ribbon Cliffs area. White Hill Rapids discussed in paragraph 5, column 2, page 35, can be located on the Symons Survey Maps (U.S. Army) of the upper Columbia, October, 1881. The location is the present-day site of Ribbon Cliffs. The purpose of including this article was to provide insite as to the physical conditions of the Ribbon Cliff area at the time of the earthquake.

<u>Pages 38-47, Appendix D</u> contain copy of a Chinook Dictionary, published in 1871. As stated on page 39, this Chinook jargon is composed of words taken from the dialect spoken by the Indians of that name who inhabited that area near Astoria on the northwest Oregon coast. The Chinook language was developed by the whites into a trade language. However, it was not a common language to anyone except the whites. All of the Indian tribes had their own languages. Although many Indians could speak Chinook, few except the Chinooks actually used it. The purpose of including this dictionary as supporting information is to provide the reader with some level of information that he can used to evaluate the credibility of various reports on the 1872 earthquake that include words reportedly from the Indian language. For example, in the article from the Walla Walla Union, October 4, 1873 (Appendix B, page 13) the sulphurous water is called, "halluima chuck". There are no words of similar sound or derivation in the Chinook Dictionary. Another example of misuse

regarding the Indian language can be found in the 1874 article from the Spirit of the West newspaper (Appendix B, page 17) regarding the, "earthquake phenomena of Lake Chelan." This article is important because of its use (by several investigators) as proof of the earthquake effects at Lake Chelan. On page 17, third paragraph, third sentence, reference is made to the poor Siwash. Siwash was a derogatory ethnic slur made up by the whites. A literal translation of Siwash is "Dirty Indian." Also in the third sentence of the third paragraph, page 17 there is a phrase "Wake Klosa Sockalee Tyee biss sulux," with the translation that is reported to mean "not good, great spirit very angry." The Chinook Dictionary contains no words equivalent to any of those used in this phrase. In addition, there are no words that begin with B or have the letter X such as in sulux, which is likely Latin term. Another example of the misuse of Indian language, comes from the Wenatchee Daily World article regarding Henry Livingstone, (top of page 57, Appendix B) whichs states in the first paragraph, first sentence, "Mesatchee Moos Moos Menaloose Siwash". The translation reported is "The mad bulls down in the earth will kill the Indians". No success was had using the Chinook Dictionary to arrive at this translation. Another use of the Indian language is found in the second paragraph on page 57, Appendix B. In the first sentence, "Sah-ha-lee Tyee" (God) was mad with them unless they treated the Indian "right". Tyee is a coastal Indian term for salmon. We have been unsuccessful in determining the derivation of the term

Sah-ha-lee.

Page 48-50, Appendix D is a letter from Father Urban Grassi, a Jesuit priest serving the area from Autanum Mission near Yakima. This letter has two pieces of important information. The letter establishes the name of the Indians that lived along the Wenatchee River as the Sinpesquensi. They were by far the most prominent and powerful tribe in the area. On the bottom of the second paragraph, in the first column, page 50, is the mention of the 1872 earthquake. Other than the shaking that apparently frightened some of the Indians, no other effects were noted by this tribe in the Wenatchee area and the area to the west and northwest along the Wenatchee River Valley.

Pages 51-62, Appendix D contain a copy of another letter from Father Urban Grassi in the original Latin and part of the translation that was attempted by a novice priest at Gonzaga University sometime during the last 40 years. The information of importance in this letter can be found on page 57, beginning with the first paragraph, second sentence describing two tribes. The first blank should read "Intielikum" which was the name for the Entiat Tribe at that time. The second paragraph, the first blank should read "Sinpesquensi" and the second blank should read "The Intielikum". The third blank in the second paragraph should again read "Sinpesquensi". The third paragraph describes the earthquake affects on the Intielikum or Entiat Tribe. The

effects are most noticable because the tribe was situated in areas concentrated along the Columbia River and were directly in the path of the Ribbon Cliffs landslide. They were also effected by the water that backed up from the landslide. Additional important information in from the letter by Father Grassi regards the lack of remotely similar type of descriptive effect of the earthquake on the Chelan Indians as reported in the article from the Spirit of the West newspaper, Walla Walla (page 16, Appendix B).

Page 63-76, Appendix D are the information regarding Captain Ingalls and the reported lost gold mine. Page 63 is taken from the popularized version of the 1872 earthquake, "The Night The Mountain Fell", published by the Wenatchee Daily World. This article establishes the legend of Captain Ben Ingalls and the lost gold mine of Ingalls Creek which is near Blewett Pass to the south and west of Wenatchee. Page 64 contains an article from the publication "Kittitas Frontiersman" with a more accurate account of Captain Ben Ingalls. This article states that Ingalls was a scout for the army during the Indian Wars of 1855-56. The article goes on to state that Ingalls was shot and killed by a Jack Knot in approximately 1860. The article on pages 65-67, Appendix B, from the Wenatchee Daily World, August 10, 1951 appears to be the source of the original myth about Captain Ingalls and his involvement with the 1872 earthquake. The article from the Wenatchee Daily World of December 26, 1951,

pages 68-71, Appendix B, refutes the previous article and places Ingalls back in the time frame of 1860. The article on pages 72-76, Appendix B, concludes the story about Captain Ingalls. On page 75, Appendix B, it is again established that Ingalls was killed by Jack Knot in 1860.

Page 78, Appendix D in the second column, second paragraph, describes both the 1872 earthquake and during the summer of 1874, another series of earthquakes. It is likely that these earthquake were the same. No evidence of any felt earthquakes in 1874 were reported for the eastern part of Washington State was found in the contemporary local newspapers.

Pages 81-91, Appendix D contain an article on the Hope British Columbia landslide that was thought to be triggered or associated with two earthquakes of approximately magnitude 3. A discussion of the 1872 earthquake and the fact that it apparently had little effect on this landslide is found on page 86.

Pages 92-111, Appendix D contain all the pertinent information that could be obtained regarding John McBride and Jack Ingram and their handyman John Warren. This information is considered important because McBride's account represents the only first-hand account from the Wenatchee area. About all that can be established from this information is that both McBride and Ingram, who had set up the trading post, were probably guilty of

selling liquor to the Indians. The arrest record and subsequent information on their flight from justice lends further support that McBride was not of the highest character. There is little doubt that McBride was, in fact, in the area of Wenatchee at the time that the earthquake occurred. However, it is likely that he left the Wenatchee area within less than one week after the earthquake and travelled to Portland. Therefore, he could not have reported to any great degree on the aftershocks of the 1872 earthquake in the Wenatchee area. An interesting sidelight has to do with the handyman A. J. Warren. In the Holden 1898 Catalog of Earthquakes on the Pacific Coast (Smithsonian Miscellaneous Collection #1087) and in Townley's 1919 Earthquake Catalog of the Pacific Coast of North America (BSSA Bulletin Vol. 9, #3, 1919) an earthquake in 1867 of Intensity X is shown for Fort Klamath in Oregon (see page 8, Appendix C, Coombs et. al. 1976). The report of the earthquake, in the form of a letter to the Oregon Sentinel from one L. Tennyson, Quatermaster's Clerk at Fort Klamath, is an artful composition of earthquake descriptions that in many ways resembles others of the time. In the Townley and Allen, 1939 Descriptive Catalog of Earthquakes (BSSA Vol. 25, #1, 1939) it is stated that there was no earthquake in 1867 nor was there any L. Tennyson in the Quartermaster Corp. Investigations by Townley demonstrated that the description of this earthquake was the fertile imagination of a bored soldier named Warren who had nothing better to occupy his time.

Pages 112-117, Appendix D are taken from a description of George B. McClelland's journey through the Pacific Northwest in 1854. The purpose of including the McClelland information was to show that the conditions around Ribbon Cliffs were unstable and could possibly have developed by landsliding prior to the time of the 1872 earthquake. One of the best descriptions of the Ribbon Cliff area can be found as part of footnote #149 on the bottom of pages 115 and 116, and the bottom paragraph on page 115. In addition, the location of Lake of Osoyoos and Okanogan Lake are established on page 112, footnote #161.

Page 118-121, Appendix D are excerpts from ledger books for the Miller-Freer trading post at Wenatchee which John McBride and Jack Ingram had started. These ledgers show that McBride was in the area on December 9th, prior to the December 14, 1872 earthquake and that Ingram was in the area on December 16th after the earthquake. There is no record of either Ingram or McBride up through January 14th at the time that McBride's letter shows up in the Portland newspaper.

Pages 120-124, Appendix D are a copy of a letter from Thomas Morris of the Northern Pacific Railroad that outlines the 1872 railroad route survey of Ward and Sheets. On page 121, which contains the first page of the letter, in the third paragraph, second sentence, Morris describes his meeting with Henry Livingstone. Livingstone was hired as a guide on the 9th of

July, 1872. On the top of the second page of the letter, first paragraph, Morris describes how he changed crews. It is thus probable that the report for the Wenatchee area by Henry Livingstone as shown on page 56, Appendix B, from the Wenatchee Daily World, June 7, 1932, is a fabrication.

Pages 125-127, Appendix D are also from Thomas Morris, Engineer for the Pacific Division of the Northern Pacific Railroad. Page 126 shows that all of the railroad engineering for that year was completed and the crews paid off as of November 30, 1872. This information also refutes Livingstone's claim to have been in the area of Lake Wenatchee working for the railroad in December 1872.

Pages 128-138, Appendix D contain a copy of Professor Plummer's paper on recent volcanic activity read before the Washington Academy of Science. Professor Plummer was located at the University of Washington and his paper represents one of the earliest scientific accounts of geologic phenomena on the Pacific Coast. The description of the 1872 earthquake is found on page 7 of Professor Plummer's paper (page 134, Appendix D) and indicates rather strong effects in the vicinity of Seattle to Olympia. The next to the last paragraph on page 7 (page 134 of Appendix D) there is a short statement about earthquakes in 1874. This is the only mention of 1874 earthquakes found other than the report from the Yakima paper and one historical book.

Page 139-147, Appendix D contain parts of a popularized historical account of the Indians in the Columbia Plateau, "Half Son on the Columbia." On page 141, Appendix D, in the bottom paragraph can be found the first record of earthquake prediction. On page 142, Appendix D in the second paragraph, a statement is made that the white settlers coming into Walla Walla report that since the middle of February, 1873, the country between Wenatchee and Lake Chelan had not seen one day free from tremors. The historical records of the area show that what settlers were coming into Walla Walla, were coming from Colville on the north or from Pendleton on the south and were going towards Wenatchee. It is unlikely that many were coming from Wenatchee back towards Walla Walla. It is also known from the historical records that the first settlers after 1872 to move into Wenatchee area did not arrive until 1880 because of restrictions by the Army.

Page 148-164, Appendix D, contains a short report by Shannon & Wilson, Inc. regarding the population distribution for the area and the communications and weather at the time of the 1872 earthquake. This information was available to all investigations in late 1976 and early 1977 and had been previously submitted as a reference.

Pages 162, Appendix D contains a part of another popularized version of the history of eastern Washington. The bottom

paragraph on column one, page 162 is a reference to the 1874 earthquake in the Yakima River area. It is likely that this is a further perpetuation of a probably erroneous report that have been previously published in the history of Yakima County (page 78, Appendix D, second column, last paragraph).

Page 163, Appendix D contains a second-hand account from one of the pioneers of the Wenatchee area. John H. D. Smith moved into Orondo, directly across the river from the Ribbon Cliffs area, in 1880 according to the census records for the area. His account, at best, represents a second-hand version since he was barely born in 1880.

Page 164-165, Appendix D contain an excerpt from another popularized version on the Indian history of the area. This version of the 1872 earthquake is interesting in that it represents a very common type of report for an earthquake at this time. For example, see the report from Baker, Oregon, Bedrock Democrat dated December 18, 1872, page 3, Appendix B, in the second paragraph or the report from Colfax, Washington from the Walla Walla Union, February 1, 1873, page 22, Appendix B.

Page 166, Appendix D contains two second-hand accounts of the 1872 earthquake, one for the Seattle area of King County and one for the Spokane Bridge area, Spokane County. Both of these reports appear to support other contemporary reports from those

areas.

<u>Page 167, Appendix D</u> contains a clipping from the Vernon, British Columbia news that was the source of the original assignment of intensity VII by Dr. Milne (1956). Later reports developed for the Coombs Panel study were more instrumental in convincing the Coombs' Panel that the original intensity assignment for Vernon should be VII. Vernon, British Columbia is located at the north end of Okanogan Lake.

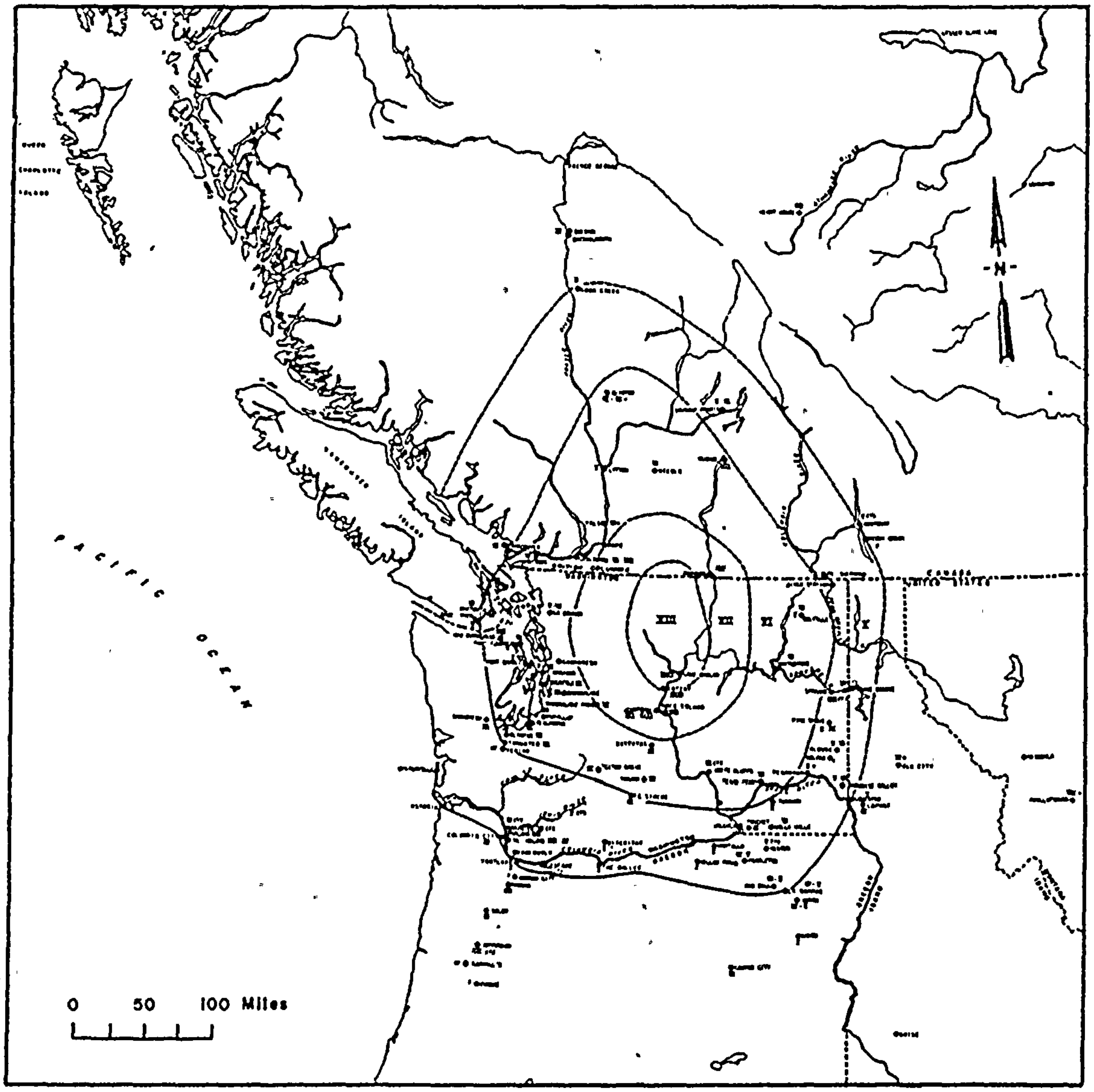
<u>Page 168-174, Appendix D</u> contain the calculations regarding a balanced rock found in an area just south and east of the present town of Omak and Okanogan, Washington. This balanced rock is somewhat of an enigma, both because of the delicate nature of the pedestal on which it was resting and the reports of falling rocks and rolling rocks during the time of the earthquake for the surrounding area. Although the calculation included in pages 169-174 is crude, the resulting accelerations values appear to be reasonable for this area.

<u>Page 175-177, Appendix D</u> contain excerpts from a history of Stevens, Ferry, Okanogan and Chelan Counties, published in 1904. The report of the 1872 earthquake is found in column 1, bottom paragraph, page 176. This report is similar to other reports that came from the area. On page 177 is the biography of John Wapato. In the last sentence, first column, under John

Wapato, it is stated that he established a trading post on the Columbia River 12 miles from Lake Chelan where he traded with the Indians and the Hudson Bay Company. It is probable that this may be slightly exaggerated since the Hudson Bay Company left the area in the early 1860's.

Pages 178-184, Appendix D contain excerpts from the Wilkes-U.S. Navy expedition up the Columbia River around 1840. This article provided additional information that can be used to assess the conditions at Ribbon Cliffs prior to the 1872 earthquake. The discussion of the area around Ribbon Cliffs starts on the bottom paragraph, page 181 with the reference to the Pischous River (the present day Wenatchee). From there to the third paragraph on page 182, is a description of the trip up to the Entiat River. In the second paragraph at the top of page 183, it appears that way was blocked requiring them to cross the Columbia River.

Page 185-187, Appendix D is a copy of the Modified Mercalli Scale used by the Coombs' Panel as reference in assigning intensities to the 1872 earthquake.



EXPLANATION

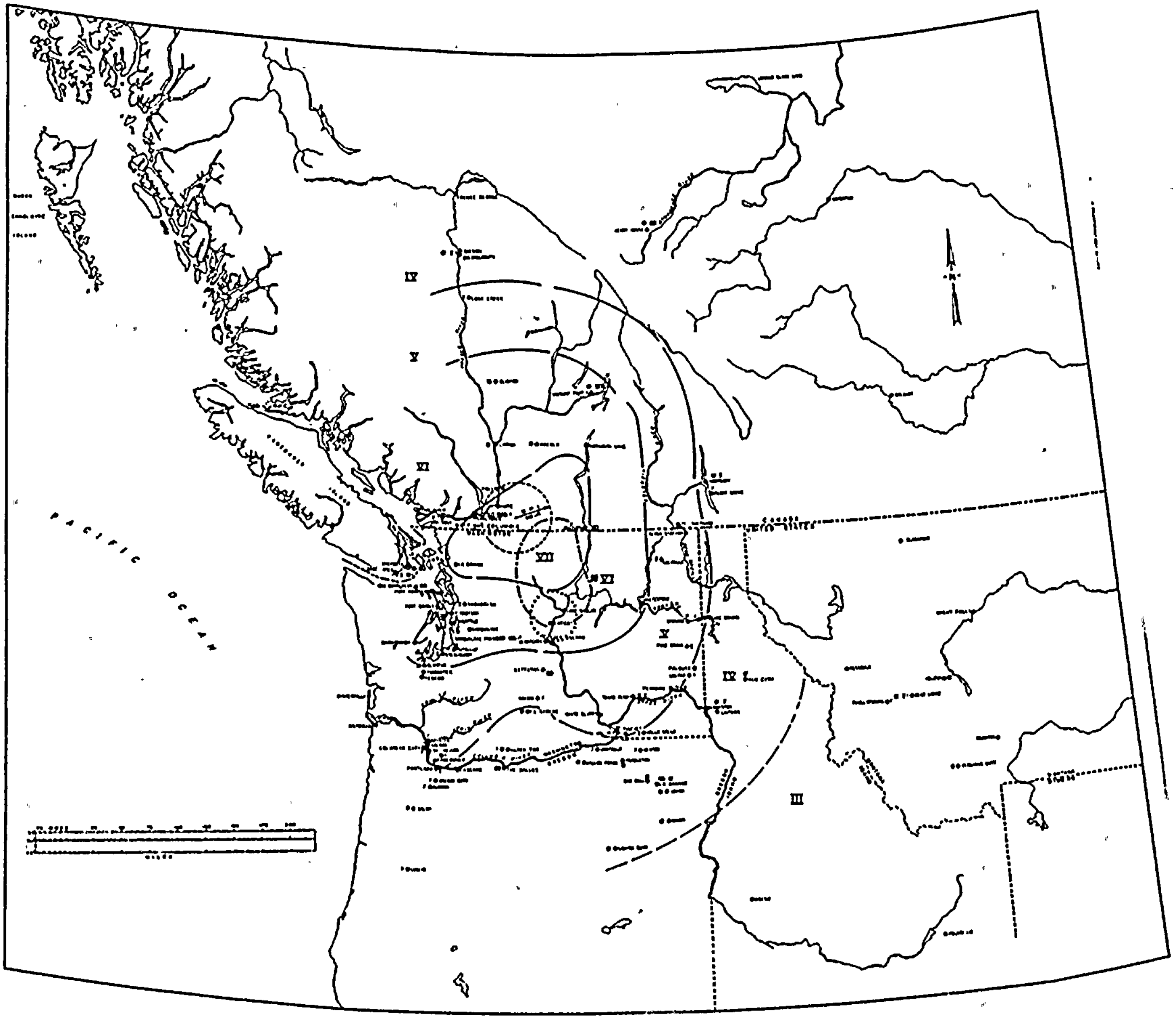
a) Isoseismal map prepared by the Review Panel (1976)

- - - Isoseismal, dashed where assumed

VI Modified Mercalli Intensity

F Felt

NF Not Felt



EXPLANATION

—— ISOSEISMAL, DASHED WHERE ASSUMED

V MODIFIED MERCALLI INTENSITY ACCORDING TO WPPSS (1977)

F FELT

------- EPICENTER AREA ACCORDING TO MILNE (1956)

—·—·— MEIZOSEISMAL AREA ACCORDING TO COOMBS et al (1976)

·········· MEIZOSEISMAL AREA ACCORDING TO PSP&L (1977)

■ BALANCED ROCK (OMAK LAKE)

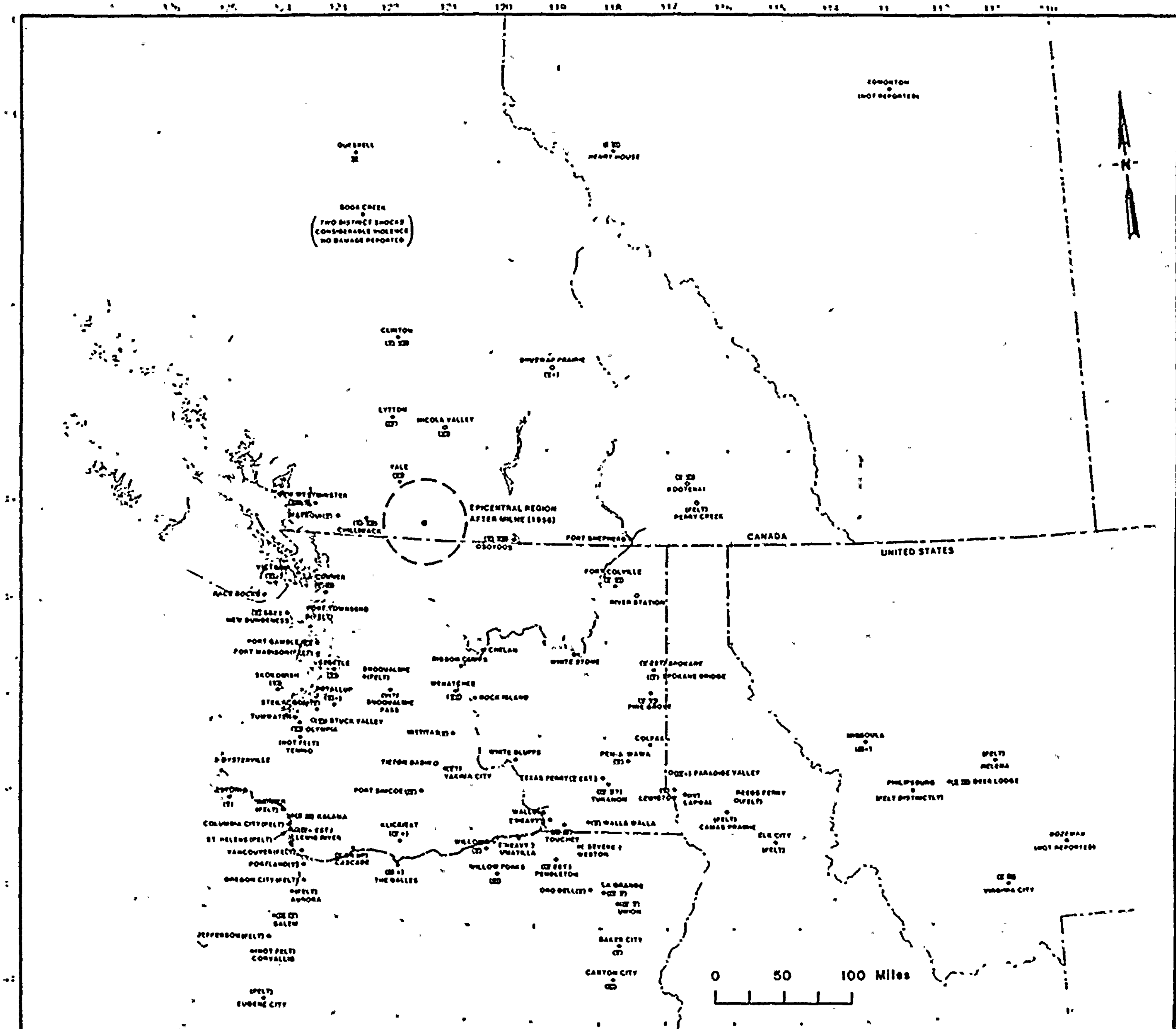
ATTACHMENT 361.19-2

EXPLANATION

XI • Solid dot: location of felt report and intensity (mm)

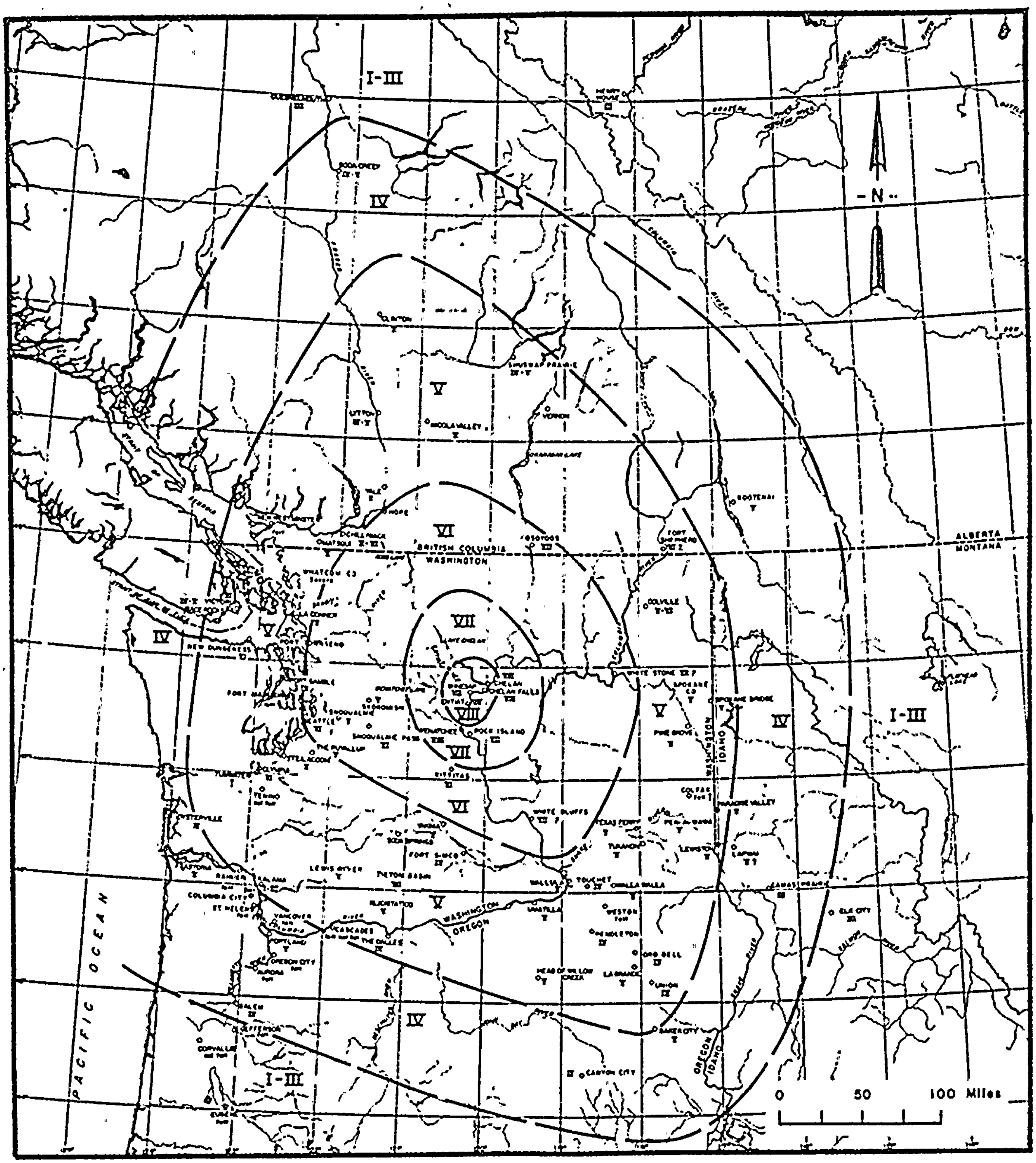
• Solid dot: location of felt report, intensity unassigned

o Open circle - location estimated

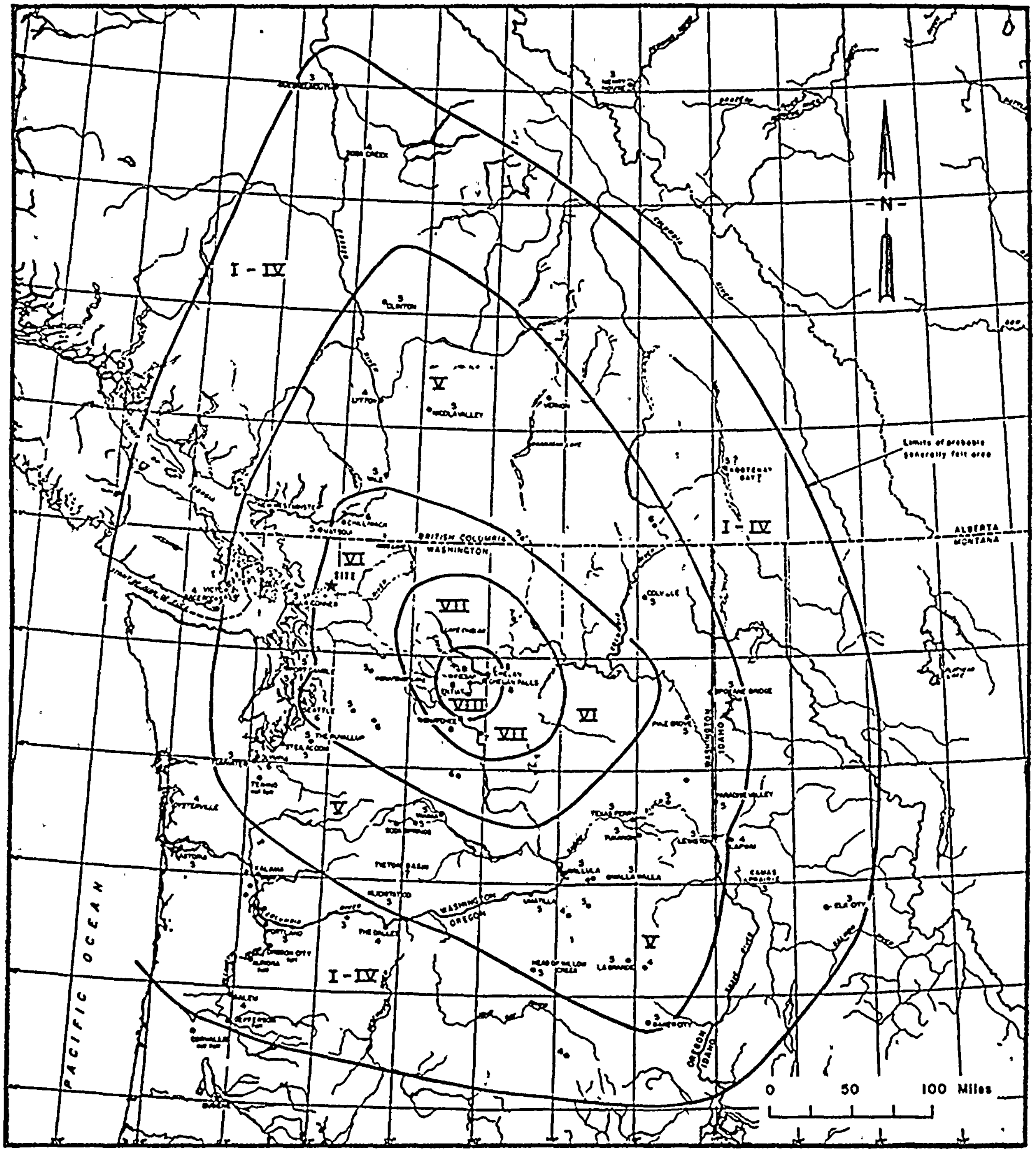


b) Distribution of Intensity, Weston (1971)

ATTACHMENT 361.19-3



b) Isoseismal map prepared by Puget Sound Power and Light (1976)



EXPLANATION

a) Isoseismal map prepared by Nina Scott (1976)

5 M. M. Intensity V

Felt - No details

NOTE:

Outside the generally felt area, the earthquake was reported at Eugene, Oregon and Henry House, Canada. It is questionable whether or not it was felt at Virginia City, Montana.

TABLE 2R B-4

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WGR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)***
Astoria, Oregon		V	V	V	V	
Aurora, Oregon	Felt	Felt	III	Felt	Felt (ND)	
Baker City (Baker), Oregon	IV	V	V	V	V	
Bozeman, Montana			III			
Camas Prairie, Idaho		Felt	IV	III	III	
Canyon City, Oregon	IV	III	IV	IV	IV	
Cariboo, British Columbia						
Cascades, Oregon	NF	II or NF		Felt	I-III	
Cascades, Washington			III?			
Chelan Falls, Washington				Strong VIII	VIII	IX
(Lake) Chelan, Washington			VIII	Strong VIII	VIII	IX
(Lower Lake) Chelan, Washington					VIII	IX
Chilliwack, British Columbia	VII-VIII?	VI-VIII, VI-VII	VI-VII	V-VI	VI	
Clinton, British Columbia	VI	VI-VIII	VI-VI+	V	V	
Colfax, Washington	Felt	no descriptive account	Felt	Felt (?)	Felt(ND)	
Columbia City, Oregon	Felt	Felt	IV	Felt	Felt (ND)	
(Fort) Colville, Washington	V	V-VI, V+	VI	V	V	
North of Colville, Washington					VII(?)	
Corvallis, Oregon		NF	NF	NF(nor in rest of upper Willamette Valley)	NF (and upper Willamette Valley)	

TABLE 2R [illegible] (CONTINUED)

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WGR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)***
(The) Dalles, Oregon	III	III+	V	IV	IV	
Deer Lodge, Montana	IV-V?	II-III	IV			
Duwamish Head, Washington		VI*				
Elk City, Idaho		Felt	IV+	III	III	
Entiat, Washington			VIII	Strong VIII	VIII	IX
Eugene City, Oregon	Felt	Felt	Felt	Felt	Felt (ND)	
Fort Shepherd, British Columbia				VI?		
Fort Simcoe, Washington	IV	IV	IV	IV	IV	
Helena, Montana	IV	Felt	III			
Henry House, Alberta	II-III	I-III	III	III	III	
Jefferson, Oregon		Felt	III?	Felt	Felt (ND)	
Kalama, Washington	II	II-III	III	I-III	I-III	
Kittitas (Valley), Washington	≥III		VI	VI	VI	VI
Klickitat, Washington (Klickitat County)	IV?	IV+	V?	V	V	
Kootenai (Kootenay), British Columbia	IV-V	V-VI	V?	V	V	
La Conner, Washington		V-VI	V-VI	V	V	
La Grande, Oregon	III-IV	IV-V	IV-V	V	V	
(Fort) Lapwai, Idaho		IV	IV	IV	IV	
Lewis River, Washington	III-IV?	IV*	V?	V	V	
Lewiston, Idaho	IV-V	V	V	V	V	
Lytton, British Columbia	IV	IV	V	IV-V	IV	

TABLE 2R (CONTINUED)

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WGR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)***
Matsqui, British Columbia	V?	V	VI	V	V	
Missoula, Montana		III+				
New Dungeness, Washington	VII	VI*	VII	VI		VI
New Westminister		Felt		Felt		
Nicola, British Columbia	VI	VI	VI	V	V	
O'Damet (O'Harmet, O'Damet) British Columbia		IV-V		V	V	
Olympia, Washington	VI	VI	VI	VI	VI	VI
Okanogan Lake (Vernon), British Columbia			VII			VII?
Oregon City, Oregon	Felt	Felt	Felt	Felt	Felt (ND)	
Oro Dell, Oregon	IV	V	IV-V	IV	IV	
Okanogan and Oyouius Lake, Washington					VII	
Osoyoos Lake, (Okanogan and Oysuius Lake) B. C.	VII	VI-VII	VII	VII	V	VII?
Oysterville, Washington		V		IV	IV	
Paradise Valley, Idaho		IV+	IV-V	V	V	
Penawaw (Pen-a-wawa), WA	IV-V	V	V+	V	V	
Pendleton, Oregon	IV	IV*	IV-V	IV	IV	
Pen d'Oreille River, Washington	?				?	
Perry Creek, British Columbia	Felt	Felt	Felt	Felt	Felt (ND)	
Phillipsburg, Montana	Felt	Felt Distinctly	III+		Felt	
Pine Grove, Washington	V	V-VI	V-VI	V	V	

TABLE 2R B-[illegible] (CONTINUED)

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WGR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)***
Port Discovery, Washington		V+				
Port Gamble, Washington	(VI)**	VI	V-VI	V	V	
Portland, Oregon	V	V	V	V	V	
Port Madison, Washington	(VI)	Felt	V-VI	Felt	Felt(ND)	
Port Townsend, Washington	(VI)	Felt	VI		Felt(ND)	
Puyallup, Washington	(VI)	VI+, VI	VI	V	V	
Quesnell, British Columbia	Felt					
Quesnellmouth, British Columbia	IV-V?	III	IV	III	III	
Race Rocks, British Columbia	V-VI?	IV?	V	IV-V	IV	
Rainier, Oregon	Felt	Felt	IV?	Felt	Felt(ND)	
Reed's Ferry, Idaho		Felt	IV	III		
Rock Island, Washington			VII	VII	VII	
Salem, Oregon	II	III-IV	IV	IV	IV	
(Camp) San Juan Island			Felt			
Seattle, Washington	V	V, VI	VI	VI	VI	
Shuswap Prairie, British Columbia	VI-VII	V+	V-VI	IV-V		
Skokomish, Washington	V	VI	VI?	V		
Skykomish, Washington					V	
Snoqualmie, Washington	Felt	Felt	VI	V	V	
Snoqualmie Pass, Washington	(VI-VII)?	VI?		VI	VI	

TABLE 2R (CONTINUED)

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WCR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)***
Soda Creek, British Columbia	V		V	IV-V	IV	
Spokane County, Washington				V		
Spokane, Washington		V*				
Spokane Bridge, Washington	Felt	IV	VI?	V	V	
Steilacoom, Washington	V	V	VI	V	V	
St. Helens, Oregon	Felt	Felt	III-IV	Felt		
Stuck Valley		VI				
Tenino, Oregon		NF	NF	NF	NF	
Texas Ferry, Washington	IV-V	V*	VI	V	V	
Tieton Basin (Nasty Creek), Washington		no period account	VI	VII	VII	
Touchet, Washington	III	III-IV	IV	IV	IV	
Tukanon, Washington		IV-V?	V	V	V	
Tumwater, Washington			VI	?	V	
Umatilla, Oregon	Felt	Heavy	V	V	V	
Union (Union County), Oregon	IV	IV-V	IV-V	IV	IV	
Vancouver, Washington	(VI)	Felt	VI	Felt	Felt(ND)	
Vernon, British Columbia					Felt(?)	
Victoria, British Columbia	VI-VII	VI, VI+	VI	VI	VI	
Virginia City, Montana	II	II-III	III	II-III	Felt	
Walla Walla, Washington	V	V	VI	V	V	
Wallula, Washington	IV	Heavy	VI	V	V	
Wenatchee, Washington	VI		VII-VIII	VIII	VIII	

TABLE 2R B-4 (CONTINUED)

LIST OF LOCATION AND MM INTENSITY VALUES

	WPPSS (1977)	WGR (1976)	Combs et al (1976)	PSP&L (1977) (Bechtel)	PSP&L (1977) (N. Scott)	USGS (1977)
Weston, Oregon	Felt	Severe	V?	Felt	V	
Whatcom County, Washington				Severe		
Winesap, Washington				Strong VIII		
White Bluffs, Washington			VI?	VII (?)	VII	
White Stone (Whitestone) Washington ,			VI	VII (?)	VII	
Willow Forks, Oregon	IV	III	V	IV	IV	
(Head of) Willow Creek, Oregon		V		V		
Yale, British Columbia	VI	VI	VI+	V		
Yakima, Washington		V?	VI	V		

* Estimated
** Intensities in parentheses were reported in a newspaper from a location other than that given.
NF Not Felt
ND No Details
*** Intensities assigned are only for nine locations.

Fort Colville W. T. Dec 31st 1872.

Genl R. H. Milroy.
Superintendent of Ind. Affairs.
Olympia. W. T.

Sir:

I have the honor to report that nothing worthy of particular notice occurred at the Agency during the past month, until the evening of the 14th inst at half past two O'clock when we were startled by quite a severe shock of an Earthquake, which was followed by four or five other distinct shocks at intervals during the night; slight vibrations have been felt nearly every day since, and on the morning of the 28th about half-past ten, there was a very perceptable shock.

Most of the Indians that I have heard from are very much frightened, and in some instances fatal results have followed. One woman of the Lower Spokanes lost her mind, and wandered off to the mountains, and was found dead a day or two afterwards; several others are quite ill from its effects.

The earthquake was particularly severe in the vicinity of Okanagan and Osoyoos Lake. Two Indians who came over from there, report that a point of land projecting into the Lake has disappeared, and that the earth has opened from eighteen inches to two feet in several places. They state also that the Country was full of Smoke to the North, and that a noise resembling thunder comes from the same direction. There is great consternation among the Okanagan Indians, and I have determined to send over the Interpreter to endeavor to pacify them, and to report upon the results of the earth quake.

I have the satisfaction of reporting a marked improvement in the moral condition of the Indians of this Agency since my arrival here, most of the Colville and Spokane have abandoned the evil habits of gambling and dissipation. The Chiefs & Head men seem much encouraged and full of hope for the future. They are anxiously waiting for news concerning the Reservation, and believe that some satisfactory arrangement will be made in the Spring and that work at the Agency will be commenced in earnest.

Very respectfully
Your Obt. Servt.
John A. Simms
Spl. Ind. Agt.

DR. HOWARD A COOMBS
CONSULTING GEOLOGIST
3856 46TH AVENUE NORTHEAST
SEATTLE, WASHINGTON 98105

TELEPHONE (206) 522-9242

DEC 21

December 18,1981

Mr. Ronald Chitwood
Washington Public Power Supply System
P. O. Box 968
Richland, WA 99352

Dear Ron:

David Tillson asked that I review the evaluation of the 1872 earthquake as felt at the little town of O'Hamet (O'Damet or O'Yamet) British Columbia as reported in the Victoria Daily Standard on December 16, 1872.

I reviewed the Modified Mercalli scale and placed my intensity evaluation at V11.

To check on this evaluation I called Dr. Wm Milne in Victoria and asked that he also evaluate the intensity at O'Hamet. He replied the intensity should be V11. Neither of us knew where the little town was located at the time we made our evaluation.

This was a good piece of detective work by Tillson to trace the location of the town along the telegraph line.

Yours very truly,

Howard

Howard A. Coombs

Attachment 361.19-8

Three Embarcadero Center, Suite 700
San Francisco, California 94111
415-956-7070

Woodward-Clyde Consultants

14940-4122.2
269

December 23, 1981

Washington Public Power Supply System
3000 George Washington Way
P.O. Box 968
Richland, Washington 99352

Attention: Mr. Ron Chitwood
Program Manager

Subject: Washington Public Power Supply System
Nuclear Project WNP-2 and WNP-1/4
Hanford FSAR Geologic Support
Agreement No. C-0560
Review of O'Damet Report From 1872 Earthquake

Gentlemen:

At Mr. David Tillson's request, I have reviewed the O'Damet report published in the December 17, 1982, Daily British Colonist from Victoria, B.C. I have assigned MM intensity VII to this report based on the element of the report stating "...the shock threw down several cattle...". Other elements of this report can occur at lower intensities (i.e, MM V - VI) but would be expected to accompany an intensisty MM VII description as well.

I am pleased to note that the WCC isoseismal map fit this intensity assignment very well when the location of Oyama was later placed on the map.

Sincerely,

Tom Turcotte
Tom Turcotte
Senior Project Seismologist

David J. Gross
David J. Gross
Project Manager

TT/DJG:dla

Attachment 361.19-9

OKANAGAN VALLEY, BRITISH COLUMBIA

Baudre, Reverend F. M., O.M.I., "Letter to D'Herbormez dated December 28, 1872, from Okanagan Valley", Manuscript in possession of Archives Deschatelets, Ottawa, Canada.

The earthquake which we have experienced has a great effect on our savages who believed that the last hour of the world had arrived. I know some who passed the night in prayer. At the moment of the earthquake, some of the Indians were engaged in their extravagant dances. As the others, they were so frightened by the dance of the earth that they knelt down praying, shouting and crying. They asked me a thousand questions about the earthquake: what it was; would it return.

In the vicinity of Osoyoos Lake the shock was stronger; rocks were detached from the mountains. A man was thrown to the ground; two horses were killed, and I do not know exactly where but near Similkameen the earth opened and a stinky smoke came out of that crevasse.

As for us, we thought that our house was going to collapse. We got up to escape from that danger but we escaped with only our fear.

OKANAGAN MISSION, BRITISH COLUMBIA

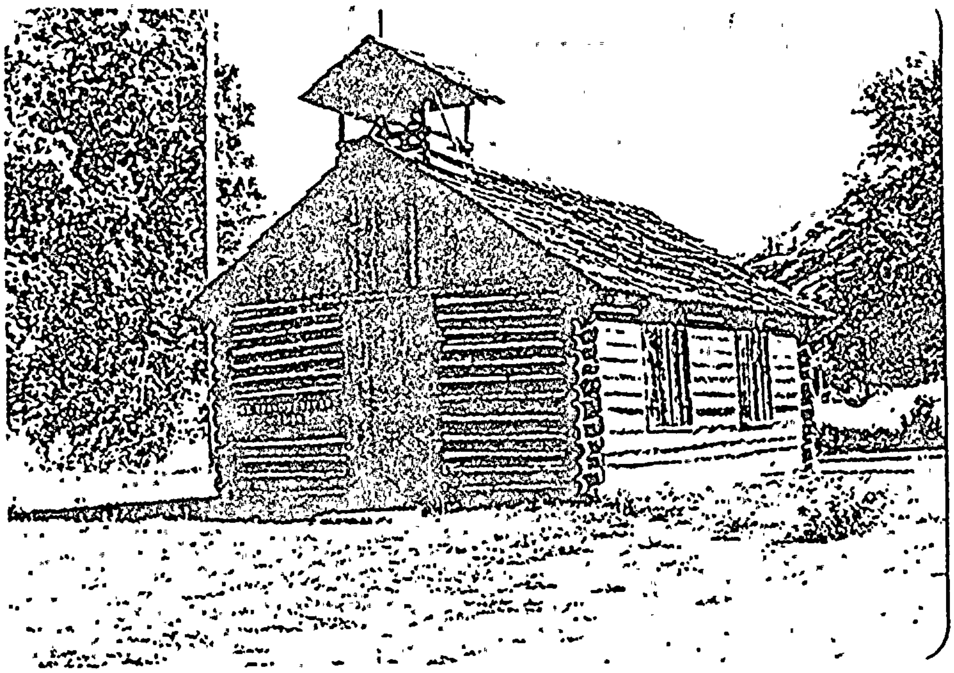
Baudre, Reverend F. M., O.M.I., "Letter to D'Herbormez dated January 21, 1873, from Okanagan Mission", Manuscript in possession of Archives Deschatelets, Ottawa, Canada

The savages of Similkameen are in the greatest consternation. Numerous times during (these) weeks they experienced earthquakes. Two savages who had come from Similkameen reported to me that their brothers from Colville were announcing that the end of the world was not far off.

