Commonwealth Edison
1400 Opus Place
Downers Grove, Illinois 60515

May 18, 1992

Dr. Thomas E. Murley, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Attention: Document Control Desk

Subject: Byron Ultimate Heat Sink

Byron Units 1 and 2,
NRC Docket Numbers 50-454 and 50-455

References:
(1) T.K. Schuster to T.E. Murley letter dated January 9, 1992.
(2) T.K. Schuster to T.E. Murley letter dated March 31, 1992.

Dear Dr. Murley:

The purpose of this letter is to transit an "Information Only" copy of the revised pages of the Byron/Braidwood UFSAR related to the Byron Units 1 and 2 Ultimate Heat Sink (UHS). The UFSAR revisions are provided as an attachment to this letter and are being submitted per a Commonwealth Edison commitment in Reference (1). These updates are the result of the Design Basis Reconstitution for the Byron UHS and are in support of the amendment to Byron Station Technical Specifications as requested in Reference (2). Also included in the attachment is the previously provided UFSAR Change Log, DPR 4-009.

If there are any questions or comments, please contact me at (708) 515-7292.

Sincerely,

David J. Chrzanowski
Nuclear Licensing Administrator

Attachment - UFSAR Change Log DPR 4-009 with affected UFSAR pages.

cc: A. Bert Davis, Regional Administrator - RIII, w/Attachment
R. Pulsifer, Project Manager - NRR/PDIII-2, w/o
A. Hsia, Project Manager - NRR/PDIII-2, w/Attachment
S. DuPont, Senior Resident Inspector (Braidwood), w/o
W. Kropp, Senior Resident Inspector (Byron), w/o

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ATTACHMENT

Byron/Braidwood UFSAR Change Log

and

Affected UFSAR Pages

Byron/Braidwood
UFSAR Change Log
DRP 4-009

Section	Page	Description of Change	Reason/Basis	References/Remarks
2.3.1.2.4BY	2.3-10BY	Delete paragraph describing the maximum water makeup required by the UHS	Replace with new description on page 2.3-11BY	Clarify proper wet-bulb temperature. UHS final report, page 12
2.3.1.2.4BY	2.3-11BY	Insert "(Revision 2, January 1976)"	Editorial	UFSAR Section A1.27
2.3.1.2.4BY	2.3-11BY	Change "98°F" to "100°F"	Document system design basis	"Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation: Part VII," Calculation NED-M-MSD-19, Revision 0, dated March 2, 1992
2.3.1.2.4BY	2.3-11BY	Revise paragraphs discussing UHS design temperature and meteorological data	Clarify design basis of UHS cooling towers	UHS final report, page 12
2.3.1.2.4BY	2.3-11BY	Revise three paragraphs discussing the cooling tower makeup water supply	Document calculation results	"Byron Ultimate Heat Sink Cooling Tower Basin Makeup Calculation," Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992 and Calculation NED-M-MSD-19, Revision 0, dated March 2, 1992
2.3.6BY	2.3-52BY	Add reference 32	Citation of ASHRAE exceedance value in subsection 2.3.1.2.4	Reference 16 of UHS final report
2.4.11.5BY	2.4-20BY	Revision of paragraph discussing cooling tower makeup	Document calculation results	Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992
2.4.11.6BY	2.4-23BY	Revise paragraph discussing compliance with Regulatory Guide 1.27	Document calculation results	Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992

Section	Page	Description of Change	Reason/Basis	References/Remarks
2.4.11.6BY	2.4-23BY and 2.4-23aBY	Change "normal" to "minimum" (two places)	Document system design basis	Calculation NED-M-MSD-19, Revision 0, dated March 2, 1992
2.4.11.6BR	2.4-22BR	Replace "The design . . . power" with "The ESCP has . . . seismic event."	Document review of Braidwood UHS with respect to Byron UHS design basis reconstitution	Memo from B. J. Adams to D. E. St. Clair dated November 4, 1991 (RA-91-004)
2.5.6.9BR	2.5-112BR	Change "in situ" to "in-situ"	Editorial	Editorial
2.5.6.9BR	2.5-112BR	Insert "The ESCP . . . event."	Document review of Braidwood UHS with respect to Byron UHS design basis reconstitution	Memo from B. J. Adams to D. E. St. Clair dated November 4, 1991 (RA-91-004)
6.2.1.1.3	6.2-3	Add new paragraph describing the containment analyses contained in subsection 9.2.5	Document differences in the Chapter 6 and Chapter 9 analyses	UHS Final Report, Section III.C, page 18
6.2.2	6.2-38	Add new paragraph describing the containment analyses contained in subsection 9.2.5	Document differences in the Chapter 6 and Chapter 9 analyses	UHS Final Report, Section III.C, page 18
9.0	9.0-iii	Insert new subsections	Editorial	New sections are being added
9.0	9.0-xii	Show Tables 9.2-6, 9.2-12, and 9.2-13 as "Deleted," revise the title of Table 9.2-11, and add Table 9.2-16	Editorial	Changes are per this DRF

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Section	Page	Description of Change	Reason/Basis	References/Remarks
9.0	9.0-xv	Show Figure 9.2-5 as "Deleted"	Editorial	Figure is being deleted
9.0	9.0-xv (cont'd)	Show Figure 9.2-6 as "Deleted" and denote Figure 9.2-8 as applying to Braidwood only	Editorial	Changes are per this DRP
9.0	9.0-xvi	Denote Figures 9.2-9 through 9.2-14 as applying to Braidwood only, add Figures 9.2-30 and 9.2-31	Editorial	Changes are per this DRP
9.2.1.2.1	9.2-2	Revise section	Reflect design basis	UHS Final Report
9.2.1.2.2	9.2-2	Insert "Actual System . . . flows."	Specify that the stated flow rate is "typical"	UHS Final Report, Section II.E, page 13
9.2.1.2.2	9.2-2a	Insert reference to Table 9.2-16	Editorial	New table is being added
9.2.1.2.2	9.2-3	Insert "and are normally open"	Document normal system operation	Normal operation
9.2.1.2.2	9.2-3	Insert reference to Table 9.2-16	Editorial	New table is being added
9.2.1.2.2	9.2-3	Replace "Each" with "At Byron, the", replace "tower is" with "towers are" and delete "Both towers . . . in operation"	Editorial	System design basis
9.2.1.2.3	9.2-4	Delete "From a . . . division"	Editorial	Tables 9.2-12 and 9.2-13 are being deleted