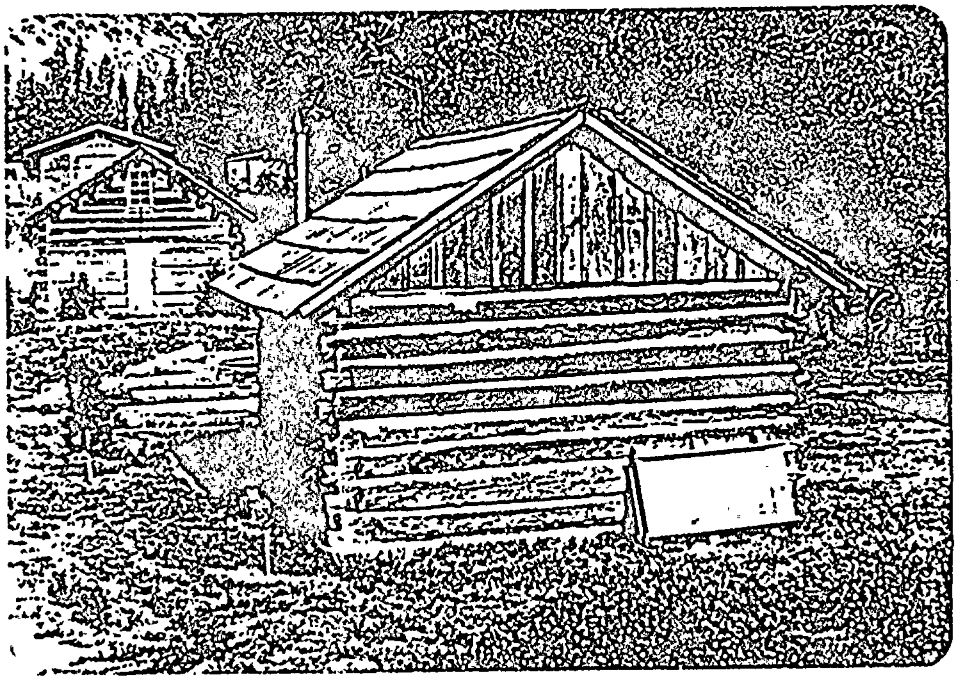
OKANAGAN MISSION, BRITISH COLUMBIA

Baudre, Reverend F. M., O.M.I., "Letter to D'Herbormez dated March 7, 1873, from Okanagan Mission, "Manuscript in possession of Archives Deschatelets, Ottawa, Canada

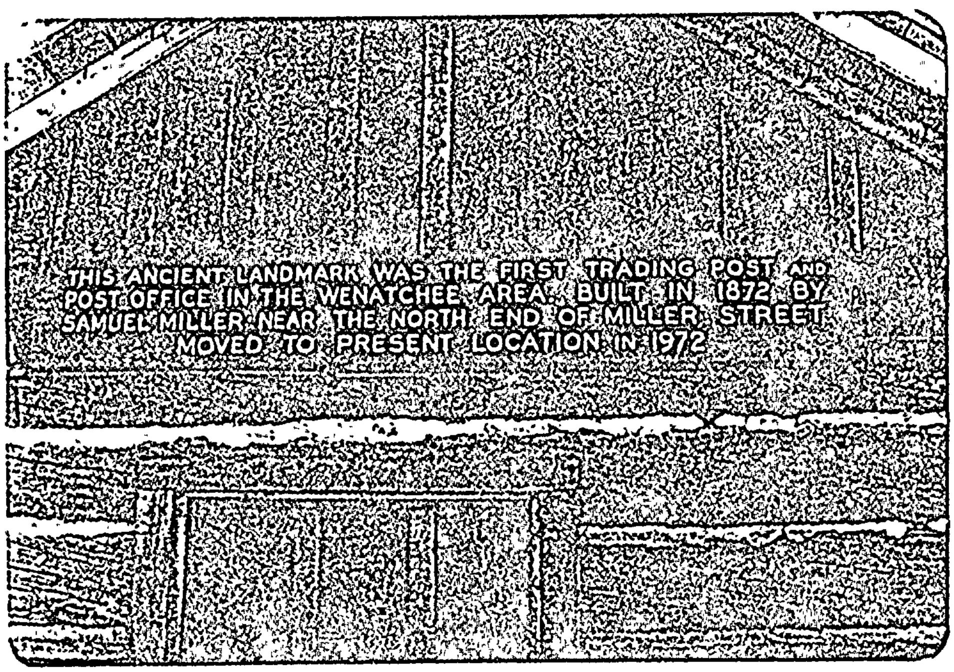
Some weeks after the earthquakes which happened near Christmas I received a visit from many savages from Similkameen; among them were two, one of which was a chief named Shious (manuscript unclear). They were and are yet still very frightened from the first shock and many others that they have had since Christmas.



St. Francis Xavier Mission



Miller-Freer Trading Post



Miller-Freer Trading Post

2

3.6 PROTECTION AGAINST DYNAMIC EFFECTS ASSOCIATED WITH THE POSTULATED RUPTURE OF PIPING

This section describes the design bases and design measures that are implemented for WNP-2, to ensure that the primary containment vessel and all essential equipment inside and outside primary containment, including components of the reactor coolant pressure boundary, have been adequately protected against the effects of blowdown jet and reactive forces, and pipe whip resulting from postulated rupture of piping located either inside or outside of primary containment. Specifically, description is provided for measures, implemented for WNP-2, to ensure that any such postulated accident does not result in loss of required function, which is necessary to mitigate the consequences of that particular accident, and place the reactor in a cold shutdown condition; taking due account of a single, random active component failure.

The implementation of criteria for protection of safety-related systems from the effects of pipe rupture, as defined herein, is based on an evaluation of systems, equipment, and components which had been physically arranged as of mid-~~[illegible]~~ 1981. ~~Upon substantial completion of the physical arrangement of all systems, equipment, and components, and upon subsequent re-evaluation of the availability of safe shutdown systems under the postulated accident conditions, an updated description of the protection to be provided against pipe rupture will be furnished by ammendment to this FSAR.~~

add attachment

3.6.1 PLANT DESIGN FOR PROTECTION AGAINST POSTULATED PIPING FAILURES IN FLUID SYSTEMS OUTSIDE PRIMARY CONTAINMENT

In accordance with Branch Technical Position APCSB3-1, Section B, Article 4 "Implementation", the Washington Public Power Supply System Nuclear Project Number 2 meets the requirements of Subsection C which reads in part "... Designs of plants for which construction permit applications were tendered before July 1, 1973 and operating licenses are issued after July 1, 1975 should follow the guidance provided in the December 1972 letter from A. Giambusso, Appendix B this position..." Accordingly, 3.6.1 of the WNP-2 FSAR follows Appendix B guidelines.

Appendix B requests information in twenty-one categories. This section is organized to follow these twenty-one categories. The numbering of each paragraph describes the section, 3.6.1, and the category .X, where X represents the question in Appendix B being answered.

The methods and criteria employed to investigate the effects of postulated high and moderate energy fluid system ruptures

8201260136

Attachment to P. 3.6-1

The physical arrangement of systems, equipment, and components is essentially complete. Verification of the protection of safety related systems, equipment, and components from the effects of ~~post~~ pipe rupture will be provided by a final walkdown prior ~~to~~ fuel load. The final walkdown will also consider ~~incorporate~~ any design changes to essential systems, equipment, or components which may have occured.

3.6.1.4 Summary of Dynamic Analysis of Categor; I Pip ng and Supports

3.6.1.4.1 Design Basis Breaks for the Dynamic A .alysi Outside Primary Containment

Table 3.6-6 lists the number of design basis brea .s on hich the dynamic analysis is based as well as the part cular piping subsystem involved, ~~the diameter of the pc tulat d rupture, the orientation of the postulated ruptur -refe ences to the figures illustrating the location of the p stula ed break and references to the figures illustrating he ti e dependent thrust generated by blowdown from the p stula ed rupture.~~ (* See attachment)

3.6.1.4.2 Diagrams of Mathmematical Models Usec in th Dynamic Analysis

3.6.1.4.2.1 Models Used for Pipe Whip Restraint Desig

A description of the mathematical models used to .esign the pipe whip restraints is presented in 3.6.2.2.2.

3.6.1.4.2.2 Models Used for Structural Analysis

Descriptions of the mathematical models and proce iures sed to ensure adequacy of Seismic Category I structur :s are presented in 3.6.1.6, 3.6.1.7, 3.6.1.8, 3.6.1.9 and 3.6.1. 0.

3.6.1.4.2.3 Models Used to Represent Jet Strean Dynam cs

Descriptions of the procedure used to model the c 'namic of a jet stream caused by a postulated rupture of a iigh e ergy fluid piping system are presented in 3.6.2.3.1.

3.6.1.4.3 Effect of Postulated Fluid Piping Sys :em Ru tures on Structures, Systems or Components Necess ry for Safe Reactor Operation

A discussion is presented in 3.6.1.11 concerning :he ef ects of postulated high and moderate energy fluid pip: ig sys em failures on structures, systems and components ne :essar to shutdown and maintain the reactor in a cold shutc own cc - dition.

attachment for p. 3.6-4

the diameter of the pipe, the plan figure showing the piping subsystem, the maximum blowdown thrust or the thrust vs. time figure; and the room or area containing the postulated break.

The locations of all postulated high and moderate energy fluid piping system ruptures dictate where this study is to be performed.

The input described above is coded to indicate: the location of the system or component by elevations ~~and grid(a)~~, the

---

~~(a) The reactor building is subdivided into 42 grids each measuring approximately 20' x 20'. This permits rapid location of any component on the floor plan.~~

~~Figure 3.6-37 illustrates the locations of the grids.~~

electrical division to which the component belongs; what the function of the component is; the various references, such as the drawings, in which the component is found; devices interconnecting the component and another system; and additional information of this type. This coding facilitates storage of the input for retrieval at any time.

~~The design basis break locations are also coded to indicate the elevation, room and grid in which the rupture is postulated to occur. Figure 3.6-41, Sheets a to h, illustrate the high energy break locations while Figure 3.6-42, sheets a to h illustrate the moderate energy break locations.~~ (* See attachment I)

3.6.1.11.2 Method of Analysis for Postulated High Energy Fluid System Ruptures

3.6.1.11.2.1 Effects of Postulated Passive Component Failures

(* See attachment II)

~~Postulated high energy ruptures are assumed to destroy all equipment in the grid containing the rupture as well as all additional contiguous grids, where each contiguous grid is considered separately in this analysis, in conjunction with the grid containing the rupture.~~ After identifying what equipment becomes inoperable, a single random active component failure is postulated in a system not effected by the postulated high energy fluid system rupture. Additionally, if the direct consequences of the postulated rupture results in a reactor or turbine trip, off-site power is assumed unavailable.

3.6.1.11.2.2 Analytical Procedure

After all the consequences of the postulated passive and active component failures are evaluated, an analysis determines if safe reactor control is maintained. The following guidelines are used in this analysis:

a. For postulated ruptures of fluid piping systems, ensure that core cooling and reactivity control is maintained.

b. Demonstrate that redundant components or systems necessary to safely shutdown and cool the reactor are not involved in the postulated passive component failure.

c. Demonstrate that off-site radiological consequences do not exceed relevant standards.

Attachment I for p. 3.6-7

Table 3.6-6 lists the high energy design basis break locations outside containment, the piping subsystems involved, the pipe diameter, the plan figure showing the piping subsystem, the maximum blowdown thrust or the thrust vs. time figure, and the room or area containing the postulated pipe break. Figure 3.6-41, sheets a thru h, illustrate the high energy break locations outside containment.

Figures 3.6-12 thru 3.6-36 illustrate and list the high energy break locations inside containment.

Moderate energy crack locations are postulated in accordance with Standard Review Plans 3.6.1 and 3.6.2.

Attachment II for p. 3.6-7

Postulated pipe breaks in high energy fluid systems are investigated to determine their effects on the ability to bring the plant to a safe shutdown and to limit the offsite radiological consequences to an acceptable level as stated in 10CFR50.

On a case by case basis, the effects of pipe whip, jet impingement, and the resulting environmental conditions on safety related equipment are evaluated. The effects of the postulated pipe break are dependent on the fluid properties of the system, the location and orientation of the pipe break, the proximity to safety related systems, components, and structures, and the individual design limits of the safety related systems, components, and structures.

Pipe breaks in high energy systems are postulated according to the criteria in section 3.6.2.1.

This type of analysis is performed on a grid by grid basis for all grids containing high energy fluid piping systems. The analysis does not consider specifically which pipe, in what location, generates the postulated rupture nor does the analysis consider the energy level of the postulated pipe whip. Pipe whips are assumed, as stated in 3.6.1.11.2.1, to damage equipment and components within the grid containing the rupture and one contiguous grid to such a degree as to render those components inoperable. Delete

Since postulated pipe whip energy levels are not computed for this redundancy analysis, it is initially assumed that whipping pipes do not penetrate structures, and that they do not generate secondary missiles, such as spalled concrete missiles generated by pipe whip impacts on compartment walls. This assumption is then verified, and those cases where penetration and/or spalling occurs are reanalyzed to ensure that safe reactor operation is maintained.

3.6.1.11.3 Method of Analysis for Postulated Moderate Energy Fluid System Ruptures

3.6.1.11.3.1 Approach

Postulated ruptures, in moderate energy fluid systems, do not generate pipe whip. The analysis investigates the effects of the environment which results from such a postulated rupture on safety related equipment, including the effects of water spray.

* add attachment I

3.6.1.11.3.2 Method of Analysis

The locations of all postulated ruptures, resulting in through-wall leakage cracks, are identified and coded for later retrieval. The analysis assumes that the spray resulting from a postulated moderate energy rupture causes the malfunction of all equipment not enclosed by watertight compartments. within the grid enclosing the postulated rupture, as well as all contiguous grids, where each contiguous grid is considered separately in this analysis in conjunction with the grid containing the rupture.

Additionally, a single random active component failure in a system not effected by the postulated passive component failure is postulated. If the direct consequences of the passive component failure results in a turbine or reactor trip, then off-site power is assumed unavailable.

3.6.1.11.4 Summary of Analysis

The analyses discussed in 3.6.1.11.2 and 3.6.1.11.3, do not identify any location where a postulated passive component

the most damaging

Attachment I
to 3.6-8

The effects of the postulated moderate energy pipe cracks are dependent on the fluid properties, available fluid resevoir, drain systems, location of the safety related equipment, components, and structures, and the individual design limits of the safety related equipment, components, and structure.

Where moderate energy pipe cracks are postulated in close proximity to high energy systems, the environmental analysis ~~considerations~~ compares the effects of both high and moderate energy pipe ruptures. The most limiting case is evaluated for safe-cold shutdown.

Moderate energy pipe cracks are postulated according to the criteria in section 3.6.2.1.

failure in a high or moderate energy system precluded the safe shutdown and cooling of the reactor. Therefore, the ruptures in fluid piping systems, which are postulated, have no effect on the ability to bring the reactor to a cold shutdown condition.

(add attachment I)

Piping layouts for areas containing high and moderate energy lines, whose failure can affect the performance of safety related equipment, are presented as Figures 3.6-43 to 3.6-62, inclusive.

3.6.1.11 discusses in detail the methods used to demonstrate that no single postulated passive component failure, in conjunction with a single active component failure, precludes safe shutdown of the plant.

The following should serve to further clarify the method of analysis:

(add attachment II)

a. ~~Postulated ruptures in high energy fluid piping systems are assumed to develop sufficient thrust to render inoperable all electrical and mechanical equipment within the grid containing the break and each contiguous grid considered separately as defined in 3.6.1.1.2.1, regardless of whether the pipe is capable of generating such a thrust.~~

b. (add attachment III)

Impacted pipes of smaller nominal diameter than the impacting pipe are assumed to fail, regardless of wall thickness of impacted pipe. Impacted pipes of both larger nominal diameter and thinner wall thickness than the impacting pipe are assumed to develop through wall leakage cracks.

c. Additionally, a single random active component not affected by a) and b) is assumed to malfunction. Should a) or b) result in a turbine-generator or reactor trip, then offsite power is assumed unavailable.

d. After a), b) and c) above have been evaluated, possible shutdown modes are analyzed. If shutdown is possible, the postulated passive component failure is not significant from a safety standpoint.

e. Should alternate shutdown modes not be available then:

Attachment I for 3.6-9

This analysis by actual examination of the plant is undertaken to provide results based on as-built conditions. Design drawings are used to supplement the study in cases where piping or equipment have not been installed. Prior to fuel load, a walkdown of the plant ~~will be~~ is performed to verify the results of the analysis and confirm that all design modifications have been implemented.

for 3.6-9

Attachment II

The forces developed at each postulated high energy pipe break are determined by the methods of section 3.6.2.2. The effects of the resultant pipe whip and jet impingement are evaluated. Credit is taken for automatic isolation and operator action to mitigate the consequences of the postulated pipe break, if the equipment required for this function is not affected by the break or included in section 3.6.1.11.4(c) below.

for 3.6-9

Attachment III

As a first step, all equipment ~~contacted~~ impacted by the whipping pipe or jet is assumed to fail. If the equipment is required for safe-cold shutdown or accident mitigation, a detailed analysis is performed to determine if the equipment will actually fail. Structures contacted by the whipping pipe or jet are evaluated for structural adequacy by the methods of section 3.6.2.2.

(1) Reroute or relocate cable, pipe or equipment to prevent loss of function.

(2) If (1) is not feasible, shield the adversely affected component(s) to prevent loss of function.

f. The flooding and environmental effects of moderate energy failure are evaluated to determine whether they are more severe than the high energy breaks and are addressed in 3.6.1.15.

(add attachment)

An example of an analysis used to determine if the consequences of a postulated rupture of the RCIC turbine steam supply line in the "C" RHR pump room are acceptable, is included as follows:

a. For a postulated rupture of the 4" RCIC(14)-4 in the RHR "C" pump room, the following are assumed inoperable:

(1) LPCS System - Loss of cable ISM7-50 which is LPCS Motor Feeder.

(2) RHR-P-2C - Loss of RHR Pump "C"

(3) No RHR-V-64C - RHR C - Minimum Flow Line

No SW-V-24C - Service Water Supply to RHR "C" Pump

No RHR-V-4C - RHR C - Suppression Pool Suction

No RHR-V-21 - RHR C - Return to Suppression Pool

No RHR-FN-1 - HVAC Cooler for RHR "C" Cubicle

(4) Piping 4" or less can be ruptured:

1.5" RHR(12)-1

2" RHR(22)-1

2.5" SW(6)-2

2.5" SW(26)-2

Attachment 3.6-10

The area temperature is evaluated by determining the limiting postulated pipe break and using RELAP 4/MOD 5 (Ref. 3.6-21). The limiting pipe break for temperature analysis is that pipe break giving the highest energy release rate over the longest blowdown period.

The effects of flooding are evaluated by determining the limiting pipe break and calculating the effects of the fluid release. The limiting pipe break for flooding analysis is that pipe break with the highest mass flow rate over the longest blowdown period.

Peak differential pressure analysis results are provided in Table 3.6-12 and discussed in 3.6.1.20.

Refer to 3.6.1.13 for electrical equipment environmental qualifications.

b. The systems which are not available for mitigation of the accident are:

RHR "C"

RCIC

LPCS

c. Analysis:

Steam dump to the main condenser would be used to depressurize and cool the reactor. This is a normal shutdown. Note that in the above case, a single random active component failure in any system, will not preclude safe reactor shutdown. Offsite power is available.

3.6.1.12 Control Room Habitability

A postulated rupture of either the main steam or feedwater piping has no effect on the continued habitability of the control room, since the radiation dose that control room personnel receive as a result of a postulated rupture is below the allowable limits.

The nuclear steam supply system (NSSS) piping outside of primary containment within the reactor building is enclosed by the main steam tunnel. The main steam tunnel, provided with pressure-relieving blowout panels, is designed to withstand the worst postulated piping system rupture attributable to the NSSS within the steam tunnel.

The high energy piping in the main steam tunnel is provided with pipe whip restraints as described in 3.6.1.5. These restraints limit the motion of the free ends of the ruptured NSSS piping to preclude the impact of the NSSS piping with the main steam tunnel structure.

The remaining high energy piping outside the primary containment is not routed in the vicinity of the control room, or does not possess sufficient energy to adversely affect the structural integrity of the control room wall.

Additionally, a remote shutdown panel is provided to permit safe reactor shutdown to a cold condition in the event the control room must be evacuated.

3.6.1.13 Electrical Equipment Environmental Qualifications

All electrical systems, necessary for safe shutdown and necessary to maintain the plant in a safe shutdown condition, are designed to remain functional in the general area environment resulting from a high energy line break or from leakage cracks in moderate energy piping. Specific equipment is either:

a. Designed to remain functional as long as necessary in the general area environment.

b. Isolated from the general area environment in compartments capable of maintaining normal equipment operating conditions.

Certain rotating equipment cannot be designed to function in the more severe, local steam environment. However, due to physical separation, rotating equipment, of not more than one sub-system, is exposed to the local conditions which exceed the general area accident environment. Required redundancy is thus maintained for safety equipment.

Refer to 3.11 for a more complete description of environmental design of electrical equipment.

3.6.1.13.1 Identification of Equipment

Safety equipment required to mitigate the consequences of an accident and, place the reactor in a cold shutdown condition is listed in Table 3.11-2. The table also indicates the required duration, following an accident, which equipment is required to operate.

3.6.1.13.2 Environmental Design

Refer to 3.11 for a discussion of environmental design and an analysis of safety related electrical components. The section identifies the safety related equipment that must operate in a hostile environment, and Table 3.11-2 indicates the postulated environmental envelope conditions for both the general and local accident areas.

3.6.1.13.3 Jet Impingement Barriers

For results of the steam system study, see 3.6.1.11.4. ~~Since there are no locations outside containment where a postulated~~

Analysis ~~[illegible]~~ indicates jet impingement barriers are not required at WNP-2 since no postulated ~~[illegible]~~ pipe break ~~[illegible]~~ precluded reactor safe shutdown.

~~[illegible]~~

Some room walls, floors, and ceilings act as jet impingement barriers, however.

~~passive component failure precluded reactor safe shutdown, jet impingement barriers are not required at WNP-2~~.

3.6.1.13.4 Control Room Equipment

Control room environmental effects, resulting from pipe break accidents, are discussed in 3.6.1.12. The postulated pipe breaks have no effect on the control room environment. All control room equipment, therefore, remains functional following a break.

3.6.1.13.5 Onsite Power Distribution System Equipment

Refer to 3.11

3.6.1.14 Design Diagrams of NSSS Piping

Figures 3.6-38 to 3.6-40, inclusive, illustrate the routing of NSSS piping from the outboard end of the containment penetrations to the turbine building.

3.6.1.15 Flooding Analysis

A study investigating the potential flooding attributable to the postulated rupture of high energy fluid piping systems outside primary containment is provided below.

3.6.1.15.1 Postulated Rupture of the Reactor Feedwater Piping

The reactor feedwater piping outside primary containment, inside the reactor building, is completely enclosed by the main steam tunnel to provide protection against the dynamic effects of postulated fluid piping system ruptures. The main steam tunnel is provided with a blowout panel to discharge steam, to the atmosphere, above the turbine building. A second blowout panel provides for water drainage from the main steam tunnel into the turbine building.

3.6.1.15.1.1 Consequences

The postulated rupture, of the feedwater piping in the main steam tunnel, would scram the reactor on low water level.

The isolation valves, on the reactor pressure boundary, would close to prevent loss of reactor coolant. A postulated active component failure could prevent the inboard isolation valve from closing, while the dynamic effects of the passive

3.6.1.18.3.6 Postulated Ruptures of the Auxiliary Steam, Heating Steam, Auxiliary Condensate and Heating Steam Condensate Piping

The consequences of a rupture in any of the above, including the dynamic effects of pipe whip and the resulting environmental conditions, are investigated as described in 3.6.1.11. In no instance does a postulated rupture of these systems preclude reactor shutdown to a cold condition.

These systems provide no emergency function which would be required to mitigate the consequences of a postulated piping failure. Therefore, normal reactor shutdown as well as the emergency methods described would not be simultaneously impaired.

3.6.1.18.3.7 Postulated Rupture of the Reactor Water Cleanup System Piping

The consequences of a reactor water cleanup system piping rupture are investigated as discussed in 3.6.1.11. In no circumstance, does the postulated failure of reactor water cleanup system piping preclude the availability of all shutdown modes. Since the reactor water cleanup system does not fulfill any safety function, nonoperability has no impact on the safe shutdown of the reactor.

3.6.1.19 Seismic and Quality Classifications of Piping Used in the Dynamic Analysis

Table 3.6-7 gives the seismic and quality classifications of all piping listed in Table 3.6-6. Refer to 3.2 for descriptions of the various seismic and quality classifications.

3.6.1.20 Method Used to Predict Blowdown Rates and Subcompartment Pressure Transient After a Postulated Pipe Break

3.6.1.20.1 Blowdown Analysis for a Postulated Pipe Break Outside the Primary Containment

The analytical approach used to determine the blowdown mass and energy rates from a postulated pipe break outside the primary containment are described in 3.6.1.20.1.1 through 3.6.1.20.1.3.

v = velocity (ft/sec)

s = linear acceleration (ft/sec^2)

A = area of panel (ft^2)

P = average pressure (lbs/ft^2)

t = time (sec)

The frictional force is neglected. The solution of the above equation is:

$$s = s_o + (v_o + \frac{F}{2m} t) t \qquad \text{(Eq. 3.6.1.20.3.3-4)}$$

where s_o and v_o are values for s and v at t = 0.

The displacement, s, of the panel and the opening area as functions of time are determined by iterative procedures.

Pertinent properties of blow-out panels C and D are furnished in Table 3.6-15.

Figures 3.6-130 and 3.6-131 are plots of the pressure transients and Figures 3.6-132 and 3.6-133 are plots of the temperature transients for a postulated pipe break in Node 1.

Figures 3.6-134 and 3.6-135 are plots of the pressure transients and Figures 3.6-136 and 3.6-137 are plots of the temperature transients for a postulated pipe break in Node 2.

Blow-out panels C and D are assumed to blow off at the differential pressure noted in 3.6.1.20.3.2.

3.6.1.20.3.4 ~~3.6.20.3.4~~ Analysis for a Postulated Pipe Break in the Tunnel Extension

Figure 3.6-138 shows the nodalization scheme for a postulated pipe break in the tunnel extension. Nodes 1 and 2 represent the tunnel extension. The vertical pipe restraint (see Figures 3.6-6g, 3.6-6h, 3.6-6j and 3.6-6k) divides Node 1 and 2. Nodes 3, 4 and 5 represent the following portions of the turbine generator building:

a. Node 3 represents the portion between the mezzanine floor at elevation 471'-0" and the operating floor at elevation 501'-0".

3.6.2.1.2.1 Postulated Pipe Break Locations in ASME Section III Class I Piping Between Primary Containment Isolation Valves

No pipe breaks are postulated in the portion of piping between primary containment isolation valves, if any of the following apply:

(1) S_n does not exceed $2.4S_m$.

(2) S_n exceeds $2.4S_m$ but does not exceed $3S_m$, and the Cumulative Usage Factor (U) does not exceed 0.1.

(3) S_n exceeds $3S_m$, but S_e and S_r are each less than $2.4S_m$, and U does not exceed 0.1.

The stress levels in the ASME Section III Class I containment penetration high energy piping are maintained at or below these limits and therefore, breaks are not postulated.[a] See 3.6.2.1.2.3 for further discussion of containment penetration piping.

→ A Insert attached

3.6.2.1.2.2 Postulated Pipe Break Locations in ASME Section III Class 2 and 3 Piping Between Primary Containment Isolation Valves

See 3.6.2.1.1.2 b. (2) for stress criteria applicable to ASME Section III Class 2 and 3 piping between containment isolation valves.

The stress levels are maintained at or below these limits and therefore breaks are not postulated. See 3.6.2.1.2.3 for further discussion of containment penetration piping.

3.6.2.1.2.3 Primary Containment Penetration Piping

Primary containment penetrations, in order to maintain containment integrity, are designed with the following characteristics:

(a) A program for augmented inservice inspection will be included in the WNP-2 Inservice Inspection Program Plans to provide one hundred percent volumetric examination; each inspection interval of all pressure boundary welds in Class I high energy piping exceeding one inch nominal diameter between containment isolation valves for which no breaks are postulated.

Insert to Page 3.6-28:

Piping systems which may have break exclusion areas between primary containment isolation valves are those determined by examining the list of high energy piping systems (see 3.6.2.1 and Table 3.6-2). Systems which do not pass through primary containment are excluded. In addition, systems which are not pressurized between the isolation valves during normal plant operation (see 3.6.2) are excluded. The remaining systems, those which may have break exclusion areas between primary containment isolation valves, are listed in Table 3.6-18. Break exclusion areas for these systems are shown on Figures 3.6-147a through 3.6-147d.

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(1) If the result of a detailed stress analysis indicates that the maximum stress range in the axial direction is at least 1.5 times that in the circumferential direction, only a circumferential break is postulated. Where usage factor is a determinant in establishing a postulated break location, the fatigue dominant stresses are examined as indicated above to determine whether longitudinal, circumferential or both are postulated.

c. Piping for which the internal energy level associated with the whipping is insufficient to impair the safety function of any structure, system, or component to an unacceptable level. Any line restrictions (e.g., flow limiters) between the presssure source and break location, and the effects of either a single-ended or double-ended flow condition are accounted for, in the determination of the internal fluid energy level associated with the postulated pipe break reaction. The energy level in a whipping pipe will be considered insufficient to rupture an impacted pipe of equal or greater nominal pipe size, and of equal or heavier wall thickness.

For further discussion of pipe whip protection, see 3.6.2.3.3.

Protection of essential systems from the effects of jet impingement is provided where necessary to ensure reactor shutdown to a safe cold condition and to limit the release of radioactivity to within 10CFR Part 100 limits. For further discussion of criteria for protection against jet impingement, see 3.6.2.3.2.

3.6.2.2 Analytic Methods to Define Blowdown Forcing Functions and Response Models

3.6.2.2.1 Analytical Methods to Define Blowdown Forcing Functions

The rupture of a pressurized pipe causes the flow characteristics of the system to change, creating reaction forces which can dynamically excite the piping system. The reaction forces are a function of time and space and depend upon fluid state within the pipe prior to rupture, break flow area, frictional losses, plant system characteristics, piping system, and other factors. The methods used to calculate the reaction forces for various piping systems are presented in the following sections.

A rise time, not exceeding one millisecond, is assumed for the initial pulse of the fluid blowdown forcing function, unless longer crack propagation times or rupture opening times are substantiated by experimental data or analytical theory.

Blowdown forcing functions are determined by either of two general methods given below:

a. The predicted blowdown forces on pipes fed by a pressure vessel can be described by transient and steady-state forcing functions. The forcing functions used are based on methods described in Reference 3.6-3 and Reference 3.6-22. These may be simply described as follows:

P_a = Ambient pressure

u = Velocity at exit plant

ρ = Density at exit plane

A = Area of break

g = Gravitational constant

(5) Following the transient period, a steady-state period is assumed to exist. Steady-state blowdown forces are calculated, considering frictional effects. For saturated steam, these effects reduce the blowdown forces from the theoretical maximum of 1.26 P_oA. The method of accounting for these effects is presented in Reference 3.6-3 and Reference 3.6-22. For sub-cooled water, a reduction from the theoretical maximum of 2.0 P_oA is found through the use of Bernoulli's and other standard equations, such as Darcy's equation, which account for friction.

b. The following is an alternate method for calculating blowdown forcing functions.

The computer code RELAP3 (Reference 3.6-9) is used to obtain exit plane thermodynamic states for postulated ruptures (see 3.12.11 for further discussion of RELAP3). Specifically, RELAP3 calculates exit pressure, specific volume and mass rate. From these data the blowdown reaction load is calculated using the following relation:

$$\frac{T}{A_E} = P_E - P_\infty + \frac{G_E^{\,2}\,\bar{V}_E}{g_c}$$

$$R = -\frac{T}{A_E} \times A_E$$

where:

$\frac{T}{A_E}$ - thrust per unit break area

(3) The analytical model adequately represents the mass/inertia and stiffness properties of the system.

(4) Pipe whipping is assumed to occur in the plane defined by the piping geometry and configuration, and to cause pipe movement in the direction of the jet reaction.

(5) Piping contained within the broken loop, is no longer considered part of the reactor coolant pressure boundary (RCPB). Plastic deformation in the pipe is considered as a potential energy absorber. Limits of strain are imposed which are similar to strain levels allowed in restraint plastic members. Piping systems are designed so that plastic instability does not occur in the pipe at the design dynamic and static loads, unless damage studies are performed which show that the consequences do not result in the direct damage of any essential system or component.

(6) Components, such as vessel safe ends and valves, which are attached to the broken piping system and do not ~~sever~~ serve a safety function or whose failure would not further escalate the consequences of the accident, are not designed to meet ASME Code requirements for essential components under faulted loading. However, if these components are required for safe shutdown, or if they serve a safety function to protect the structural integrity of an essential component, then these components are designed to Code limits for faulted conditions and to ensure operability.

3.6.2.3.2 Jet Impingement Effect

3.6.2.3.2.1 Physical Separation

The physical separation of different essential systems and components is used to ensure that the plant retains function of sufficient essential systems to assure safe shutdown in the event of a postulated LOCA, and subsequent generation of a jet stream together with an additional single random active component failure and the loss of offsite power.

Where physical separation cannot be used to protect systems, a detailed analysis is performed to determine the effects of jet impingement on their operability. If necessary, barriers are provided to protect structures, systems and components required for a safe shutdown, to prevent offsite radiological consequences, and to mitigate the effects of a LOCA.

3.6.2.3.2.2 Jet Impingement Evaluation

The evaluation of the adequacy of physical separation included the inspection of all essential systems and their components that are necessary to start, operate, and control the essential systems required for safe shutdown. The evaluation included the following:

a. Review pipe break locations inside primary containment, to provide conservative jet stream ~~orientation and geometry.~~

b. (add notes as shown on attachment)

c. ~~b.~~ Review signals that result in the actuation of essential systems.

d. ~~c.~~ Review signals that are necessary to be returned to inside primary containment, to activate the shutdown systems.

e. ~~d.~~ Review availability of power that is required inside primary containment to operate the essential systems.

f. ~~e.~~ Review mechanical engineered safety systems required for safe shutdown.

attachment to p.3.6-47

b. Review effected equipment by both design drawing examination and plant walkdown.

f. This condition is typical for all conduits leading to the ADS valves.

3.6.2.3.2.7 Mechanical Engineered Safety Systems

Under conditions involving a LOCA, a loss of off-site power, and the failure of any one diesel generator, the availability of redundant essential systems is determined by study of design drawings ~~sketches~~ and by field walkdown, of the physical location of these systems to verify that sufficient separation is provided between two redundant systems. Specifically, two situations are investigated:

a. The possibility of a jet from an essential system destroying or, in any way, damaging its redundant system. For example, in the case of failure of Diesel Generator II, the possibility of a pipe whip or jet from the HPCS damaging the LPCS and ADS is investigated.

b. The possibility of a jet, from a high energy line, being capable of damaging an essential system and its redundant system. For example, in the event of Diesel Generator II failure, in conjunction with a possible jet or pipe whip from the RCIC, which may be capable of damaging the LPCS, ADS, HPCS or related systems, thus preventing the plant from being brought to a safe shutdown, is investigated.

All essential systems are examined to ensure that they will be capable of performing their required function after a jet impingement.

3.6.2.3.2.8 Jet Impingement on Major Structures Inside Primary Containment

a. Jet Impingement loading on the steel primary containment vessel, is discussed in 3.8.2.

b. Jet impingement loading on the concrete and steel internal structures of the steel primary containment vessel, is discussed in 3.8.3.

3.6.2.4 Guard Pipe Assembly Design Criteria for Dual Barrier Containment

Since the containment structure does not utilize dual barriers, guard pipes or other protective devices which limit the pressurization of the space between the two barriers of a dual barrier containment are not used. The use of guard pipes is restricted to Type 1 penetration assemblies (reference Figure 3.8-5) as described in 3.8.6.1.1.

3.6.2.5 Implementation of Criteria for Pipe Whip and Jet Impingment Protection

The effects of jet impingement are discussed in 3.6.2.3.2. The implementation of criteria for pipe whip protection is discussed below.

3.6.2.5.1 Piping Systems Outside Primary Containment

Studies are performed as described in 3.6.1 to assure that in the event of a postulated pipe rupture, sufficient equipment remains functional to mitigate the consequences of the particular pipe rupture, including considerations of failure of a single random active component. The study indicates that pipe whip supports are required ~~only~~ within the main steam tunnel [and to protect normally open isolation valves that are required to close.] Pipe whip protection requirements in the main steam tunnel are discussed in 3.6.2.5.4.11.

(add attachment)

3.6.2.5.2 Piping Systems Inside Primary Containment

High energy piping systems inside primary containment subject to postulated pipe rupture, are tabulated in Table 3.6-2. Specific criteria, for determination of break locations and dynamic effects associated with the postulated rupture of piping, are discussed in 3.6.2.1. The function and features of pipe whip restraints are discussed in 3.6.2.3.3. Equipment and system requirements subsequent to a postulated pipe rupture in a fluid system are discussed in 3.6.2.5.3.

Pipe whip restraints are furnished when it is necessary to limit pipe movements, resulting from a postulated break, which could otherwise cause unacceptable damage to equipment necessary to mitigate the consequences of the particular postulated pipe rupture, including considerations of a single random active failure. For high energy piping inside primary containment, this includes the following:

attachment for p. 3.6-56

Pipe whip protection requirements for isolation valves are discussed in 3.6.2.5.3.6.

a. Assurance of primary containment leak tightness.

b. Assurance that potential for damage is such that the maximum pipe break areas and/or combinations of pipe break areas do not exceed the values described in 3.6.2.5.3.2 so that emergency core cooling system capability is not impaired.

c. Assurance that the control rod drive system maintains sufficient function to assure reactor shutdown.

d. Assurance that there is sufficient capability to maintain the reactor in a safe shutdown condition.

The criteria used to define pipe rupture locations for piping systems discussed in 3.6.2.5.4 follows 3.6.2.1.1.1b(1) except for the following which follow 3.6.2.1.1.1b(2):

a. One elbow only, in each of the two redundant reactor feedwater systems inside primary containment, in 3.6.2.5.4.2 and in Figures 3.6-16a and 3.6-17a.

b. The entire standby liquid control (SLC) system in 3.6.2.5.4.4 and in Figure 3.6-19a.

c. The entire RPV drain system in 3.6.2.5.4.13 and in Figure 3.6-32a.

Figures 3.6-12a through 3.6-35 show the piping configurations for each high energy system inside primary containment and include numerical identification of all significant points of interest in the piping system, locations of pipe whip supports and postulated pipe break locations. The pipe whip supports are identified by the acronym PWS followed by an identification number on Figures 3.6-12a through 3.6-34a and as noted on Figure 3.6-35.

3.6.2.5.3 System Requirements Subsequent to Postulated Pipe Rupture

3.6.2.5.3.1 Control Rod Insertion Capability

To maintain the ability to insert the control rods in the event of a pipe break, no more than one in any array of ~~none~~ nine control rod drive (CRD) withdrawal lines may be completely crimped (totally blocked). Complete ~~serverence~~ severence of withdrawal lines does not affect the rod insert function. Protection of

the CRD insert lines is not required, since a reactor pressure of 450 psig or higher, can adequately insert the control rods.

No postalated pipe break resulted in severence or total crimping of the CRD insert or withdrawal lines. (See Reference 3.6/23)

for the 20-inch cooling return loop are mounted on a specially designed structure between the diaphragm floor and radial beams in the elevation 512 ft. platform, as shown in Figure 3.6-10.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided for the RHR shutdown cooling supply and return system to assure safety as defined in 3.6.2.5.2.

For the two, 12-inch shutdown cooling return loops, pipe whip restraints are provided to prevent impact with primary containment wall and the diaphragm floor. The pipe whip restraints also prevent impact with the CRD piping bundles located above the elevation 512 ft. platform. The ECCS system and the ADS systems are protected by separation, being located at higher elevations.

For unrestrained sections of this system, analysis shows a plastic hinge does not develop at the recirculation pipe, and pipe whip does not occur.

For the 20-inch shutdown cooling supply loop, pipe whip restraints are provided to prevent impact with primary containment and the diaphragm floor. Impact with the CRD piping is precluded by a 90° separation from both CRD piping bundles.

3.6.2.5.4.6 RCIC RPV Head Spray System

a. System Arrangement

The RPV head spray system is a 6-inch line that originates at the top of the RPV dome. After a 2 ft. vertical riser and a 2 ft. horizontal run, there is a normally closed valve that limits the high energy portion of this system to a total length of 4 feet.

b. Pipe Whip Protection

The postulated pipe breaks for this system are shown in Figure 3.6-26a. ~~Pipe whip restraints are not required for this system.~~
Pipe whip restraints for this system are shown in Figures 3.6-26C, 26D.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided to assure safety as defined in 3.6.2.5.2. The location of the normally closed valve limits the high energy section of this system ~~such that the unrestrained motion of the pipe resulting from postulated breaks can only impact the reactor vessel head.~~ (add attachment)

3.6.2.5.4.7 Low Pressure and High Pressure Core Spray (LPCS, HPCS) Piping

a. System Arrangement

The LPCS and HPCS are 12-inch piping systems with similar arrangements inside primary containment. They originate at elevation 561 ft. from the reactor at azimuths 120° and 240° respectively, and drop vertically to an elevation just below the main steam relief valve platform where, there is an expansion loop in a horizontal plane leading to a penetration through primary containment. In the vertical section, there is a normally closed check valve located as close as possible to the reactor, thereby limiting the portion of piping in both systems considered high energy under the definition given in 3.6.2.1.

b. Pipe Whip Protection

The postulated pipe breaks and pipe whip restraints for the LPCS and HPCS systems are shown in Figures 3.6-27a and 3.6-28a. Where pipe breaks are postulated inside primary containment the two lines are restrained to prevent the unacceptable motion of these pipes. These restraints are mounted directly onto the sacrificial shield wall.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided for the LPCS and HPCS systems to assure safety as defind in 3.6.2.5.2. Pipe whip restraints are

Attachment to page 3.6-66

Pipe whip restraints have been provided to absorb energy and prevent direct impact with the containment vessel head.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided for the RPV head vent piping to assure safety as defined in 3.6.2.5.2. There are no safety related systems in the vicinity of the RPV head vent piping and pipe whip restraints are provided to protect the primary containment structure.

3.6.2.5.4.11 Main Steam and Reactor Feedwater Piping Inside Main Steam Tunnel

a. System Arrangement

The four, 26-inch main steam and two, 24-inch reactor feedwater lines inside the main steam tunnel originate at the primary containment penetrations and run horizontally to the end of the tunnel. At this point, the six lines drop vertically and are then routed horizontally within the turbine generator building. An isolation valve is located in each line just beyond the penetration.

b. Pipe Whip Protection

The postulated pipe breaks and pipe whip restraints for the main steam and reactor feedwater lines inside main steam tunnel, are shown in Figures 3.6-33a and 3.6-34a. Where breaks are postulated, the six lines are restrained to prevent unacceptable motion. The restraints are mounted on steel structures which then tie into the concrete walls and floors.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided for the main steam and reactor feedwater lines inside the main steam tunnel to assure safety. ~~as defined in 3.6.2.5.2.~~

~~The basis for providing Protection in this area is to prevent pipe whip impact with adjacent isolation valves and to prevent pipe break damage escalation. The six lines and the six isolation valves in this area are located in close proximity to each other. A pipe break in one of~~

add attachment
Insert

~~the six lines, if unrestrained, may result in pipe whip impact with adjacent isolation valves, possibly rendering them inoperative. Futhermore, unrestrained motion may cause impact with other lines, which may result in escalation of pipe breaks. Such a condition may unacceptably increase the severity of the initial pipe break.~~

3.6.2.5.4.12 Residual Heat Removal System (RHR) - Low Pressure Core Injection

a. System Arrangement

The RHR/LPCI piping consists of three, 14-inch loops whose arrangement is the same for two loops with the third loop being the mirror image of the other two. The piping originates at the reactor vessel at elevation 552 ft., rises vertically to elevation 563 ft. where there is a horizontal section with a check valve. This valve is normally closed, limiting the high energy portion of each loop. After the valve, the normally unpressurized section of piping drops to an elevation just below the main steam relief valve platform where it is routed to a penetration through primary containment at elevation 534 ft.

b. Pipe Whip Protection

The postulated pipe breaks and pipe whip restraints for the three RHR/LPCI mode piping loops are shown in Figures 3.6-20a, 3.6-21a and 3.6-22a. Where pipe breaks are postulated, the three piping loops are restrained to prevent unacceptable motion. The restraints for this system are mounted onto the sacrificial shield wall and also on structures which tie back to the sacrificial shield wall.

c. Verification of Pipe Whip Protection Adequacy

Sufficient pipe whip protection is provided for the RHR/LPCI mode piping to assure safety as defined in 3.6.2.5.2. The pipe whip restraints

Insert to Page 3.6-70:

Pipe whip restraints are provided to prevent pipe whip impact with the main steam or feedwater isolation valves. In addition, impact with adjacent main steam or feedwater lines is prevented. Refer to Figures 3.6-6g through 3.6-6k.

3.6-21 Idaho National Engineering Laboratory, RELAP4/MOD5, A Computer Program For Transient Thermal-Hydraulic Analysis of Nuclear Reactors and Related Systems, Volume I: RELAP4/MOD5 Description, Volume II: Program Implementation, Volume III: Checkout Application, National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia,

3.6-22 ANSI/ANS 58.2, 1980, "Design Basis for Protection of Light Water Nuclear Power Plants from the Effects of Postulated Pipe Rupture"

3.6-23 G.E. Proprietary Report NEDE 24834, June 1980, General Electric Company "Hanford 2 Crimped CRD Line"

Replace with attached table

TABLE 3.6-6 Page 1 of 5

DESIGN BASIS BREAK LOCATIONS OUTSIDE PRIMARY CONTAINMENT

Break No.	Line Designation	Diameter Inches	Grid Location	Plan Location Figure	Thrust vs. Time Figure (s)
1	AS(11)-2	4	5	3.6-43	3.6-87,88
2	RCIC(13)-4	4	7	3.6-48	3.6-65,66
3	RCIC(13)-4	4	25	3.6-47	3.6-65,66
4	RCIC(20)-4	4	25	3.6-48	3.6-63,64
5	AS(11)-2	4	5	3.6-43	3.6-87,88
6	AS(11)-2	3	12	3.6-43	---
7	RCIC(13)-4	4	13	3.6-49	3.6-65,66
8	RWCU(2)-4	6	13	3.6-49	3.6-67,68
9	RWCU(2)-4	6	14	3.6-50	3.6-67,68,86
10	RWCU(1)-4	6	17	3.6-50	3.6-79,80
11	CRD(12)-3	8	---	See 3.6.1.20	---
12	AS(11)-2	3	12	3.6-43	---
13	RWCU(1)-4	6	4	3.6-51	3.6-81,82
14	RWCU(2)-4	6	14	3.6-51	3.6-67,68,86
15	RWCU(2)-4	6	17	3.6-51	3.6-81,82
16	RCIC(13)-4	4	25	3.6-47	3.6-63,64
17	RCIC(13)-4	4	25	3.6-47	3.6-63,64
18	RCIC(14)-2	2	25	3.6-47	---
19	RCIC(14)-2	2	7	3.6-48	---
20	RCIC(13)-4	4	7	3.6-48	3.6-65,66
21	RCIC(14)-2	4	25	3.6-48	---
22	RCIC(13)-4	4	25	3.6-48	3.6-63,64
23	RCIC(20)-4	4	25	3.6-48	3.6-63,64
24	RWCU(5)-3	6	41	3.6-53	---
25	RWCU(5)-3	6	41	3.6-53	---

TABLE 3.6-6 (Continued)

Break No.	Line Designation	Diameter Inches	Grid Location	Plan Location Figure	Thrust vs. Time Figure (s)
26	RWCU(5)-3	6	42	3.6-53	---
27	RCIC(14)-2	2	13	3.6-49	---
28	RCIC(13)-4	4	13	3.6-49	3.6-65,66
29	RWCU(2)-4	6	13	3.6-49	3.6-67,68
30	RCIC ~~RWCU~~(13)-4	4	14	3.6-49	3.6-69,70
31	RWCU(2)-4	6	14	3.6-49	3.6-67,68,86
32	RWCU(5)-3	6	41	3.6-49	---
33	RWCU(5)-3	6	41	3.6-49	---
34	RWCU(2)-4	6	14	3.6-50	3.6-67,68,86
35	RWCU(2)-4	6	14	3.6-50	3.6-67,68,86
36	RWCU(2)-4	4	11	3.6-50	3.6-73,74
37	RWCU(1)-4	4	11	3.6-50	3.6-71,72
38	RWCU(1)-4	4	11	3.6-50	3.6-71,72
39	RWCU(1)-4	4	11	3.6-50	3.6-71,72
40	RWCU(1)-4	4	17	3.6-50	3.6-71,72
41	RWCU(2)-4	4	18	3.6-50	3.6-73,74
42	RWCU(1)-4	4	17	3.6-50	3.6-71,72
43	RWCU(1)-4	4	18	3.6-50	3.6-71,72
44	RWCU(1)-4	4	17	3.6-50	3.6-71,72
45	RWCU(1)-4	4	17	3.6-50	3.6-71,72
46	RWCU(1)-4	4	11	3.6-50	3.6-73,74
47	RWCU(2)-4	4	11	3.6-50	3.6-73,74
48	RWCU(2)-4	4	11	3.6-50	3.6-73,74
49	RWCU(2)-4	4	17	3.6-50	3.6-73,74
50	RWCU(2)-4	4	18	3.6-50	3.6-73,74

TABLE 3.6-6 (Continued)

Break No.	Line Designation	Diameter Inches	Grid Location	Plan Location Figure	Thrust vs. Time Figure (s)
51	RWCU(2)-4	4	18	3.6-50	3.6-73,74
52	RWCU(1)-4	4	18	3.6-50	3.6-75,76
53	RWCU(1)-4	4	18	3.6-50	3.6-71,72
54	RWCU(2)-4	6	17	3.6-50	3.6-77,78
55	RWCU(1)-4	6	17	3.6-50	3.6-79,80
56	RWCU(1)-4	6	17	3.6-51	3.6-79,80
57	RWCU(1)-4	6	17	3.6-51	3.6-79,80
58	RWCU(1)-4	6	10	3.6-51	3.6-81,82
59	RWCU(7)-3	6	10	3.6-51	3.6-81,82
60	RWCU(1)-4	6	4	3.6-51	3.6-81,82
61	RWCU(1)-4	6	4	3.6-51	3.6-81,82
62	RWCU(6)-4	6	4	3.6-51	3.6-83,84
63	RWCU(1)-4	6	4	3.6-51	3.6-83,84
64	RWCU(1)-4	4	10	3.6-51	3.6-85
65	RWCU(1)-4	4	4	3.6-51	3.6-85
66	RWCU(2)-4	6	3	3.6-51	3.6-67,68,83,84
67	RWCU(2)-4	6	9	3.6-51	3.6-67,68,83,84
68	RWCU(2)-4	6	9	3.6-51	3.6-67,68,86
69	RWCU(2)-4	6	14	3.6-51	3.6-67,68,86
70	RWCU(2)-4	6	14	3.6-51	3.6-67,68,86
71	AS(11)-2	4	5	3.6-43	3.6-87,88
72	CO(16)-2	2.5	5	3.6-43	3.6-89,90
73	AS(11)-2	4	5	3.6-43	---
74	CO(16)-2	2.5	5	3.6-43	3.6-89,90
75	CO(16)-2	2.5	6	3.6-43	3.6-89,90

Break No.	Line Designation	Diameter Inches	Grid Location	Plan Location Figure	Thrust vs. Time Figure (s)
76	CO(16)-2	2.5	6	3.6-43	3.6-87,88
77	AS(16)-2	3	6	3.6-43	3.6-93,94
78	AS(16)-2	2.5	6	3.6-43	3.6-91,92
79	CO(16)-2	1	6	3.6-43	3.6-87,88,91,92, 93.94
80	CO(16)-2	1	6	3.6-43	3.6-91,92
81	AS(3)-2	2	6	3.6-43	3.6-93,94
82	AS(11)-2	3	12	3.6-43	3.6-93,94
83	AS(11)-2	3	12	3.6-43	3.6-93,94
84	AS(11)-2	3	12	3.6-43	3.6-93,94
85	HS(1)-2	2	12	3.6-43	3.6-95,96
86	HS(1)-2	4	18	3.6-43	3.6-97,98
87	HCO(11)-2	3	12	3.6-58	3.6-99
88	HCO(11)-2	3	12	3.6-58	3.6-99
89	HCO(11)-2	3	6	3.6-58	3.6-99
90	HCO(11)-2	3	2	3.6-58	3.6-100,101
91	HCO(11)-2	3	2	3.6-58	3.6-100,101
92	HCO(11)-2	3	1	3.6-58	3.6-100,101
93	HCO(11)-2	3	7	3.6-58	3.6-100,101
94	HCO(5)-2	2	17	3.6-59	3.6-102
95	HCO(5)-2	2.5	18	3.6-59	3.6-102
96	HCO(5)-2	2.5	18	3.6-59	3.6-102
97	HCO(5)-2	2.5	18	3.6-60	3.6-102
98	HCO(5)-2	3	17	3.6-60	---
99	HCO(5)-2	3	18	3.6-60	---
100	HS(9)-2	2.5	18	3.6-60	3.6-105,106

TABLE 3.6-6 (Continued)

Break No.	Line Designation	Diameter Inches	Grid Location	Plan Location Figure	Thrust vs. Time Figure (s)
101	HS(9)-2	2.5	18	3.6-60	3.6-87,88,107
102	HS(1)-2	4	12	3.6-60	3.6-108,109
103	HCO(9)-2	2	12	3.6-60	3.6-110,111
104	HCO(9)-2	2	12	3.6-60	3.6-110,111
105	HS(9)-2	2.5	6	3.6-60	3.6-112,113
106	HS(9)-2	3	6	3.6-60	3.6-112,113
107	HCO(11)-2	3	12	3.6-62	3.6-99
108	HCO(11)-2	3	12	3.6-62	3.6-99
109	HCO(11)-2	3	12	3.6-62	3.6-99

reak No.	Line Designation	Isometric No. (M200)	Diameter (Inches)	Max. Force (KIPS) or Thrust vs. Time Figure	Plan Location Figure
1	RCIC (13) - 4	120 - 1	4	Later	3.6 - 49
2	"	120 - 2	"	3.6 - 69, 70	"
3	"	120 - 3	"	3.6 - 65, 66	"
4	"	120 - 4	"	Later*	3.6 - 48
5	"	120 - 5	"	"	"
6	"	120 - 6	"	"	"
7	"	120 - 7	"	"	"
8	"	120 - 8	"	"	3.6 - 47
9	"	120 - 9	"	"	"
10	"	120 - 10	"	3.6 - 63, 64	"
11	RWCU (1) - 4	126 - 1	6	3.6 - 79, 80	3.6 - 51
12	"	126 - 2	"	3.6 - 75, 76	3.6 - 50
13	"	126 - 3	4	Later*	"
[illegible]	"	126 - 4	"	"	"
[illegible]	"	126 - 5	2	"	"
16	"	126 - 6	6	3.6 - 81, 82	3.6 - 51
17	RWCU (2) - 4	128 - 7	"	3.6 - 67, 68	"
18	"	128 - 8	"	Later*	"
19	"	128 - 9	"	"	"
20	"	128 - 10	"	"	3.6 - 50
21	"	128 - 11	"	"	3.6 - 49
22	"	128 - 12	"	"	"
23	RWCU (3) - 4	129 - 39	"	LATER*	3.6 - 50
24	"	129 - 40	"	"	"
25	"	129 - 41	"	"	"
26	"	129 - 42	"	"	"
27	"	129 - 43	4	"	"
28	"	129 - 44	"	"	"
[illegible]	"	129 - 45	"	"	"
30	"	129 - 46	"	"	"
31	"	129 - 47	3	"	"
32	"	129 - 48	4	"	"
33	"	129 - [illegible]	"	[illegible]	[illegible]

Break No.	Line Designation	Isometric No. (M200)	Diameter (Inches)	Max. Force (KIPS) or Thrust vs. Time Figure	Plan Location Figure
34	RWCU (3)-4	129-50	3	Later*	3.6-50
35	MS (20)-4	134-1	2	"	3.6-44
36	"	134-2	"	"	"
37	"	134-3	"	"	"
38	"	134-4	"	"	"
39	"	134-5	3	"	"
40	AS (11)-2	139-1	"	3.6-97, 98	3.6-43
41	"	139-2	"	Later*	"
42	"	139-3	"	3.6-93, 94	"
43	"	139-4	4	Later*	"
44	"	139-5	"	"	"
45	"	139-6	"	"	"
46	"	139-7	"	"	"
47	"	139-8	3	"	"
[illegible]	"	139-9	4	"	"
49	"	139-17	2	3.6-95, 96	"
50	AS (10)-2	141-10	6	Later*	"
51	"	141-11	"	"	"
52	"	141-12	"	"	"
53	RWCU (1)-4	142-20	4	"	3.6-51
54	"	142-21	"	"	"
55	"	142-22	"	"	"
56	"	142-23	"	"	"
57	RWCU (1)-3	144-24	"	Later*	3.6-53
58	"	144-25	"	"	3.6-51
59	"	144-26	"	"	"
60	"	144-27	"	"	"
61	"	144-28	"	"	"
62	"	144-29	6	"	"
[illegible]	RWCU (2)-3	144-30	"	Later*	"
64	"	144-31	4	"	"
65	"	144-32	6	"	"
66	"	144-33	"	"	"
67	"	144-34	"	"	"

Break No.	Line Designation	Isometric No. (M200)	Diameter (Inches)	Max. Force (KIPS) or Thrust vs. Time Figure	Plan Location Figure
6[illegible]	RWCU (2)-3	144-35	6	Later*	3.6-51
69	"	144-36	"	"	3.6-53
70	HS (9)-2	148-1	3	3.6-112,113	3.6-43
71	HS (1)-2	148-2	4	Later*	"
72	HS (5)-2	148-4	"	3.6-105,106	"
73	"	148-5	2	Later*	"
74	"	148-6	"	"	"
75	"	148-7	"	"	"
76	"	148-8	"	"	"
77	"	148-9	"	"	"
78	"	148-10	"	"	"
79	"	148-11	"	"	"
80	"	148-12	"	"	"
[illegible]	HS (9)-2	148-13	"	"	"
82	HS (1)-2	148-14	4	3.6-87,88,107	"
83	HCO (11)-1	149-1	6	Later*	3.6-62
84	"	149-2	4	"	"
85	HCO (11)-2	149-3	"	"	3.6-58
86	"	149-4	3	"	"
87	"	149-5	"	3.6-99	"
88	"	149-6	"	3.6-100,101	"
89	"	149-7	"	Later*	3.6-62
90	"	149-8	"	3.6-102	3.6-59
91	HCO (5)-2	149-9	2.5	Later*	"
92	"	149-10	"	"	"
93	"	149-11	"	"	"
94	"	149-12	"	"	"
[illegible]	RFW (1)-4	335-1	24	"	3.6-49
96	"	335-2	"	"	"
97	"	335-3	"	"	"
98	"	335-4	"	"	"

reak No.	Line Designation	Isometric No. (M200)	Diameter (Inches)	Max. Force (KIPS) or Thrust vs. Time Figure	Plan Location Figure
[illegible]	AS (9)-2	342-13	6	Later*	3.6-43
100	"	342-14	4	"	"
101	AS (1)-2	342-15	8	"	"
102	AS (3)-2	342-16	2	"	"
103	MS (1)-4	400-8	26	"	3.6-44
104	"	400-9	"	"	"
105	"	400-10	30	"	"
106	"	400-11	26	Later*	"
107	"	400-12	"	"	"
108	"	400-13	30	"	"
109	"	400-14	26	"	"
110	"	400-15	"	"	"
111	"	400-16	30	"	"
11[illegible]	"	400-17	"	"	"
1[illegible]	"	400-18	26	"	"
114	"	400-19	"	"	"
115	"	400-20	30	"	"
116	"	400-21	"	"	"
117	CO(3)-2	440-1	2.5	Later*	N/A
118	"	440-2	"	"	"
119	"	440-3	"	"	"
120	HS(5)-1	447-19	6	"	N/A
121	"	447-25	"	"	"
122	"	447-26	"	"	"
123	"	447-27	"	"	"
124	HS (1)-1	448-15	6	Later*	N/A
125	"	448-16	"	"	"
126	"	448-17	"	"	"
127	"	448-18	"	"	"
12[illegible]	"	448-19	"	"	"
1[illegible]	"	448-20	"	"	"
130	"	448-21	"	"	"
131	"	448-22	"	"	"
132	"	448-23	4	"	"
133	"	448-24	"	"	"

reak No.	Line Designation	Isometric No. (M200)	Diameter (Inches)	Max. Force (KIPS) or Thrust vs. Time Figure	Plan Location Figure
13[illegible]	HCO (5) - 1	449-13	3	Later*	N/A
135	"	449-14	"	"	"
136	"	449-15	"	"	"
137	"	449-16	"	"	"
138	"	449-17	"	"	"
139	"	449-18	"	"	"
140	"	449-19	"	"	"
141	"	449-20	"	"	"
142	"	449-21	"	"	"
143	"	449-22	"	"	"
144	"	450-23	"	"	"
145	"	450-24	"	"	"
146	"	450-25	"	"	"
147	"	450-26	2.5	"	"
1[illegible]	"	450-27	"	"	"
149	"	450-28	"	"	"
150	MS (9) - 4	451-6	3"	Later*	N/A
151	"	451-7	"	"	"
152	CRD (12) - 3	N/A	8"	N/A	See Section 3.6.1.18.3.5 and the response to NRC Question 010.14

* - Information is scheduled to be ready for staff review in late 1982.

TABLE 3.6-7 Page 1 of 2

SEISMIC AND QUALITY CLASSIFICATIONS

Line Designation	Diameter	Classification Seismic	Classification Quality
RCIC(13)-4	4	I	I
RCIC(14)-2	2	I	I
RWCU(5)-3	6	I	I
RWCU(2)-4	6	I	I
RWCU(2)-4	4	I	I
RWCU(1)-4	4	I	I
RWCU(1)-4	6	I	I
RWCU(7)-3	6	I	I
RWCU(6)-4	6	I	I
AS(11)-2	4	I	II
CO(16)-2	2.5	II	II
AS(16)-2	3	I	II
AS(16)-2	2.5	I	II
CO(16)-2	1	II	II
AS(3)-2	2	I	II
AS(11)-2	3	I	II
AS(11)-2	2	I	II
AS(1)-2	4	I	II
HCO(11)-2	3	I	II
HCO(5)-2	2	I	II
HCO(5)-2	2.5	I	II
HCO(5)-2	3	I	II
HS(9)-2	2.5	I	II
HS(1)-2	4	I	II
HCO(9)-2	2	I	II
HS(9)-2	3	I	II

Replace with attached Table

TABLE 3.6-7 (Continued)

Line Designation	Diameter	Classification	
		Seismic	Quality
HCO(11)-2	1	I	II
RFW	All	I	II/I*
MS	All	I	I

* Piping up to outboard isolation valve quality Class I, piping beyond outboard isolation valve quality Class II.

TABLE 3.6-7

SEISMIC AND QUALITY CLASSIFICATION

Line Designation	Diameter	Classification Seismic	Classification Quality
RCIC (13)-4	4	I	I
RWCU (1)-4	4,6	I	I
RWCU (2)-4	4,6	I	I
RWCU (1)-3	4	I	I
RWCU (2)-3	4,6	I	I
RWCU (3)-4	4,6	I	I
RWCU (5)-3	4,6	I	I
RWCU (6)-4	6	I	I
RWCU (7)-3	6	I	I
AS (1)-2	4,8	I/II	II
AS (3)-2	2	I	II
AS (10)-2	6,8	I/II	II
AS (11)-2	2,3,4	I	II
AS (16)-2	2.5,3	I	II
CO (3)-2	2,2.5	II	II
HCO (5)-1	2.5,3	II	II
HCO (5)-2	2,2.5,3	I	II
HCO (9)-2	2	I	II
HCO (11)-1	2.5,4,6	I	II
HCO (11)-2	3	I	II
HS (1)-1	4,6	I/II	II
HS (1)-2	2,4	I	II
HS (5)-1	6	I/II	II
HS (5)-2	4.3	I	II

TABLE 3.6-7

SEISMIC AND QUALITY CLASSIFICATIONS

Line Designation	Diameter	Classification Seismic	Classification Quality
HS (9)-2	2.5,3	I	II
RFW	All	I	II/I*
MS	All	I	I

* Piping up to outboard isolation valve quality Class I, piping beyond outboard isolation valve quality Class II.

~~AMENDMENT NO. 9~~
~~April 1980~~

TABLE 3.6-11

DESIGN LOADS IN AREAS WHERE PIPING FAILURES OCCUR

PIPE BREAK NOS.	ROOM	ELEV. (Ft.)	DIFFERENTIAL PRESSURE (psi)	DIFFERENTIAL TEMPERATURE (°F) INT. TO INT.	INT. TO EXT.	LIVE LOAD (psf)	HUNG LOADS (psf) FROM FLOOR	FROM CEILING	EQUIP. LOADS (Kips)
8-10. ~~16 to 18~~	R 15	422	0.51	0°	40°	-	-	59	1.4k Pump
4 ~~19 to 20~~	R 113	441	0.33	0°	40°	250	59	68	None
5-7 ~~21 to 23~~	R 112	441	0.51	0°	40°	250	59	68	None
41-45 ~~24 to 26~~	R 206	471	0.05	0°	40°	250	32	34	None
1, 2, 21, 22 ~~27 to 31~~	R 313	510'-6"	0.48	0°	40°	250	40	30	None
~~32 to 33~~	~~R 305~~	~~501~~	~~0.08~~	~~0°~~	~~40°~~	~~1000~~	~~34~~	~~85~~	~~None~~
20 ~~34 to 35~~	R 408	522	1.0	0°	-	250	41	88	None
13-15, ~~36 to 45~~, 70 - 34	R 406 & 407	522	15.0	0°	-	250	126	0	1.5k Pump
12, 23, [illegible], 32 ~~46 to 55~~	R 409	535	11.0	0°	-	250	40	80	None
60, 61, 65 ~~56 to 57~~	R 511	548	4.4	20°	-	400	80	55	None
18, 53-56, 62-64 ~~58 to 68~~	R 510	548	1.8	20°	-	400	65	51	Heat Exchs. 16.2 & 29.5
19 ~~69 to 70~~	R 509	548	2.1	20°	-	400	88	50	None
~~71 to 72~~	~~R 106~~	~~444~~	~~0.09~~	~~0°~~	~~40°~~	~~250~~	~~74~~	~~84~~	~~None~~
~~73 to 82~~	~~R 206~~	~~471~~	~~0.05~~	~~0°~~	~~40°~~	~~250~~	~~84~~	~~34~~	~~Vaporizer~~
40, 47, 49, 70-82 ~~83 to 86~~	R 604	572	0.03	0°	40°	250	15	36	~~None~~ Heat & Vent Unit 51K
~~87 to 93~~	~~R 206~~	~~471~~	~~0.05~~	~~0°~~	~~40°~~	~~250~~	~~75~~	~~45~~	~~Vaporizer~~
90-94 ~~94 to 97~~	R 504	548	0.00	0°	40°	400	59	15	None
~~98 to 106~~	~~R 604~~	~~572~~	~~0.03~~	~~0°~~	~~40°~~	~~250~~	~~15~~	~~36~~	~~Heat and Vent Unit 51K~~
6	R308	501	0.41	0°	40°	1000	63	55	none
Steam Tunnel	R 310	501	20.0	20°	-	1000	277	41	None

NOTES:
1. For location of pipe break nos., see Figures 3.6-43 thru 3.6-62
2. For vertical and horizontal seismic factors, see 3.7
3. ~~For pipe break thrust loads at pipe break number locations, see Table 3.6-6~~

SUMMARY OF SUBCOMPARTMENT PRE… ANALYSIS[a]

Compartment Where Break Occurs			Piping System	Differential Pressure			
Elevation (ft.)	Room Number	Description	Line Designation	Maximum Differential (psi)	Differential Between the Rooms	Time of the Peak (sec)	Design Pressure (psi)
~~422~~	~~R11/R106~~	~~HPCS Pump Room~~	~~4" AS (11)-2~~	~~0.09~~	~~R11, R106/R206~~	~~1.6~~	~~0.15~~
				~~0.09~~	~~R11, R106/R12, R114~~	~~1.6~~	~~0.15~~
				~~0.09~~	~~R11, R106/R10, R105~~	~~1.6~~	~~0.15~~
422	R14/R113	RHR Pump Rooms	4" RCIC(13)-4	0.33	R14, R113/R206	0.33	0.50
				0.33	R14, R113/R12, R114	0.33	0.50
				0.33	R14, R113/R15, R112	0.33	0.50
422	R15/R112	RCIC Pump Room	4" RCIC(13)-14	0.51	R15, R112/R206	0.53	0.76
				0.51	R15, R112/R14, R113	0.53	0.76
				0.51	R15, R112/R6, R116	0.53	0.76
471	R206	El. 471' Open Floor Area	4" AS (11)-2	0.05	R206/R103, R105, R106 R305, R308, R310, R306, R315	0.35	0.08
				0.05	R206/R114, R113, R112	0.35	0.08
				0.05	R206/R116, R115	0.35	0.08
501	R308	TIP Room	4" RCIC(13)-4	0.32	R308/R305, R206, R313	0.03	0.50
501	R308	TIP Room	6" RWCU(2)-4	0.48	R308/R305, R206, R313	0.35	0.60
522	R404	El. 522' Open Floor Area	8" CRD(12)-3	0.03	R404/R305, R504, R508	0.04	0.05

(a) Table applies to reactor building secondary containment, exclusive of the main steam tunnel, tunnel ventway and tunnel extension.

add notes shown below

501	R313	Valve Room @ EL. 510'	6" RWCU (2)-4	0.41	R313/R308, R408	0.35	0.60

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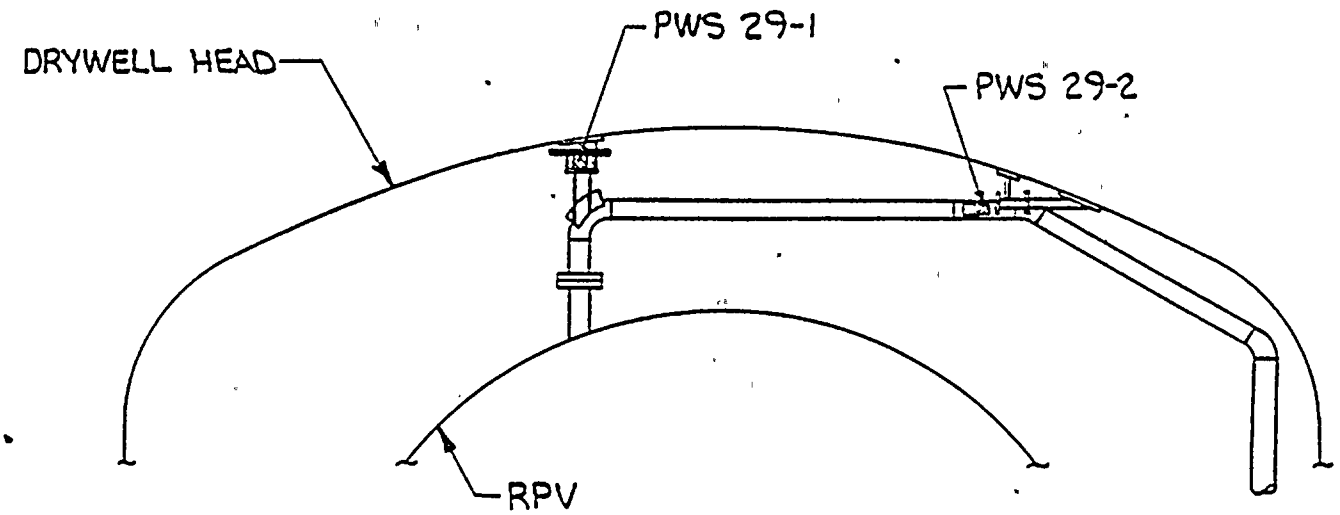
TABLE 3.6-18

PIPING SYSTEMS CONTAINING BREAK EXCLUSION AREAS BETWEEN PRIMARY CONTAINMENT ISOLATION VALVES

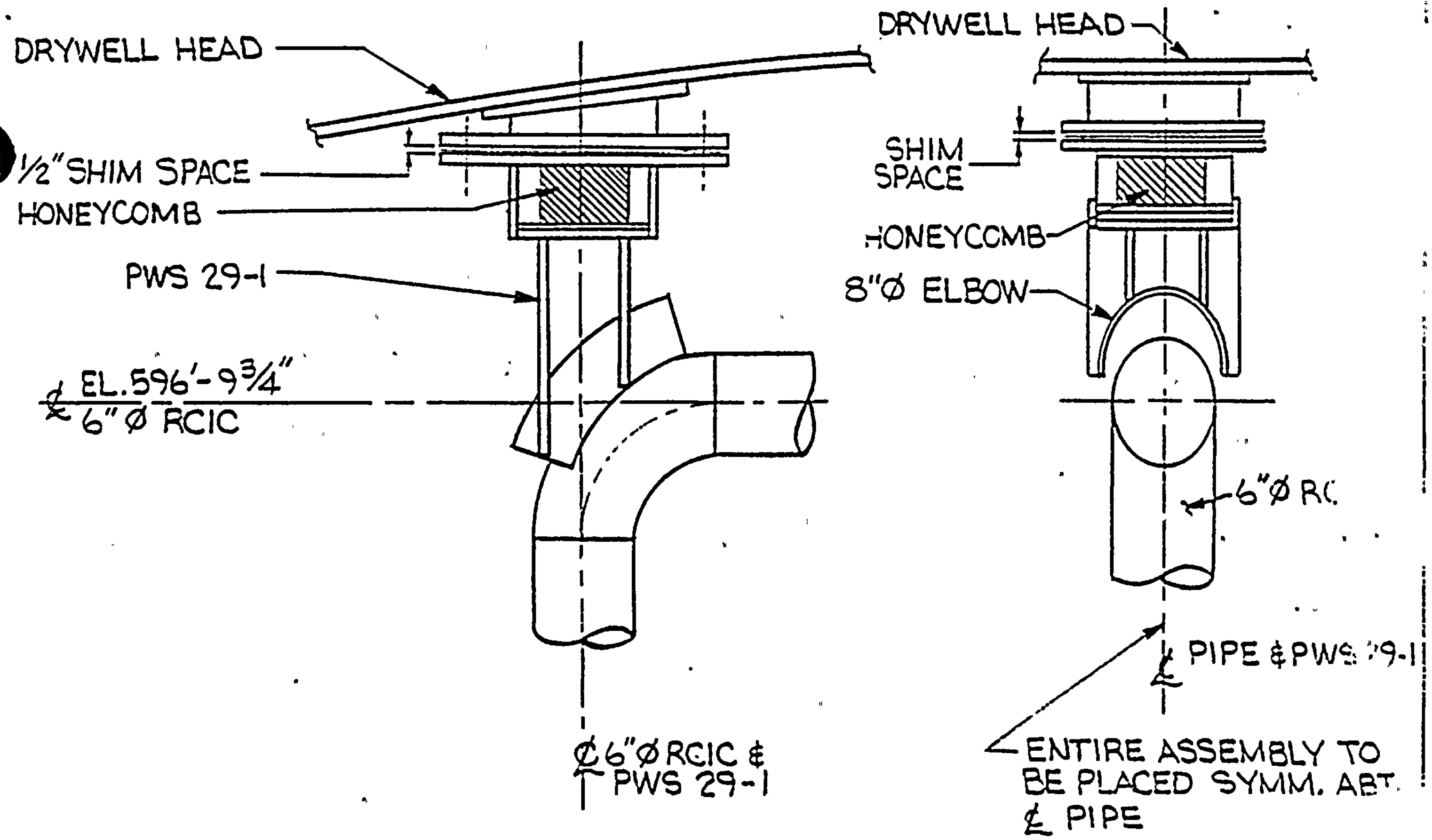
PIPING SYSTEM	PIPE SIZE
Main Steam Loop A	26"
Main Steam Loop B	26"
Main Steam Loop C	26"
Main Steam Loop D	26"
Reactor Feedwater Line A	24"
Reactor Feedwater Line B	24"
RHR Condensing Mode/ RCIC Turbine Steam	10"/4"
Reactor Water Cleanup	6"
~~Main Steam Valves Drainage Piping~~	[illegible]

Add Figures 3.6-26C
3.6-26D

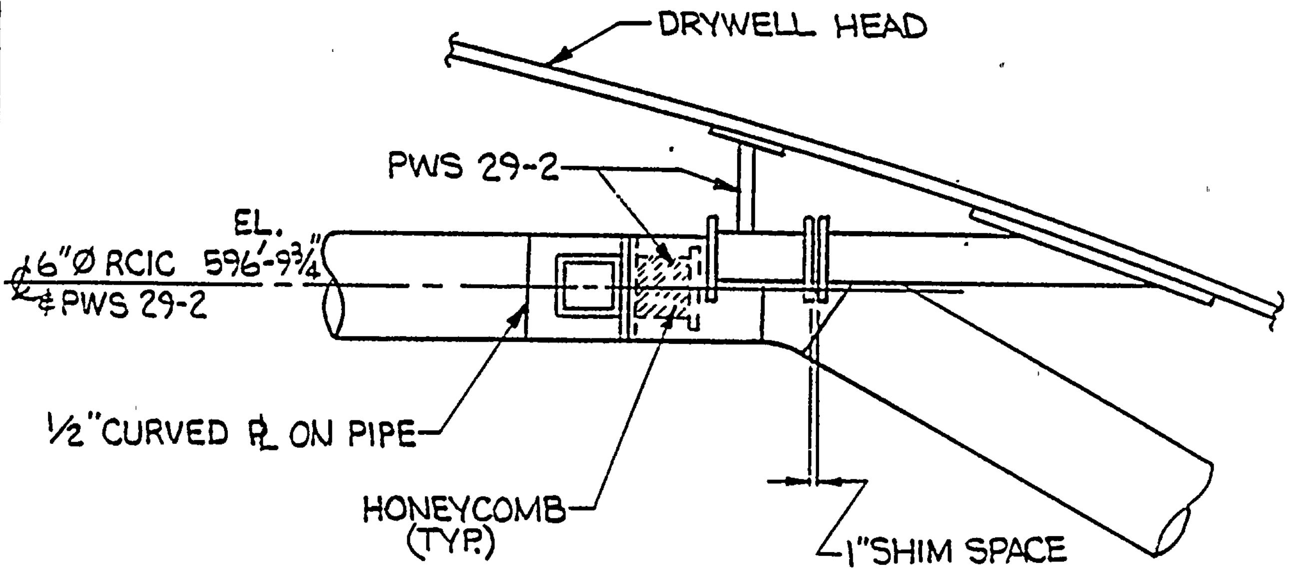
as shown
on the following pages



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	RCIC RPV HEAD SPRAY	FIGURE 3.6-28C



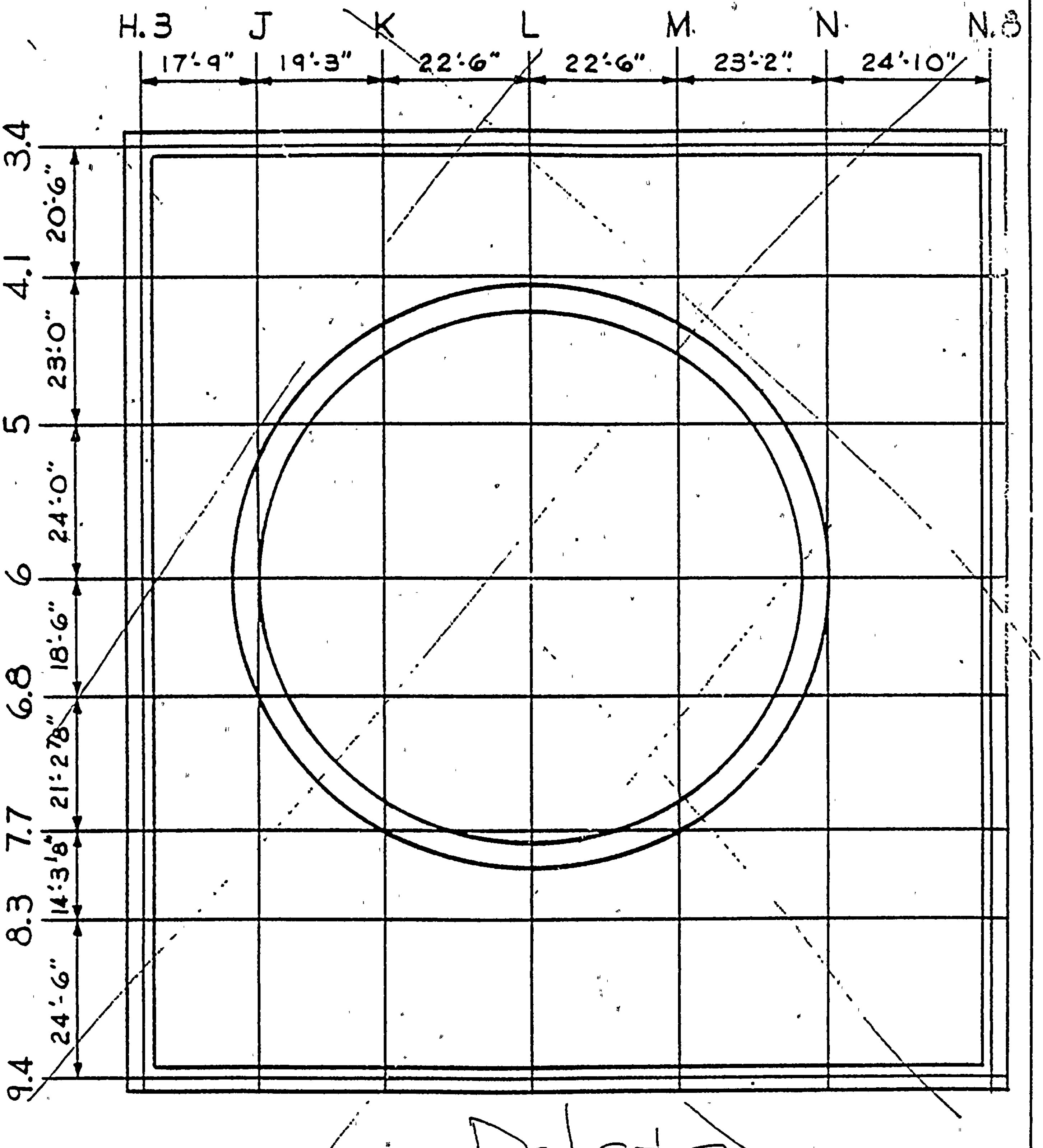
PWS 29-1



PWS 29-2

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	RCIC RPV HEAD SPRAY	FIGURE 3.6-15C

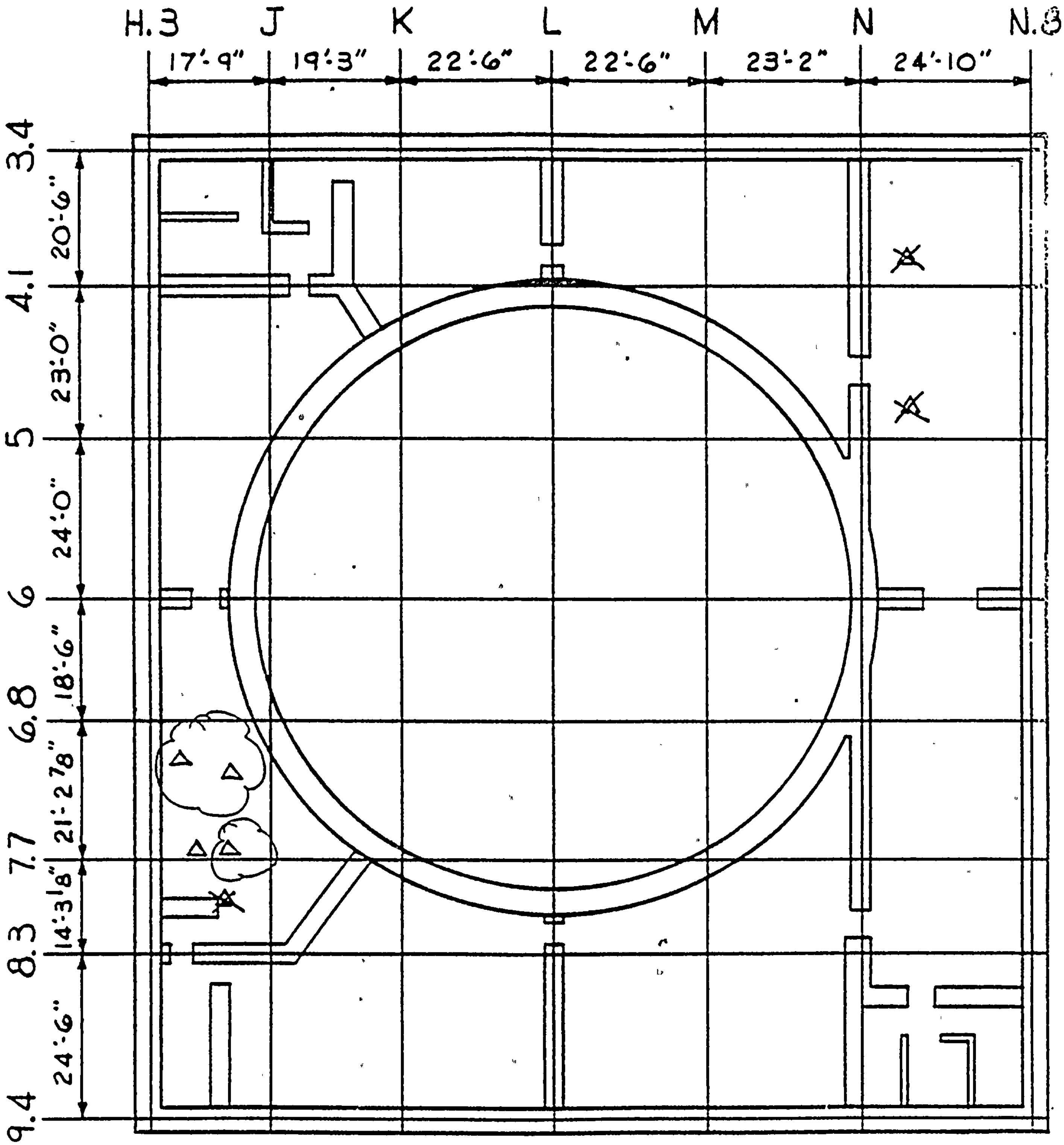
Delete



Delete

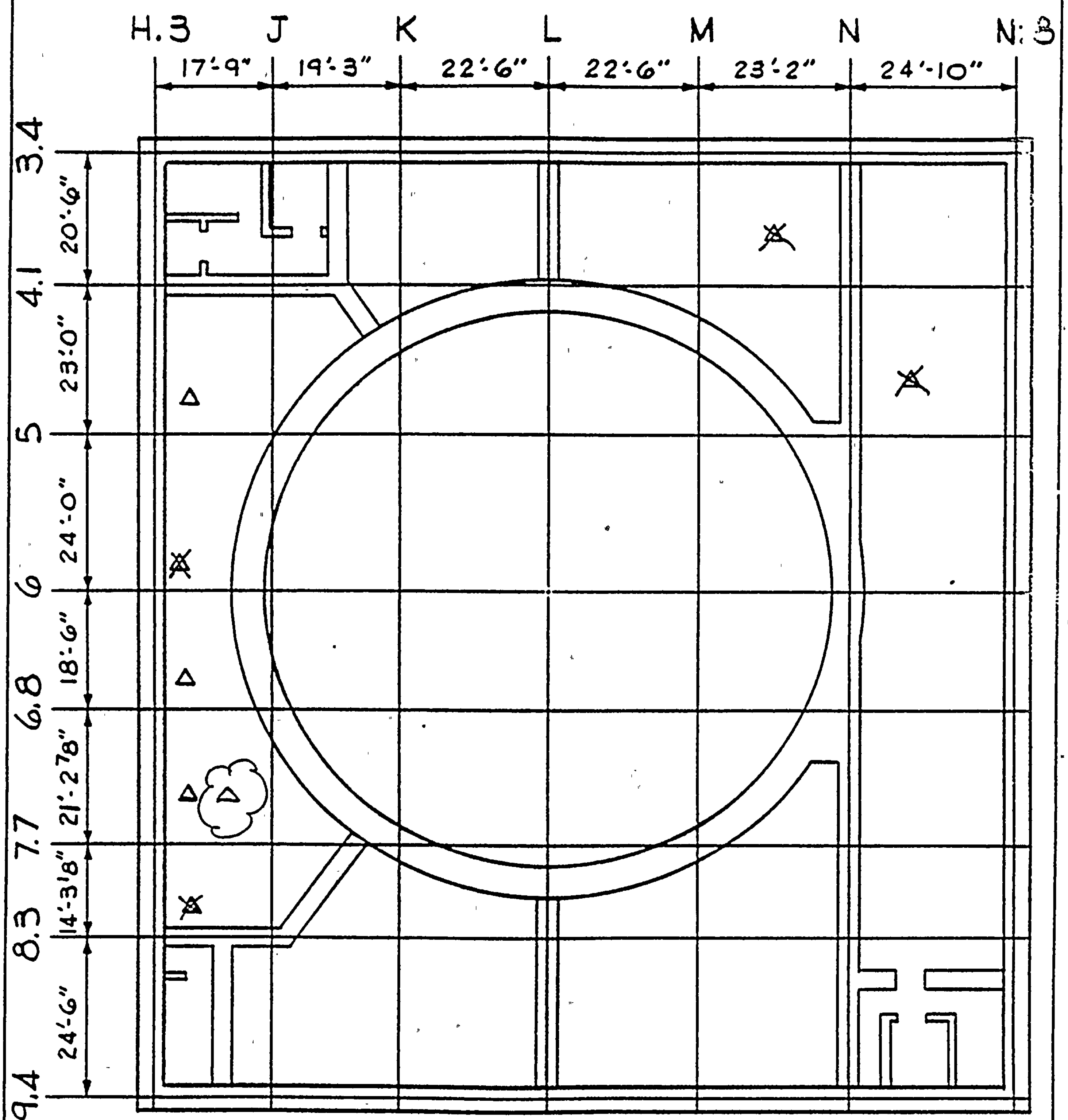
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	~~REACTOR BLDG. GRID SYSTEM~~	FIGURE 3.6-37

Revise as shown



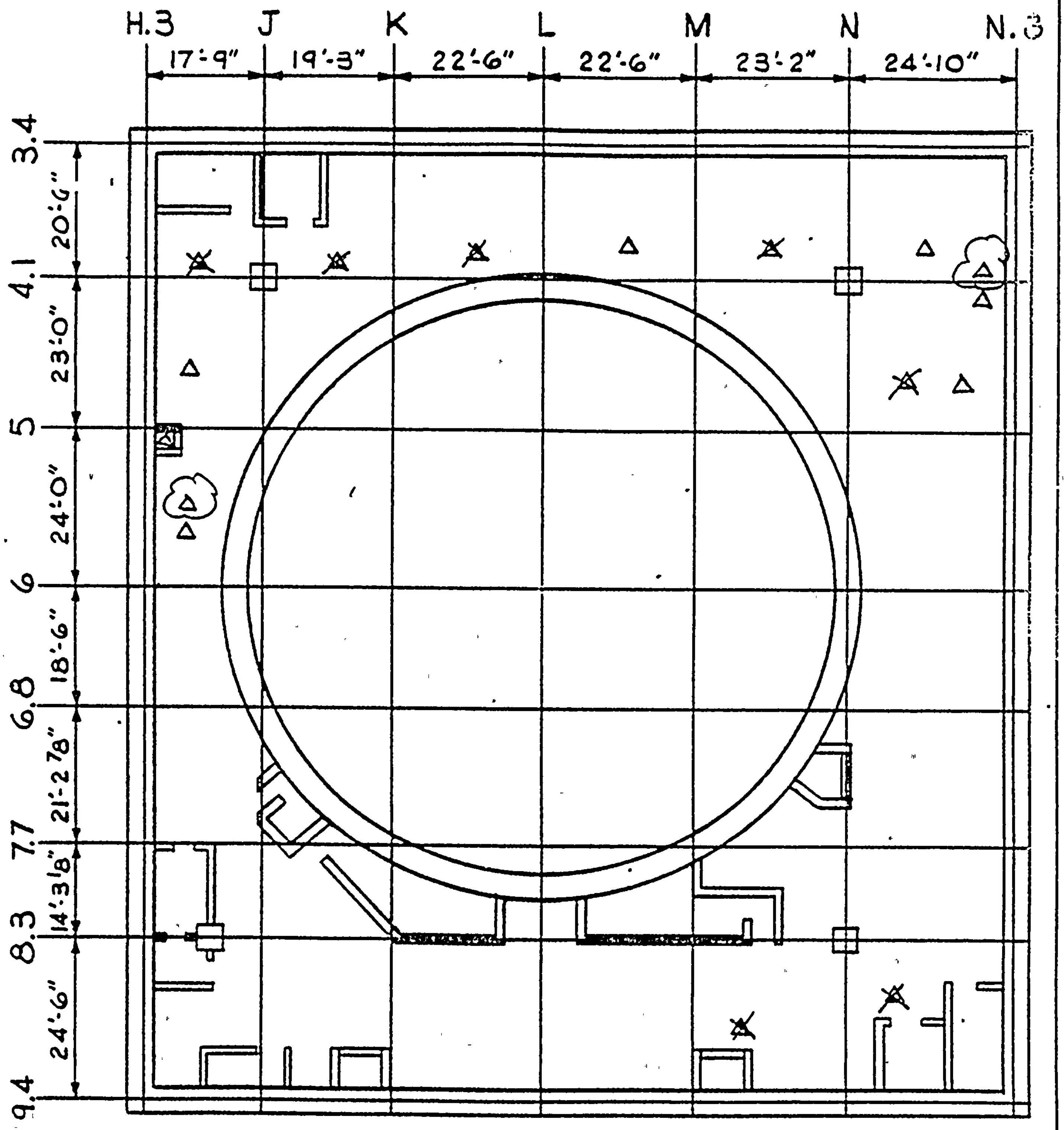
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYS. RUPTURE LOC. PLAN @ EL. 422'-3"	FIGURE 3.6-41a

Revise as shown



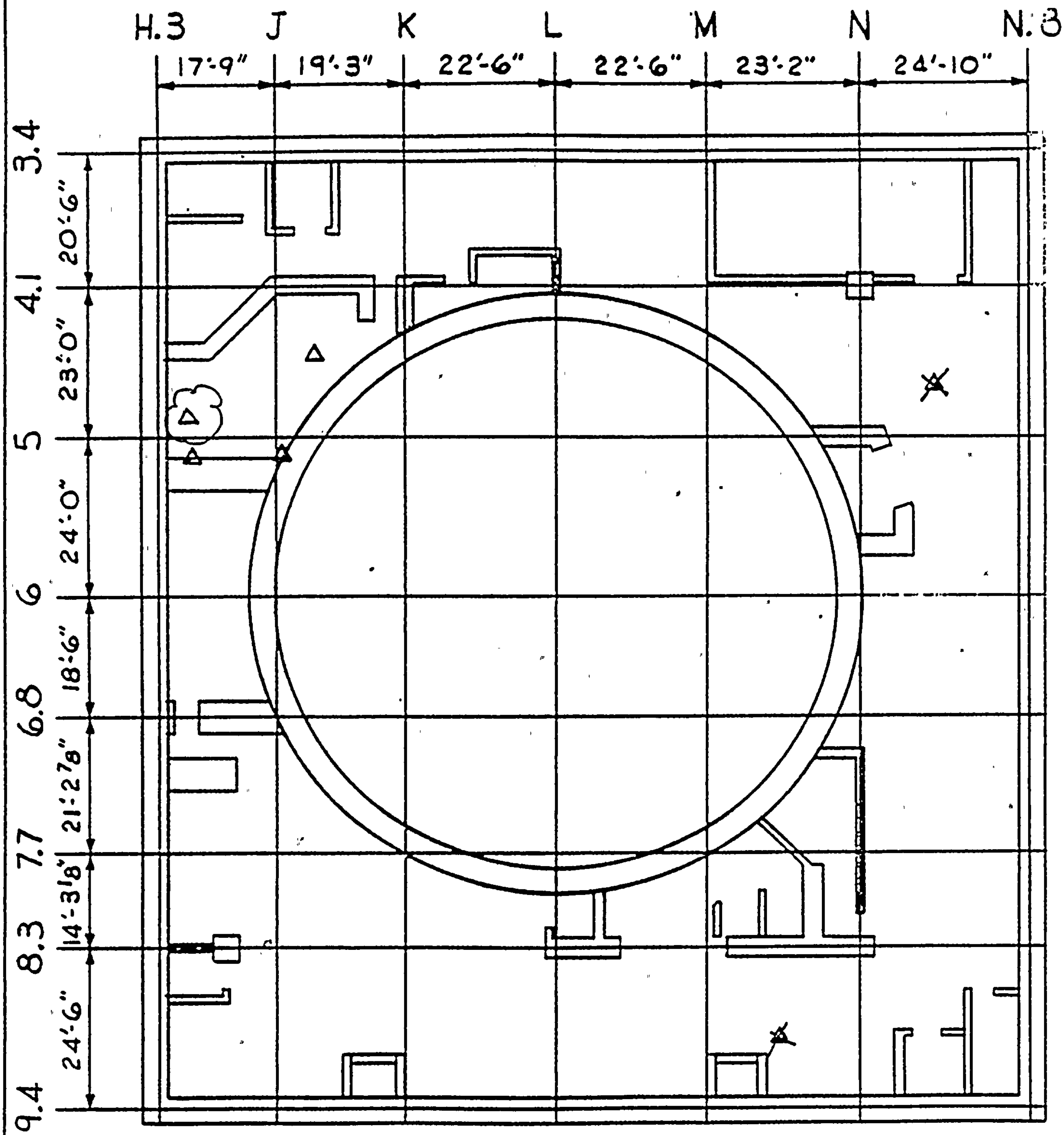
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYS. RUPTURE LOC. PLAN @ EL. 441'	FIGURE 3.6-41b