Section	Page	Description of Change	Reason/Basis	References/Remarks
9.2.5.1	9.2-29	Insert "Since the . . . active failure"	Document system design basis	UHS Final Report, Section II.A, page 9
9.2.5.1	9.2-29	Delete "redundant" and delete "Only essential . . . towers."	Editorial	Editorial
9.2.5.1	9.2-29	Insert "Components . . . Table 9.2-1" and delete "The normal . . . Btu/hr."	Reference the appropriate table for unit heat loads	Editorial
9.2.5.1	9.2-29	Delete references to Table 9.2-6 and Figures 9.2-5 and 9.2-6. Expand the discussion of Figure 9.2-7.	Editorial	Table and Figures are being deleted or revised.
9.2.5.2.1	9.2-29	Delete "above normal water level" and "trough"	Editorial	System configuration
9.2.5.2.1	9.2-29a	Change "sinks" to "sink"	Editorial	Editorial
9.2.5.2.1	9.2-29a	Delete "redundant"	Editorial	Proper terminology
9.2.5.2.1	9.2-29a	Insert description of the essential service water cooling towers	Reflect system configuration	Letter Byron 92 0114, Proposed Technical Specification Amendment, page 2
9.2.5.2.1	9.2-29a	Delete "Each of . . . hot shutdown." and insert "The ultimate . . . an occurrence"	Document system design basis	UHS Final Report, Section II.A, page 9
9.2.5.2.1	9.2-29a	Insert "The ultimate heat . . . active failure."	Document system design basis.	UHS Final Report, Section II.A, page 9
9.2.5.2.1	9.2-30	Replace "supply header" with "pump discharge"	Editorial	Proper terminology

Section	Page	Description of Change	Reason/Basis	References/Remarks
9.2.5.2.1	9.2-30	Delete stated setpoint values. Refer to "a predetermined value"	Editorial	Information is not part of the system design basis
9.2.5.2.1	9.2-30	Insert "service water cooling"	Editorial	Proper terminology
9.2.5.2.2	9.2-30	Delete "emergency"	Editorial	Proper terminology
9.2.5.2.2	9.2-30	Replace "a volume . . . to" with "sufficient . . . and for"	Document calculation results	Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992
9.2.5.2.2	9.2-31	Change "post" to "design basis" and insert "low river . . . event."	Document system design basis	UHS Final Report, Section IV.B, page 25
9.2.5.2.2	9.2-31	Delete "trough"	Editorial	Proper terminology
9.2.5.2.2	9.2-30	Change "5" to "6"	Document system design basis	Figure 9.2-28
9.2.5.2.2	9.2-31	Delete "automatically"	Reflect system operation	Normal operating procedure
9.2.5.2.2	9.2-31	Change "post" to "design basis"	Document calculation results	Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992
9.2.5.3.1	9.2-32	Insert "active", replace "either . . . its" with "while . . . safety", delete "Additionally . . .failure"	Document system design basis	Memo from T. K. Schuster to G. Contrady dated August 2, 1991, UHS Final Report section II.A, page 10
9.2.5.3.1.1	9.2-32a	Insert new subsection	Document system design basis	UHS Final Report, Sections III and IV
9.2.5.3.1.2	9.2-33	Insert new subsection title	Editorial	Divide large subsection

Section	Page	Description of Change	Reason/Basis	References/Remarks
9.2.5.3.1.2	9.2-33	Replace "above" with "in Subsection 9.2.5.3.1.1"	Editorial	Editorial
9.2.5.3.1.3	9.2-34	Insert new subsection title	Editorial	Divide large subsection
9.2.5.3.1.4	9.2-35	Insert new subsection title	Editorial	Divide large subsection
9.2.5.3.1.4	9.2-35	Replace "a slight super-cooling of" with "freezing at"	Editorial	Proper terminology
9.2.5.3.2	9.2-36	Replace stated setpoint values with "a predetermined value" (two locations), delete setpoint values (one location)	Editorial	Information is not part of the system design basis
9.2.5.3.2	9.2-37	Replace "is locked" with "remains"	Reflect system operation	Normal operating procedure
9.2.5.3.2	9.2-37	Delete discussion of post-accident evaporation, blow-down, and makeup rates	Document calculation results	Calculation NED-M-MSD-14, Revision 0, dated January 9, 1992
9.2.5.3.2	9.2-38	Delete "therefore"	Editorial	Editorial
9.2.5.3.2	9.2-38	Replace "in one . . . down" with "coincident . . . active failure"	Document system design basis	UHS Final Report, Section II.A, page 9
9.2.5.1	9.2-43	Delete references to Table 9.2-6 and Figures 9.2-5 and 9.2-6	Editorial	Table and Figures were deleted
9.2.5.1	9.2-43	Insert "The LOCA . . . calculations"	Document system design	UHS Final Report

Section	Page	Description of Change	Reason/Basis	References/Remarks
9.2.9	9.2-61	Insert references 7 through 14	Editorial	References used in preparing new subsection 9.2.5.3.1.1
9.2	9.2-62	Revise Table 9.2-1	Reflect system operation	Normal operating procedure
9.2	9.2-71	Delete Table 9.2-6	Editorial	Information contained in Figure 9.2-7
9.2	9.2-97	Revise Table 9.2-11	Reflect system design	Heat Exchanger Data Sheets, letter from S. C. Mehta to F. Lentine dated January 17, 1990
9.2	9.2-98	Delete Table 9.2-12	Editorial	Information contained in revised Table 9.2-11
9.2	9.2-99	Delete Table 9.2-13	Editorial	Information contained in revised Table 9.2-11
9.2	9.2-102	Add Table 9.2-16	Document calculation results	"Ultimate Heat Sink Design Basis LOCA Single Failure Scenarios," S&L Calculation UHS-01, Revision 1, August 5, 1991
9.2	F9.2-2, Sheet 1	Replace with new figure	Reflect system operation	Normal operating procedure
9.2	F9.2-5	Delete Figure 9.2-5	Obsolete	"Heat Load to the Ultimate Heat Sink during a Loss of Coolant Accident," S&L Calculation ATD-0063, Revision 1, April 1, 1992
9.2	F9.2-6	Delete Figure 9.2-6	Obsolete	Calculation ATD-0063 Revision 1, dated April 1, 1992

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Section	Page	Description of Change	Reason/Basis	References/Remarks
9.2	F9.2-7	Revise Figure 9.2-7	Document calculation results	Calculation AID-0063, Revision 1, dated April 1, 1992
9.2	F9.2-8 to F9.2-14	Change Figures 9.2-8 through 9.2-14 to 'Braidwood Only'	Editorial	Byron does not have a cooling pond
9.2	F9.2-9 to F9.2-14	Replace Figures 9.2-9 through 9.2-14	Document calculation results	"Thermal Performance of the Ultimate Heat Sink During a Loss of Coolant Accident," S&L Calculation AID-0109, Revision 1, April 27, 1992
9.2	F9.2-30	Add Figure 9.2-30	Document calculation results	Calculation RSA-B-91-03, Figure 14
9.2	F9.2-31	Add Figure 9.2-31	Document calculation results	Calculation RSA-B-91-03, Figure 15

water, or about 146 inches of fresh snow), which was taken as the 48-hour PMP during the winter months (December through March) (Reference 17). The design-basis snow and ice load is then 104 psf (see Subsection 2.4.2).

2.3.1.2.4 Ultimate Heat Sink Design

The ultimate heat sink at Byron consists of two wet mechanical draft cooling towers and their associated makeup system. In order to evaluate the ultimate heat sink, 30 years of meteorological data is required. Long-term data most representative of the conditions at Byron Station were recorded at Rockford. However, the Rockford NWS station has only a 28-year period of record (1950-1977). Other than Rockford, data most representative of the meteorological conditions of the Byron site and not affected by large water bodies yet still providing a conservative evaluation of the ultimate heat sink were recorded at Peoria for a 30-year period (1948-1977). Peoria data extracted from National Oceanic and Atmospheric Administration (NOAA) 3-hourly observations on magnetic tape per Reference 18 were used in evaluating the heat dissipation characteristics of the proposed wet mechanical draft cooling towers under adverse atmospheric conditions. Peoria weather data was not available for January 1952 through December 1956. The decision was made to fill this data gap with meteorological data which best reflected the conditions at Peoria. Therefore, data from Springfield, the closest NWS station to Peoria, were used to complete the 30-year meteorological data record.

Average monthly temperature and humidity are summarized in Tables 2.3-43 and 2.3-44 for the representative meteorological data from Springfield and Peoria. Included for comparison are meteorological data from the Byron site and from Rockford.

~~The maximum water makeup rate required by the ultimate heat sink was determined using the maximum 1-day evaporation period (average dry bulb temperature = 90.5°F and average wet bulb temperature = 73.0°F) and the maximum 3-hour evaporative period (dry bulb temperature = 110.0°F and wet bulb temperature = 76.0°F), which was recorded on July 18, 1954 and July 14, 1954 at 3:00 p.m., respectively. The maximum evaporative periods were defined as periods having the maximum difference between dry bulb temperature and dew-point temperature. The analysis of maximum plant water intake temperature which occurs during the period of minimum water cooling was made with the highest 3-hour wet bulb temperature of 82.0°F which was recorded on July 30, 1961 at 3:00 p.m. The maximum dew point temperature recorded at the Byron site is 77.9°F. The corresponding dry bulb temperature is 86.6°F, while the wet bulb is 80.1°F. This onsite wet bulb temperature is lower than the 82.0°F wet bulb temperature used in the design of the ultimate heat sink.~~

The UHS tower is designed to fulfill its purpose under the extreme environmental conditions set forth in Regulatory Guide

1.27 (Revision 2, January 1976). The meteorological data from Peoria were employed to identify the period of meteorological record resulting in the minimum heat transfer to the atmosphere and maximum plant intake temperature. The Peoria weather tape was also used for a water consumption analysis to verify the availability of a 30-day cooling water supply.

The design UHS tower outlet temperature is ~~98°F~~100°F. A 3-hour~~ly~~ transient computer analysis of the Peoria weather tape using the maximum heat rejection to the UHS was used to determine maximum plant intake temperature~~.~~during the period of minimum tower performance. This analysis was made with the highest three-hour wet-bulb temperature, 82°F, which was recorded on July 30, 1961, at 3:00 pm. Per Regulatory Guide 1.27 (Revision 2, January 1976), the ultimate heat sink must be capable of performing its cooling function during the design basis event for this worst case three-hour wet-bulb temperature. However, the design operating wet-bulb temperature of the ultimate heat sink is 78°F (ASHRAE 1% exceedance value). The maximum heat rejection to the UHS is from the safe shutdown of two 3411-MWet (guaranteed core thermal power) PWR reactors, as a result of ~~one unit undergoing~~ a loss-of-coolant accident (LOCA) ~~and one unit undergoing complete~~ concurrent with a loss of offsite power (LOOP) on one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures. The accident scenario also includes a single active failure. ~~external power (LOEP)~~. The maximum predicted UHS tower outlet temperature from the tower performance curves for this 3-hour~~ly~~ analysis is less than 100°F~~94.6°F. This is 3.4°F less than design~~.

~~To support the availability of a 30-day cooling water supply, a 3-hourly transient computer analysis was also made. Due to the fact that the UHS water supply is a continuous source from two diesel engine-driven, Category I makeup systems, (each having a design capability of 1500 gpm), the maximum 3-hour water consumption rate was used to check the makeup pump size. The maximum 3-hourly makeup rate required to replenish the water loss due to evaporation, drift and blowdown is less than the design capability of the pumps.~~

~~Byron has more than a 30-day supply of water because it has a continuous makeup supply from the Rock River using the Seismic Category I makeup system. The Peoria weather tape was used in a transient analysis to determine the worst 3-hourly evaporation rate using the maximum heat rejection to the UHS for the safe shutdown of two 3411-MWe PWR reactors, one unit undergoing a LOCA and the other unit undergoing a LOEP. The makeup rate required to replenish the water loss due to evaporation, drift and blowdown is less than the design capability of 3000 gpm for the two makeup pumps.~~