Revise as shown



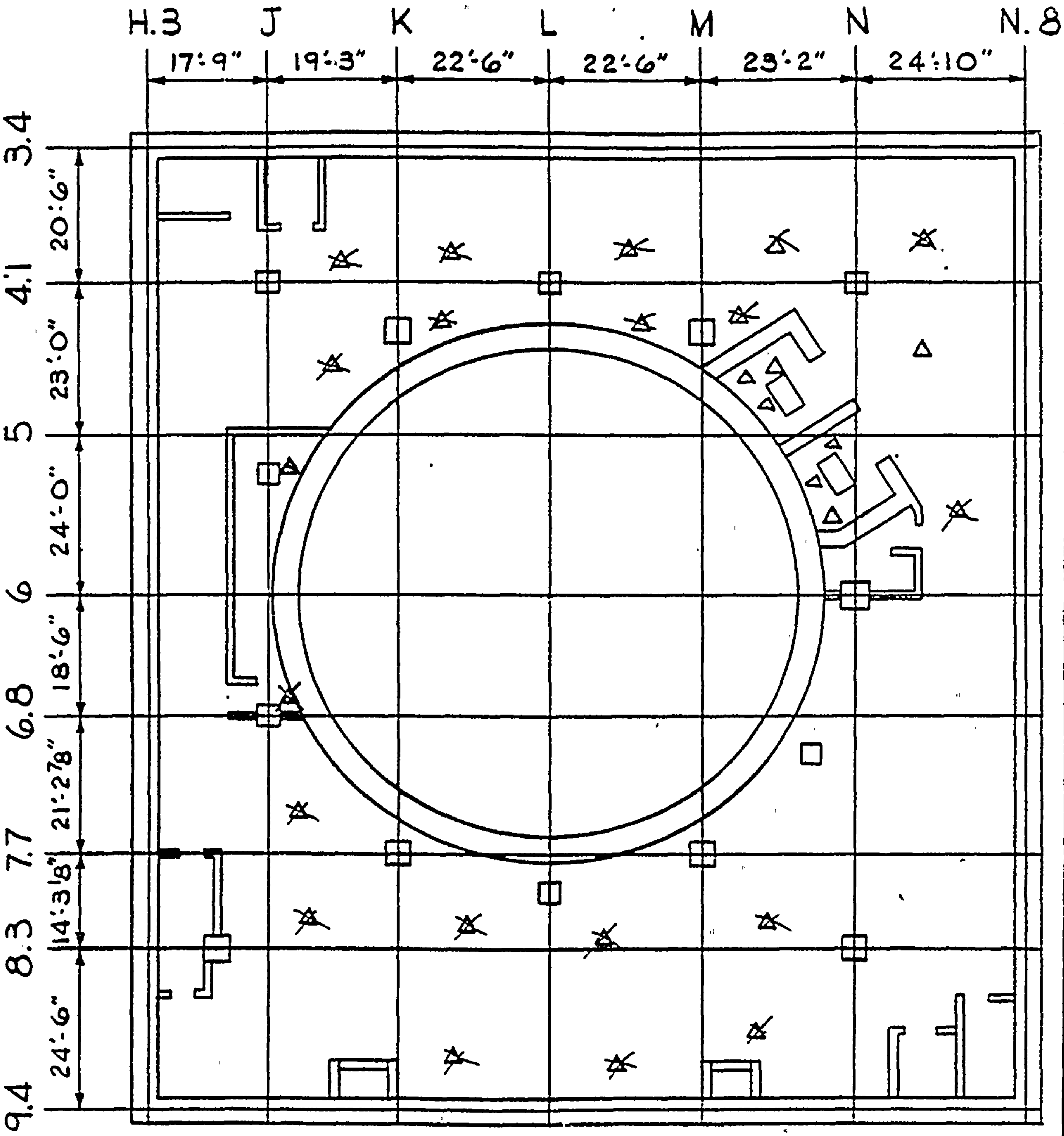
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYSTEM RUPTURE LOC. PLAN @ EL. 471'	FIGURE 3.6-41c

Revise as shown



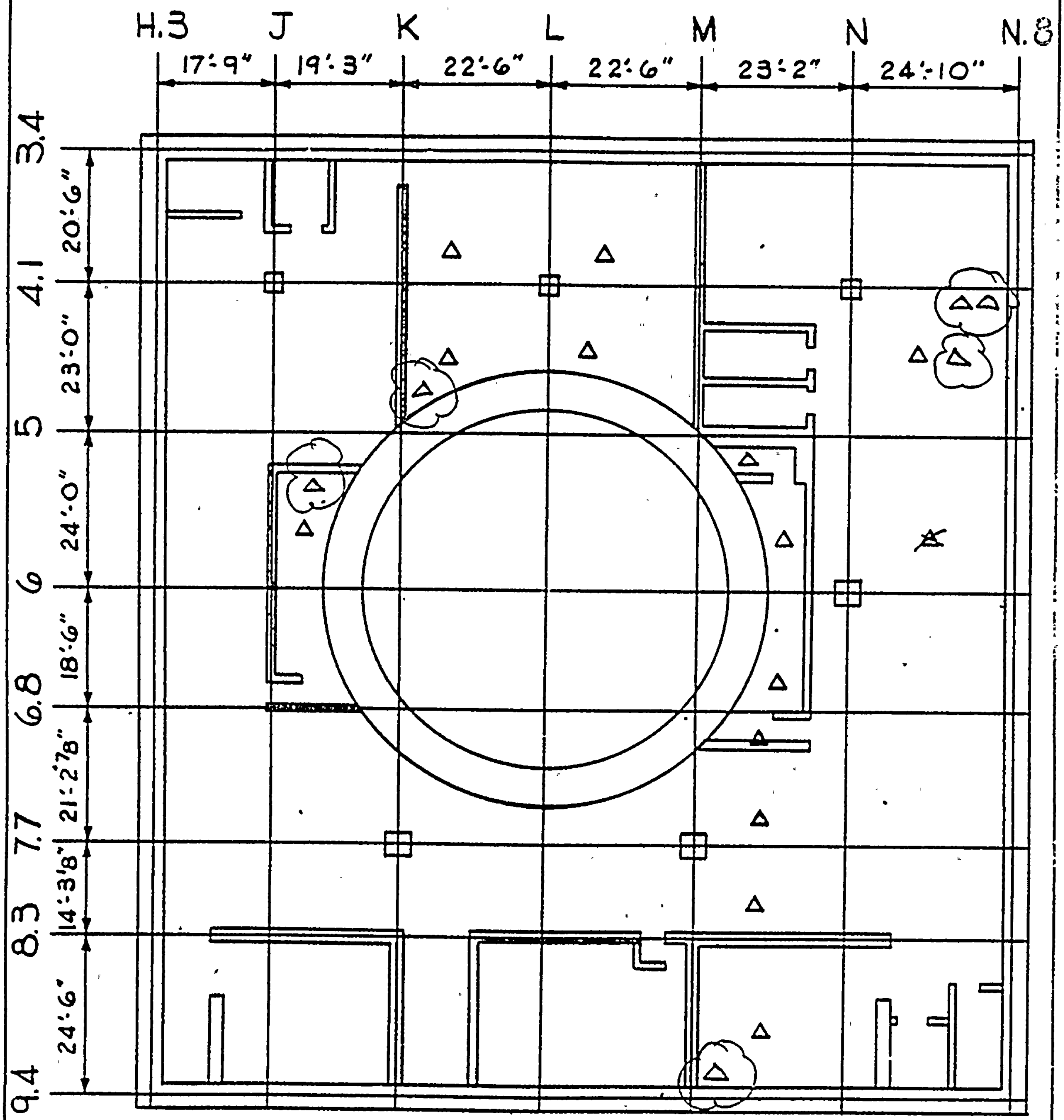
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYS. RUPTURE LOC. PLAN @ EL. 501'	FIGURE 3.6-41d

Revise as shown



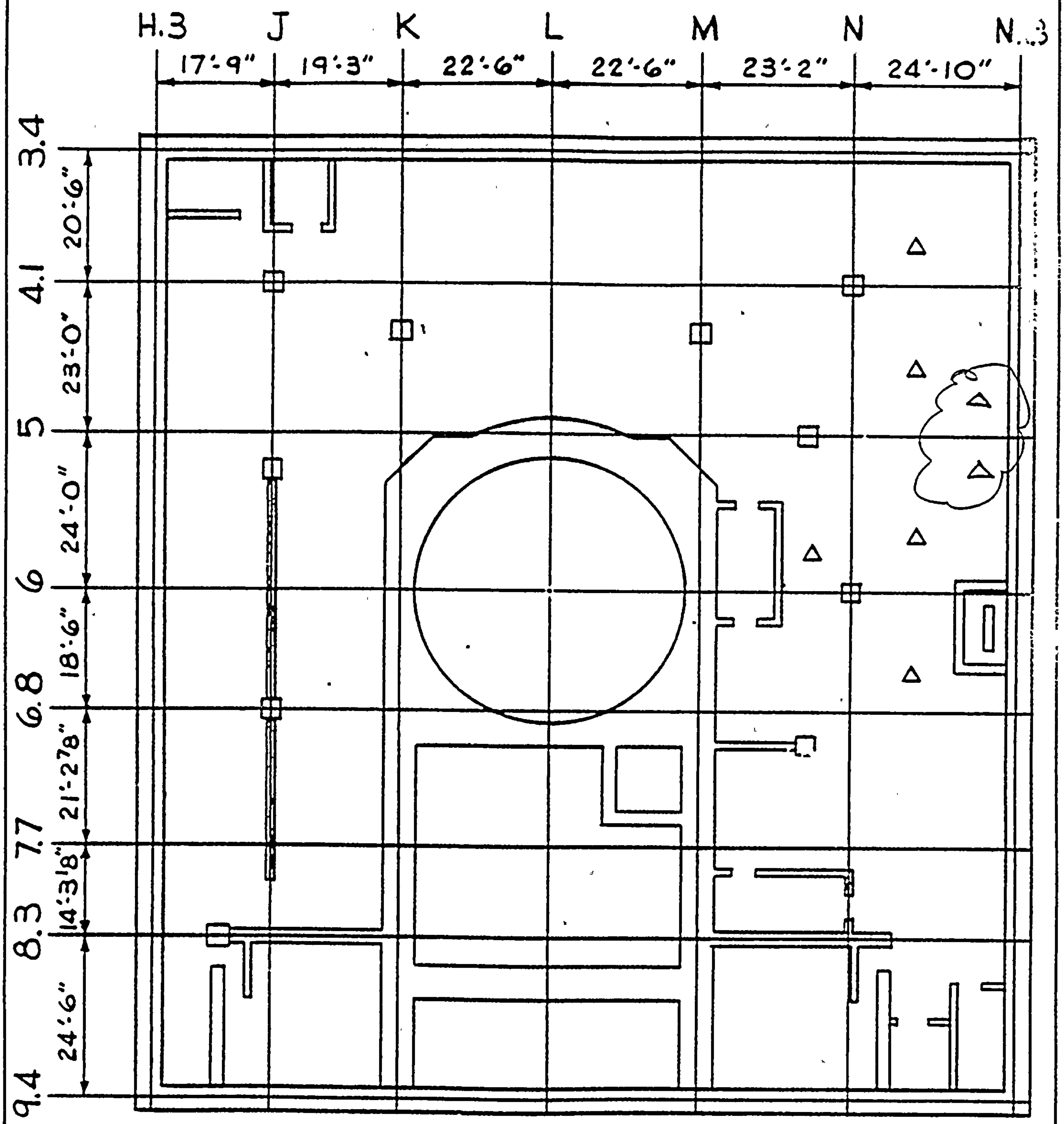
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYSTEM RUPTURE LOC. PLAN @ EL. 522'	FIGURE 3.6-41e

Revise as shown

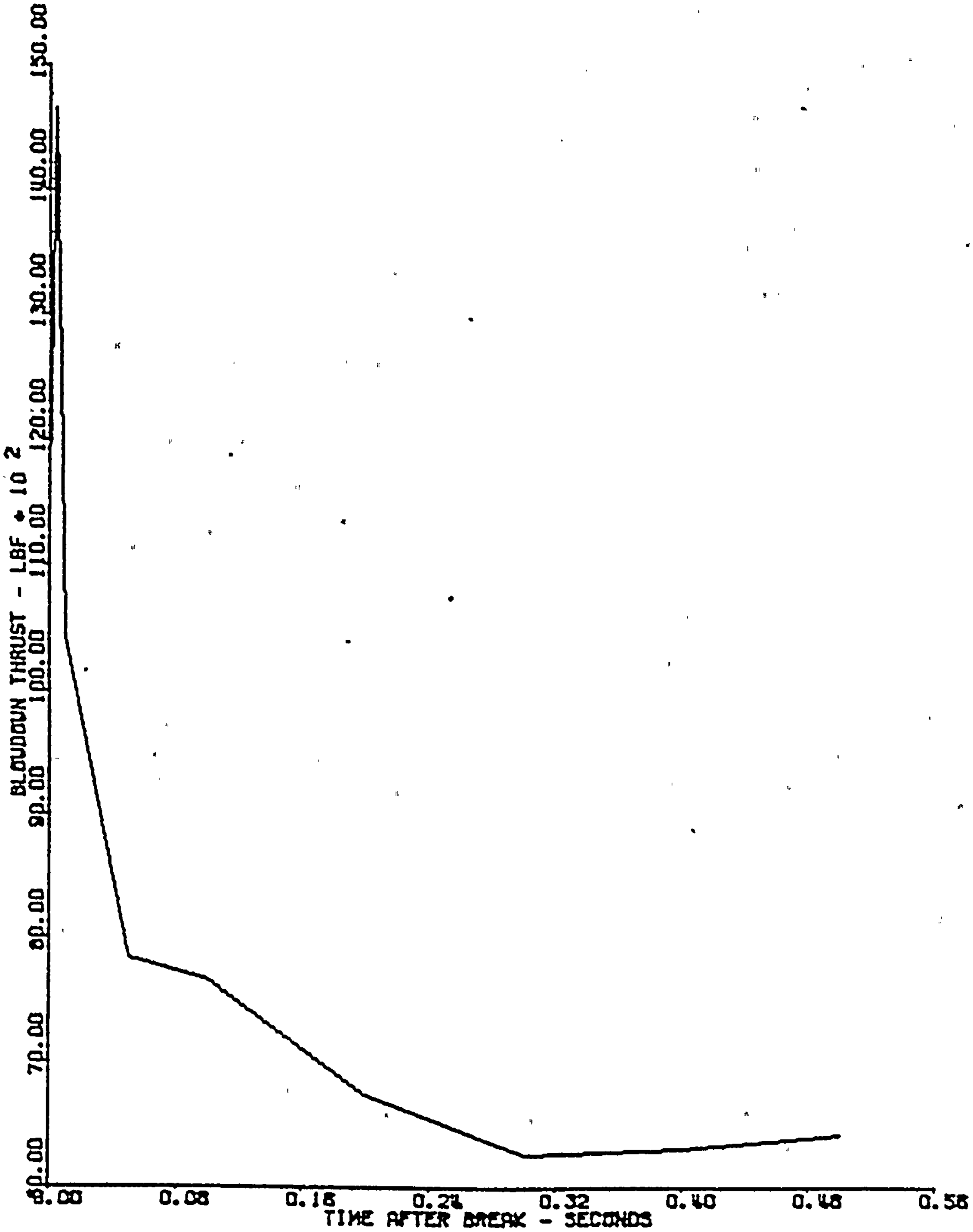


WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYS. RUPTURE LOC. PLAN @ EL. 548'	FIGURE 3.6-41f

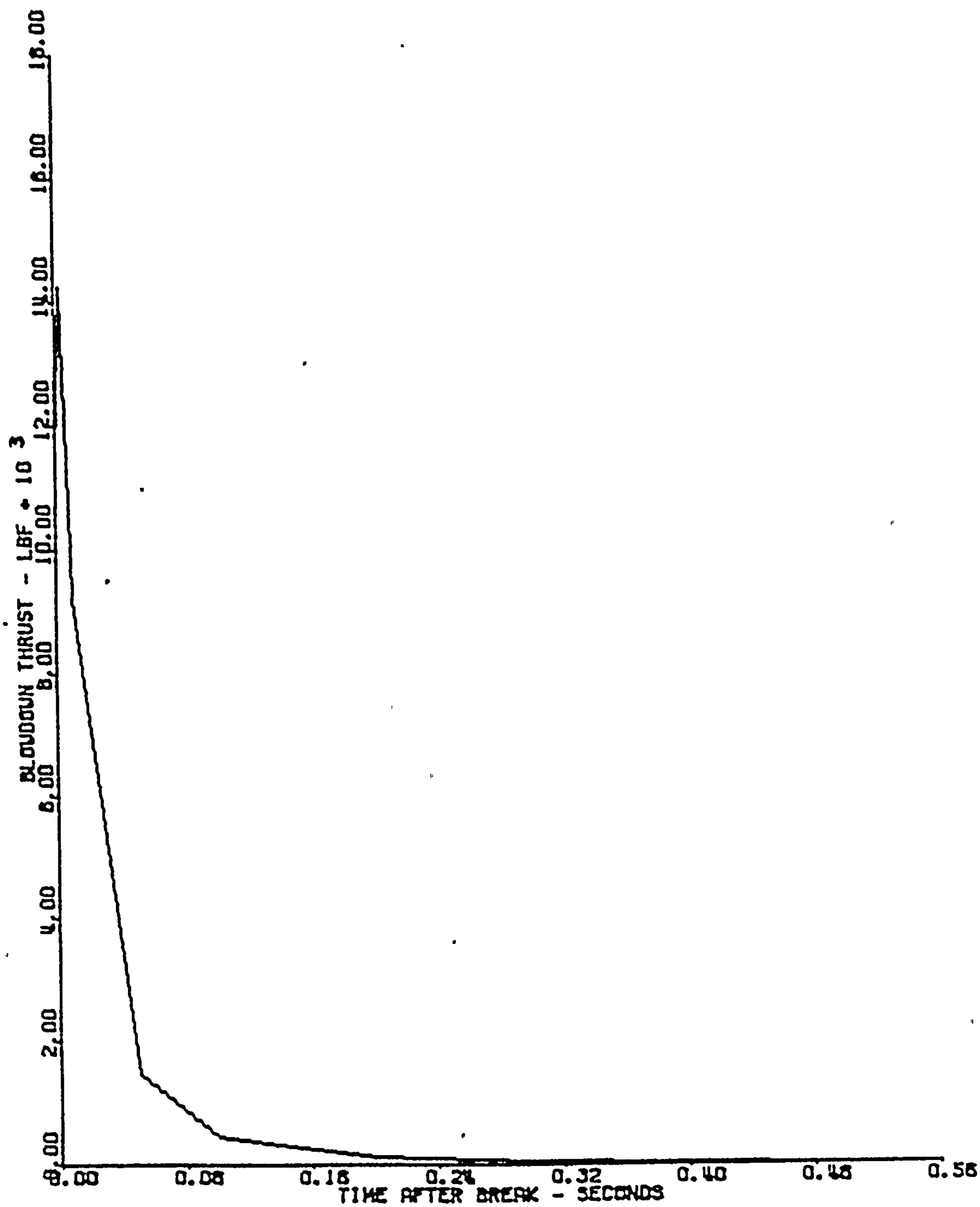
Revise as shown



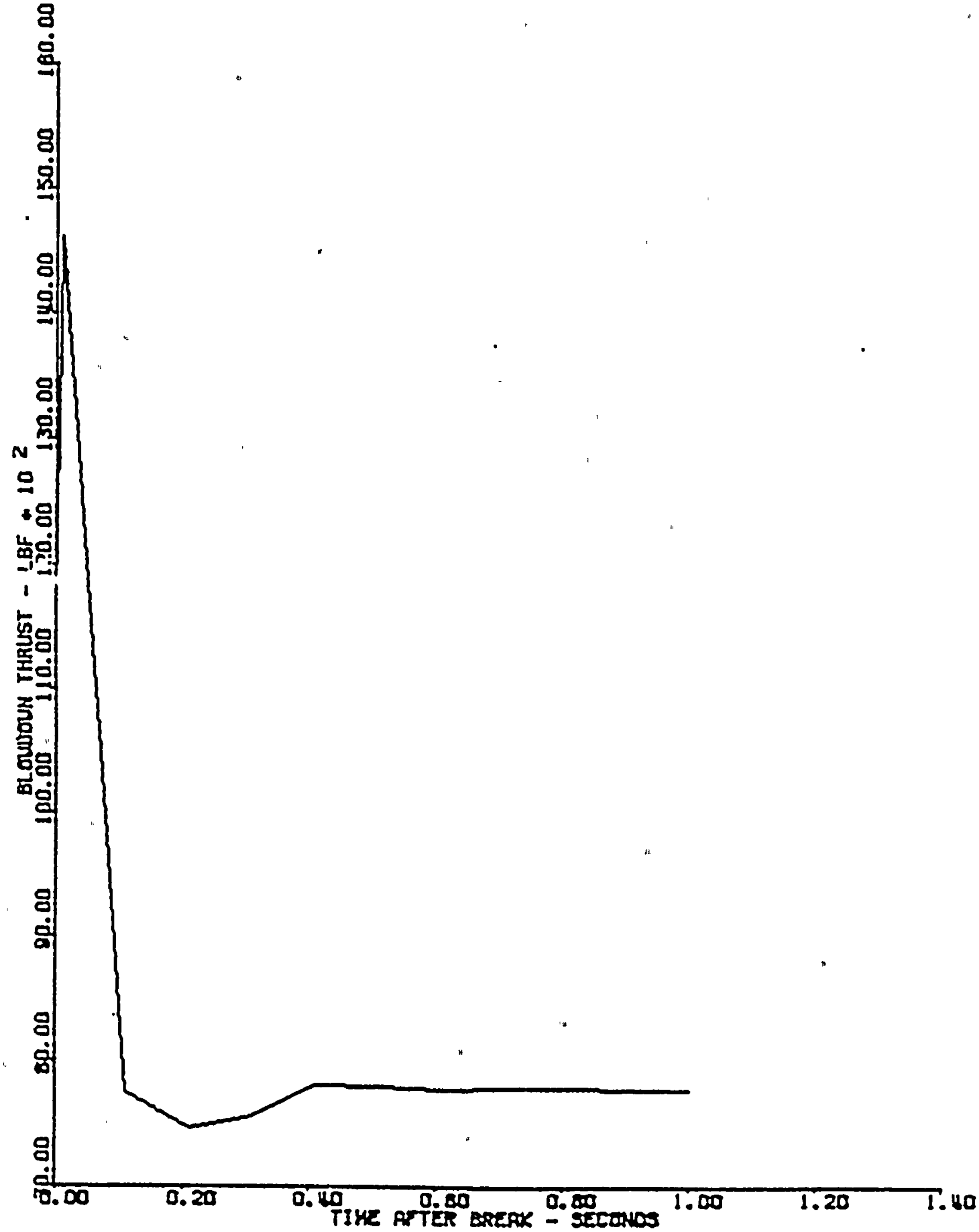
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	HIGH ENERGY FLUID PIPING SYSTEM RUPTURE LOC PLAN @ EL. 572'	FIGURE 3.6-41g



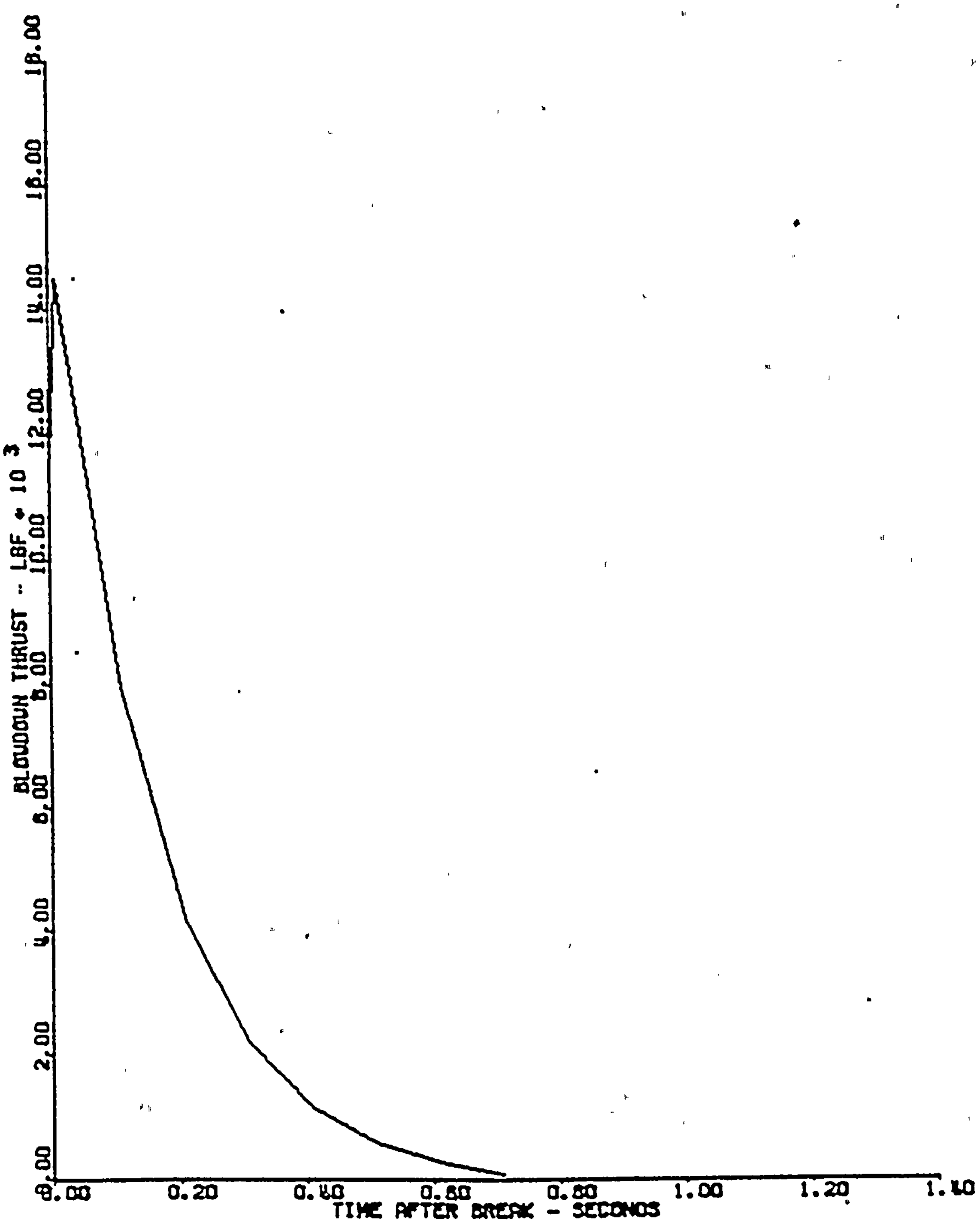
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - REACTOR SIDE OF BREAKS ~~1, 16, 17, 26, 28~~ 10	FIGURE 3.6-63



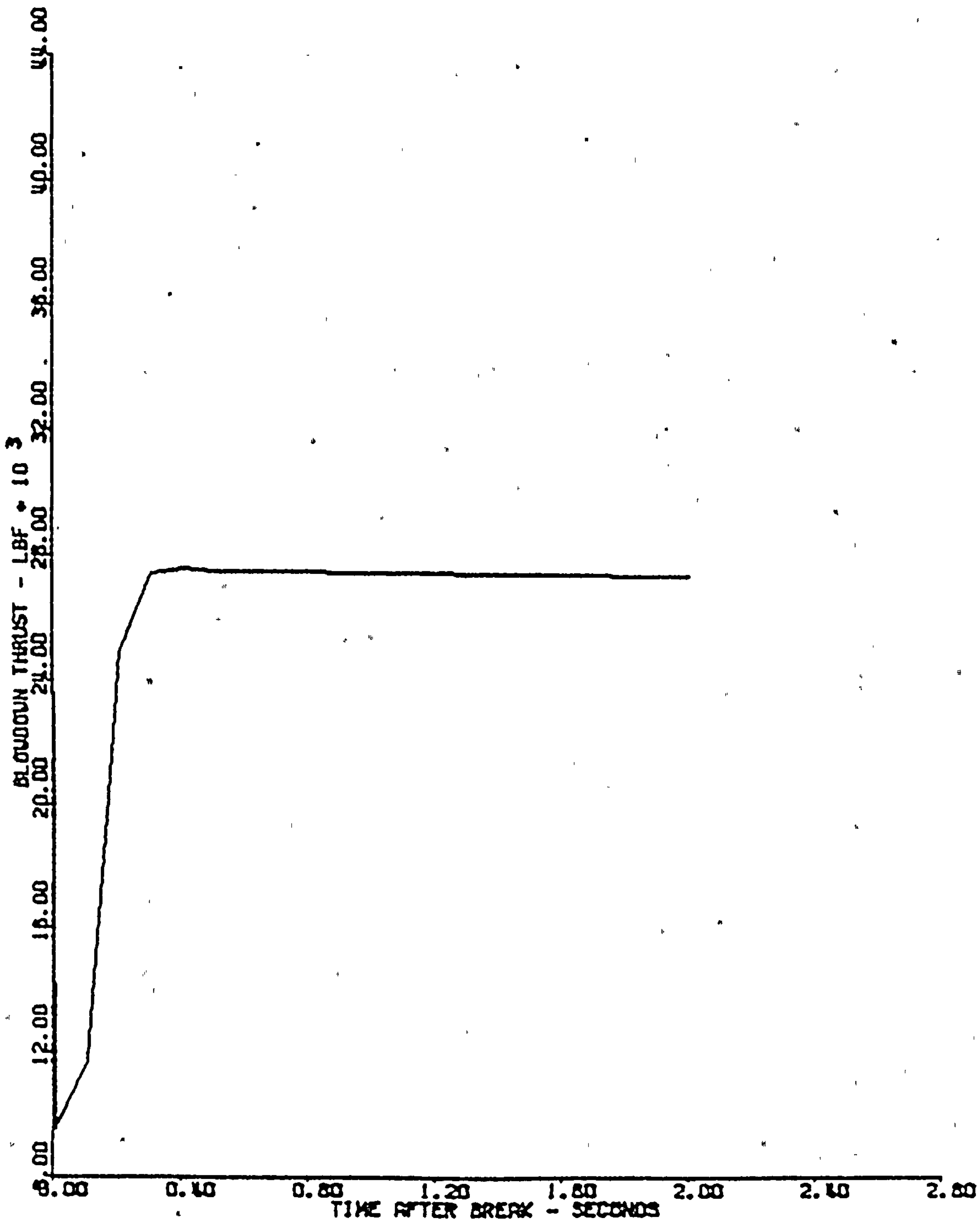
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - TURBINE SIDE OF BREAKS ~~4, 16, 17, 22, 25~~ 10	FIGURE 3.6-64



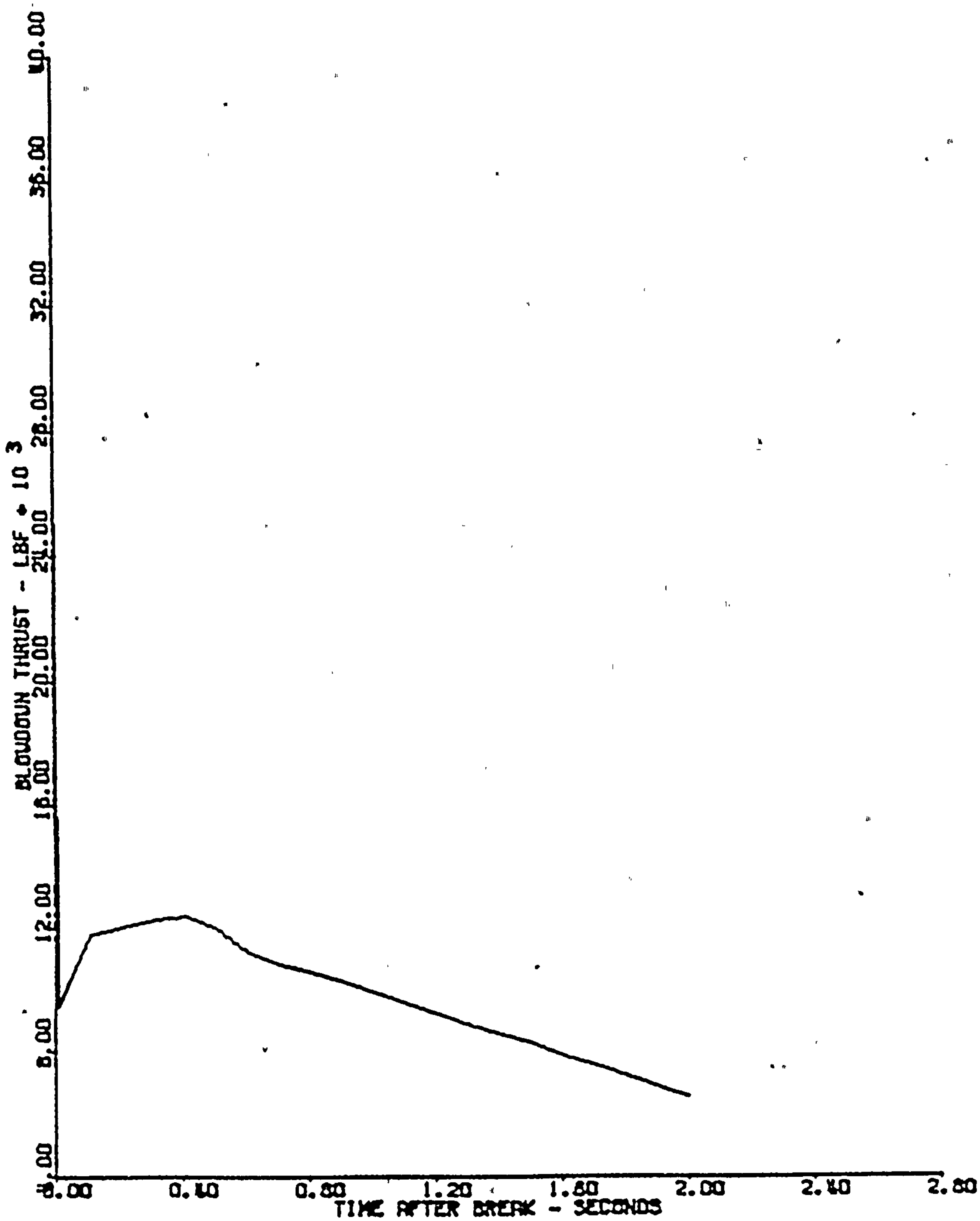
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - REACTOR SIDE OF BREAKS ~~2~~, 3, ~~7~~, ~~20~~, ~~28~~	FIGURE 3.6-65



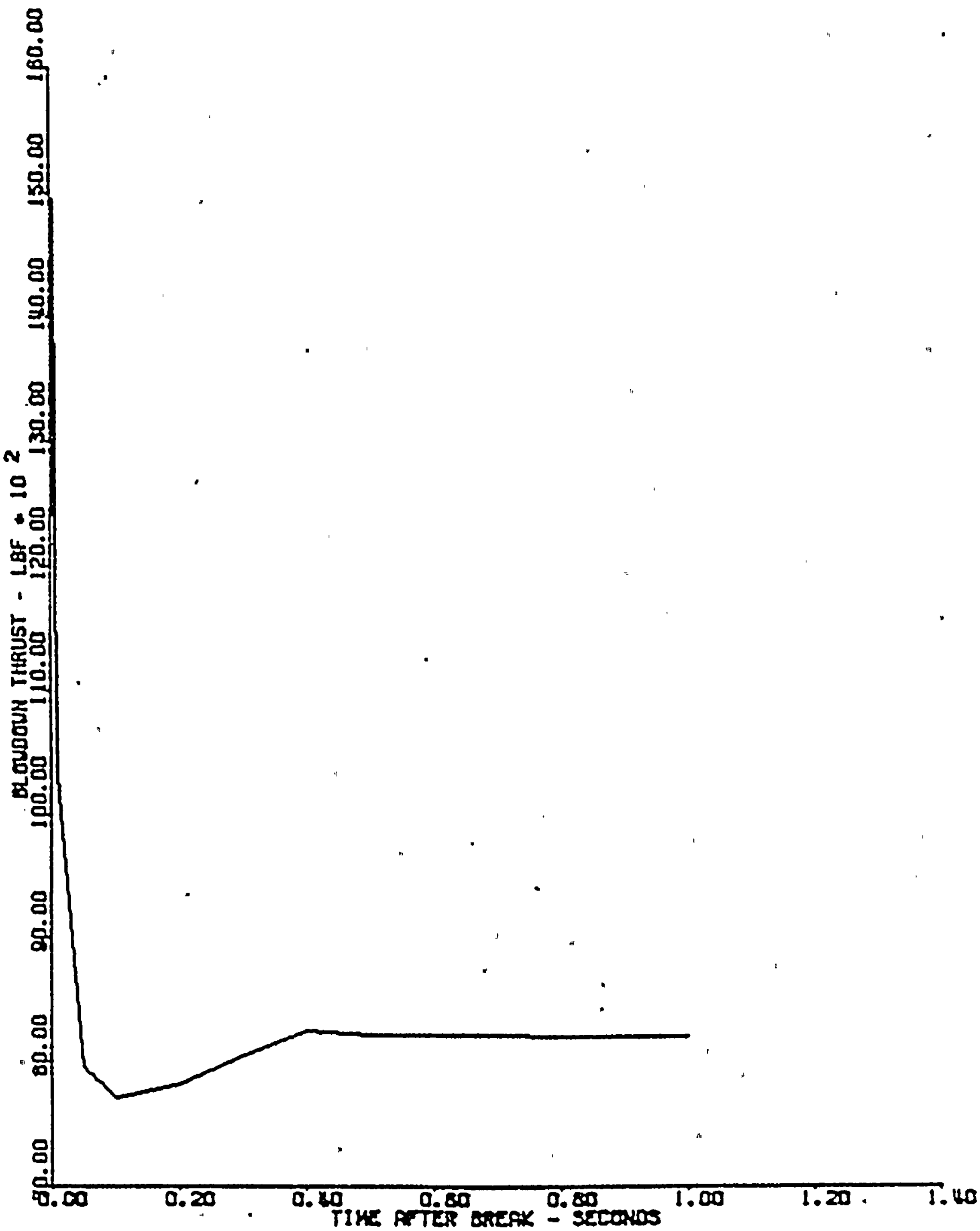
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - TURBINE SIDE OF BREAKS ~~2~~, 3, ~~7~~, ~~20~~, ~~26~~	FIGURE 3.6-66



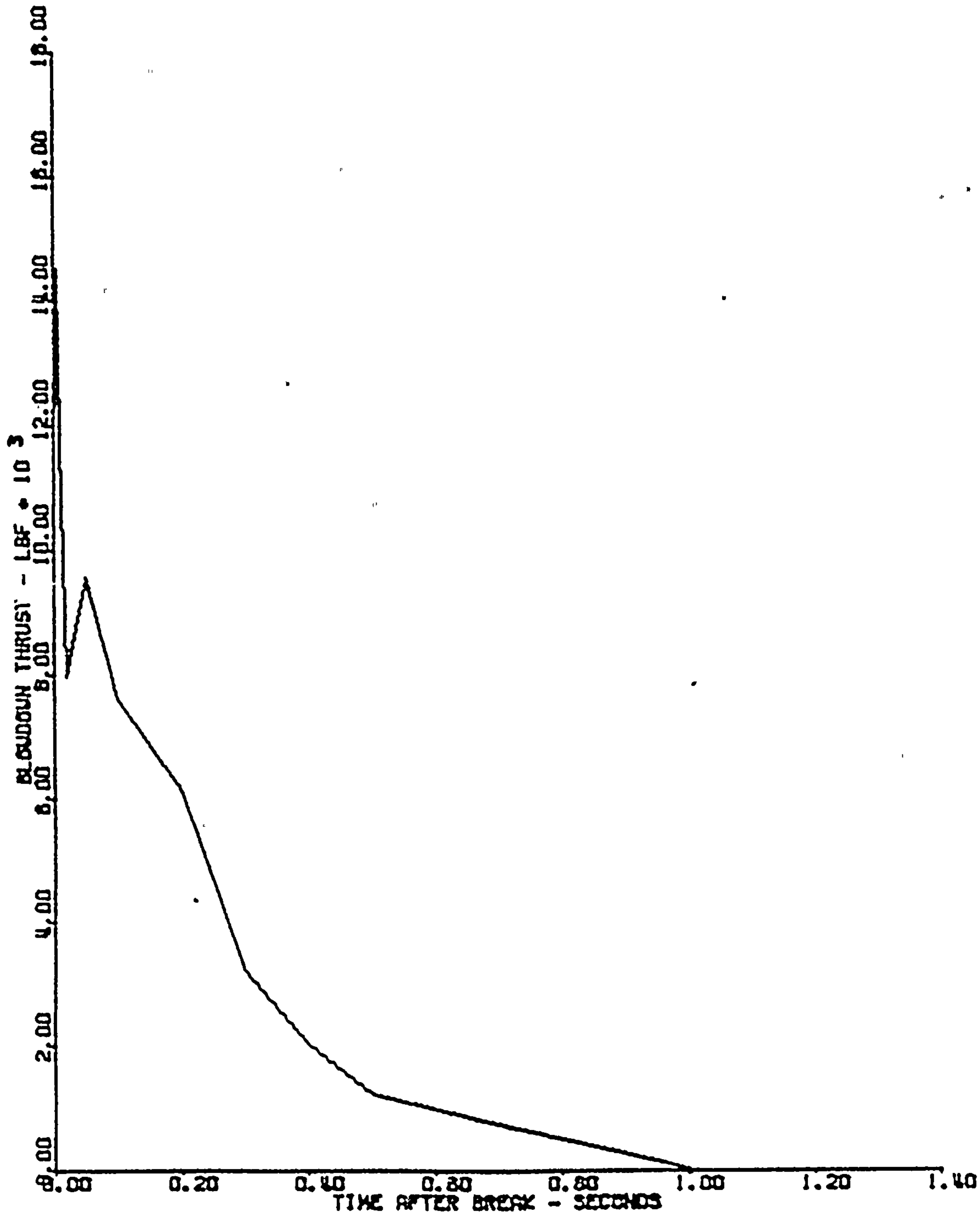
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - REACTOR SIDE OF BREAKS ~~8,9,14,29,31,34,35,66-79~~ 17	FIGURE 3.6-67



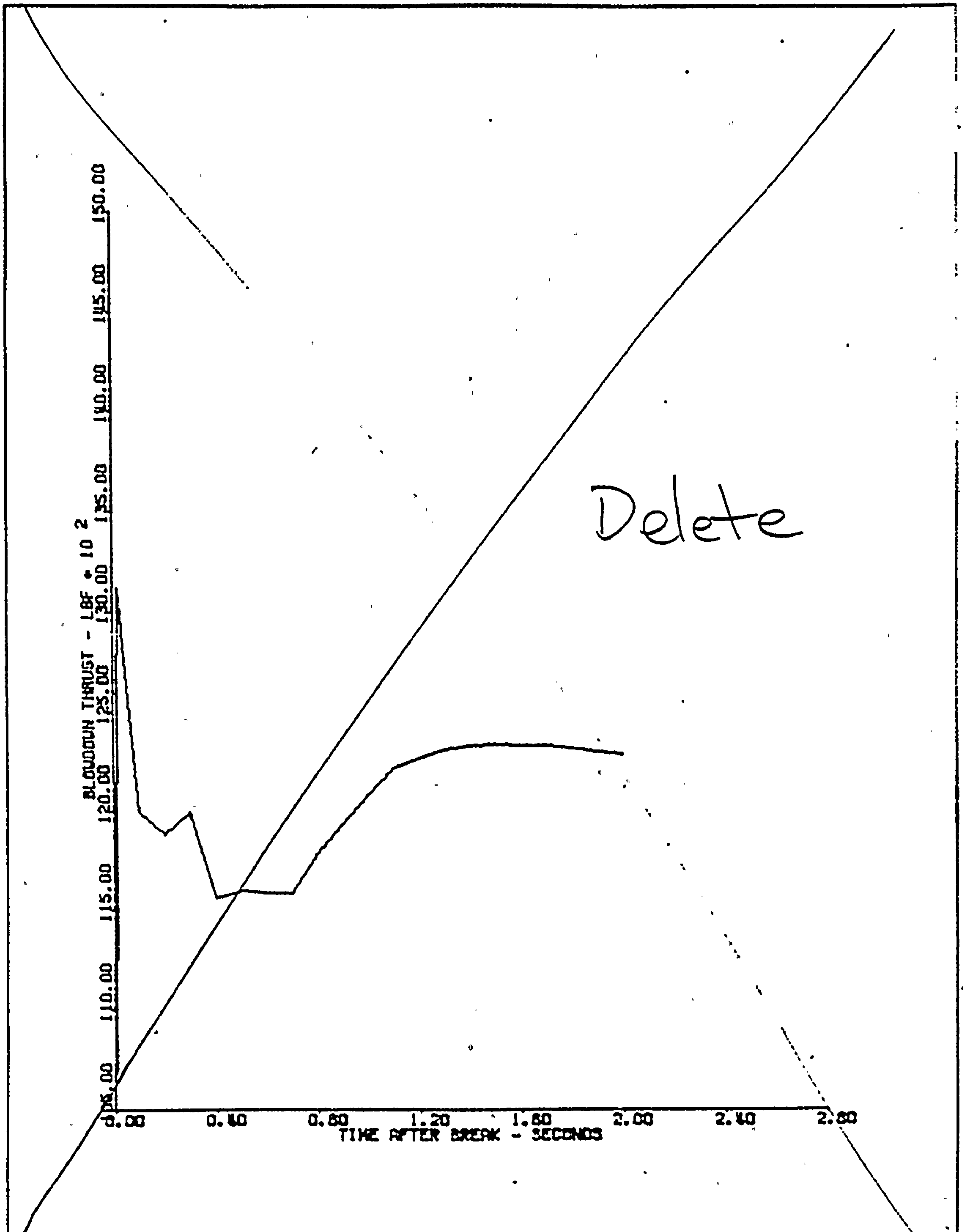
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - HEAT EXCHANGER 17 SIDE OF BREAKS ~~8,9,14,29,31,34,35,66,78~~	FIGURE 3.6-68



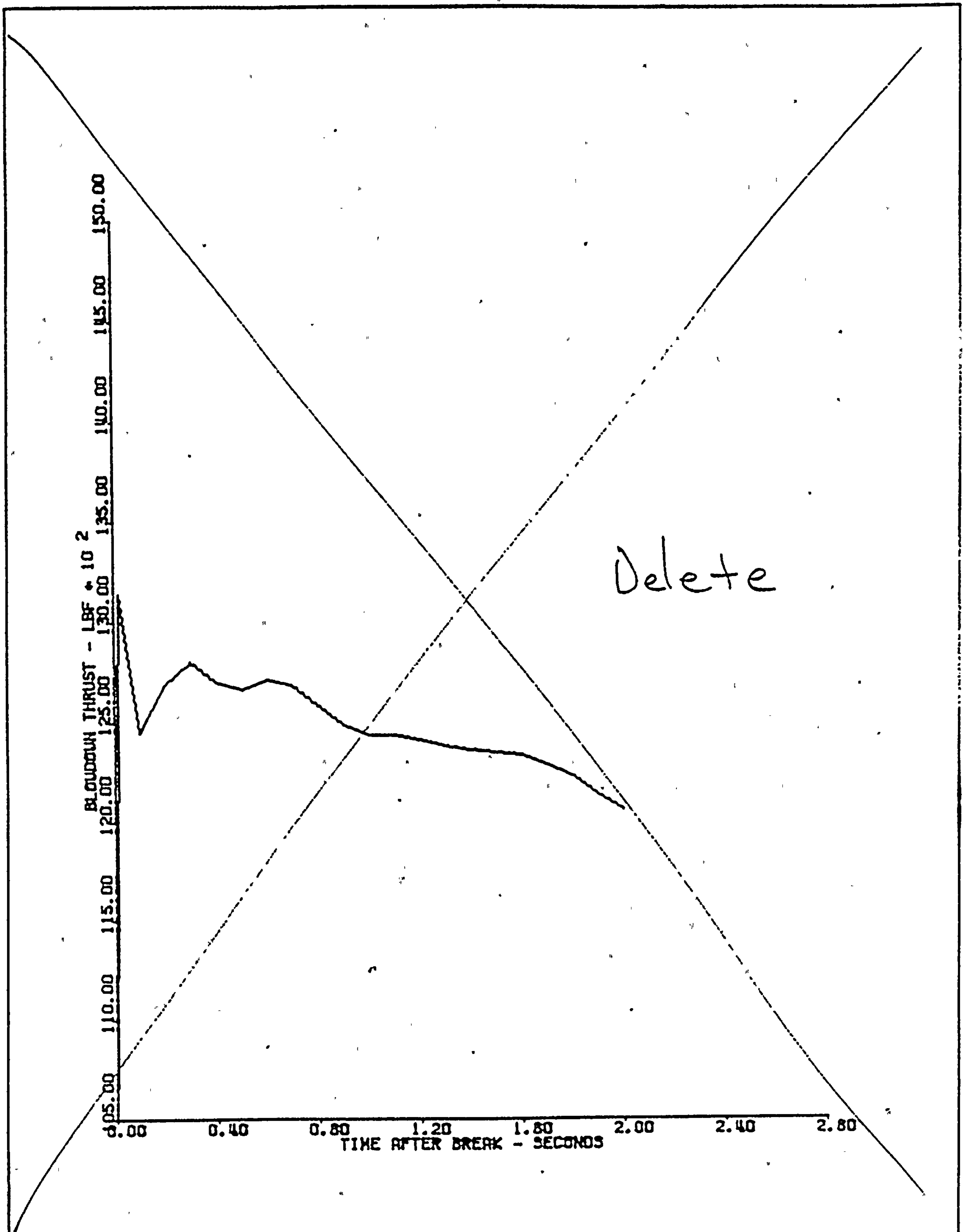
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - REACTOR SIDE OF BREAK ~~30~~ 2	FIGURE 3.6-69