~~Also, the postulation of a single failure to one of the two makeup pumps was included in our analysis of a 30-day water supply. With the single failure of one of the two makeup pumps, the makeup rate for the worst 3-hour weather condition (1,739 gpm) exceeded the design capability of one makeup pump. But the makeup rate for the worst 3-hour weather condition was determined~~

~~to exceed the capacity of one makeup pump only during the first 760 seconds of the transient. This condition results in a requirement for 1,645 gallons of water beyond the capability of the one makeup pump. Each mechanical draft cooling tower basin contains a minimum volume (inventory) of 290,000 gallons of water. This 290,000 gallons provides more than ample margin during the 760-second period in which the makeup rate exceeds the design capability of one makeup pump.~~

The maximum water makeup rate required by the ultimate heat sink was determined using the maximum one-day evaporation period (average dry bulb temperature = 90.5°F and average wet bulb temperature = 73.0°F) which was recorded on July 18, 1954. The maximum evaporative period was defined as the period having the maximum difference between dry bulb temperature and dew-point temperature.

Byron has more than a 30-day supply of water because it has a continuous makeup supply from the Rock River using the Seismic Category I makeup system. In the event that makeup from the Rock River is not available, an alternative makeup source is from the onsite deep wells. There are two deep wells which have been demonstrated to be able to supply water at a rate of 800 gpm per well for more than 30 days.

To support the availability of a 30-day cooling water supply, two analyses were performed to determine the makeup requirements under the worst 1-day weather condition, with heat rejection rate based on a LOCA and LOOP on one unit in conjunction with safe shutdown of the other unit, and a single active failure. The analysis for the makeup rate also assumed a safe shutdown seismic event.

Both the makeup system and the deep well system were demonstrated to be able to provide sufficient water to replenish water loss due to evaporation, blowdown, drift and auxiliary feedwater supply, and to provide continuous cooling for at least 30 days.

~~This period of 760 seconds is very conservatively calculated using a constant maximum heat rejection rate to the UHS.~~

For details of the ultimate heat sink design and makeup water availability, see Subsections 9.2.5 and 2.4.11.6.

2.3.1.2.5 Inversions and High Air Pollution Potential

Thirteen years of data (1952-1964) on vertical temperature gradient from Argonne (Reference 4) provide a measure of thermodynamic stability (mixing potential). Weather records from many U.S. stations have also been analyzed with the objective of characterizing atmospheric dispersion potential (References 19 and 20).

The seasonal frequencies of inversions based below 500 feet for the Byron Station are shown by Hosler (Reference 19) as:

Season	% of Total Hours	% of 24-Hour Periods With at Least 1 Hour of Inversion
Spring	30	71
Summer	31	81
Fall	37	68
Winter	31	53

Since northern Illinois has a primarily continental climate, inversion frequencies are closely related to the diurnal cycle. The less frequent occurrence of storms in summer produces a larger frequency of nights with short-duration inversion conditions.

Holzworth's data (Reference 20) give estimates of the average depth of vigorous vertical mixing, which give an indication of the vertical depth of atmosphere available for mixing and dispersion of effluents. For the Byron Station region, the seasonal values of the mean daily mixing depths (in meters) are:

Season	Mean Daily Mixing Depths	
	Morning	Afternoon
Spring	480	1400
Summer	300	1600
Fall	390	1200
Winter	470	580

When daytime (maximum) mixing depths are shallow, pollution potential is highest.

Argonne data are presented below in terms of the frequency of inversion conditions in the 5.5- to 144-foot layer above the ground as percent of total observations and in terms of the average duration of inversion conditions.

26. C. L. Mulchi and J. A. Armbruster, "Effects of Salt Sprays on and Nutrient Balance of Corn and Soybeans," *Cooling Tower Environment - 1974*, AEC Symposium Series, Technical Information Center, Oak Ridge, Tennessee, pp. 379-392, 1975.

27. E. Aynsley, "Environmental Aspects of Cooling Tower Plumes," TP 78A, Cooling Tower Institute, Houston, Texas, 1970.

28. P. T. Brennan et al., "Behavior of Visible Plumes from Hyperbolic Cooling Towers," American Power Conference, Chicago, Illinois, April 22, 1976.

29. A. Martin, "The Influence of a Power Station On Climate - A Study of Local Weather Records," *tmospheric Environment*, Vol. 8, pp. 419-424, 1974.

30. D. J. Moore, "Recent CEGB Research on Environmental Effects of Cooling Towers," *Cooling Tower Environment - 1974*, AEC Symposium Series, Technical Information Center, Oak Ridge, Tennessee, pp. 205-220, 1975.

31. S. R. Hanna and F. G. Gifford, "Meteorological effects of energy dissipation at large power parks," *Bulletin Amer. Meteor. Soc.* 56, pp. 1069-1076, 1975.

32. American Society of Heating and Refrigeration Engineers (ASHRAE) Handbook fundamentals, 1989, IP edition, pg. 24.7.

2.4.11 Low Water Considerations

2.4.11.1 Low Flow in the Rock River

Low flow frequency analyses for the Rock River at Rockton and at Como were made using the Log-Pearson Type III distribution (Reference 14). Flows at the intake were interpolated using Equation 2.4-1 in Subsection 2.4.2.

Table 2.4-15 gives flows in the Rock River at the intake for various combinations of duration and recurrence interval. Considerations of downstream dam failures are included in Subsection 2.4.11.5.

2.4.11.2 Low Water Resulting from Surges, Seiches, or Tsunami

Low water conditions resulting from surges, seiches, or tsunami are not design considerations because there are no large bodies of water near the site, nor is the site near a coastal area.

2.4.11.3 Historical Low Water

A minimum daily flow of 440 cfs was recorded at Como on August 20, 1934. The historical 1-day low flow at the intake is estimated to be 400 cfs and has a recurrence interval of more than 100 years. The corresponding river elevation at the intake is 670.4 feet.

2.4.11.4 Future Controls

Future upstream uses of Rock River water are not expected to lower minimum flows. Since most communities derive their water supply from groundwater, the trend will be toward higher future minimum flows due to increased sewage effluent discharges.

2.4.11.5 Plant Requirements

The circulating water makeup is withdrawn from the Rock River. The maximum water requirement for plant use is 107 cfs. Actual use might be less depending on plant operating loads and seasonal variability of evaporation and blowdown losses. Since only 61 cfs are used up due to evaporation and drift, 46 cfs are returned to the Rock River. Thus, the net withdrawal rate is 61 cfs. These requirements include makeup water for the essential service cooling towers, of which 2 cfs are for evaporation and drift losses and 2 cfs are for blowdown.

~~The maximum makeup rate to the essential service water cooling towers under the worst 1-day weather conditions is 1545 gpm. Since the total design capability of the essential service water makeup pumps is 3000 gpm, sufficient water is available for safe plant shutdown from the Rock River. In the unlikely event that emergency requirements can not be satisfied by surface water withdrawals from the Rock River, groundwater~~

Makeup to the essential service water cooling towers is required to compensate for losses due to evaporation, blowdown and drift. Under the design basis accident, which consists of a loss of coolant accident coincident with a loss of offsite power on one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown (do not show deletion) of the other unit using normal shutdown operating procedures and a single active failure, the maximum makeup demand under the worst 1-day weather conditions is 2000 gpm. The makeup rate decreases to approximately 1500 gpm twelve minutes after the accident and continues to decrease. Since the total design capability of the essential service water makeup pumps is 3000 gpm, sufficient water is available for safe shutdown from the Rock River. In the unlikely event that emergency cooling water requirements cannot be satisfied by makeup from the Rock River, deep wells will provide makeup to the essential service water cooling tower.

~~wells will serve for makeup to the essential service water cooling towers. The wells are capable of producing in excess of 1600 gpm and satisfy the makeup requirement.~~

A summary of the cooling water capabilities of various pumps and wells is provided in Table 2.4-16.

Table 2.4-17 illustrates the required minimum safety-related cooling water flow, the sump invert elevation and configuration, the minimum design operating level, and the required minimum pump submergence.

The essential service water makeup pumps are capable of supplying sufficient water during periods of low water resulting from the 1-day 100-year drought. From Table 2.4-15, the 1-day 100-year low flow at the intake is 454 cfs. The corresponding water surface elevation is 670.4 feet.

Backwater analyses for low-flow conditions in the Rock River indicate that a reduction of 10% in the river discharge would result in only negligible changes of water-surface levels at the pumping site and downstream. Backwater profiles were computed (Reference 13) for discharge conditions shown in Table 2.4-18 for the river reach from Sterling to the pumping site, a distance of 41 miles. Above the dam at Oregon, changes in water-surface levels due to withdrawal of 10% of the low-flow discharge would be 0.03 foot or less. Between the dams at Sterling and Oregon, the average differences in water levels would range from 0.05 to 0.09 foot, as shown in Table 2.4-18.

Water levels at Como, with and without cooling water withdrawals, were estimated from the USGS rating table for the Como gauge 3 miles downstream from the dam at Sterling. With 10% withdrawal, the change in stage would be approximately 0.08 foot at Como for the low-flow conditions listed in the table. This change confirmed water levels derived by backwater analyses since the water surface elevation at Como is not controlled by a small dam as it is above Sterling, Dixon, and Oregon.

An extremely low water level could possibly occur through combination of low river discharge and breaching of the Oregon dam 5 miles downstream. Since the lowest point on the river bottom at the intake is about 10 feet below the dam's crest, removal of the impounding effect of the dam during low flow would lower the water surface at the intake. Consequently, studies were made to determine that level. The same computer model was used as described in Subsection 2.4.3 with a channel "n" value of 0.032 and a river flow of 400 cfs, the 1-day lowest flow at the site area. The resulting water-surface holes and the well casings were grouted with concrete grout from the bottom upward in order to seat the casings into the bedrock and to provide seals preventing the movement of soil or surface contaminants into the wells. The production portion of the wells consists of uncased, open boreholes which were over-pumped after completion to remove any loose rock or drill cuttings. The type of well construction, with the length of casing welded together and seated into the bedrock, provides the maximum strength for any groundwater well. Municipal or large-volume industrial wells in northern Illinois are generally of similar or lower quality construction.

During pump testing of these wells, some caving of sandstone was observed which might interfere with the pump performance and reduce the productivity of the well. The actual zone of caving was determined by caliper-logging of the borehole and the wells were deepened to allow for any debris to collect at the bottom and still assure adequate yield. A smaller diameter casing was extended deeper into the well placing the pump setting within the cased portion of the well. This prevents any caved material from damaging the pump. With these modifications, the wells assure adequate supply to the UHS when needed.

The design elevation of the pump invert which supplies makeup to the essential service cooling tower basins from the Rock River has been based on the postulated low water elevation resulting from the breaching of the Oregon Dam during the historic low flow period. This occurrence would result with a river flow of 400 cfs, a water elevation of 664 feet 4 inches. The historic low flow of the Rock River recorded in 1939 at Como, Illinois was 440 cfs. In addition, under these conditions, an alternate source of makeup water is available from the seismically qualified deep wells.

~~An analysis has demonstrated that makeup water is available for 30 days and beyond at a rate which satisfies the most severe design basis as set forth in NRC Regulatory Guide 1.27 (Revision 2, January 1976) positions C.1.a and C.1.b. The heat sink design bases results from a postulated loss-of-coolant accident for one unit and loss of external power for the other.~~

The Byron Ultimate Heat Sink design basis accident consists of a loss of coolant accident coincident with a loss of offsite power on one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures and a single active failure. Analyses were performed to demonstrate that makeup water is available for 30 days and beyond at a rate which satisfies the most severe design basis as set forth in NRC Regulatory Guide 1.27 (Revision 2, January 1976) positions C.1.a and C.1.b. The analyses were based on the above described scenario in conjunction with the worst one day weather conditions.

Each Seismic Category I cooling tower basin at ~~normal~~ minimum water level contains 290,000 gallons, of which 200,000 gallons are available for auxiliary feedwater.

The connections between the essential service water cooling towers and the auxiliary feedwater train are provided with normally closed motor-operated valves. Protection against single active or passive failures is provided by the redundancy of the essential service water system.