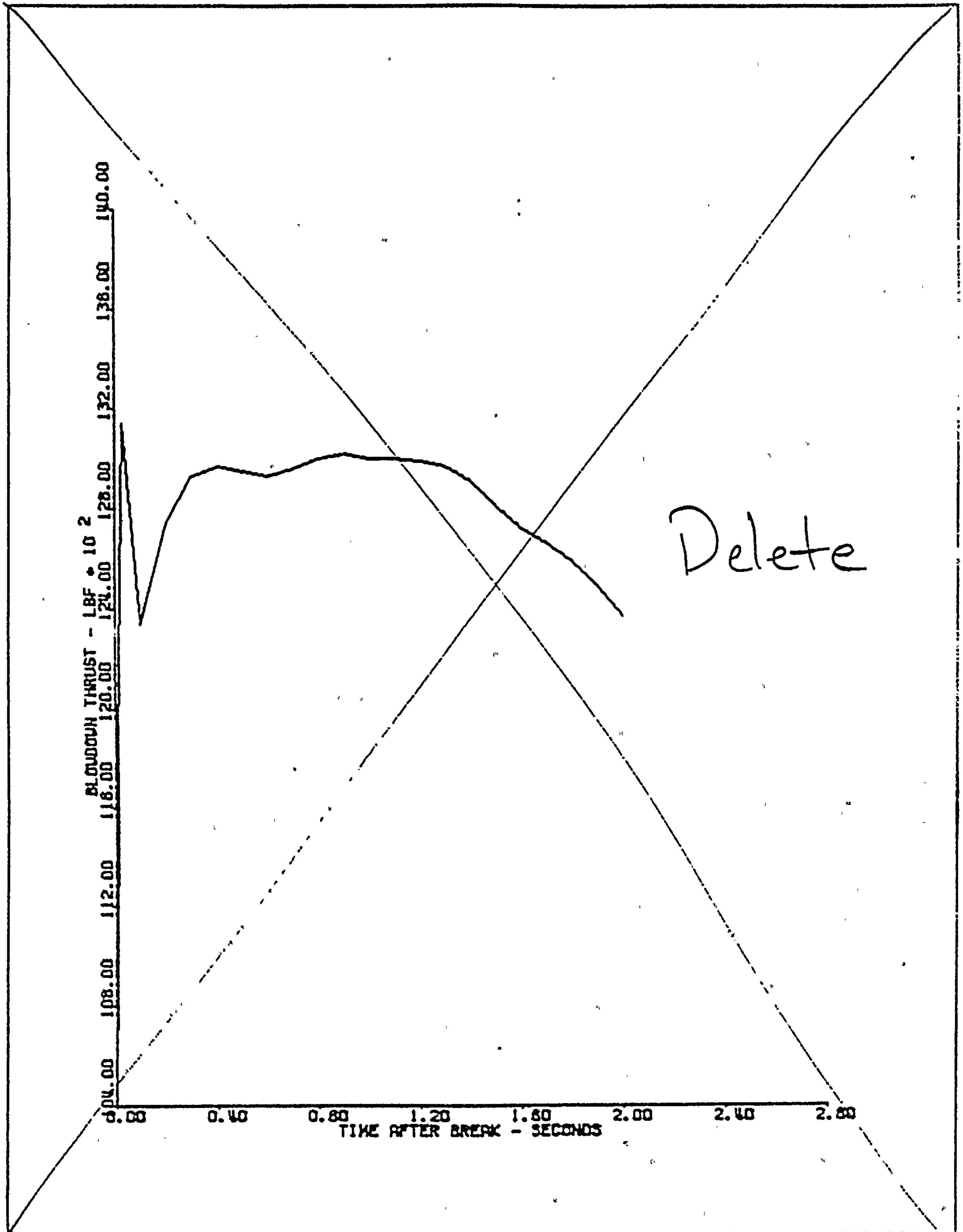
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - TURBINE SIDE OF BREAK ~~30~~ 2	FIGURE 3.6-70



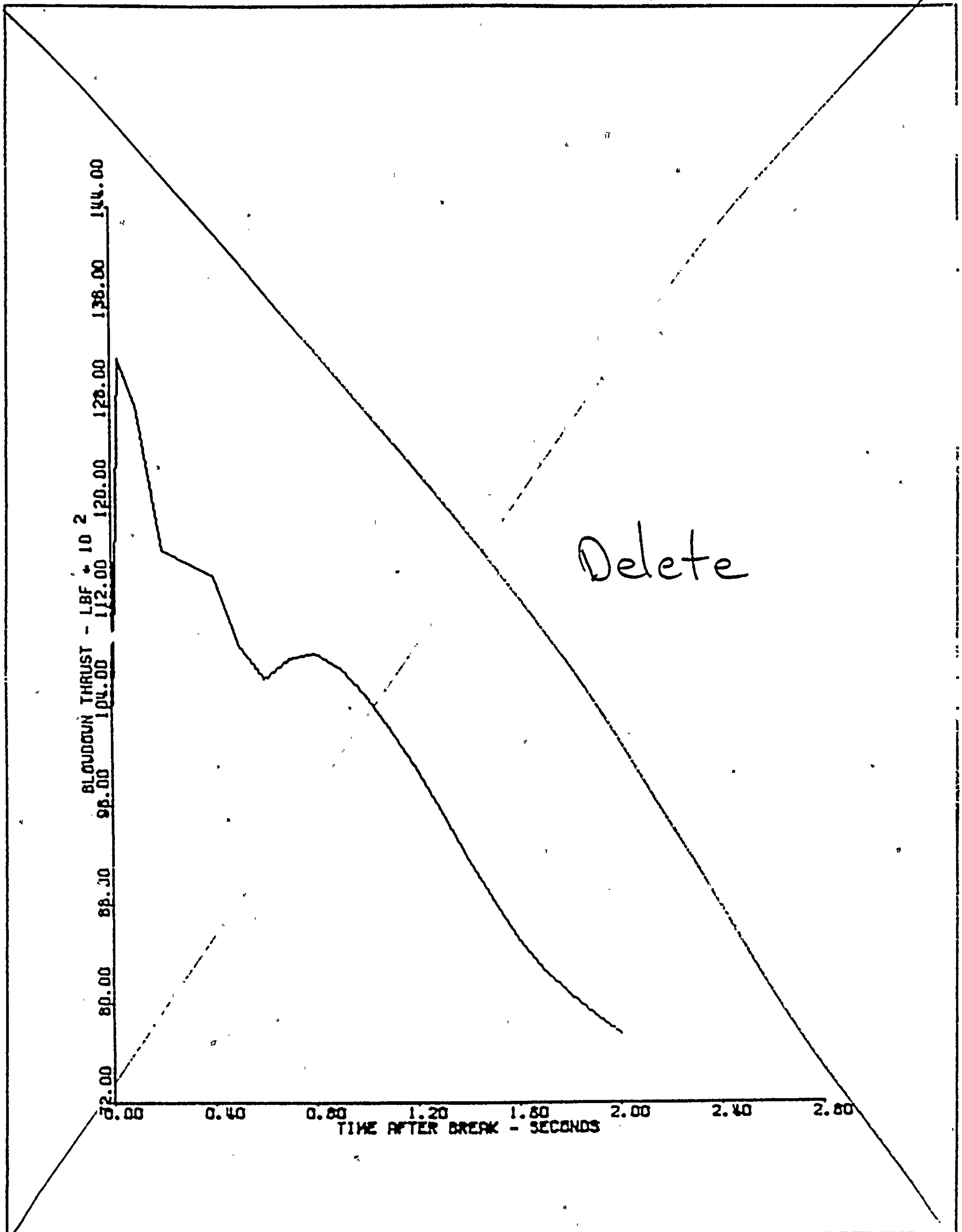
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 37-40, 42-45, 53	FIGURE 3.6-71



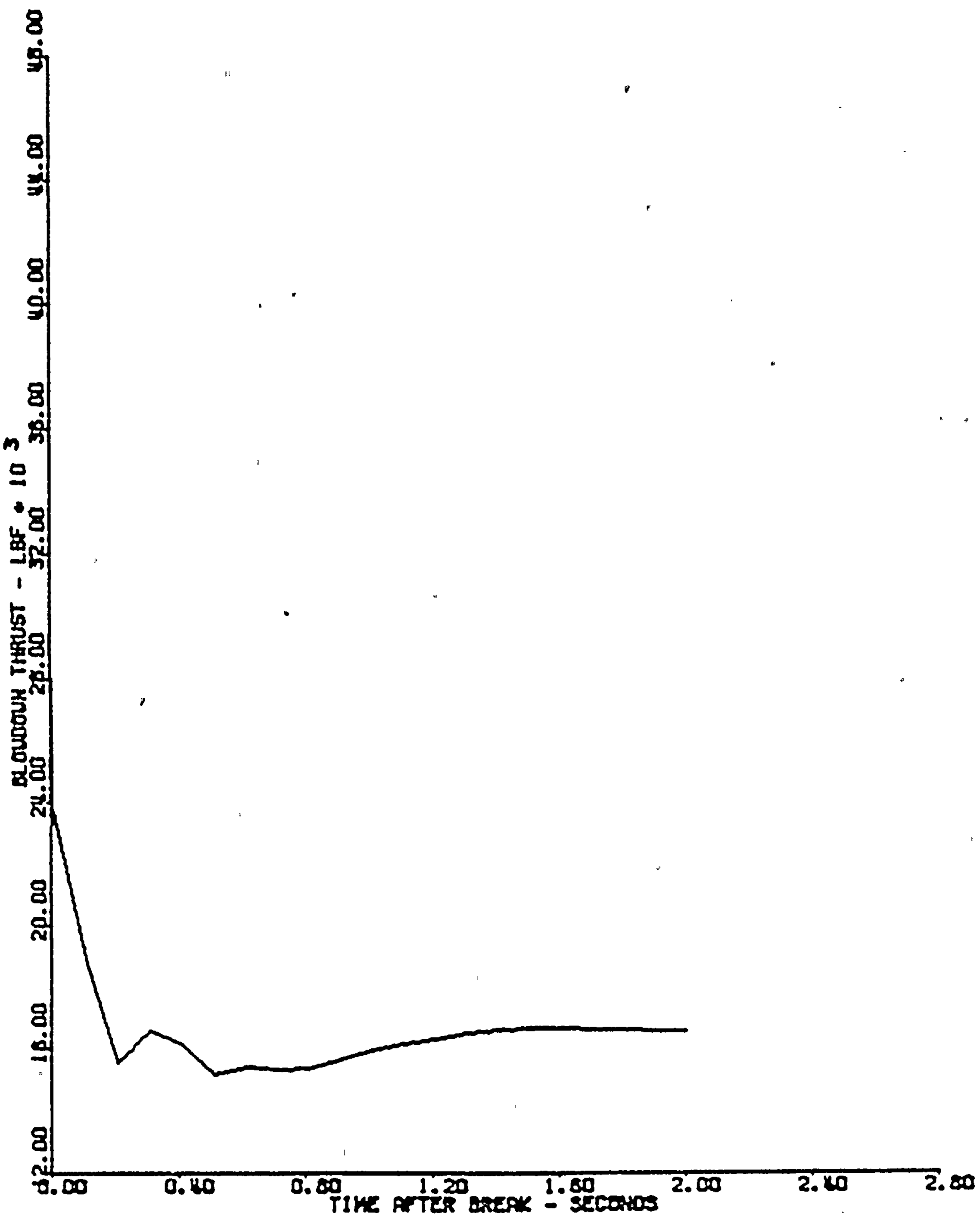
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 37-40, 42-45, 53	FIGURE 3.6-72



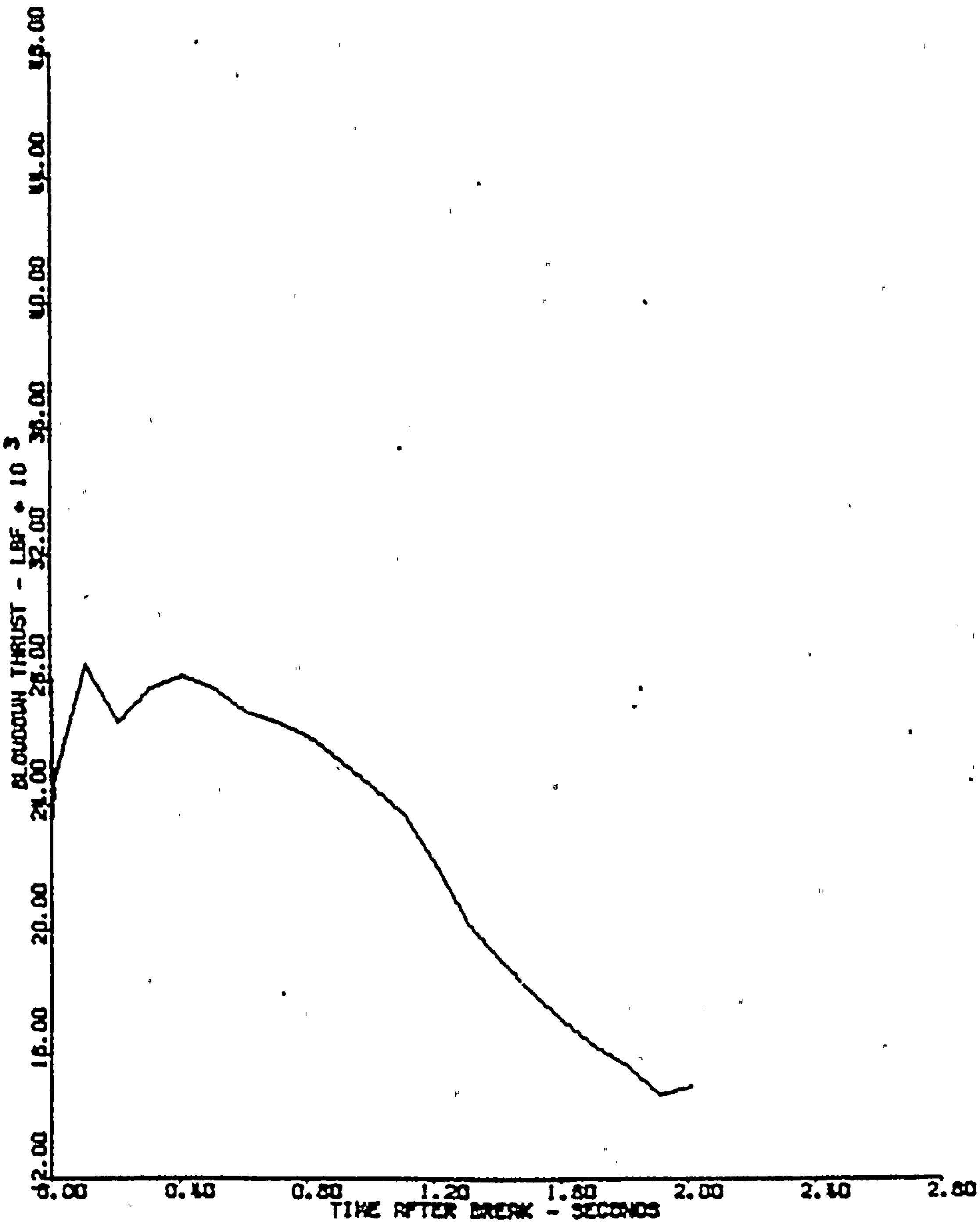
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 36, 41, 46-51	FIGURE 3.6-73



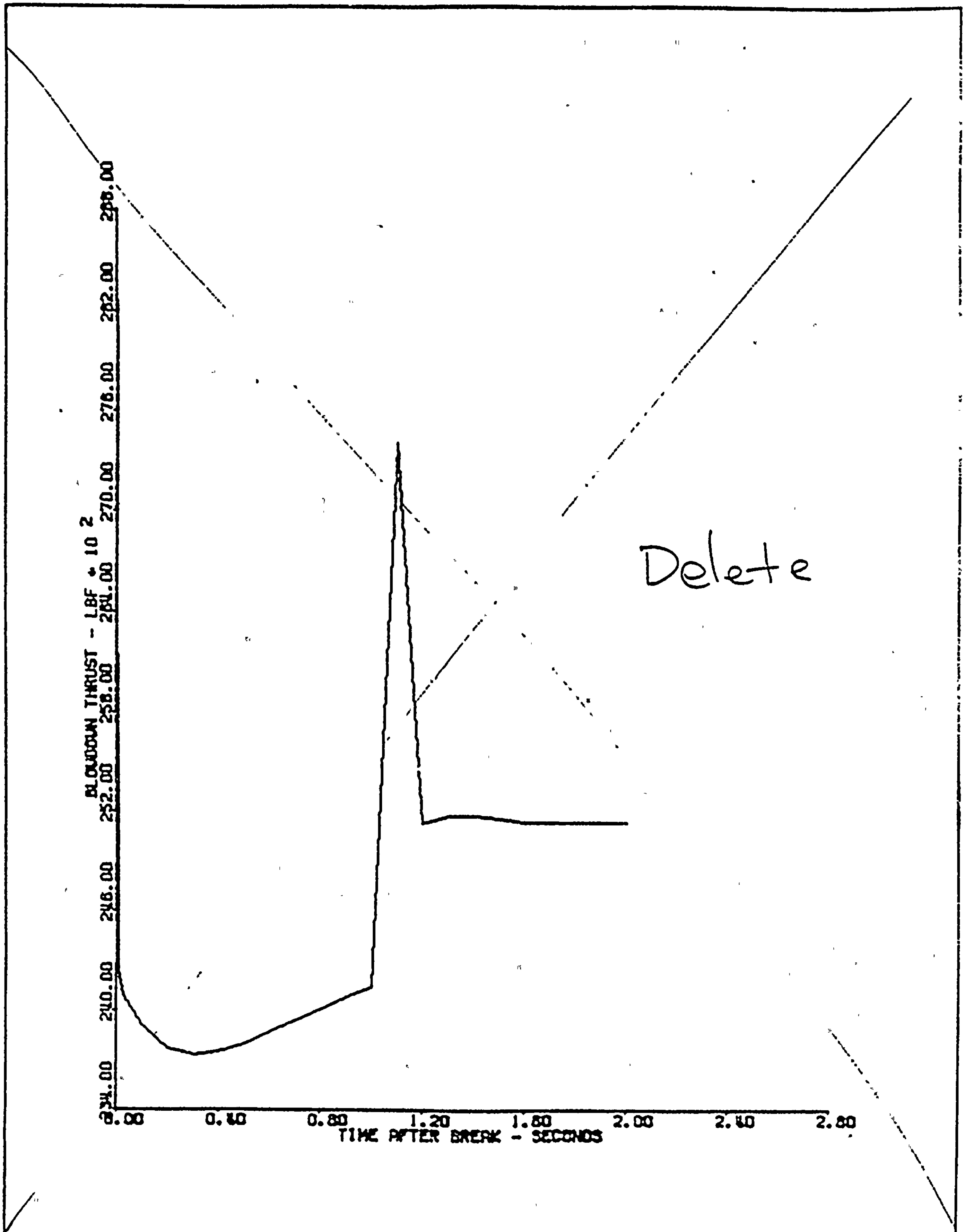
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 36, 41, 46-51	FIGURE 3.6-74



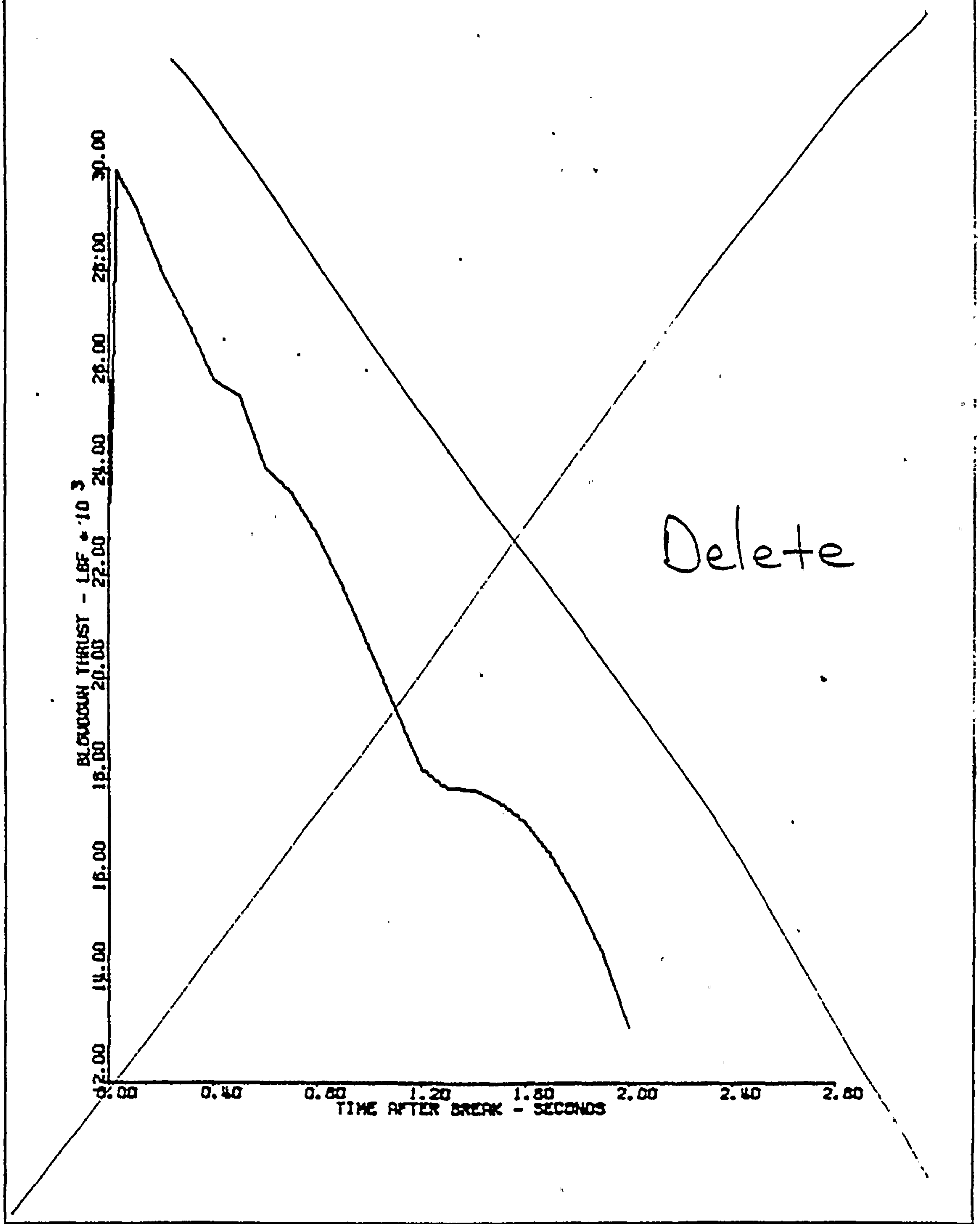
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAK ~~52~~ 12	FIGURE 3.6-75



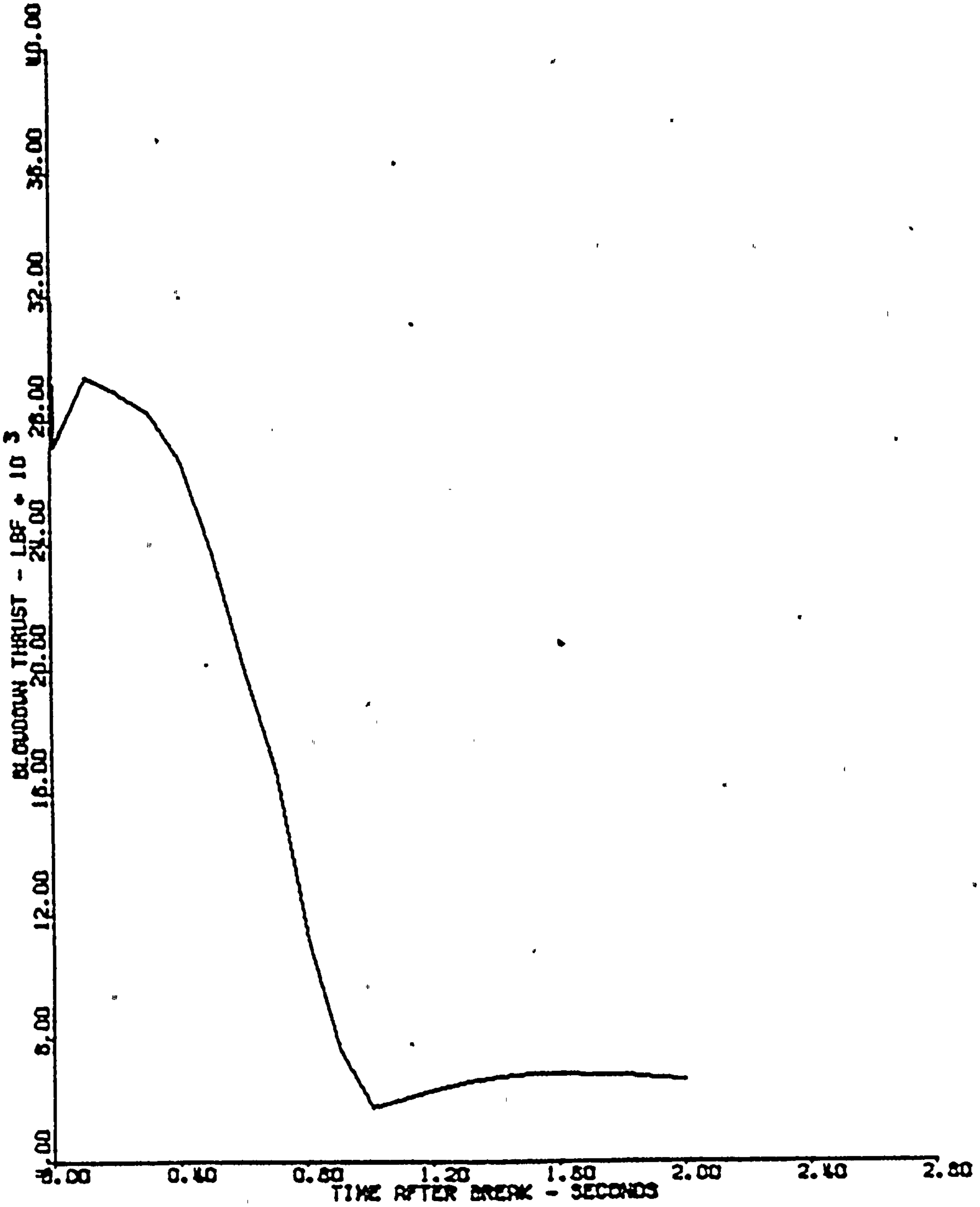
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK ~~52~~ 12	FIGURE 3.6-76



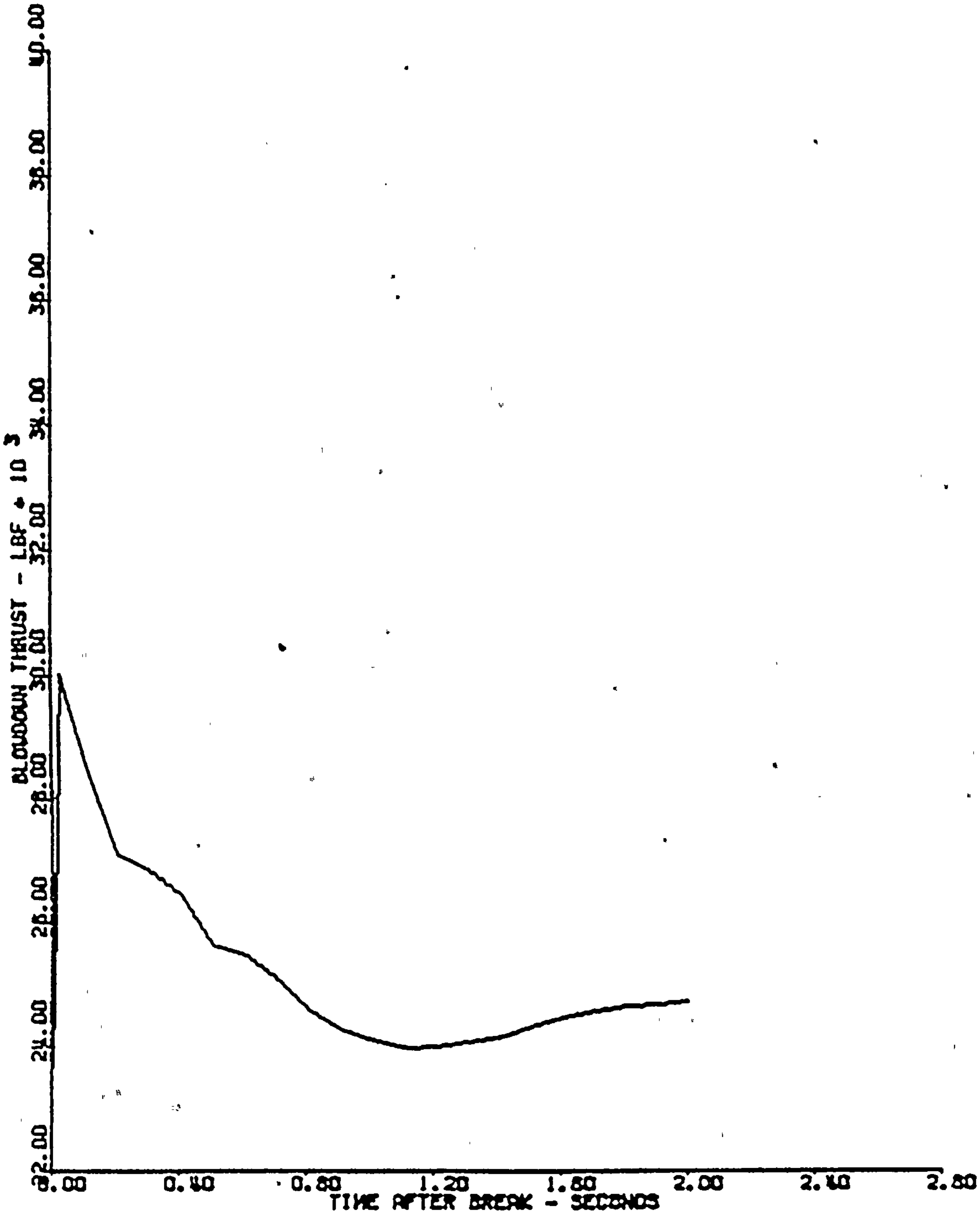
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME- UPSTREAM SIDE OF BREAK 54	FIGURE 3.6-77



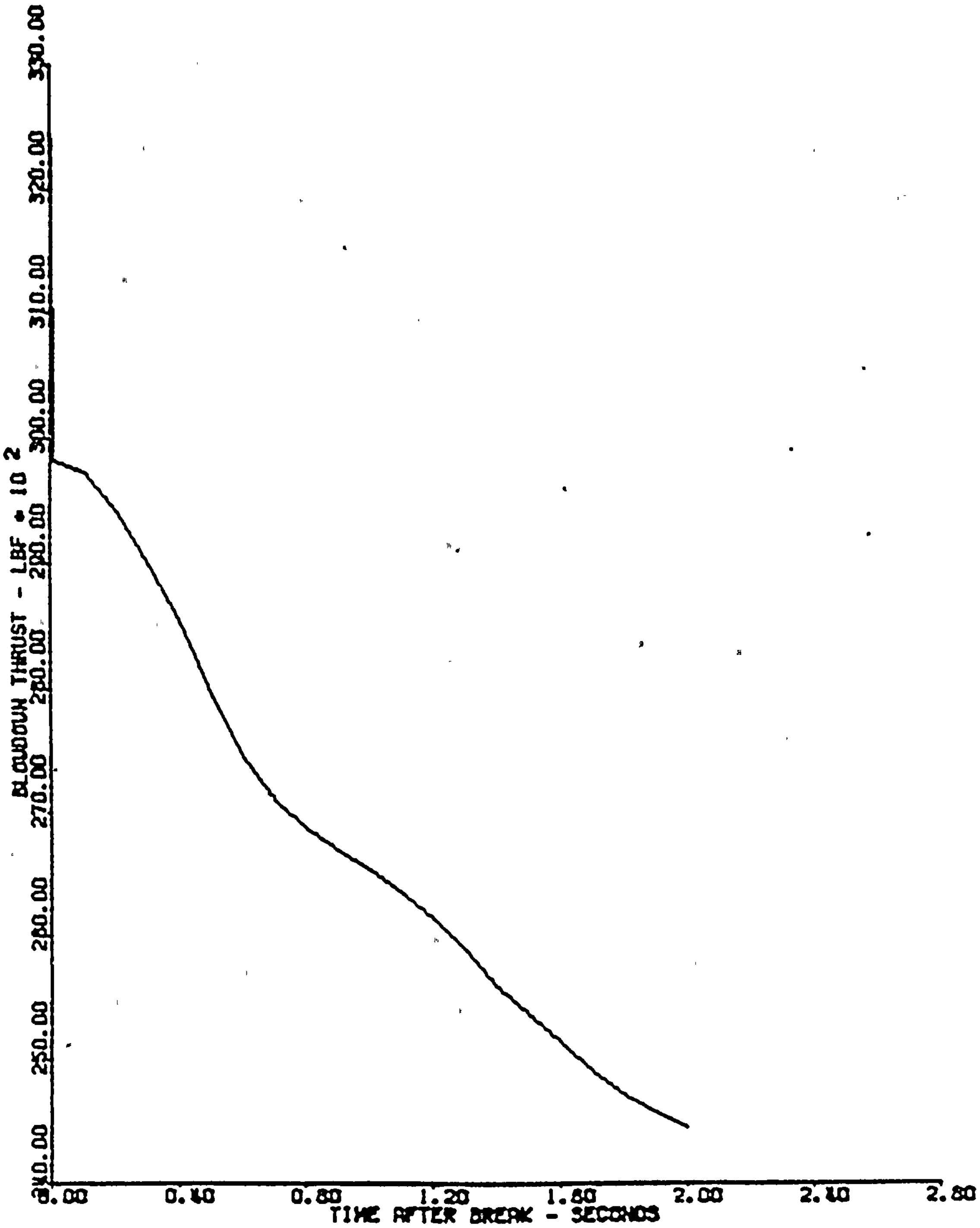
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK 54	FIGURE 3.6-78



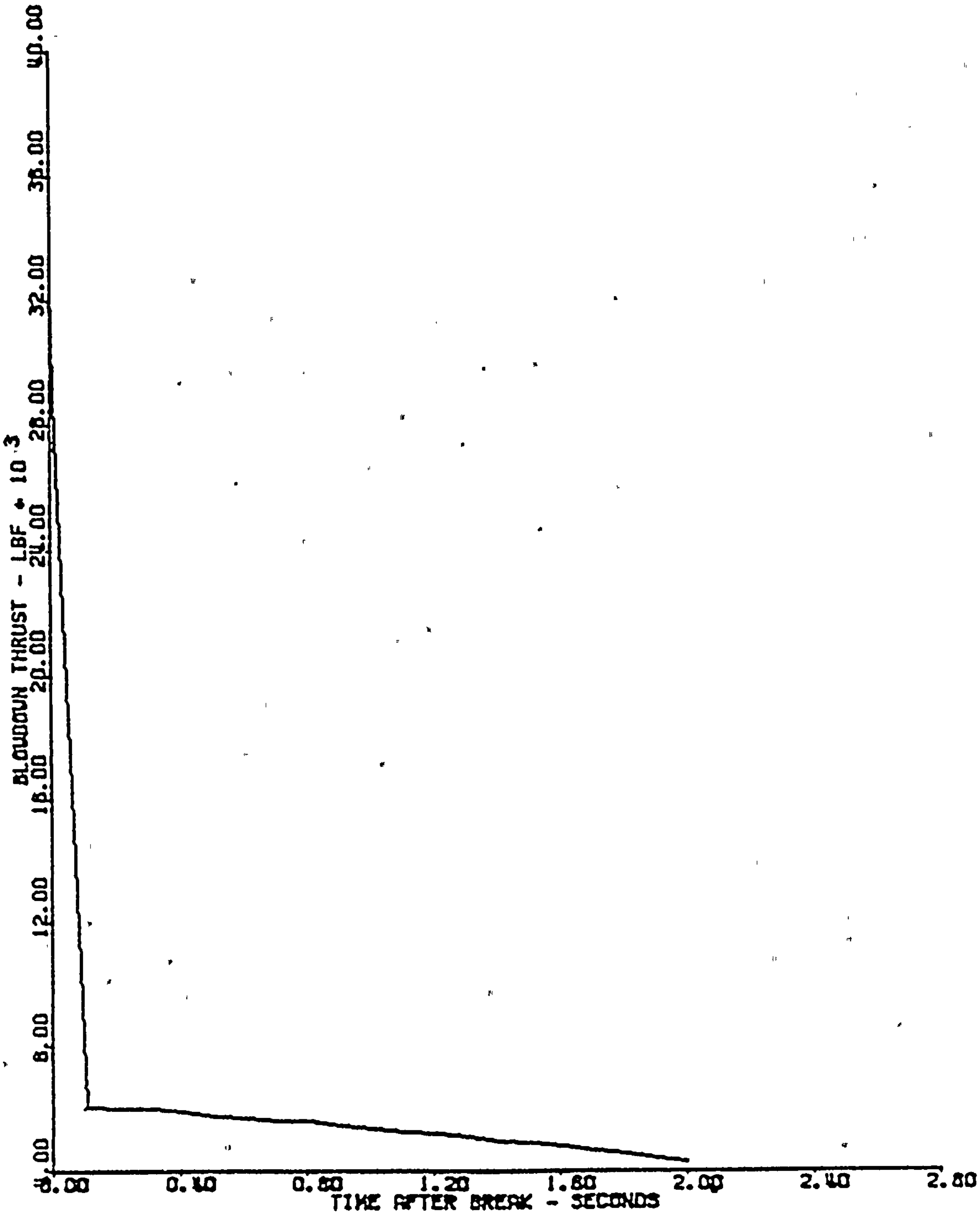
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - HEAT EXCHANGER SIDE OF BREAKS ~~10, 55-57~~ 11	FIGURE 3.6-79



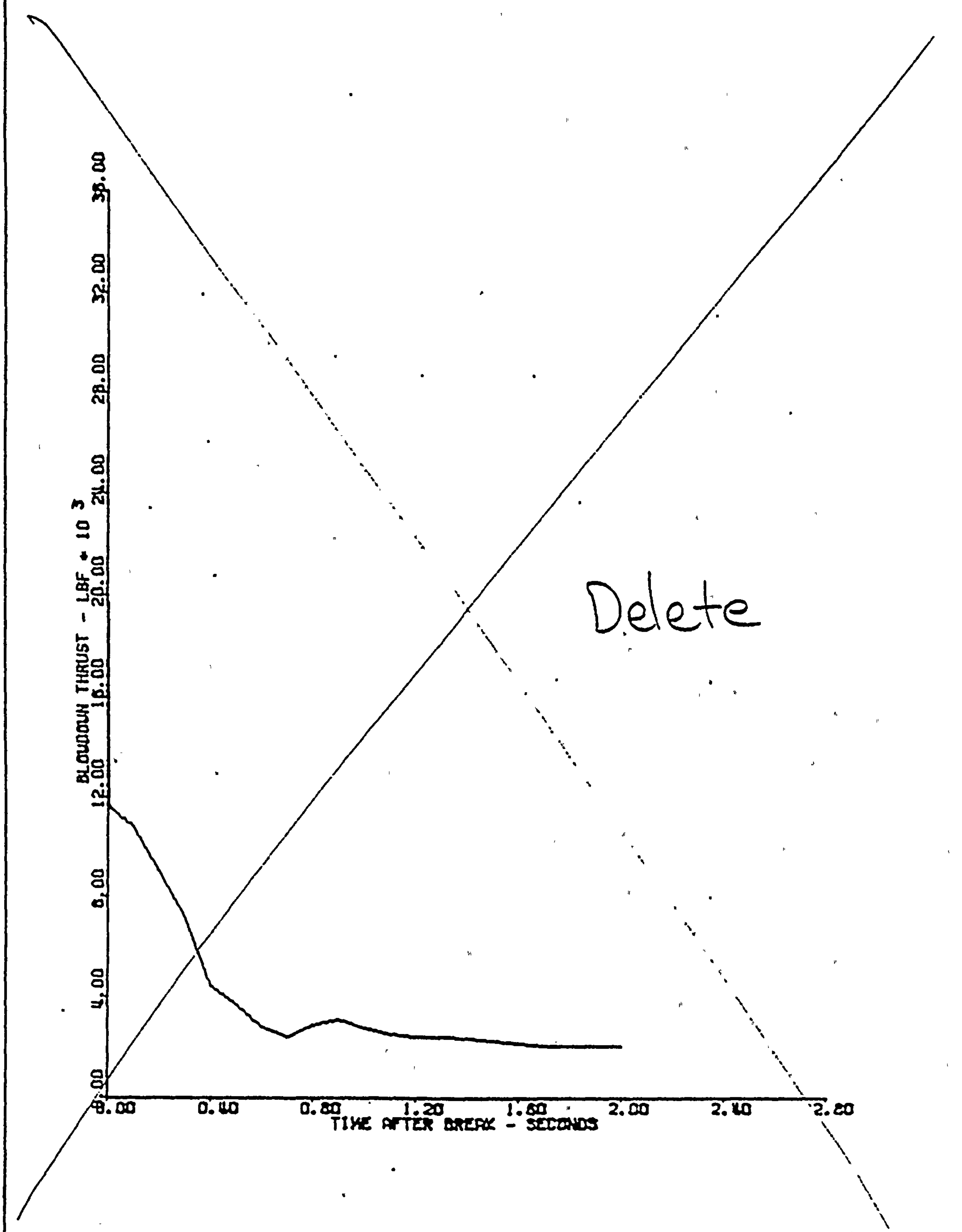
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - PUMP SIDE OF BREAKS ~~10,55-57~~ 11	FIGURE 3.6-80



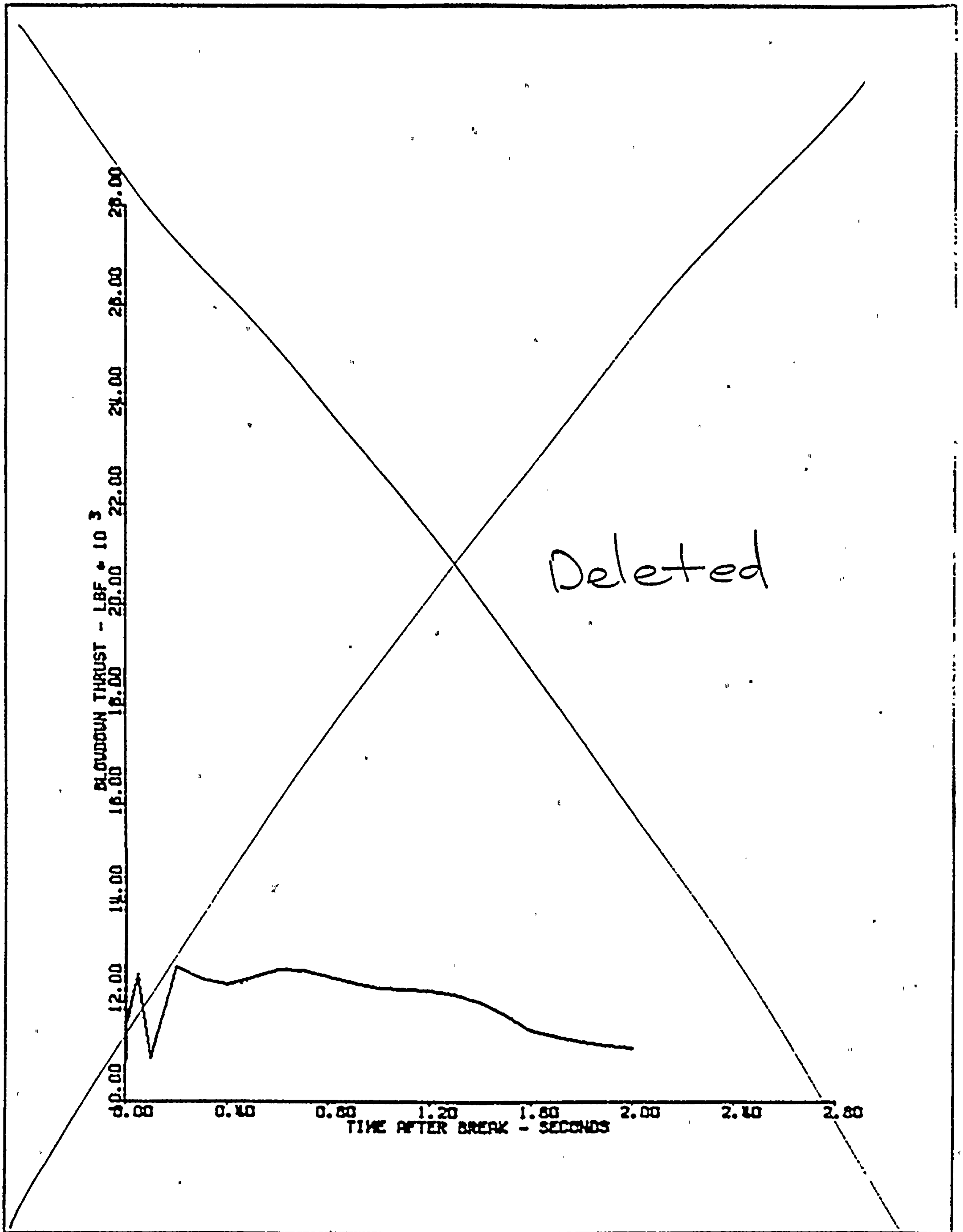
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - PUMP SIDE OF BREAKS ~~12, 15, 58-61~~ 16	FIGURE 3.6-81



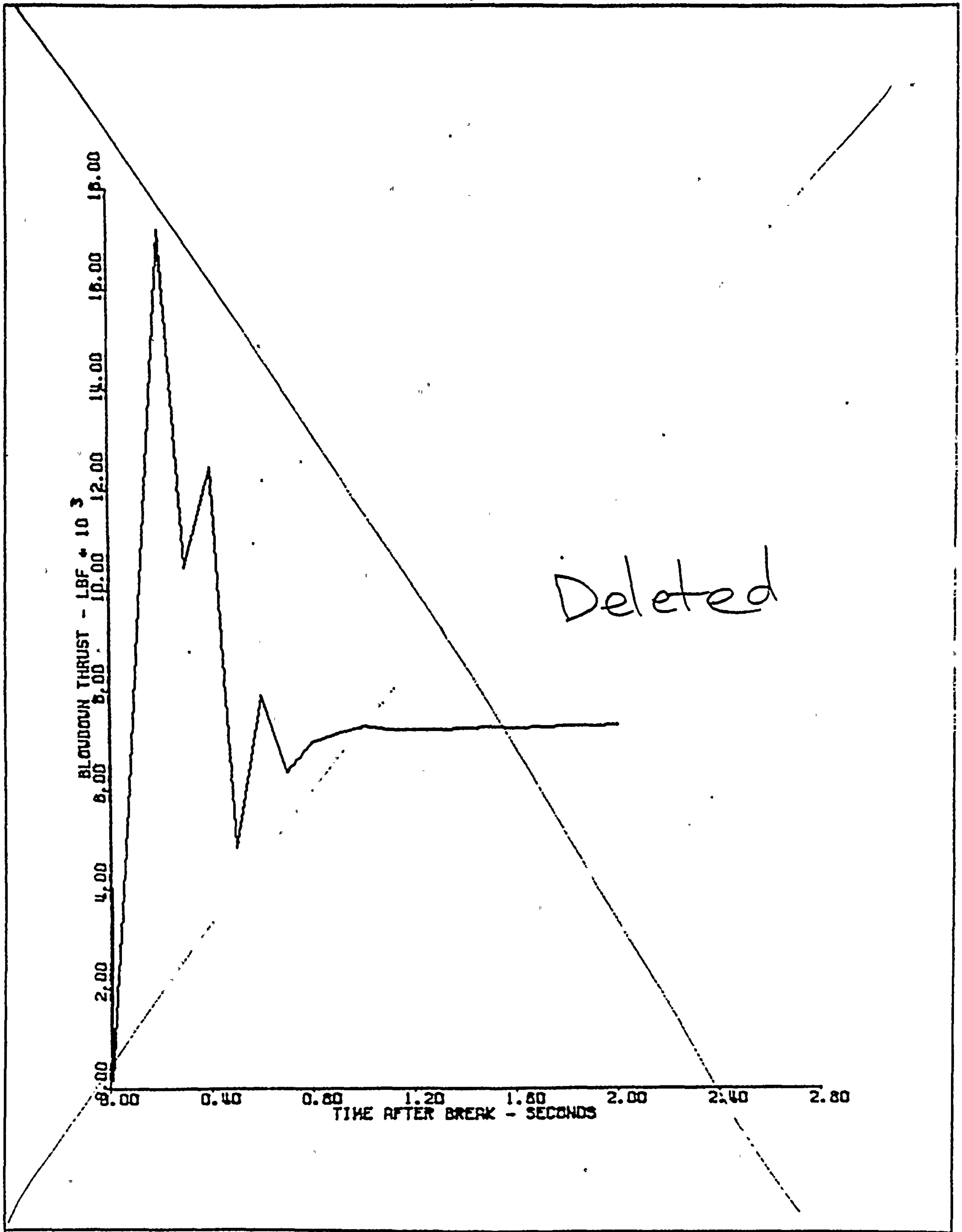
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - HEAT EXCHANGER SIDE OF BREAKS ~~13, 15, 58-61~~ 16	FIGURE 3.6-82