An analysis of the impact of supplying water to the auxiliary feedwater train from the ultimate heat sink indicates that the heat sink dependability is in no way impaired since the ~~normal~~ minimum

2.4.11.6 Heat Sink Dependability Requirements

The normal source of cooling water for the plant is the 2537-acre cooling pond. Cooling water is taken from the pond at the Pond Screen House by six circulating water pumps. Two 192-inch circulating water pipes carry water to the plant and back again to the pond. A buried pipeline from the plant takes blowdown to the Kankakee River. Makeup water is pumped from the river screen house on the Kankakee River through a buried pipeline to the northeast section of the cooling pond. Should makeup water be eliminated by system failure or extreme low flows, the pond can operate under a closed cycle system. Emergency shutdown water is available from the ultimate heat sink, namely the ESCP.

The ESCP is an excavated area located within the cooling pond designed to provide sufficient volume to permit plant operation for a minimum 30-day period without requiring makeup water in accordance with Regulatory Guide 1.27 (Revision 2, January [illegible]). ~~The design basis of the ESCP postulates one unit undergoing a loss-of-coolant accident and the second suffering a [illegible] external power.~~ The ESCP has been reviewed to determine its ability to handle the total heat dissipation requirements of the station assuming a LOCA coincident with a loss of offsite power on one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures, a single active failure, and a coincident design basis seismic event. It is estimated that water loss due to seepage and evaporation would amount to a 1.5 foot (1 foot due to evaporation and 0.5 foot due to seepage) decrease in depth of water in ESCP for such a 30-day period (see Subsection 9.2.5). The ESCP has an area of 99 acres and a depth of 6.0 feet at elevation 590.0 feet. Its area-capacity curve is given in Figure 2.4-46. Figures 2.4-47 and 2.4-48 show the ESCP and its sections and pipelines.

The intake pipes for the essential service water are in the pond screen house at a centerline elevation of 572.67 feet, over 11 feet below the bottom of the pond. The sump invert elevation of the pond screen house is 570.17 feet. At a minimum ESCP elevation of 573.92 feet at which the 30-inch intake pipes are fully submerged, the essential service water pump net positive suction head requirements are more than satisfied. This is based upon two pumps being supplied with water at their rated pumping capacity from a single 48-inch supply line and three 30-inch intake lines. Plan and elevation drawings of the pond screen house are provided in Figure 1.2-15. The intakes are protected from ice blockage by traveling screens, bar grills, and trash rakes, located at the front of the Pond Screen House. The minimum operating level is 590 feet, at which point the ESCP loses communication with the cooling pond. The essential service water pumps are located in the auxiliary building. Two essential service water discharge pipelines run from the auxiliary building to the south end of the ESCP. The description of the essential service water system can be found in Subsection 9.2.1.2.

of depth measurements at specific time intervals along track lines, spaced equally over the pond. Also, included in this report are the results of the surveys in terms of the surface area and volume capacity.

Monitoring of the ESCP is covered by Surveillance Requirement 4.7.5.

2.5.6.9 Construction Notes

The ESCP is an excavated pond within the cooling lake. Design and in-situ soil conditions were presented in subsections above. The ESCP does not depend upon man-made structural features for water retention and is constructed to remain intact during a design basis seismic event.

2.5.6.10 Operational Notes

Field observations and results of instrumentation for the ESCP are discussed in Subsection 2.5.6.8.

2.5 7 References

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containment fan cooler housing is drained to the containment base mat.

e. The containment and subcompartment atmospheres are maintained during normal operation within prescribed pressure, temperature, and humidity limits by means of the containment chilled water systems which deliver 40°F water to the dehumidifying coils within each reactor containment fan cooler. Containment penetrations cooling is accomplished by means of supplying component cooling water to the penetrations that have cooling coils. Containment ventilation systems such as the CRDM booster fans and the CRDM cooling fans are used during normal operation and require no periodic testing to ensure functional capability.

6.2.1.1.3 Design Evaluation

The short-term pressure subcompartment analysis considers a loss of offsite power. Consideration of single active failures is of no consequence, since none of the safety equipment functions during the initial seconds of the postaccident transient. The maximum calculated differential pressure in the loop compartment is 20.27 psi resulting from a double-ended hot leg (DEHL) break in volume 3 (see Table 6.2-10 for listing of volumes). The maximum calculated differential pressure in the upper pressurizer cubicle is 10.24 psi resulting from a spray line double-ended break. The maximum calculated differential pressure in the steamline pipe chase is 13.43 psi resulting from a main steamline break in volume 26.

The containment subcompartment differential pressure analysis is described in detail in Subsection 6.2.1.2. The results of the pressure transient analysis of the containment for the loss-of-coolant accidents are shown in Figures 6.2-1 through 6.2-6. Containment temperature curves are presented in Figures 6.2-7 through 6.2-12. The cases examined in this analysis determine the effects of the full range of large reactor coolant break sizes up to and including a double-ended break. Cases illustrating the sensitivity to break location are also shown. All of these cases show that the containment pressure will remain below design pressure with margin. After the peak pressure is attained, the performance of the safeguards system reduces the containment pressure. At the end of the first day following the accident, the containment pressure has been reduced to a low value. The peak pressures and margins are shown in Table 6.2-1.

Additional containment analyses were performed for the purpose of evaluating ultimate heat sink capability (see Subsection 9.2.5). The containment analyses performed for the ultimate heat sink reconstitution differ from the containment integrity analyses described here in that the heat removal rates from the reactor containment fan coolers and the residual heat removal system were maximized to determine the limiting heat load on the ultimate heat sink.

The smaller pump suction breaks, the hot leg break and the cold leg break mass and energy releases assumed that the sump water (which is pumped back through the core when the RWST empties) is at a constant temperature of saturation at the design pressure of the containment. As required by the NRC, the full

6. The main control room display/recording requirements of Regulatory Guide 1.97, Revision 3, are met for containment sump level.

Reactor support concrete temperatures are indicated inside containment. Reactor support liquid coolant, utilizing component cooling water, may be provided if the need is indicated by the concrete temperature indicators.

Refer to Section 7.3 for design details.

6.2.2 Containment Heat Removal System

The containment heat removal system consists of the reactor containment fan cooler system and the containment spray system. The reactor containment fan cooler system has no emergency function other than containment heat removal, while the primary function of the containment spray system is the removal of iodine and other radionuclides from the containment atmosphere.

The containment spray system is designed to operate following a LOCA to reduce the elemental iodine concentration of the containment atmosphere and to raise the pH of the containment sump by adding NaOH, to ensure that the iodine removed from containment atmosphere will be retained in the sump solution. The objectives are completed in approximately 30 minutes, at which time the spray injection phase is terminated. The system is then isolated from the RWST and plant valves are aligned for recirculation operation. (It should be noted that after 30 minutes most of the heat removal from containment is provided by the reactor containment fan coolers, which are safety grade for Byron/Braidwood.) Sprays are not required for long-term heat removal. Nevertheless, the containment sprays will be operated for at least 2 hours following a LOCA before they are terminated.

The RHR, CV, and SI systems are designed to operate following a LOCA to cool the reactor core. These systems are switched from injection to recirculation at approximately 30 to 40 minutes and remain in operation for the remainder of the accident. Additional fuel clad failure is not postulated while these systems are operating.

The containment spray system is discussed in Subsection 6.5.2, and the performance of both the reactor containment fan cooler system and the containment spray system under the design-basis loss-of-coolant accident condition is evaluated in Subsection 6.2.1.1.

The containment heat removal system rejects heat to the ultimate heat sink. Containment analyses to support the design bases of the ultimate heat sink are described in Subsection 9.2.5.

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9.2.1.2 Essential Service Water System

9.2.1.2.1 Design Bases

The essential service water system is illustrated in Figure 9.2-2, 9.2-21, and 9.2-22. ~~The basic design philosophy is to provide two redundant systems in each unit to service the essential heat loads in each unit. The essential loads supplied during normal plant operation, LOCA, and LOOP or normal shutdown operation~~The essential service water system is designed to ensure that sufficient cooling capacity is available to provide adequate cooling during normal and accident conditions. The components served by essential service water for normal, LOCA, and shutdown conditions are shown in Table 9.2-1.

The essential service water system is divided into two redundant loops for each unit. The system may be operated with the loops cross-tied or as two separate loops. Table 9.2-11 lists nominal design flows forte ~~each cubicle cooler served by~~ the essential service water system. Actual component flows vary depending on system alignments, mode of operation, and ambient conditions. These nominal design flow rates are ~~the same~~sufficient for all operating conditions, including normal operation, post-LOCA operation, and during a LOOP or normal shutdown. Typically, the flow rate specified is a nominal value based on maintaining a desired oil temperature or equipment temperature for long-term operation and design margin exists between the specified flow rate and the flow rate required to remove the design heat load. ~~Table 9.2-12 lists design flow rates for each essential service water train during normal operation and normal cold shutdown. Table 9.2-13 lists design flow rates for each essential service water train during post-LOCA operation.~~ In addition, either train can supply 990 gpm to the suction of the auxiliary feedwater pump of the same train. Refer to Subsection 10.4.9 for a discussion of the auxiliary feedwater system and this cross-tie.

All safety-related heat transfer equipment is designed for a 100°F essential service water inlet temperature. Heat rejection capacity of the essential service water cooling towers is discussed more fully in Subsection 9.2.5.

9.2.1.2.2 System Description

Each full-capacity essential service water loop in each unit is supplied by a single pump rated at 24,000 gpm at 180 feet ±10% total developed head. Actual system flow varies with system lineup and conditions. See Table 9.2-1 and Table 9.2-11 for the components served and the nominal rated component flows. The pumps are located on the lowest level of the auxiliary building to ensure the availability of sufficient NPSH. Emergency power is available to each pump from its respective ESF bus as shown in Table 8.3-1 and described in Subsection 8.3.1. At Byron, the suction supply is by one supply line running from each of the two redundant essential service mechanical draft cooling towers to the auxiliary building. Each supply line supplies one essential service water pump in each unit; each of the two pumps in a given unit takes its suction from a separate supply line. At Braidwood, the suction supply is by two intake lines running from the Safety Category I portion of the lake screen house essential pond to the auxiliary building. Each intake line supplies one essential service water pump in each unit; each of the two pumps in a given unit takes its suction from a separate intake line. The system, therefore, meets the single-failure criterion as shown in the analysis in Table 9.2-2 for Braidwood, and Tables 9.2-2 and 9.2-16 for Byron.

On each unit, the cross-tie header valves on the discharge of each pair of essential service water pumps are powered from separate ESF buses and are normally open. The suction line valves are each assigned to the same ESF bus as the pump with which it is associated. A cross-tie between the Unit 1 and Unit 2 essential service water systems can be established through the 1SX005 and 2SX005 valves.

At Byron, heat rejection from the essential service water system is to the essential service water cooling towers, both on a normal and on an emergency basis. The discharges from each loop in each unit are separate and fed to two separate and redundant return lines for return to the towers. The two discharges from each unit and the two return lines to the towers are arranged similar to the intakes, i.e., the two discharges from each unit run into separate return lines, and each return line is fed from one discharge from each unit. The single failure criterion is met as shown in Tables 9.2-2 and 9.2-16.

At Braidwood, heat rejection from the essential service water system is to the essential cooling pond, both on a normal and on an emergency basis. The discharges from each loop in each unit are separate and fed to two separate and redundant return lines for return to the pond. The two discharges from each unit and the two return lines to the pond are arranged similar to the intakes, i.e., the two discharges from each unit run into separate return lines, and each return line is fed from one of the two discharges from each unit. The single-failure criterion is met as shown in Table 9.2-2.

The essential cooling pond is more fully discussed in Subsection 9.2.5.

~~Each~~At Byron the essential service water cooling tower~~is~~s are designed to accommodate the heat load from both units simultaneously under both normal and accident conditions. ~~Both towers are normally utilized, one assigned to each unit, when both units are in operation.~~ The essential service water cooling towers and their auxiliary systems are more fully discussed in Subsection 9.2.5.

9.2.1.2.3 Safety Evaluation

The entire essential service water system is designated Safety Category I, Quality Group C, including supply lines, pumps, and return lines.

The essential service water supply and discharge lines join the auxiliary building and the essential service water cooling towers or cooling pond. These lines are either below or incorporated in the turbine building base mat. They are not inside the turbine building and, the lines are adequately protected from any occurrence within the turbine building. The routing of this piping is shown in Figures 9.2-21 and 9.2-22. These figures show plan and elevation views between the ultimate heat sink and the pumps.