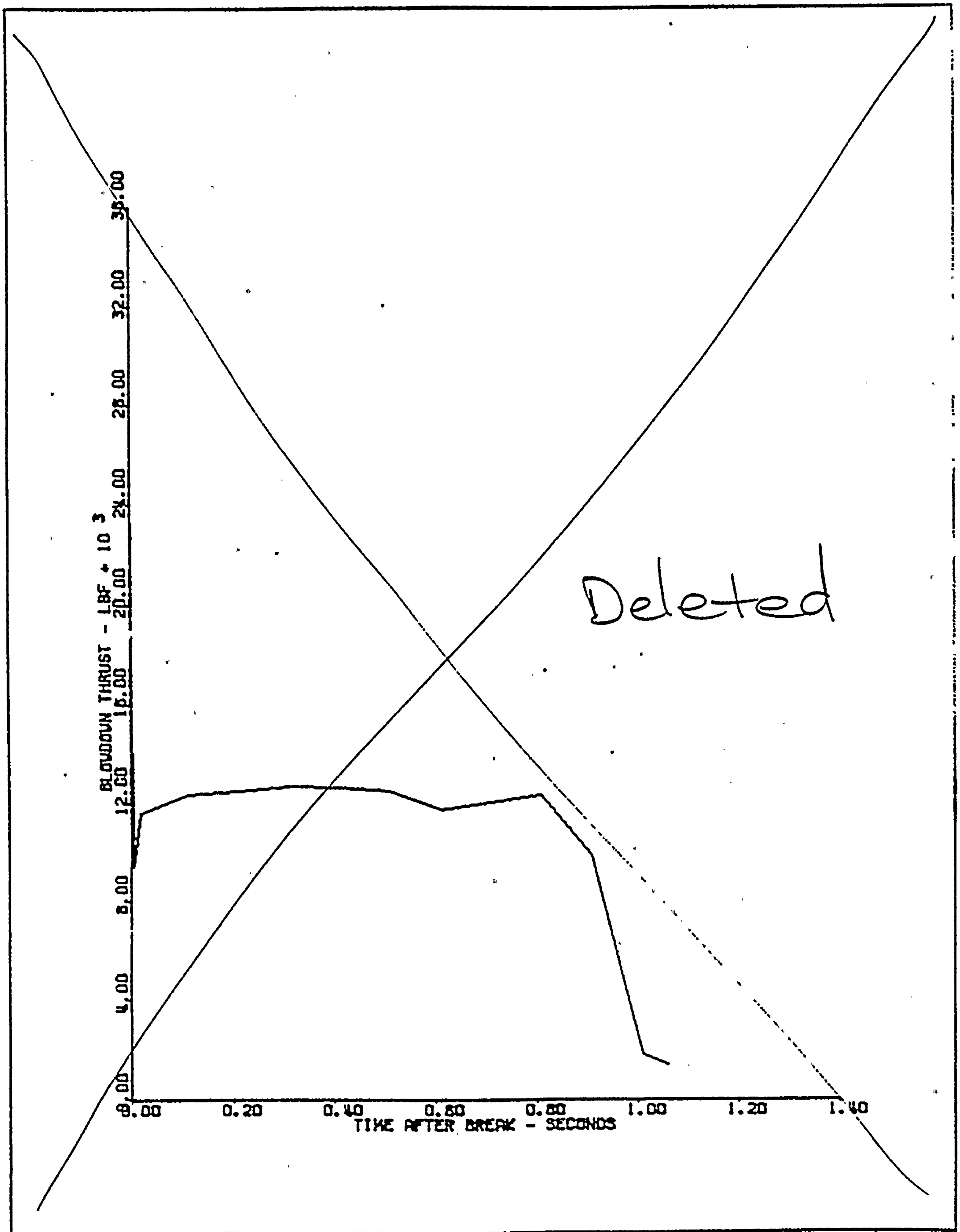
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 62, 63, 66, 67	FIGURE 3.6-83



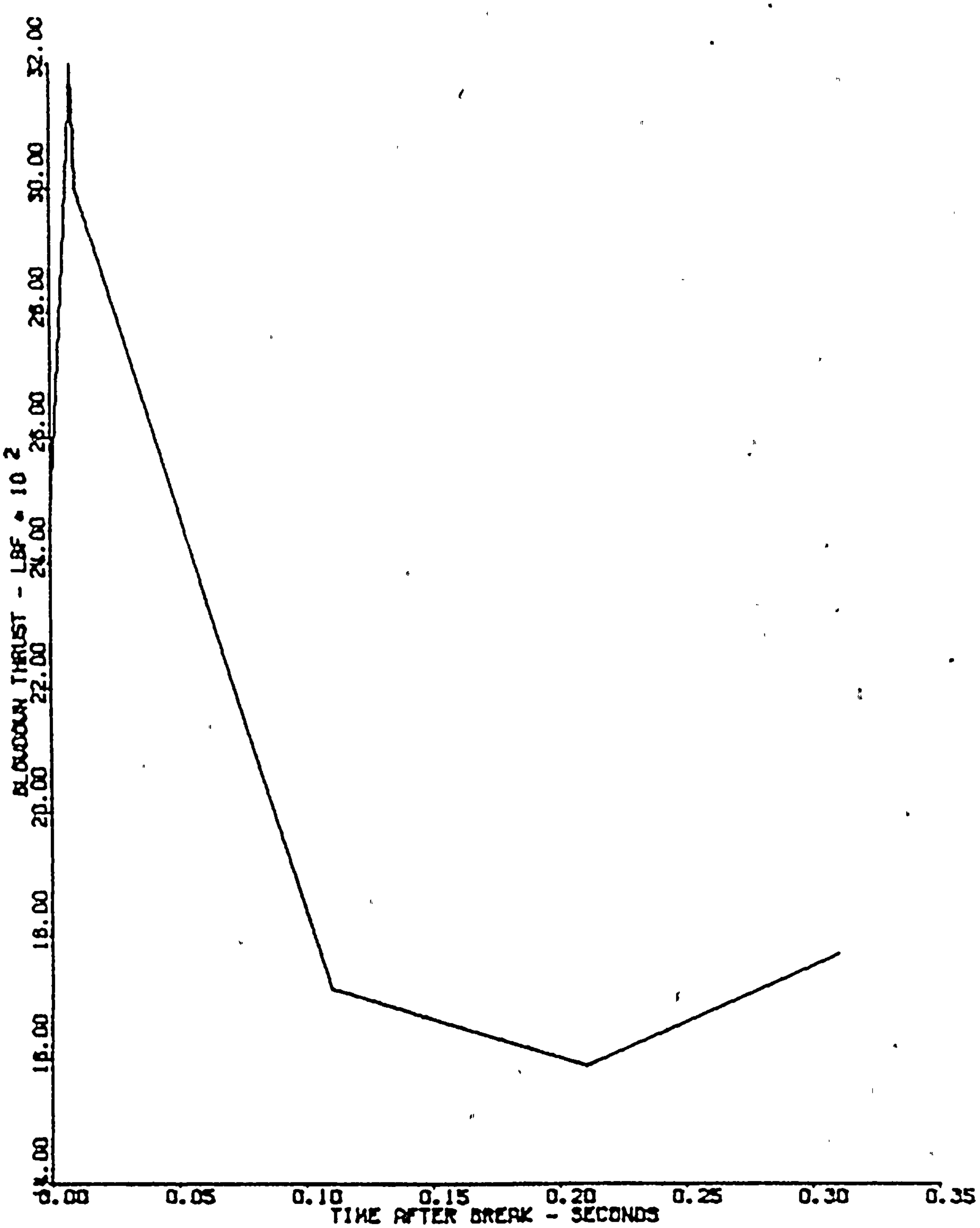
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 62, 63, 66, 67	FIGURE 3.6-84



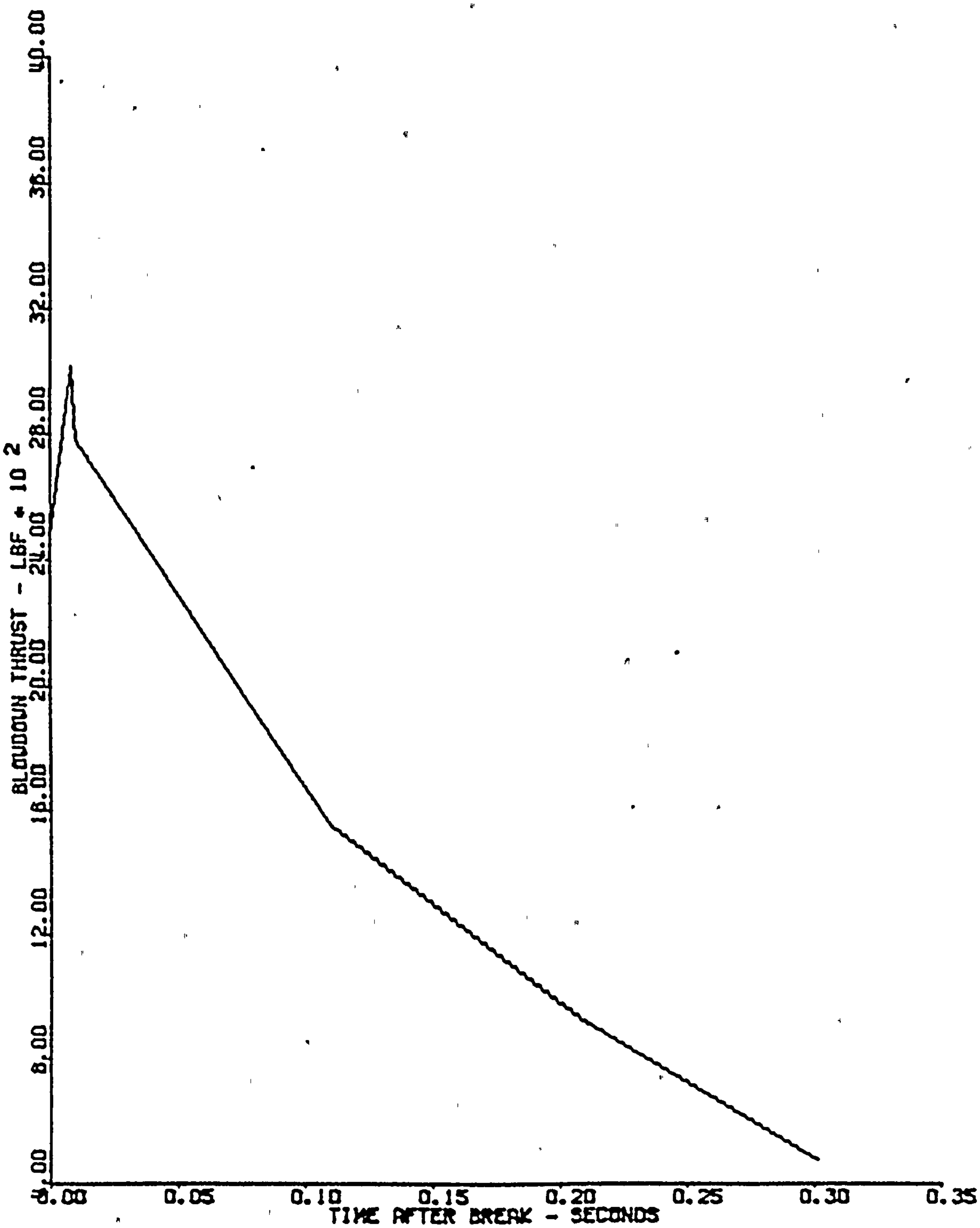
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - BOTH SIDE OF BREAKS 64, 65	FIGURE 3.6-85



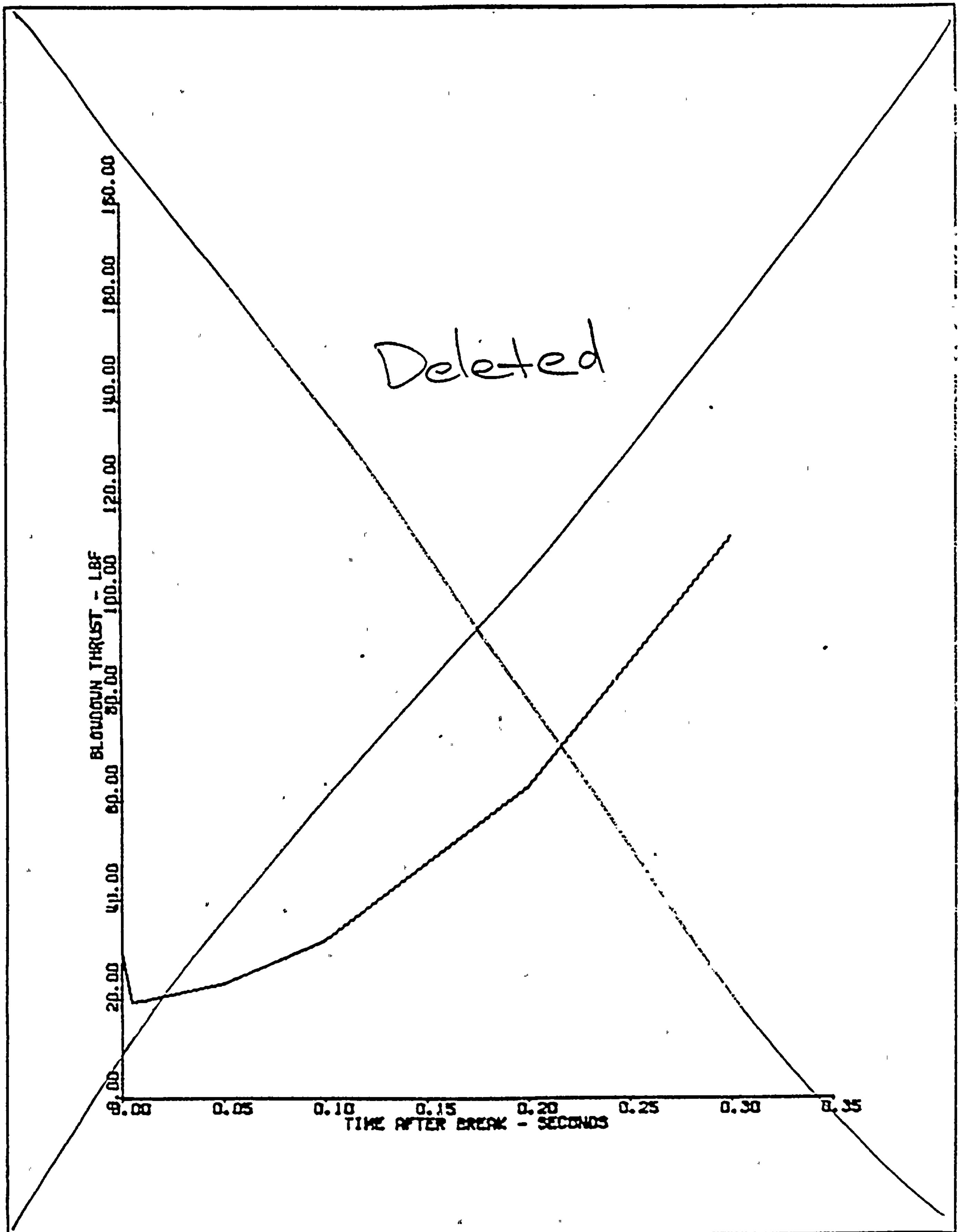
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 9, 14, 31, 34, 35, 68-70	FIGURE 3.6-86



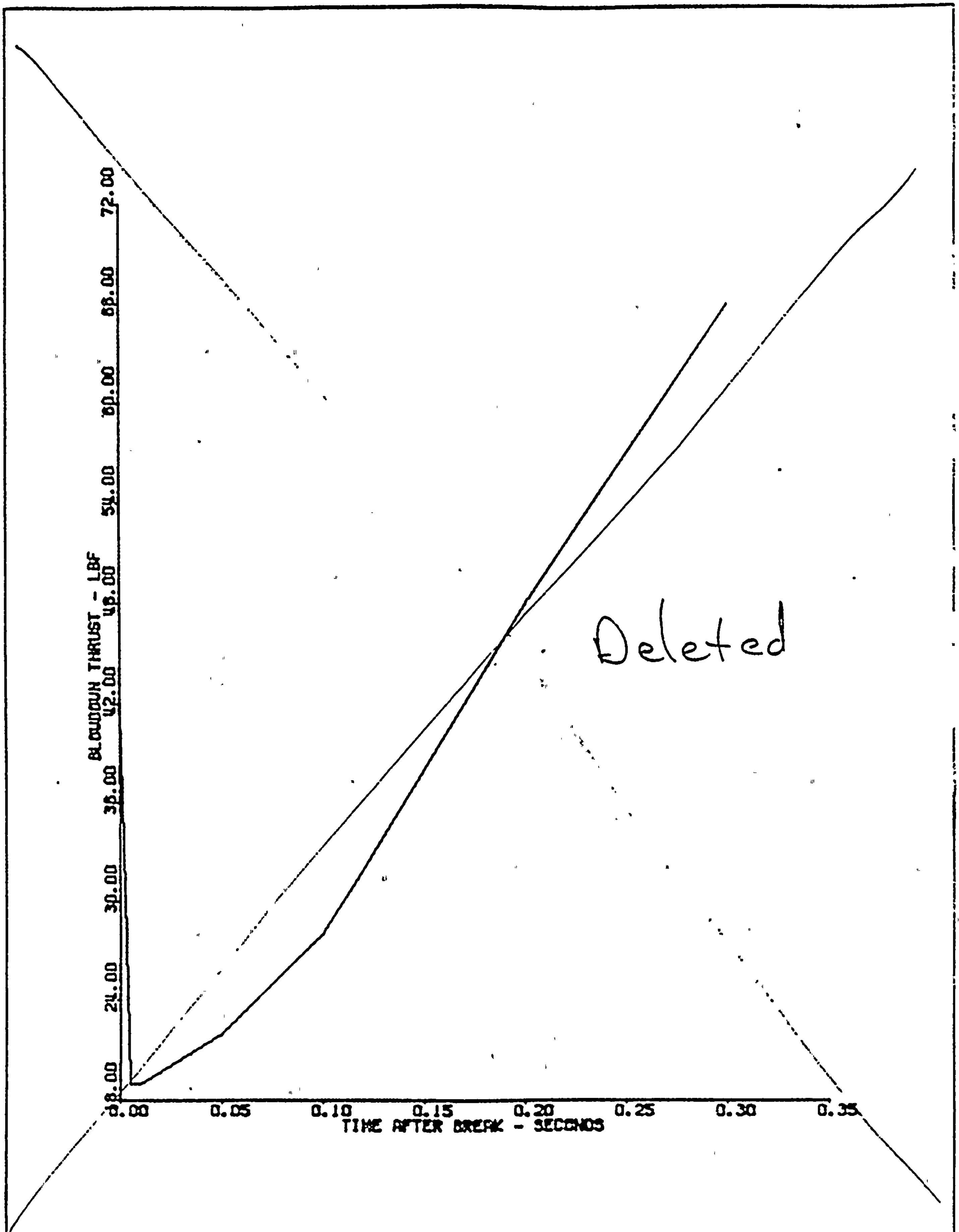
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAK ~~1, 5, 71~~, 82 ~~73, 76, 79C, 101~~	FIGURE 3.6-87



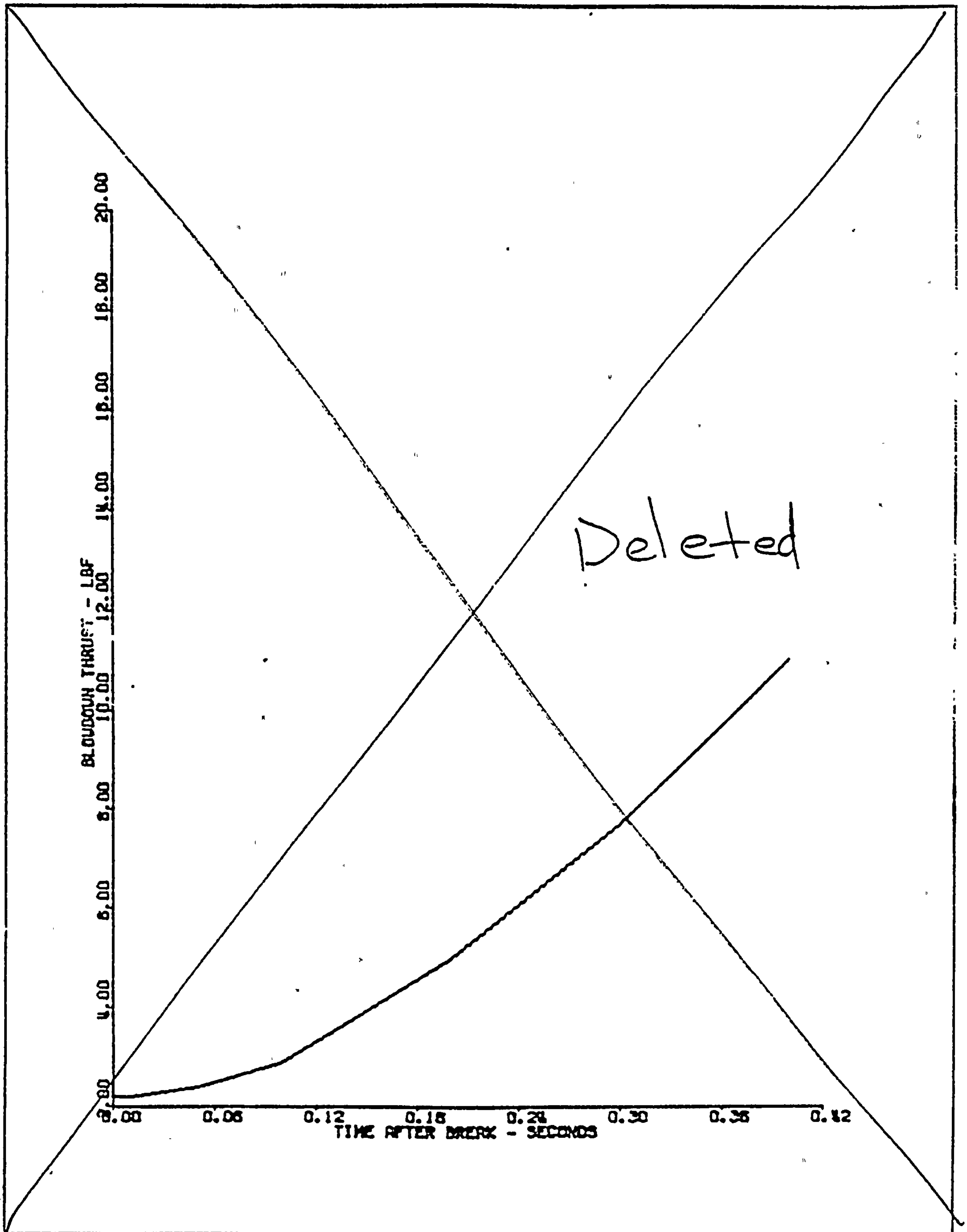
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK ~~S 1, 5, 71, 73, 76, 79C, 101~~ 82	FIGURE 3.6-88



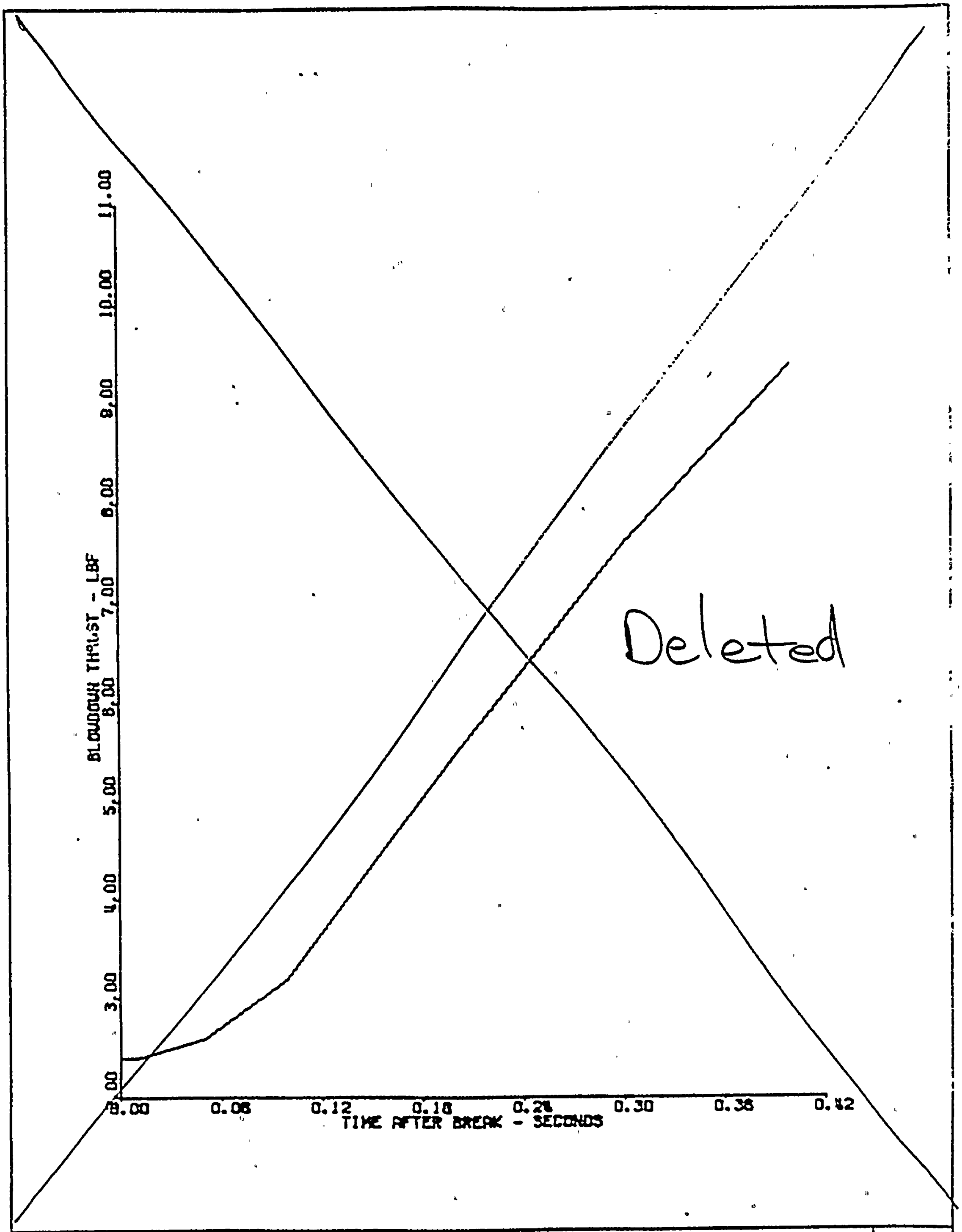
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 72, 74, 75	FIGURE 3.6-89



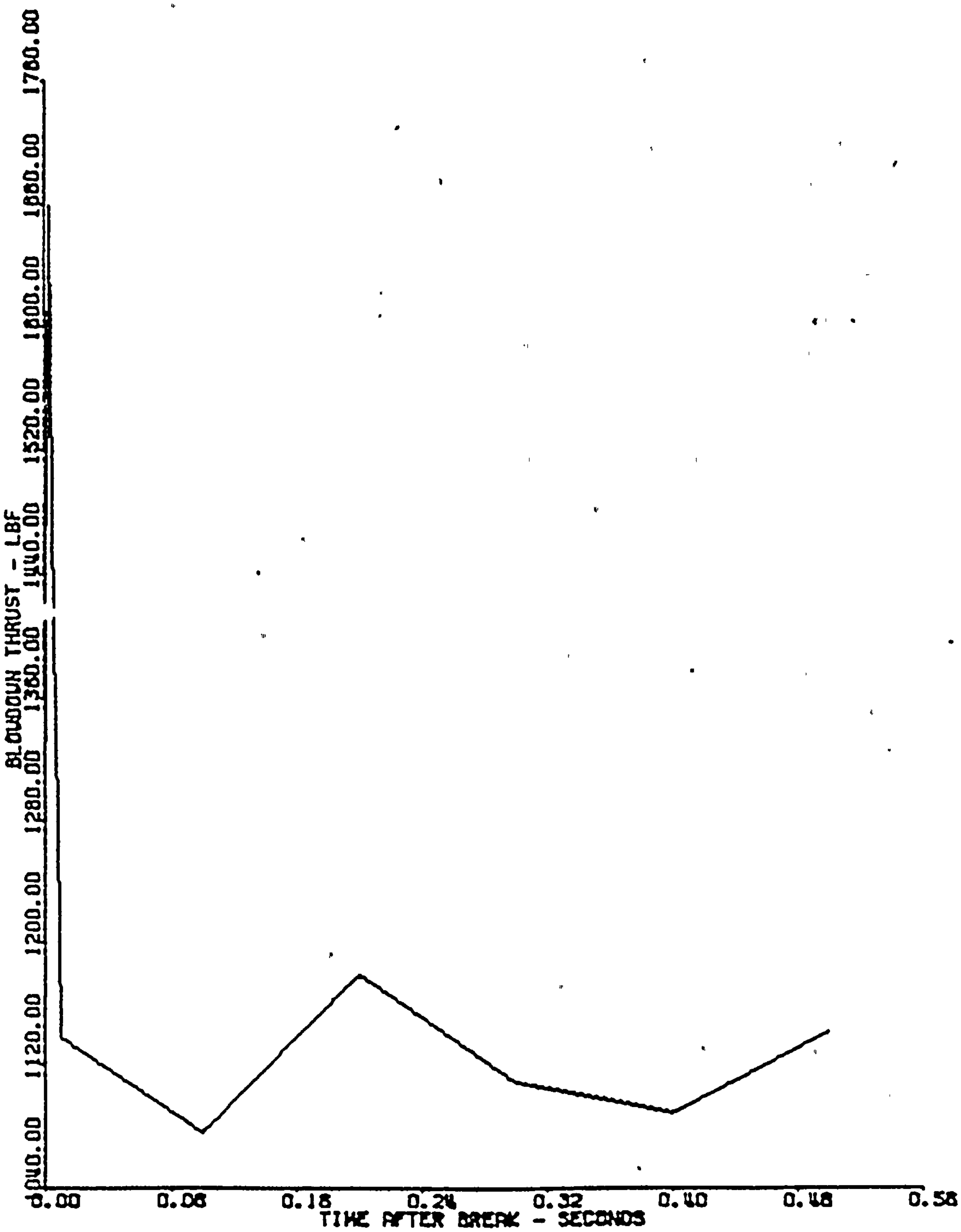
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 72, 74, 75	FIGURE 3.6-90



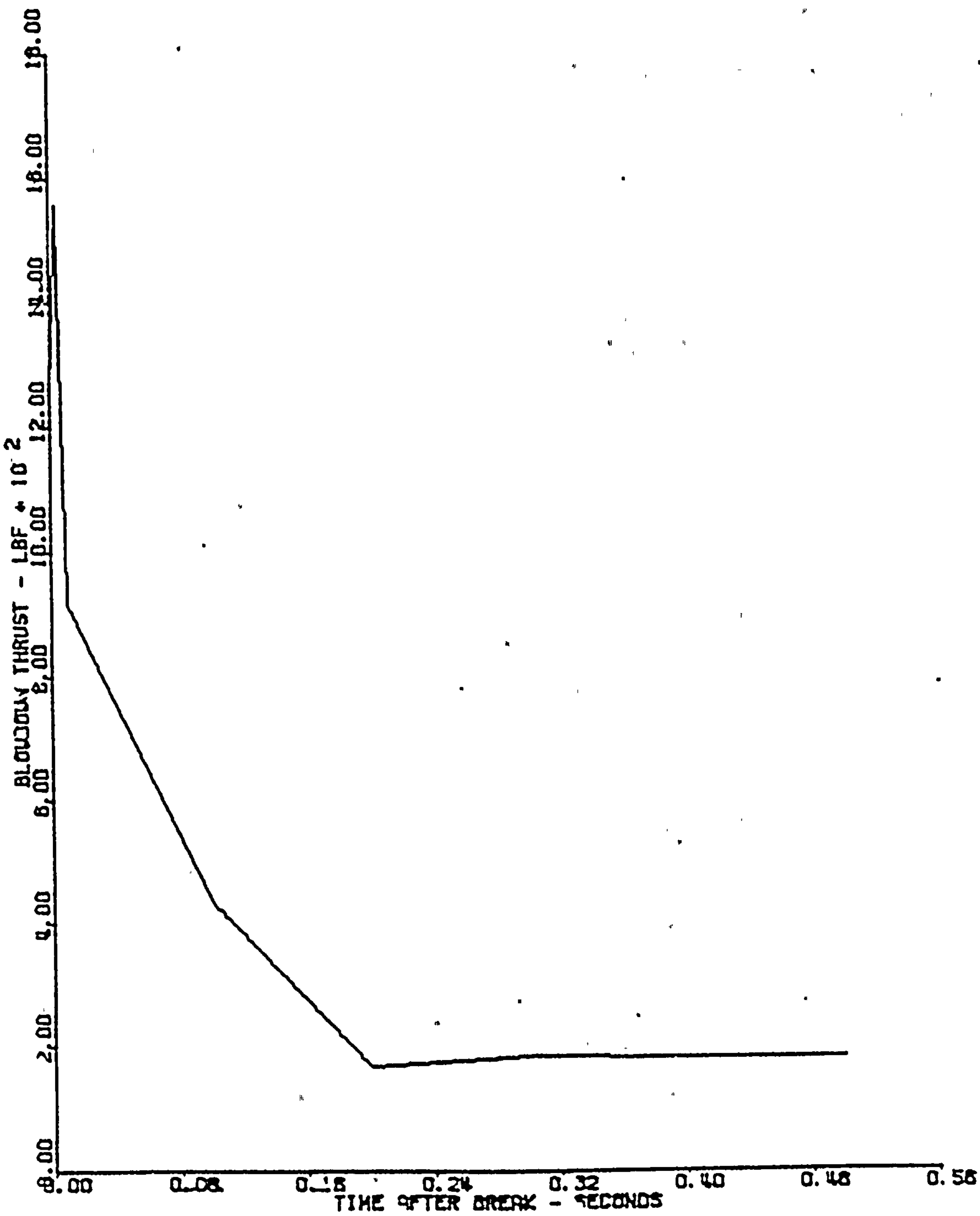
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 78, 79A, 80	FIGURE 3.6-91



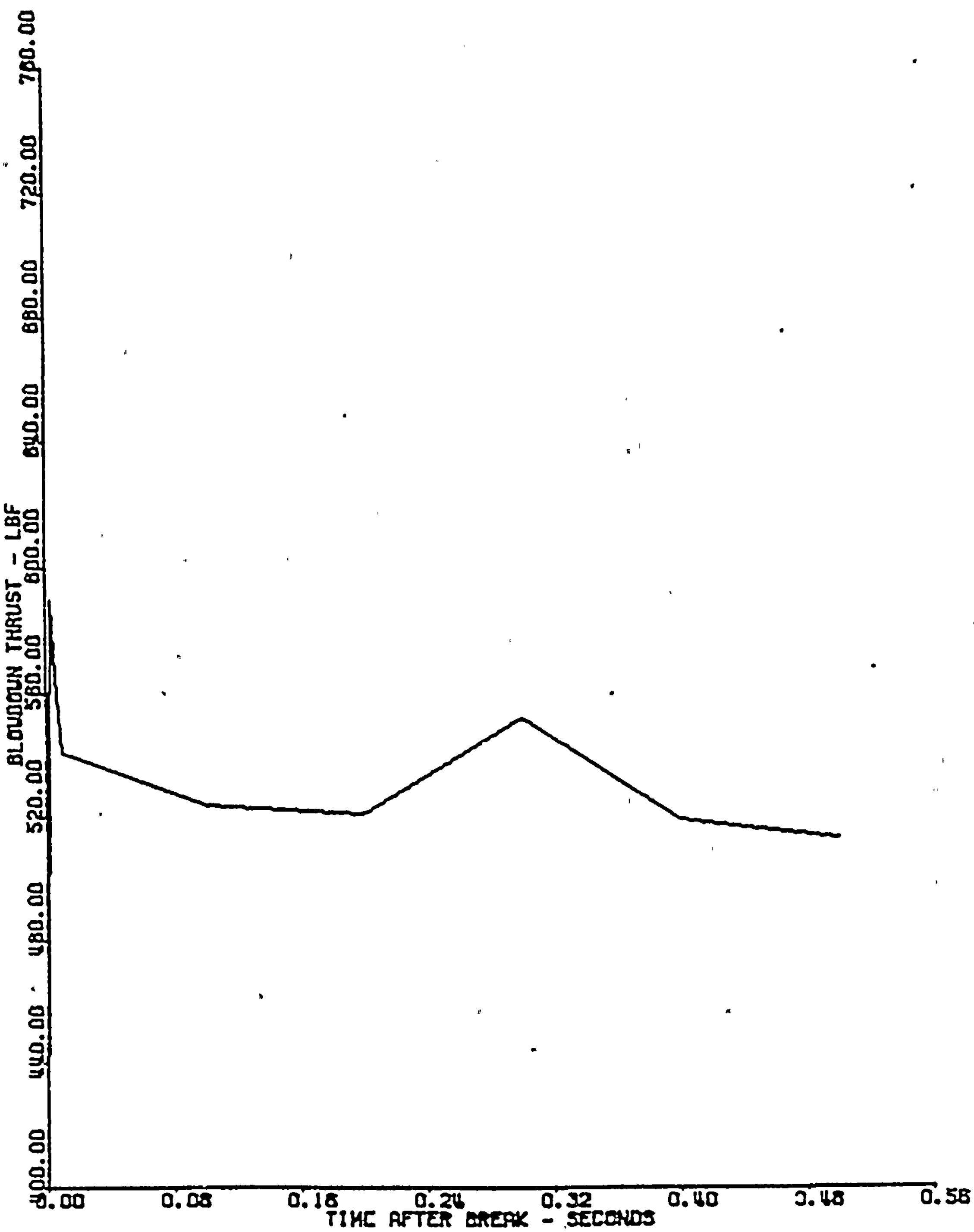
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 78, 79A, 80	FIGURE 3.6-92



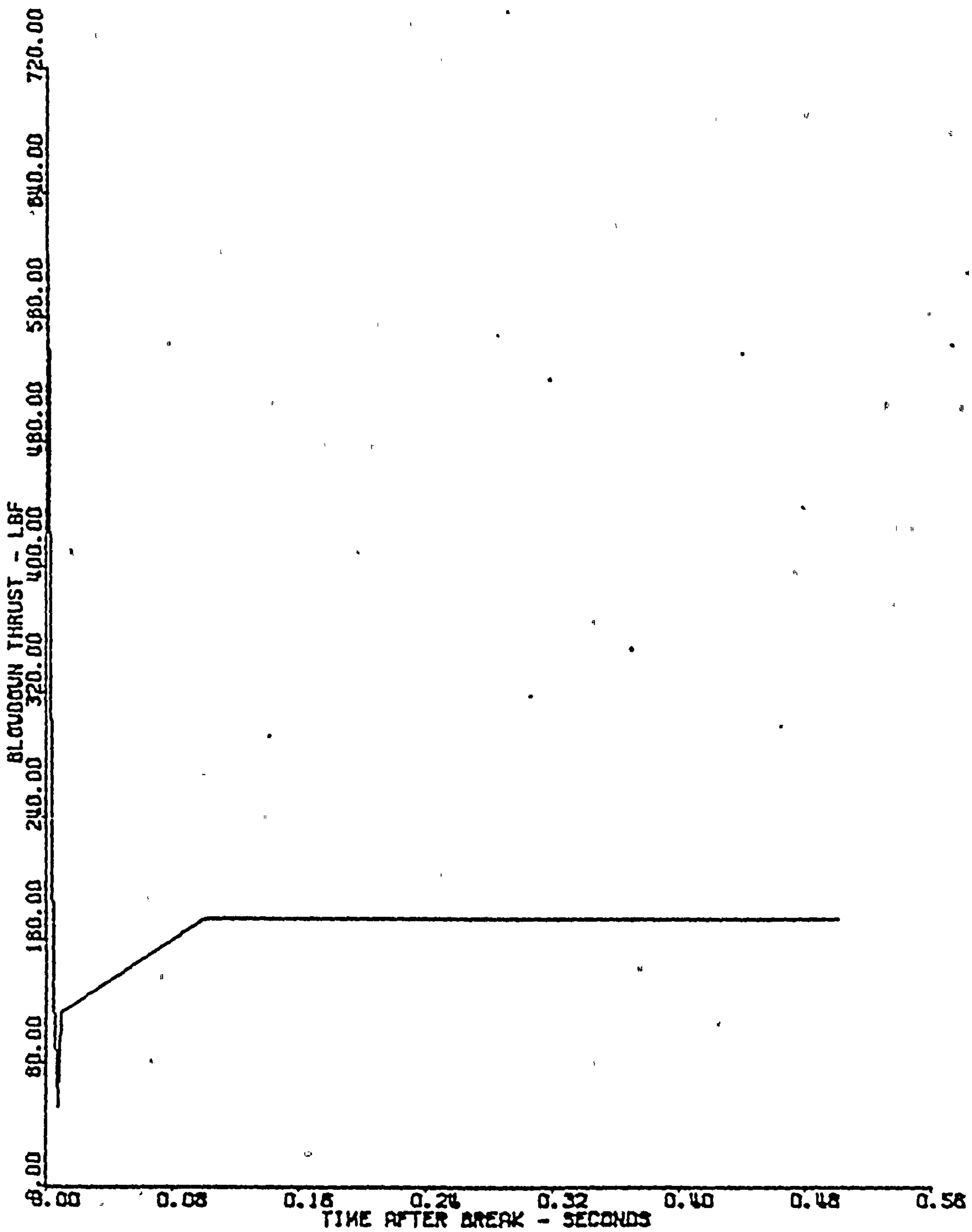
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS ~~77, 79B, 81-84~~ 42	FIGURE 3.6-93



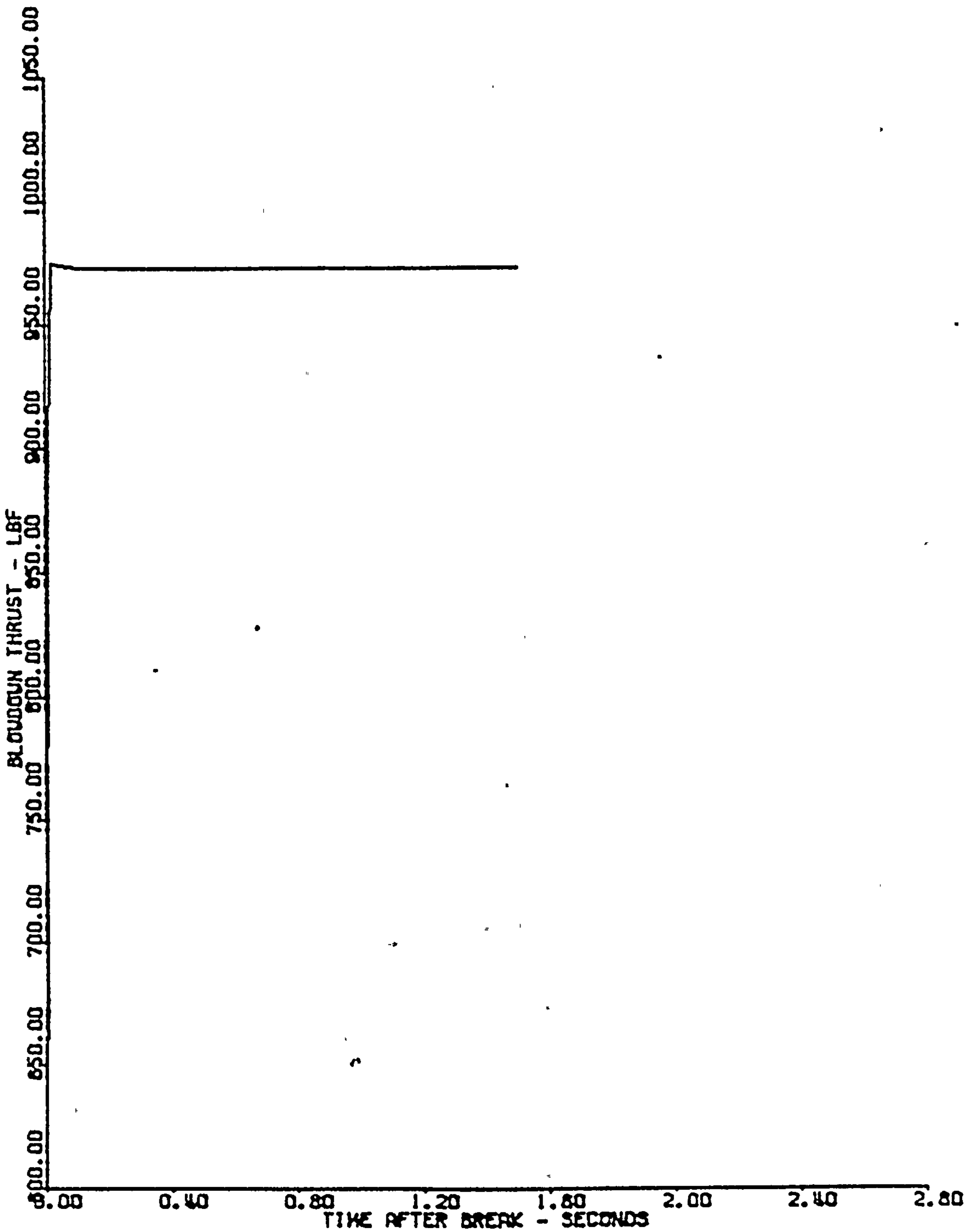
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS ~~77, 79B, 81-84~~ 42	FIGURE 3.6-94



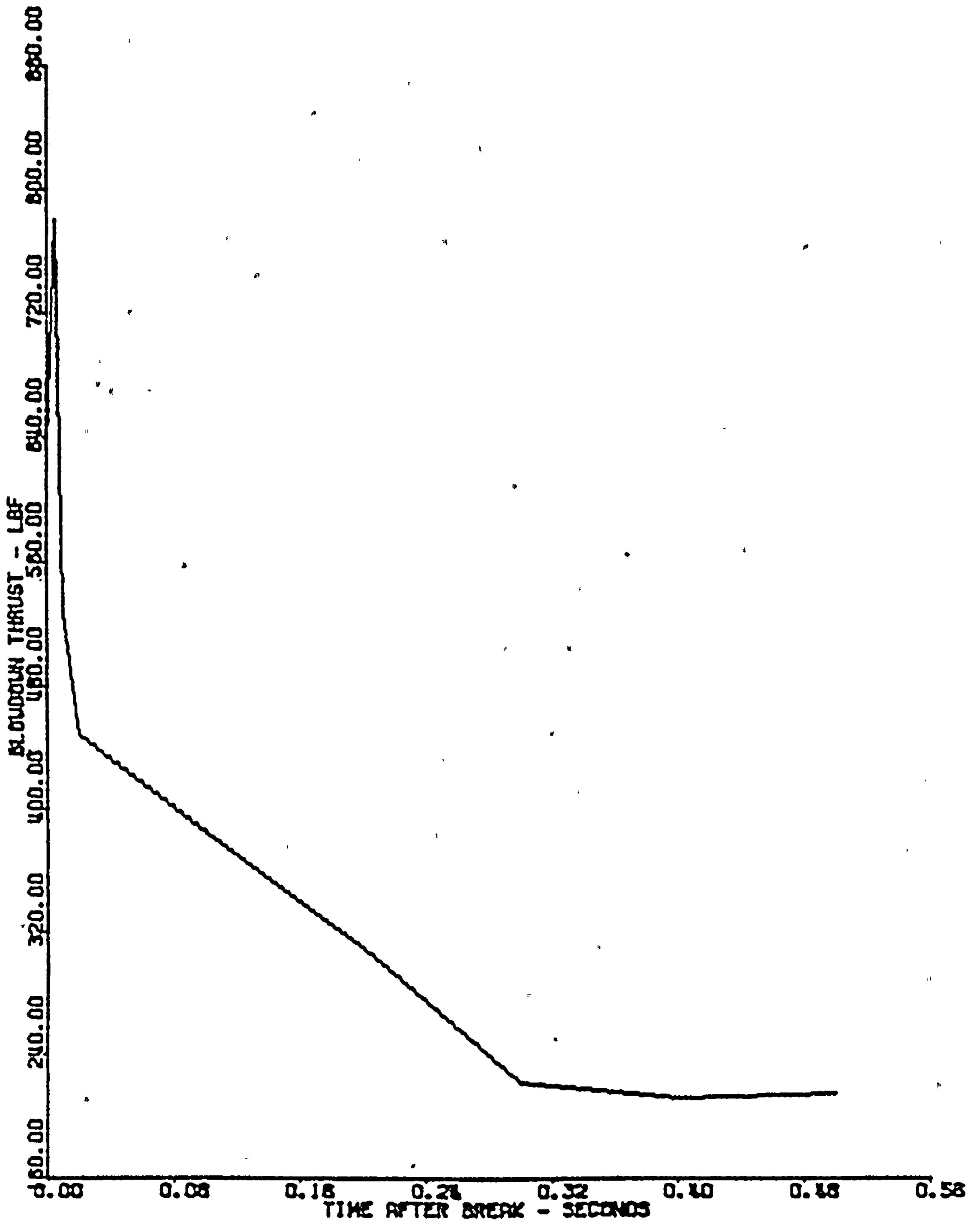
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAK ~~95~~ 49	FIGURE 3.6-95



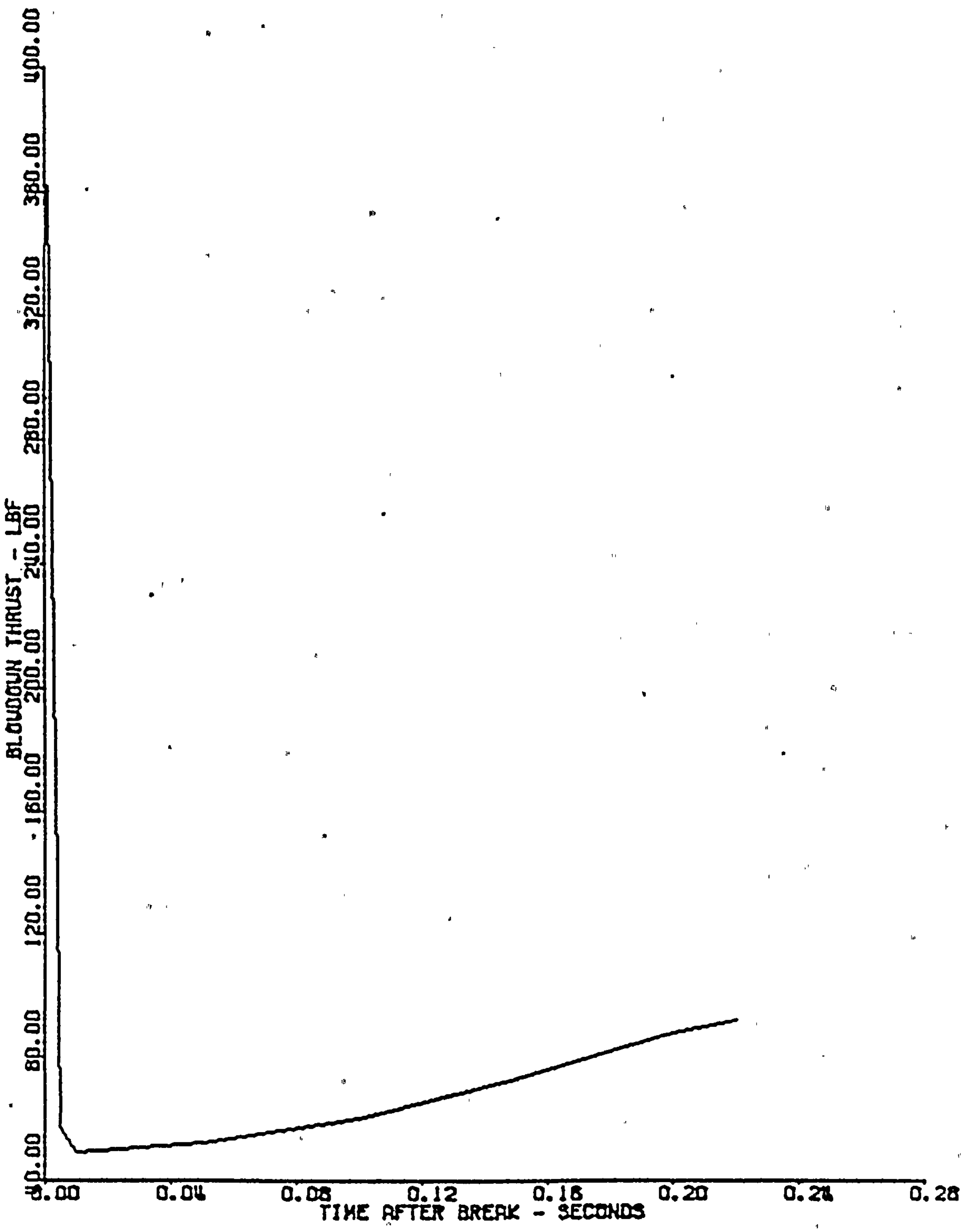
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK ~~28~~ 49	FIGURE 3.6-96



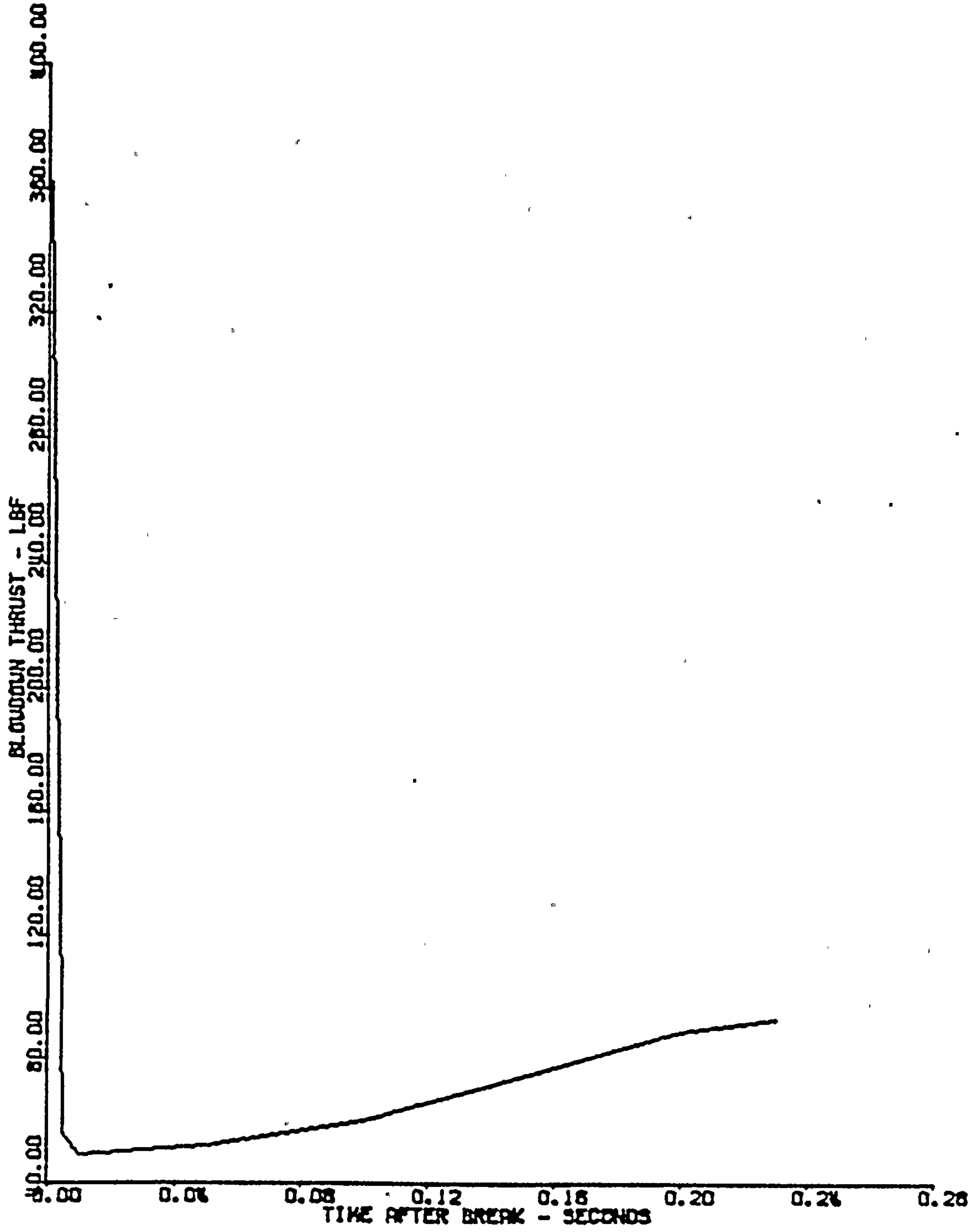
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAK 56 40	FIGURE 3.6-97



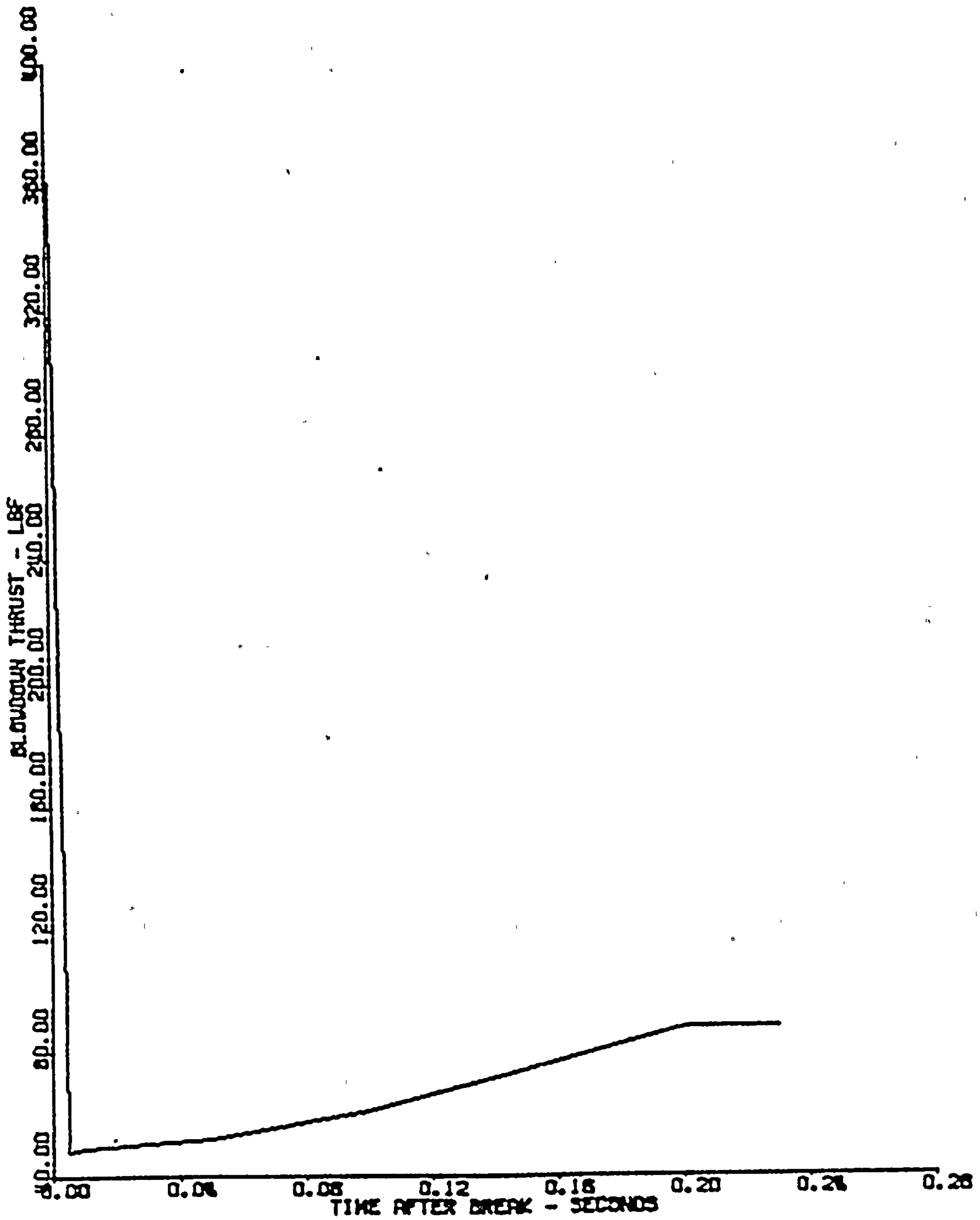
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK ~~86~~ 40	FIGURE 3.6-98



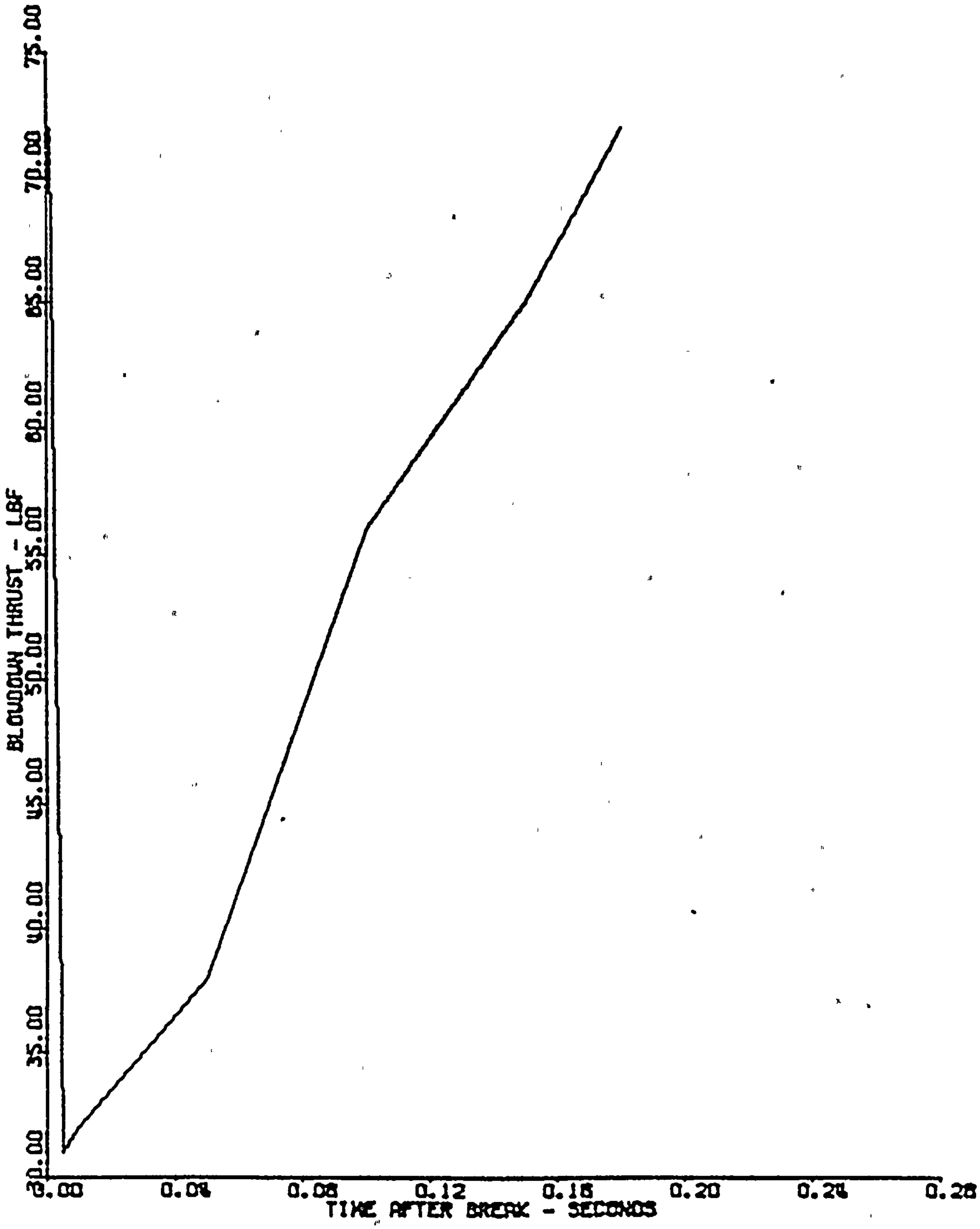
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - BOTH SIDES OF BREAKS ~~87-89, 107, 108,~~ 87 ~~UPSTREAM SIDE OF 109~~	FIGURE 3.6-99



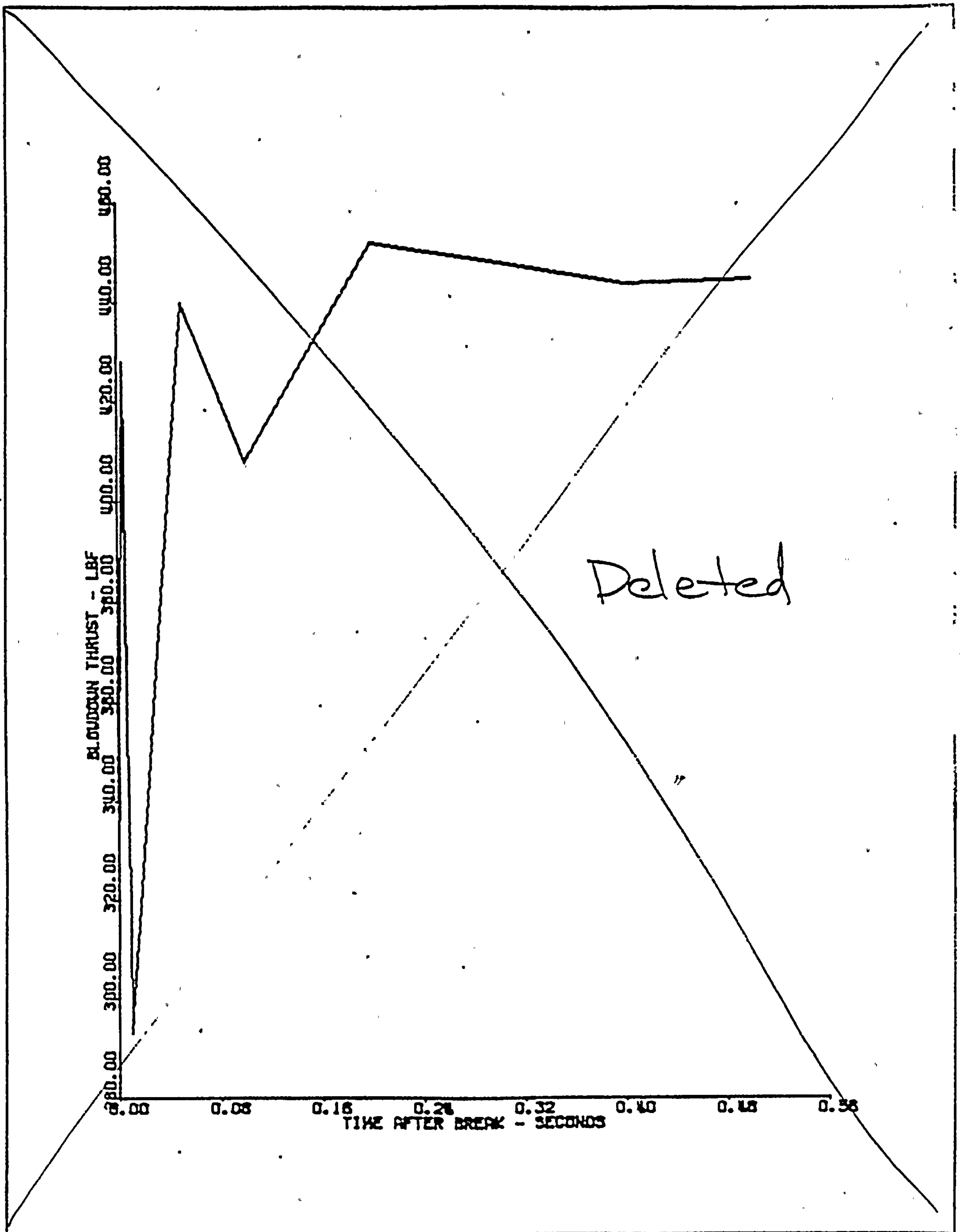
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS ~~90-93~~ 88	FIGURE 3.6-100



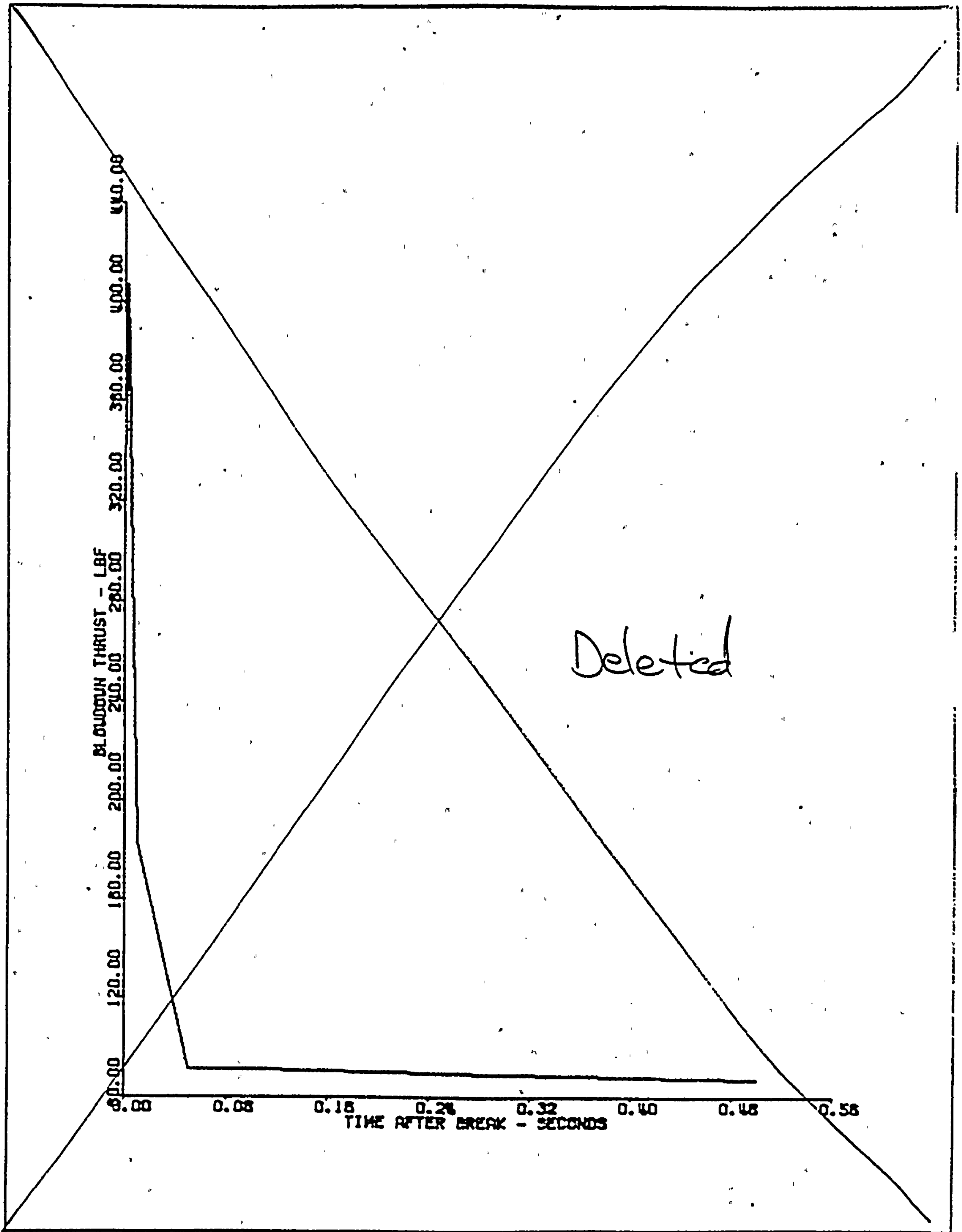
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS ~~90-93~~ 88	FIGURE 3.6-101



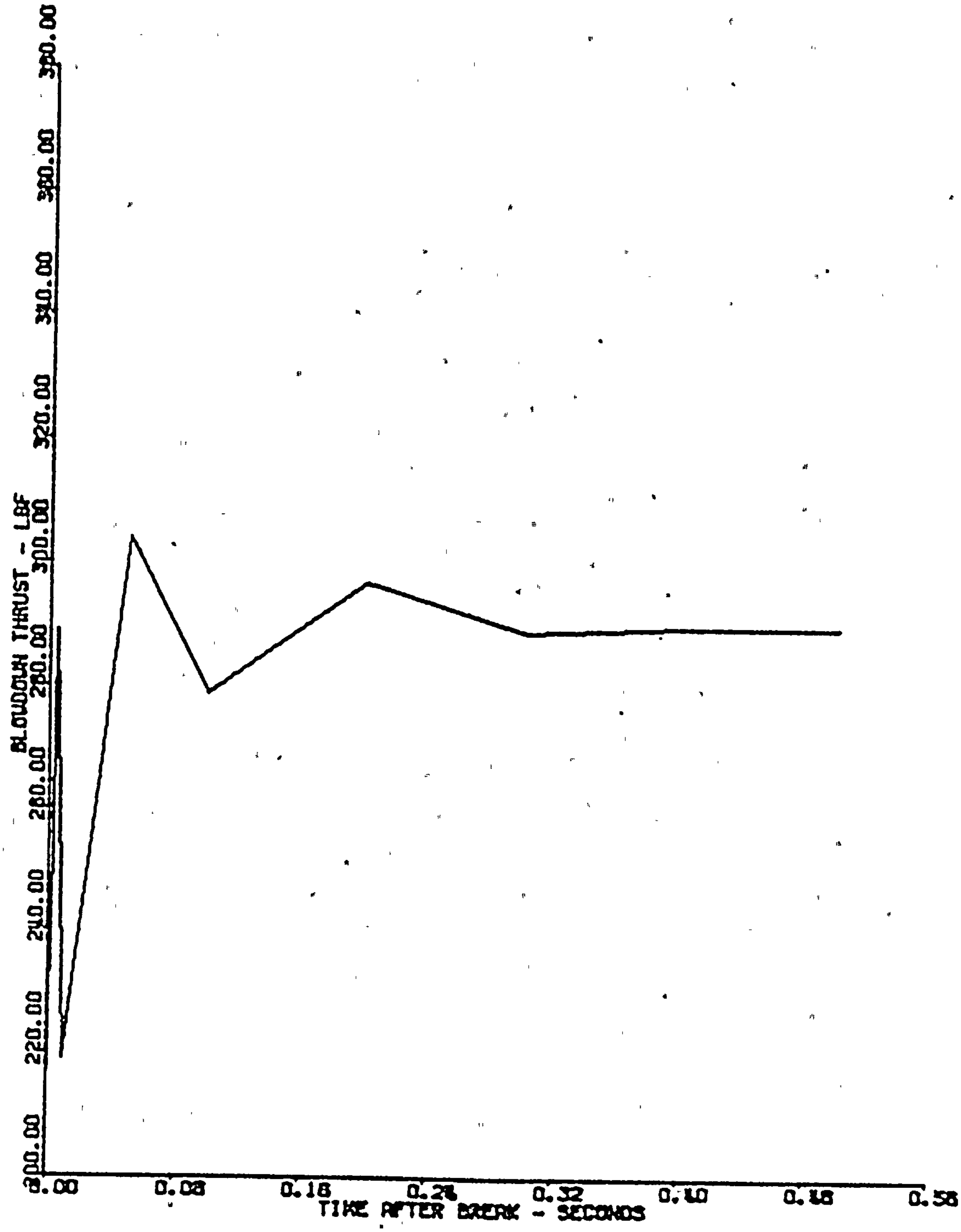
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS ~~94-97~~ 90	FIGURE 3.6-102



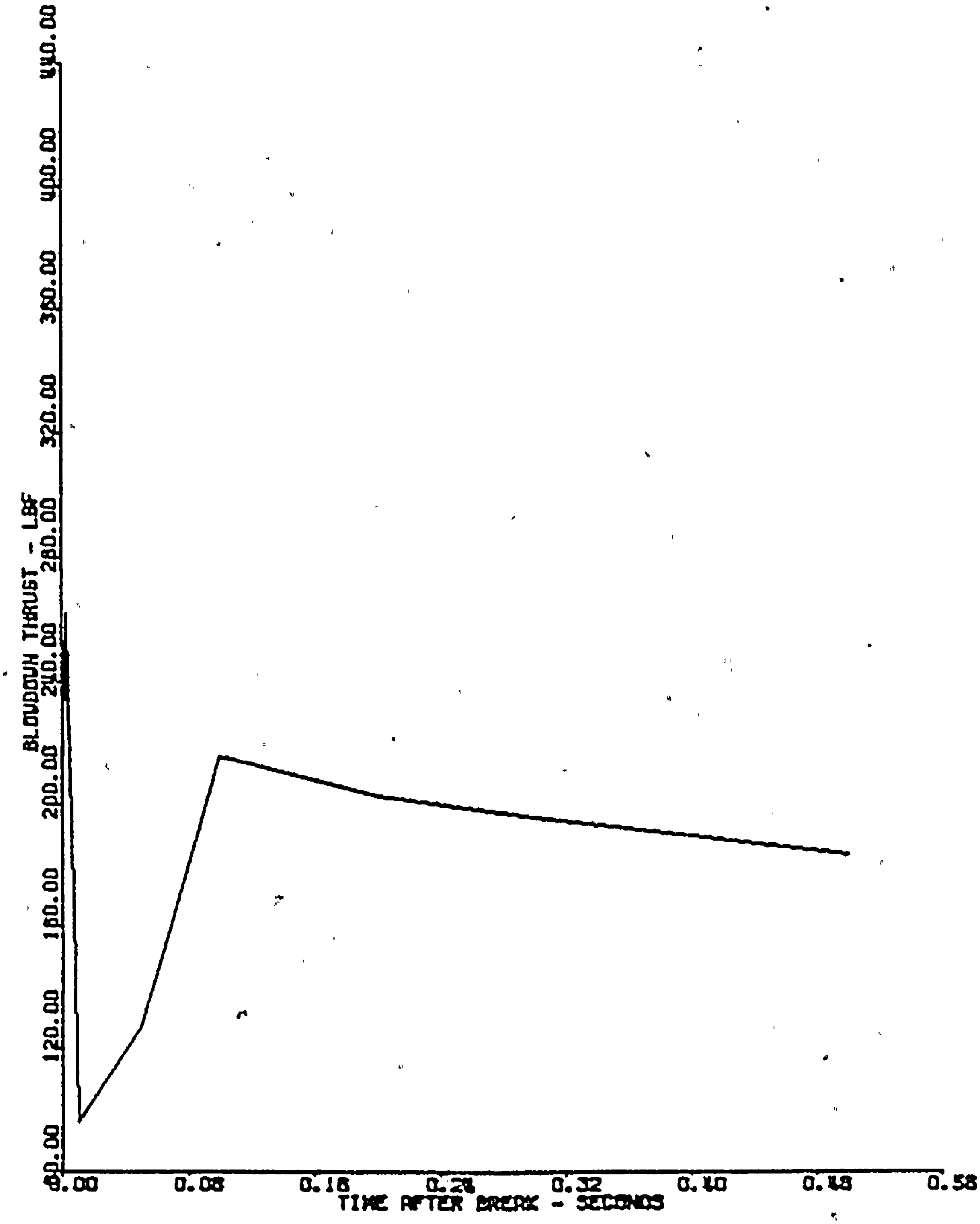
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 98A-98D, 99A-99D	FIGURE 3.6-103



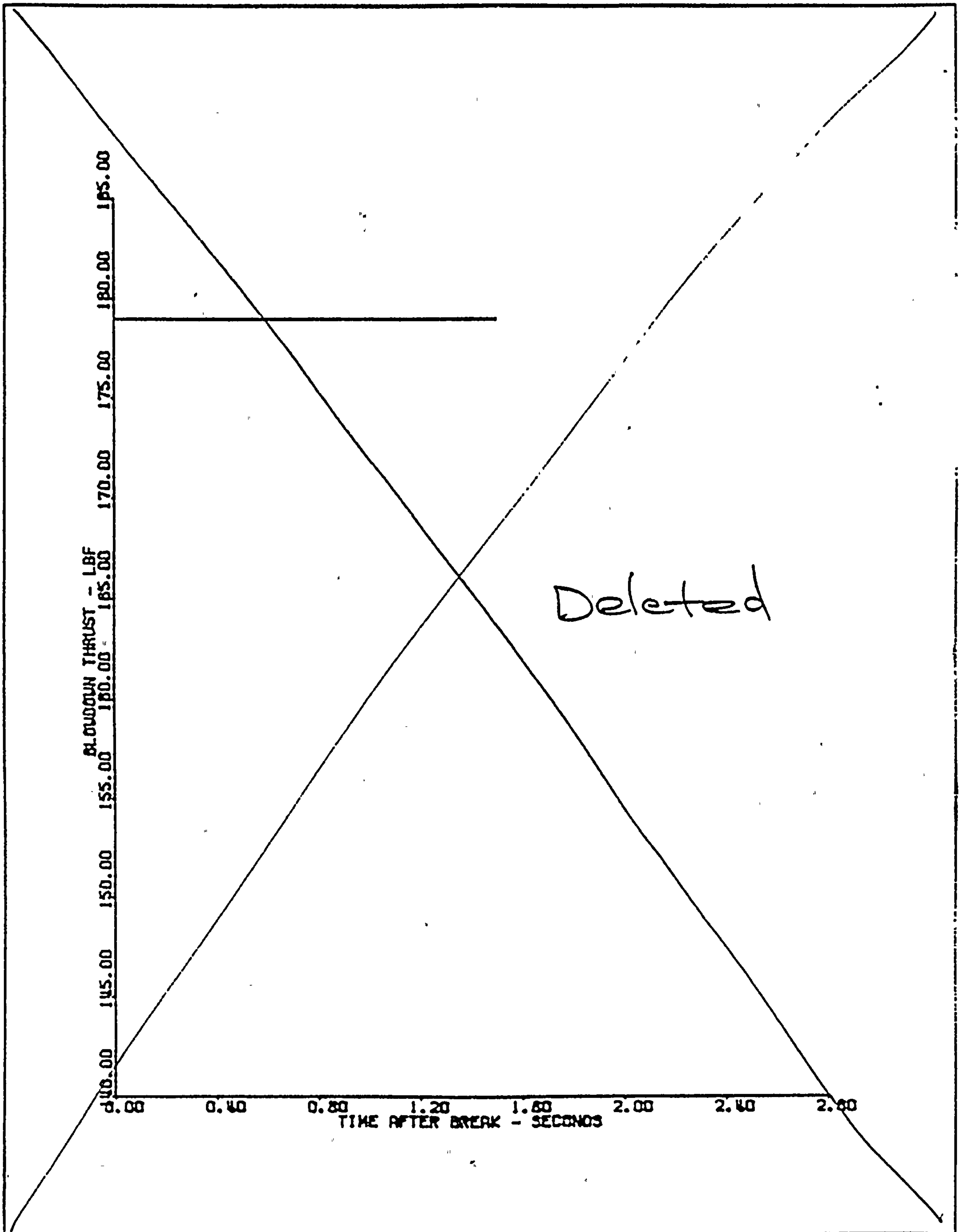
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 98A-98D, 99A-99D	FIGURE 3.6-104



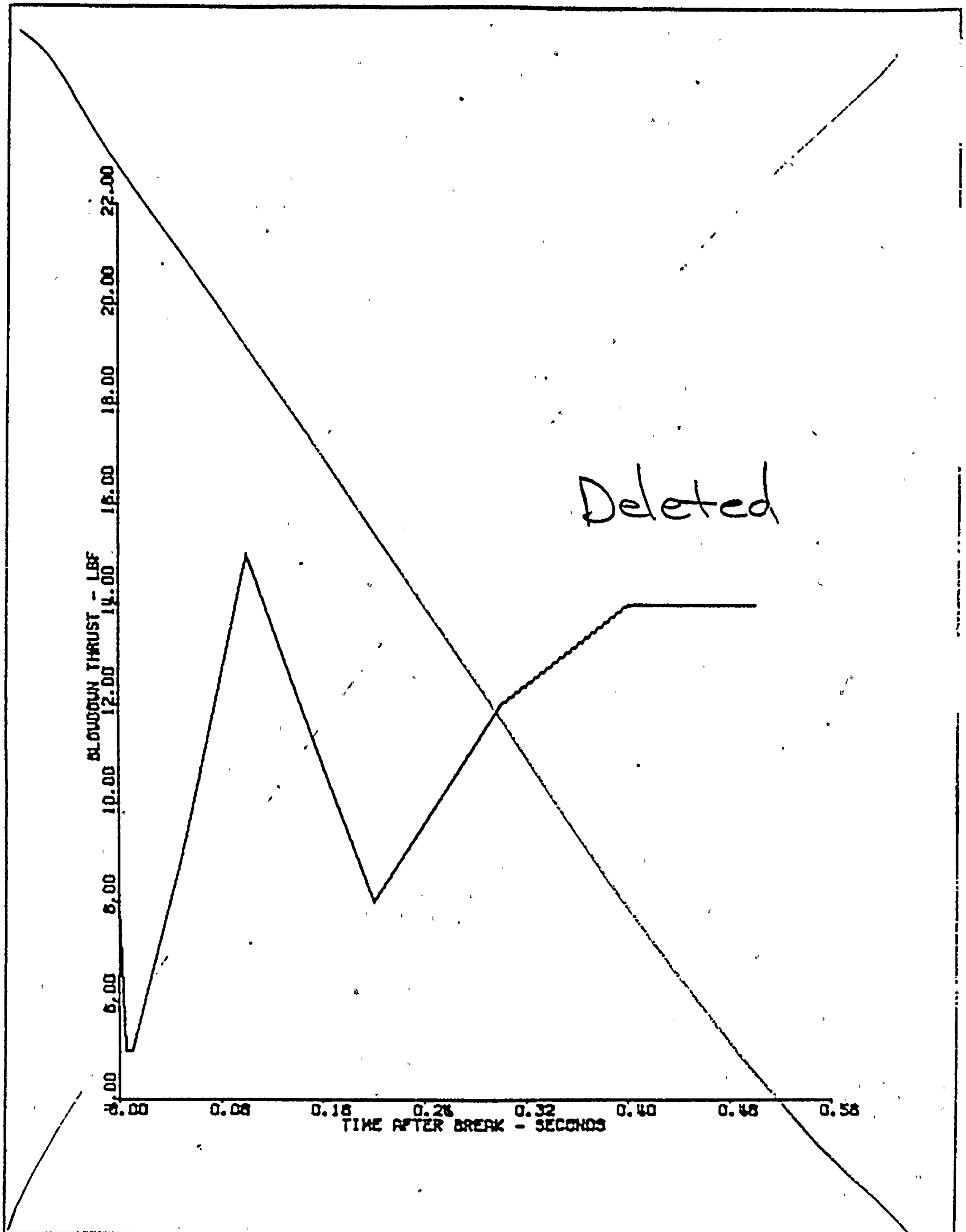
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAK ~~100~~ 72	FIGURE 3.6-105



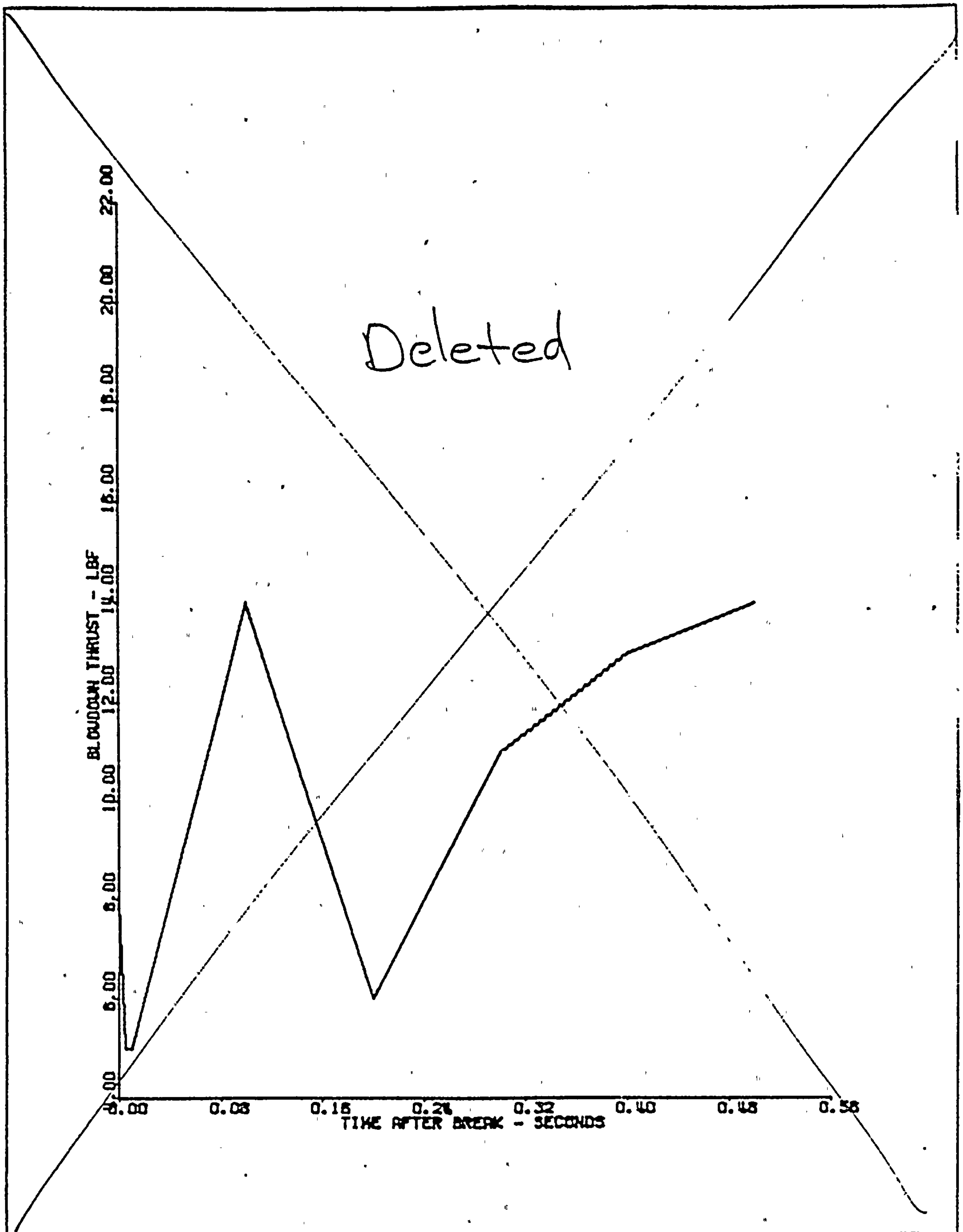
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAK ~~100~~ 72	FIGURE 3.6-106



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - EITHER SIDE OF BREAK 101	FIGURE 3.6-107



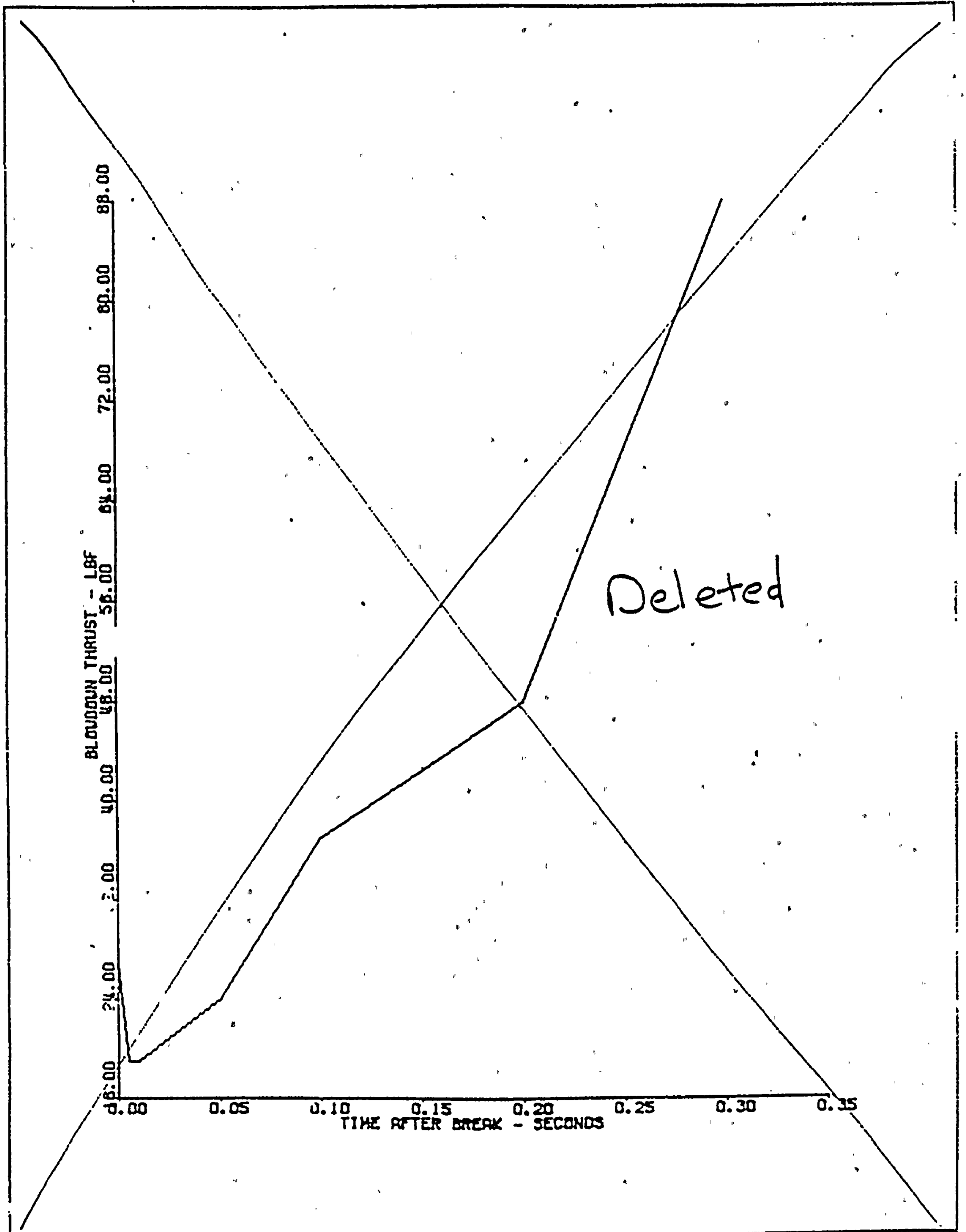
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 102, 110	FIGURE 3.6-108



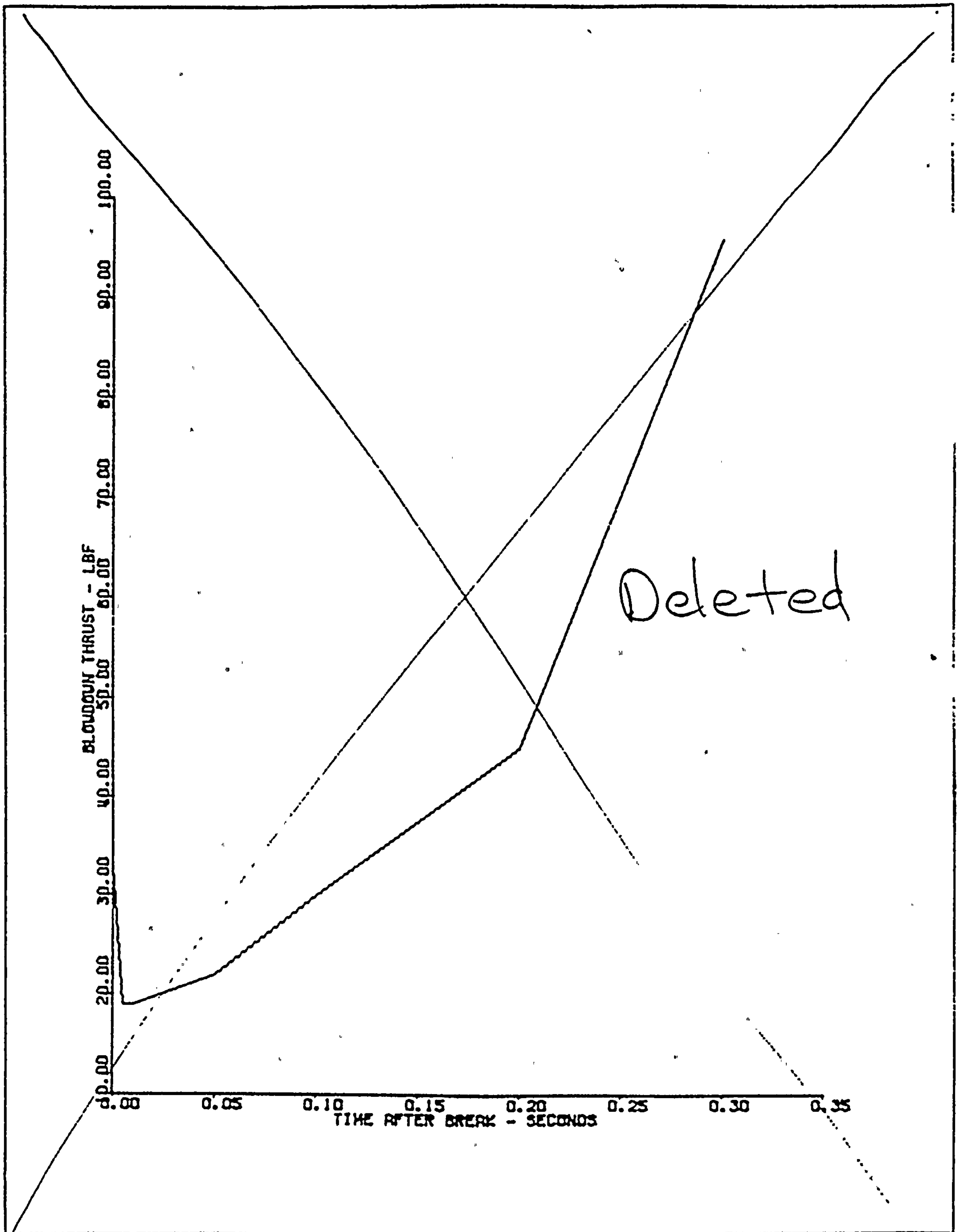
WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2

THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 102, 110

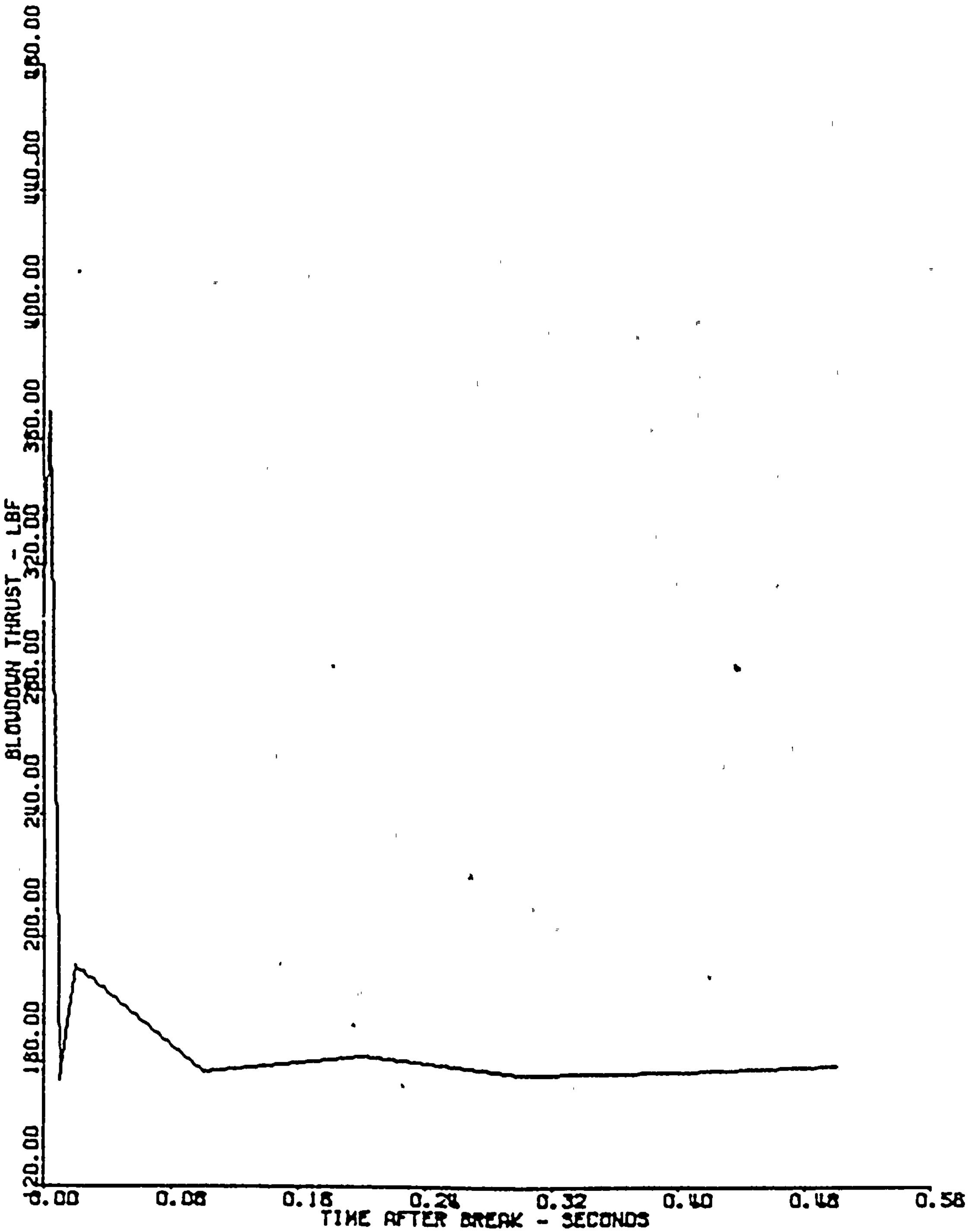
FIGURE 3.6-109



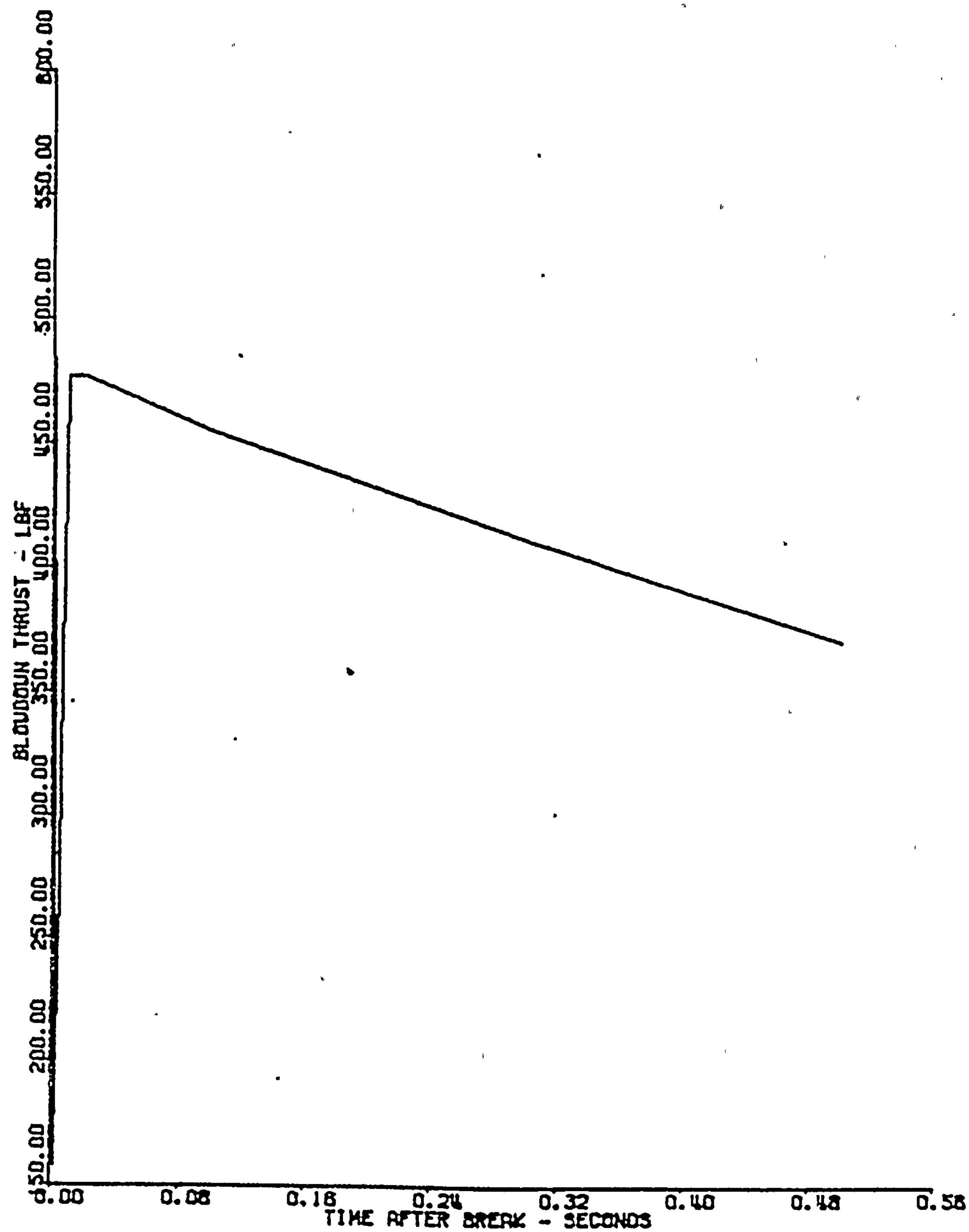
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS 103, 104,	FIGURE 3.6-110



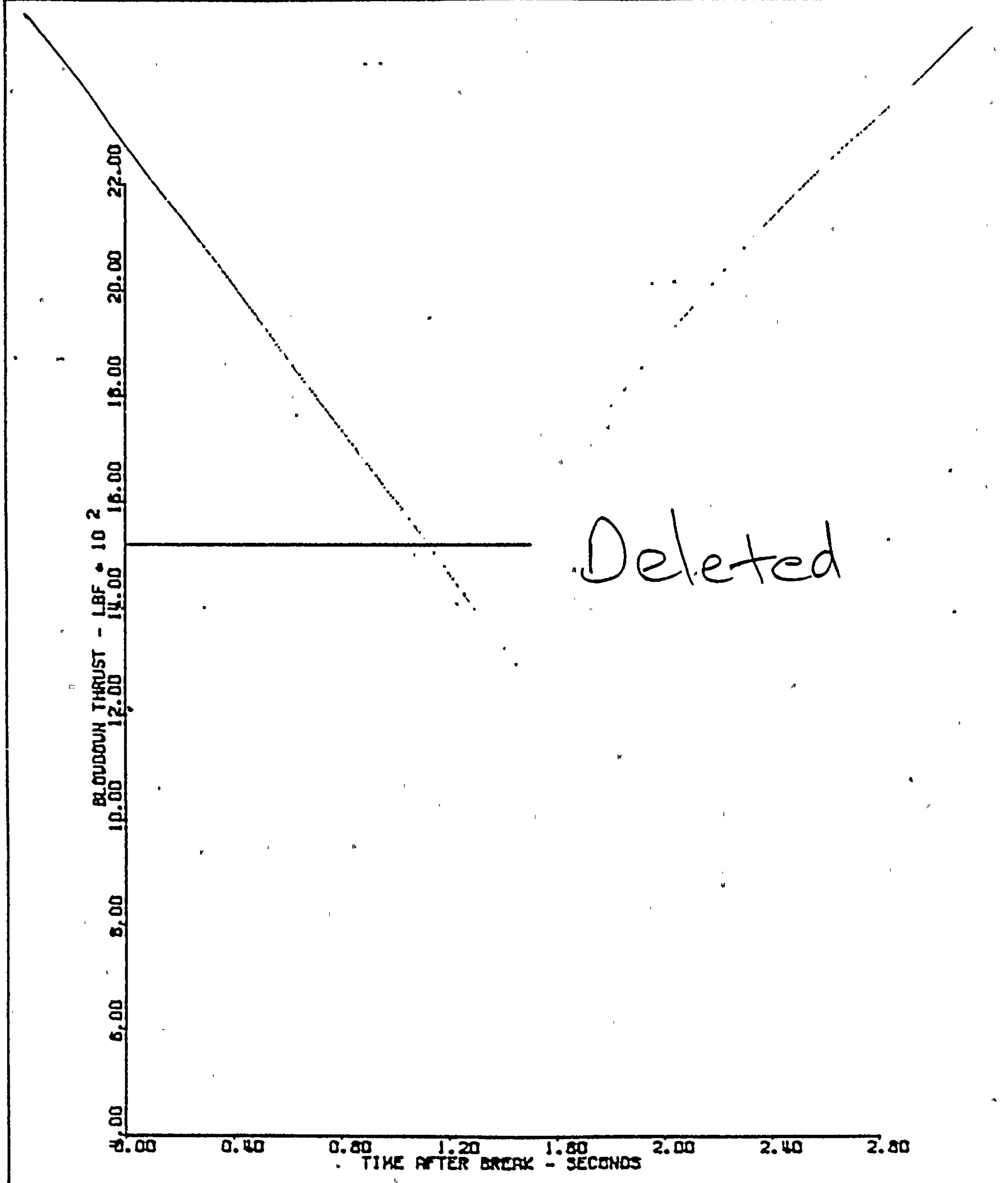
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS 103, 104	FIGURE 3.6-111



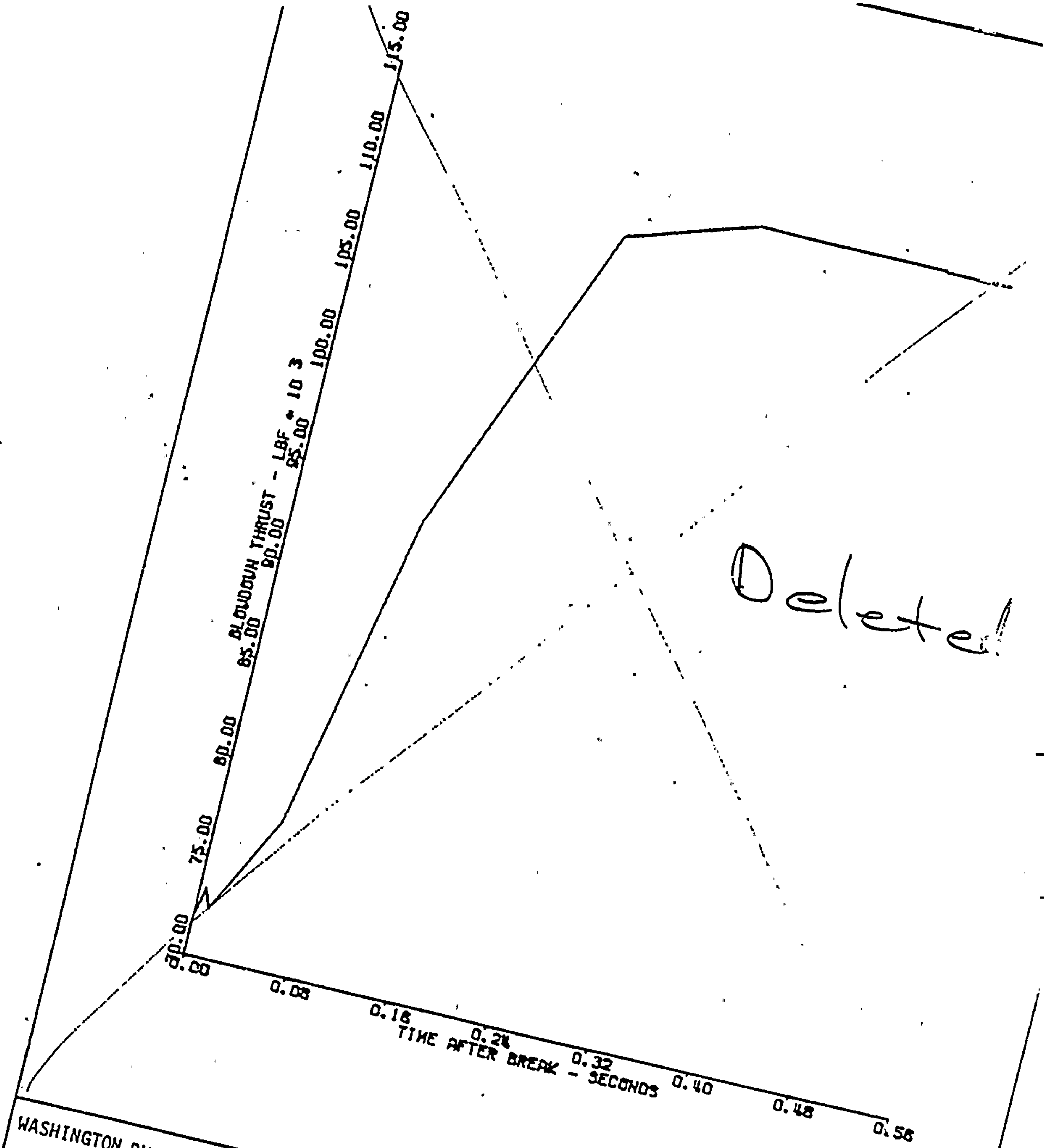
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - UPSTREAM SIDE OF BREAKS ~~105~~, ~~108~~ 70	FIGURE 3.6-112



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - DOWNSTREAM SIDE OF BREAKS ~~105~~, ~~106~~ 70	FIGURE 3.6-113



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	THRUST VS TIME - EITHER SIDE OF BREAK 111	FIGURE 3.6-114

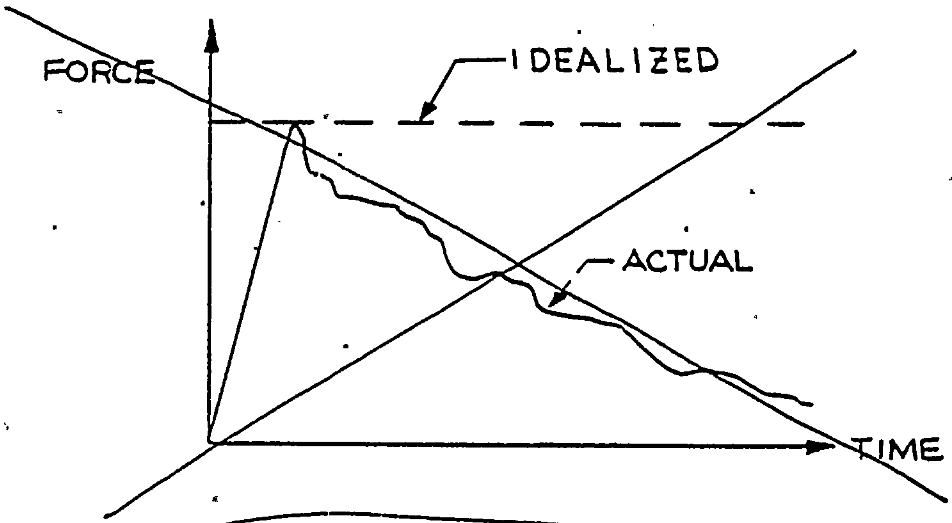


WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2

THRUST VS TIME - EITHER SIDE OF BREAK 112

FIGURE 3.6-115

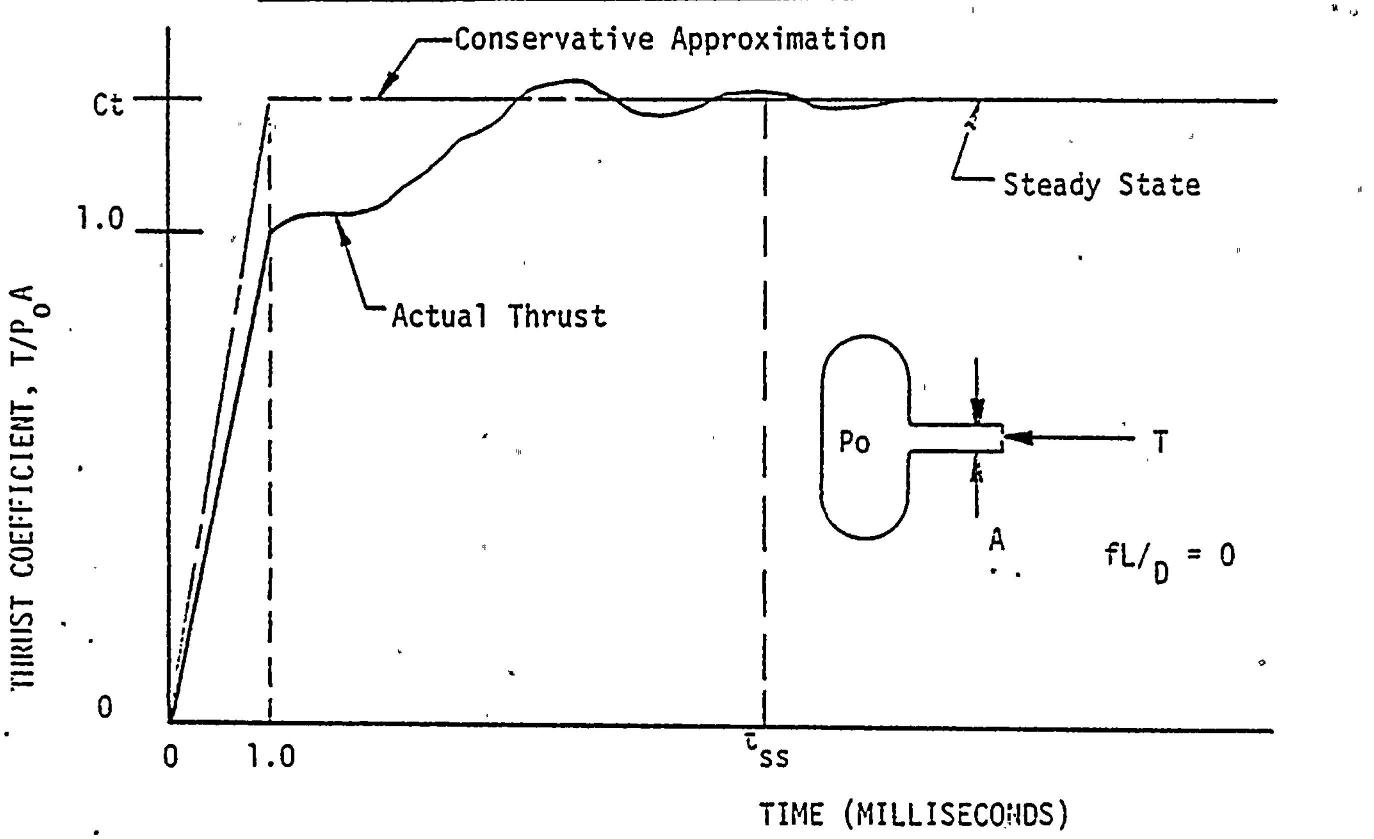
~~AMENDMENT NO. 9~~
~~April 1980~~



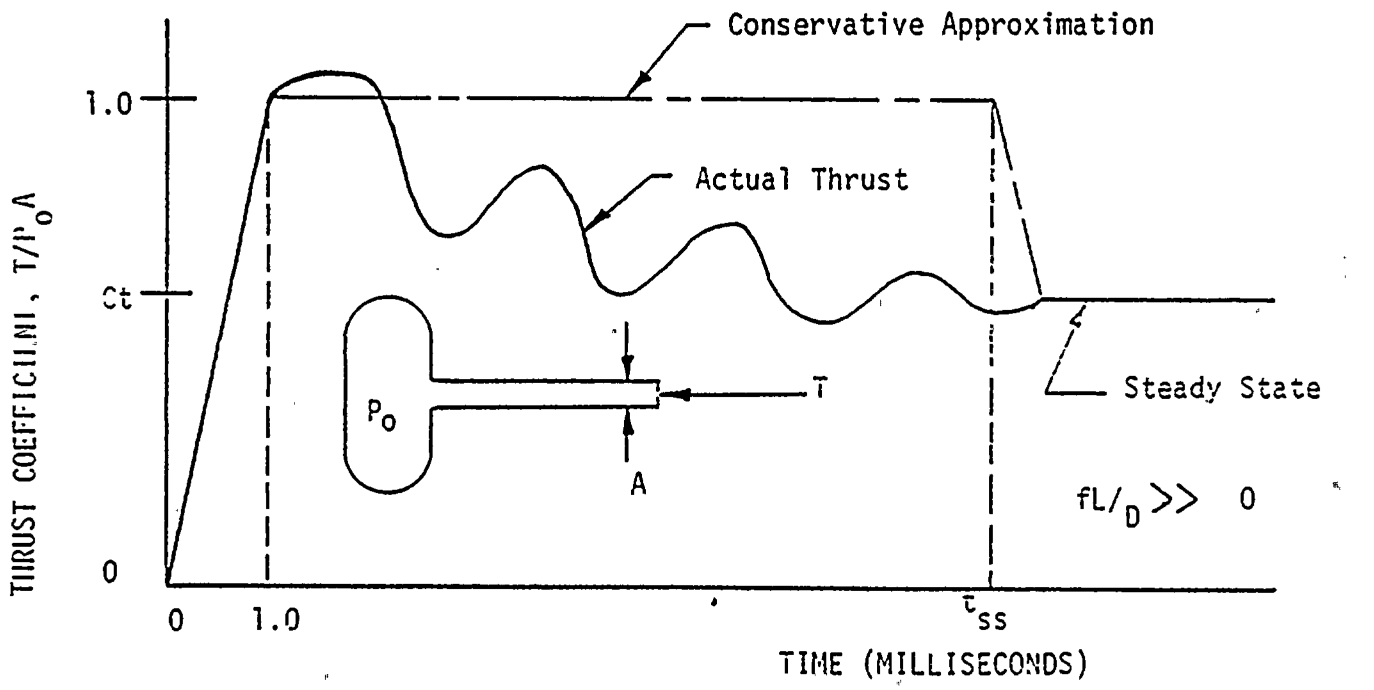
See attachment

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	TIME HISTORY OF JET IMPINGEMENT AND REACTION FORCE	FIGURE 3.6-118

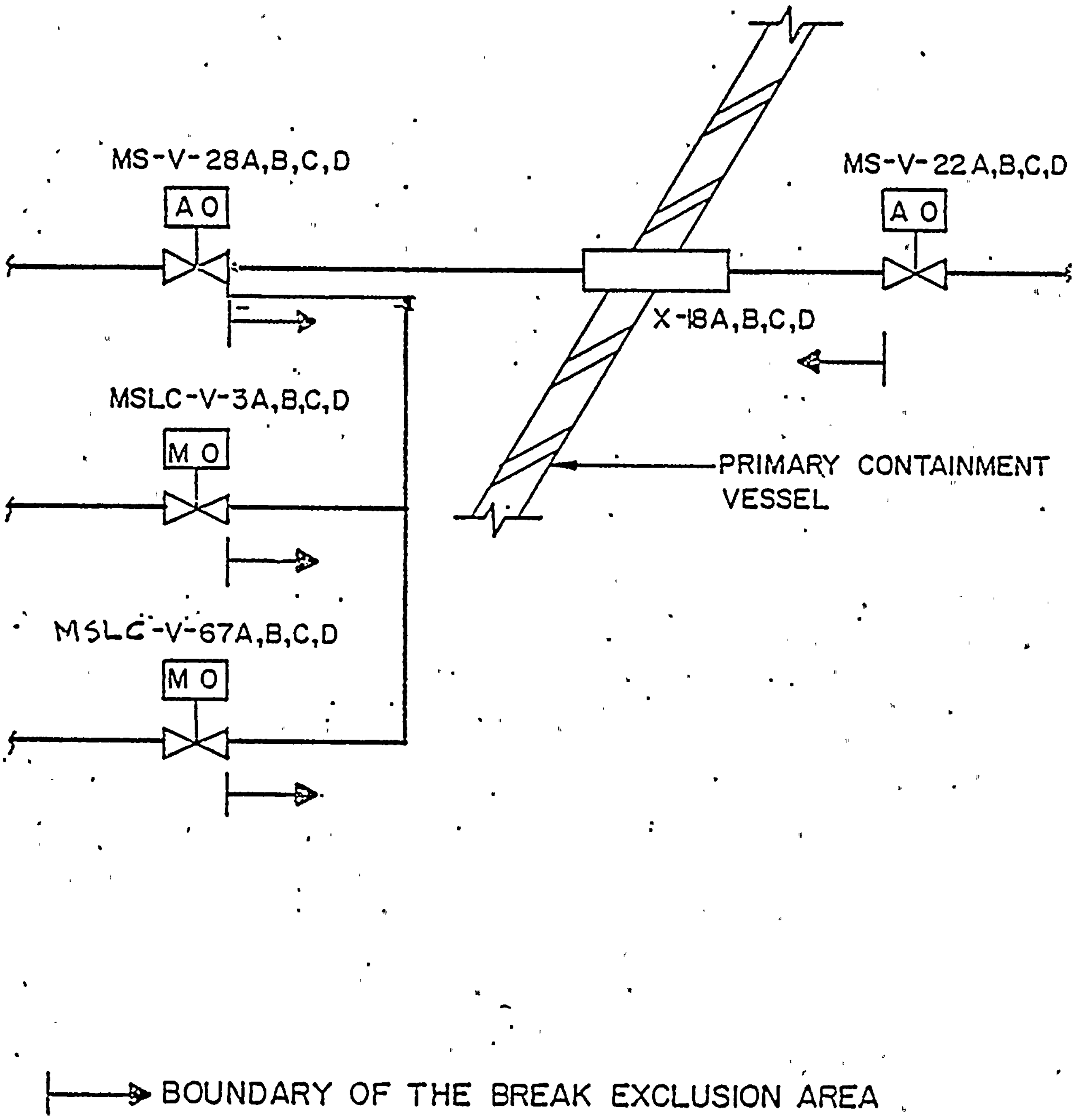
THRUST FORCE TRANSIENT, VERY LOW FRICTION FLOW



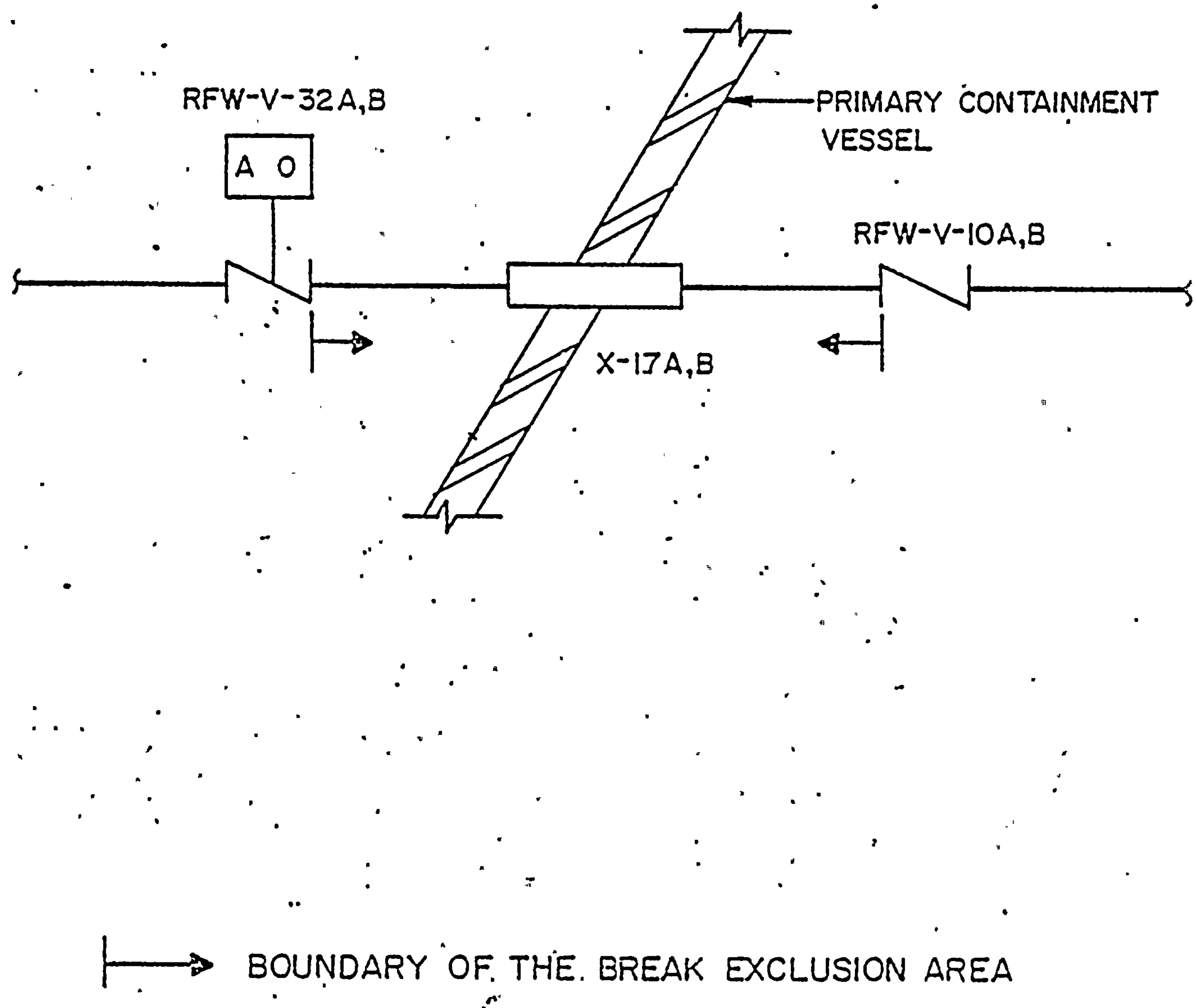
THRUST FORCE TRANSIENT, FRICTION FLOW



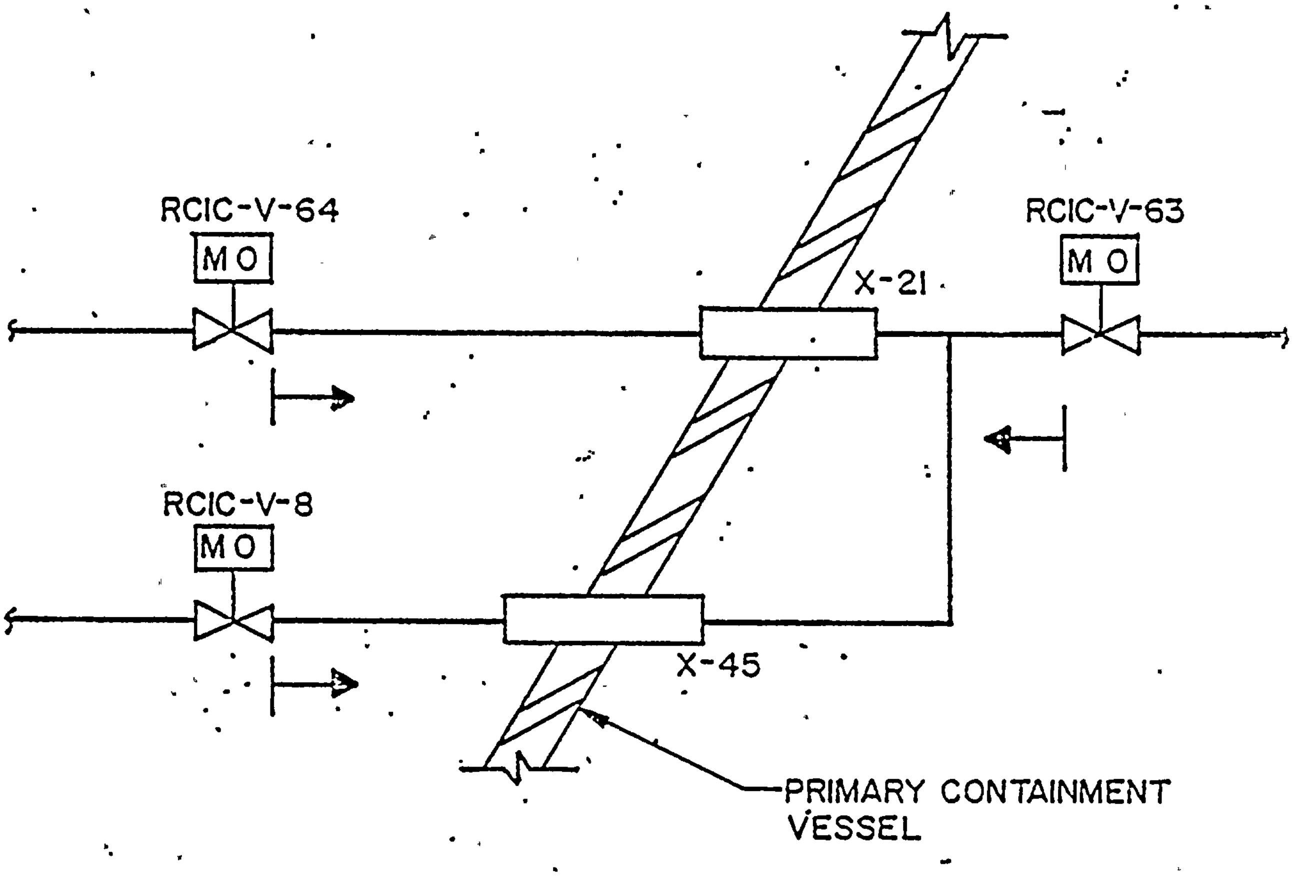
WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	TIME HISTORY OF JET IMPINGEMENT AND REACTION FORCE	Fig 3 6-118



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	MAIN STEAM PIPING SYSTEM	FIGURE 3.6-147a

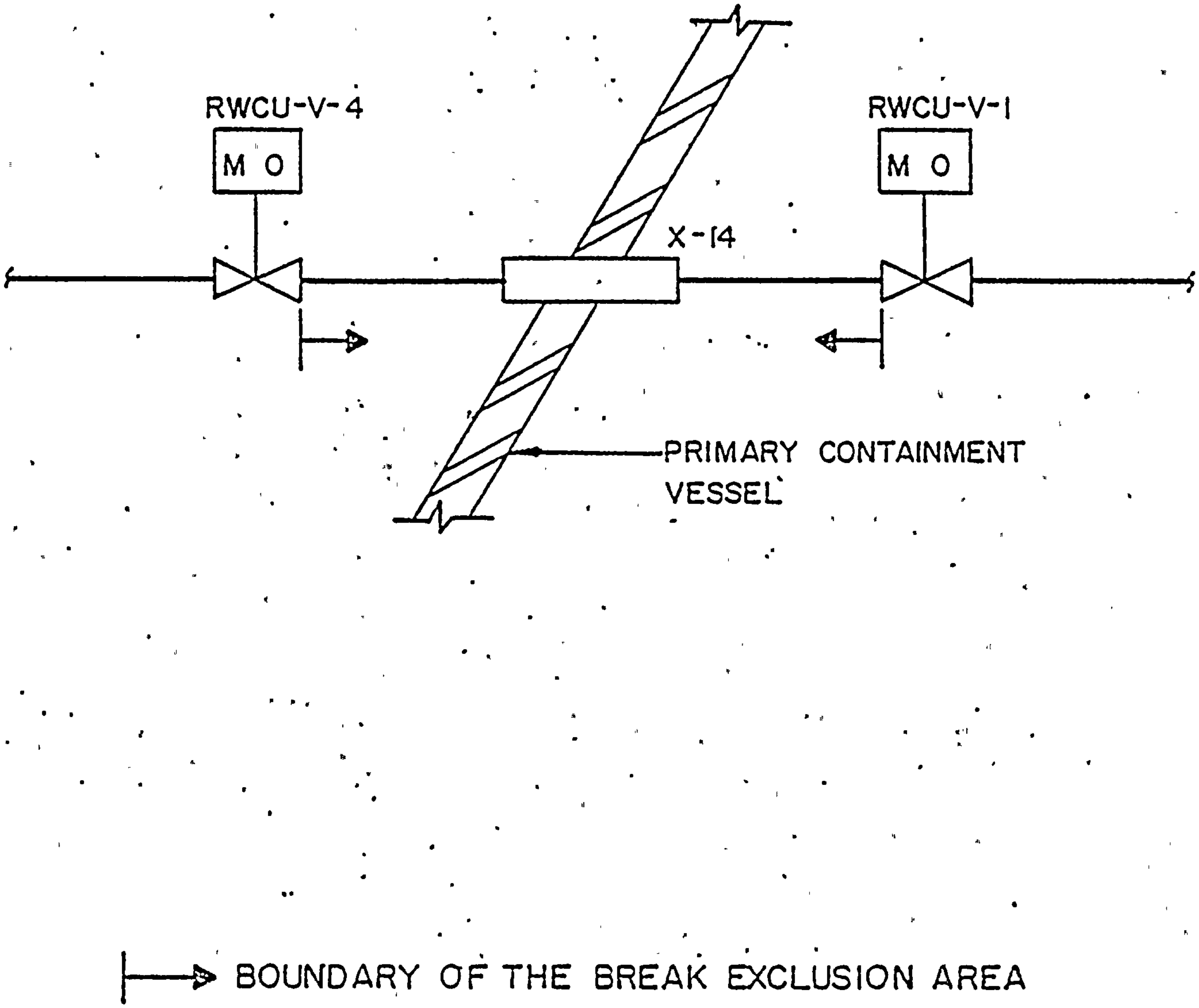


WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	REACTOR FEEDWATER PIPING SYSTEM	FIGURE 3.6-147b



BOUNDARY OF THE BREAK EXCLUSION AREA

WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	RHR CONDENSING MODE/RCIC TURBINE STEAM PIPING SYSTEM	FIGURE 3.6-147c



WASHINGTON PUBLIC POWER SUPPLY SYSTEM NUCLEAR PROJECT NO. 2	REACTOR WATER CLEAN UP PIPING SYSTEM	FIGURE 3.6-147d

SCN 80-160

Q. 110.002
(3.6.1)

Provide in Section 3.6.1.11.2.1 of the FSAR a definition of what is meant by the term "contiguous grid". Indicate clearly whether it includes the corner grids (i.e., which are diagonally adjacent). Discuss the vertical extent of a contiguous grid. Additionally, provide justification for not assuming the simultaneous destruction of equipment in more than one contiguous grid.

Response:

In the revised pipe break and missile evaluation, the "grid" approach is not used. Results of this evaluation and the methodology used will ~~be~~ are provided in ~~a future amendment after the evaluation has been completed~~ the revised Section 3.6.

Q 010.2

Expand 3.6.1 to include piping layout drawings for areas containing high and moderate energy lines whose failure can affect the performance of safety-related equipment. Provide a detailed analysis that demonstrates the method used to protect the reactor heat removal system from the effects of postulated piping system failures. Identify the assumptions and parameters used in your analysis such as flow rates through postulated cracks, pump room areas, sump capacities and floor drainage system capacities.

Response:

Figures 3.6-38 through 3.6-40 and 3.6-43 through 3.6-62 show piping configuration in areas where safety-related equipment could be affected by pipe rupture. Section 3.6.1.11.4 discusses the method of analysis used in evaluating the effect of pipe rupture on the ability to safely shut down the plant.

The approach used consists of evaluating the consequences of a postulated pipe break on any safety-related system, equipment, or components that could be affected, based on ~~physical proximity. As stated in 3.6.1.11.2 for high energy fluid system ruptures, and in 3.6.1.11.3 for moderate energy fluid system ruptures, all unprotected equipment and components in the area of the postulated break is assumed to become inoperable as a result of the break~~. A single active component failure is then assumed in a system not affected by the pipe rupture, and the ability to bring the plant to a safe shutdown condition is evaluated. If safe shutdown can be attained, no protection is provided for the systems, equipment, and components ~~assumed~~ damaged by the postulated rupture.

(add attachment I)

In the analysis for pipe breaks in moderate energy systems, flow rates through postulated cracks, pump room areas, sump capacities, and floor drainage system capacities are ~~not~~ considered. ~~since all equipment which is vulnerable from the standpoint of physical proximity is assumed to become inoperable~~. Also refer to 3.6.1.17 for a description of the capability to detect leakage and resultant flooding from fluid system piping ruptures.

(add attachment II)

~~For purposes of determining vulnerability based on physical proximity, equipment and components within the grid containing the break, and within all contiguous grids, each considered separately in conjunction with the one containing the break, are considered. Section 3.6.1.11.3.2 will be revised in Amendment 2 to the FSAR to reflect this. The grid locations used in the analysis are shown in Figures 3.6-41a through 3.6-42h.~~

add attachment III

Attachment I to Q 010.2

examination of the as-built conditions of the plant. Where the system or equipment is not installed, design drawings are used to locate the safety related components in relation to the postulated break. The effects of each postulated pipe break are examined on a case by case basis.

Attachment II to Q 010.2

Credit is taken for flow restrictions and system resistance. All components and equipment that could be sprayed or wetted are considered lost, unless contained in a water tight compartment.

Attachment III

Prior to fuel load, a final walkdown of essential systems, equipment, and components will verify protection from the effects of postulated pipe rupture. Any design modifications will be considered at this time.

Q. 010.13

For the postulated pipe breaks, you have not provided the information required to determine:

1) The mechanism which terminates the resulting blowdown; or,

2) The period of time over which blowdown occurs.

Accordingly, for each postulated pipe break or leakage crack, indicate the time over which blowdown occurs and identify the mechanism which either terminates the blowdown or limits the amount of blowdown flow. These mass and energy flow rates will be used to evaluate the peak pressures and temperatures in compartments and structures following a postulated break of the high energy pipes inside these structures.

Response: add attachment

~~Except for the main steam isolation valves which terminate blowdown flow from the reactor building side of pipe breaks in the main steam line, and check valves in the reactor feedwater lines, which terminate blowdown flow from the reactor building side of pipe breaks in the reactor feedwater lines, no mechanism terminates flow except exhausting of the inventory of fluid in the line following the pipe break.~~

Where blowdown flow is not automatically terminated by isolation valves or check valves as described above, the duration of the blowdown event as the inventory of fluid in a line is exhausted is not considered in the analysis of peak compartmental pressure and termperature. To evaluate the peak pressures and temperatures in compartments and structures following a postulated break of the high energy pipes inside the structures, the blowdown analysis is extended far beyond the initial transient until the blowdown flow becomes steady or decreases continuously. The duration of the analysis is therefore sufficient to correctly predict the peak pressures and temperatures in these compartments and structures.

For a postulated pipe break or leakage crack in the main steam lines outside primary containment, the flow from the reactor side of the break is terminated by the closing of the main steam isolation valves located in each of the four main steam lines. The main steam isolation valves start to close at 0.5 seconds after the break and are fully closed at or prior to 5.5 seconds after the break, as given in Table 15.6-6.

For a postulated break or leakage crack in the reactor feedwater lines outside primary containment, the flow from the reactor side of the break is terminated by closing of the check valves in each of the two reactor feedwater lines. The check valves start to close when the direction of flow reverses, and the flow from the reactor side of the break is therefore terminated within a fraction of a second.

Attachment to Q 010.13

Table 7.6-7 lists leak detection system instrumentation specifications. Table 6.2-16 lists valve closure times for automatic isolation functions tied into the leak detection system. Credit is taken for automatic isolation if the system capability is not affected by the postulated pipe break, or assumed as a single active component failure. Check valves close on reversal of flow in a fraction of a second. In all cases, the blowdown terminates when the inventory of ~~the~~ fluid in the line is exhausted.

AMENDMENT NO. 9
April 1980

SCN 80-144

Q. 110.004
(3.6.1)

Expand Section 3.6.1.11.3.1 of the FSAR to: (1) provide justification for not assuming the simultaneous malfunction of equipment in one or more contiguous grids; (2) describe your procedures to evaluate the effects of flooding which are discussed in Section 3.6.2.1.4.2.c of the FSAR.

Response:

Environmental and flooding effects resulting from moderate energy piping failures are not assumed to be confined by grid boundaries. ~~Upon completion of the current pipe break and missile evaluation, the FSAR text will be revised to reflect this, and to respond to part (2) of your question.~~

Refer to revised 3.6.1.11 and 3.6.1.15 for the methods of analysis to evaluate the effects of flooding.

The "grid" concept is not ~~longer~~ used in the current pipe break evaluation.

SCN 50

Q. 110.017

Indicate in Sections 3.6.2.3.2 and 3.6.2.5 of the FSAR, whether: (1) the environmental effects of postulated pipe breaks (i.e., pressure, temperature, humidity, wetting of exposed equipment and flooding), have been considered in the design of the WNP-2 facility; and (2) these environmental effects are at least as severe as those associated with a postulated crack of the same size as the postulated break.

Response:

~~The environmental effects of postulated high and moderate~~ energy ~~fluid piping systems failures are being~~ addressed in the ~~redundancy studies currently undergoing updating. A conclusion of the study will be provided at a later date.~~

The environmental effects of postulated high ~~energy~~ and moderate energy fluid syste piping failures are ~~be~~ addressed in the design of the WNP-2 facility Refer to revised 3.6.1.11, 3.6.1.15, and 3.6.1.20. Where moderate energy pipe cracks are postulated to occur in the same areas as high energy pipe breaks, the environmental effects are compared. The most damaging pipe rupture is evaluated. Refer to revised 3.6.1.11.