This has been accomplished by utilizing applicable ACI and AISC codes and imposing the SSE and the design basis tornado loads on the turbine building and the base mat design. Because these additional loads were used in the design of the turbine building base mat, the requirements of General Design Criteria 2 and 44 of Appendix A to 10 CFR 50 are satisfied. Therefore, the turbine building has the same margin of safety as the Category I structures. This complies with the Regulatory Staff position regarding interaction of non-Category I structures with Category I structures, as given in SRP Section 3.7.2.II.8. Although the specific requirements of Appendix B to 10 CFR 50 cannot be demonstrated, comparable practice was used in the construction of the turbine building base mat. The material suppliers and contractors for the construction of the turbine building were the same as for the construction of the Category I structures. The Applicant's construction personnel monitored the construction work and have ensured quality control. The quality of the construction is reflected in the average actual concrete strengths. The design requirement for the concrete compressive strength is 3500 psi. The Byron site was constructed with an average concrete strength of 5265 psi (5369 psi for Braidwood). The "in-place" strength of concrete and reinforcing steel used in the construction of the turbine building base mat exceeds the design strengths by a minimum of 28%. These strengths were achieved in both the Category I and Category II structures.

The Applicant's and contractor's quality control documentation for the construction of the turbine building base mat including the responsible quality control records are available at the plant sites.

Based on the equivalent margins of safety provided in the design of the turbine building and the Category I structures, and the quality control provided in the construction, the integrity and functionality of the essential service water piping has been assured.

Normal essential service water heat loads are as indicated in Table 9.2-1. These loads are supplied from one of the full-capacity loops in each unit, so that one of the supply pumps is in continuous operation. Upon receipt of a safeguards actuation signal, both essential service water pumps will automatically start and the diesel engine generator units will automatically start. If power is lost to the ESF buses, all safety-related equipment will be automatically sequenced to start upon restoration of bus voltage. Components are all individually sealed in (latched) so that loss of the actuation signal will not cause these components to return to the position held prior to the advent of the actuation signal. ~~From a review of Tables 9.2-11, 9.2-12 and 9.2-13, it is apparent that one pump can handle its own ESF loads plus cubicle coolers and lube oil coolers of the other division.~~

9.2.5 Ultimate Heat Sink

9.2.5.1 Design Basis

Since the ultimate heat sink is shared by two units, the condition of both units must be determined for the design basis event. The design bases accident scenario considered for the Byron ultimate heat sink is a loss of coolant accident (LOCA) coincident with a loss of offsite power (LOOP) on one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures. The accident scenario also includes a single active failure.

The ultimate heat sink for the station consists of the two ~~redundant~~essential service water mechanical draft cooling towers and the makeup system to these cooling towers. As discussed in Subsection 9.2.1.2, heat from the essential service water system is rejected to the essential service water cooling towers. The towers are used during normal operation thereby providing a means of availability and surveillance not obtainable with an emergency system maintained on a strictly standby basis. ~~Only essential heat loads are rejected to the towers.~~ Components which contribute to the essential service water heat loads are listed in Table 9.2-1.

~~The normal operating heat load of a unit is 142 x 10^6 Btu/hr. The refueling and maintenance outage heat load is 13 x 10^6 Btu/hr.~~

~~Table 9.2-6 shows heat loads rejected to the essential service water system versus time for the unit undergoing post-LOCA cooldown. Figure 9.2-5 shows the energy input to the containment versus time, and Figure 9.2-6 shows the heat removal rate versus time for one reactor containment fan cooler and one residual heat removal heat exchanger.~~ Figure 9.2-7 shows the ~~LOCA and cold shutdown heat rejection rate to the essential service water system.~~combined heat rejection rate versus time for the unit undergoing post-LOCA cooldown, plus heat rejection rate versus time for the unit undergoing safe shutdown.

9.2.5.2 System Description

9.2.5.2.1 Essential Service Water Cooling Towers

The essential service water cooling towers are part of the essential service water system, a diagram of which is provided in Figure 9.2-2. Plan and section drawings for the essential service water cooling towers are shown in Figures 9.2-23 through 9.2-27. The cold water basins of the two cooling towers are connected ~~above normal water level~~ by an overflow ~~trough~~.

The essential service water cooling towers are required for safe shutdown and are Safety Category I, Quality Class C, Seismic Category I. The essential service water mechanical draft cooling towers are the ultimate heat sink~~s~~ for the essential service water system. There are two ~~redundant~~ induced draft cooling towers of the counterflow design. Each of the two safety-related mechanical draft cooling towers consists of a water storage basin, four fans, four riser valves, and two bypass valves. ~~Each cooling tower is designed to accommodate the heat load from both units simultaneously under both normal and emergency conditions.~~

~~Each of the four cells per tower is rated at 13,000 gpm with 98°F cold water supply temperature and 138°F postaccident return temperature concurrent with 78°F ambient wet bulb. Assuming the loss of one cooling tower, the remaining cooling tower can lose~~

The ultimate heat sink is capable of providing adequate cooling capability for a LOCA coincident with a LOOP in one unit, and the concurrent orderly shutdown and cooldown from maximum power of the other unit to Mode 5 using normal shutdown operating procedures. This scenario also includes a single active failure.

~~one cell due to vertical tornado missile impacting the fan, fill and internal piping, while providing adequate cooling capability for the unit undergoing post-LOCA cooldown and the other unit undergoing hot shutdown.~~

Emergency power to the essential cooling tower mechanical draft fans is supplied from ESF buses which may be supplied by the onsite emergency diesel generators.

The temperatures of the essential service water cooling tower basin and the supply headers must be controlled to prevent freezing in the tower fill. This is accomplished by sensing ~~supply header~~**pump discharge** temperature and controlling hot water bypass valves to the cooling tower basins. A Category I sensing element and temperature controller is provided for each cooling water train for each unit. The controller provides visual indi-cation of temperature in the control room. The controller also maintains cooling water temperature ~~between 52°F and 78°F~~ in the tower basins by opening the bypass valves when the temperature drops to ~~52°F~~**a predetermined value**, so that the cooling section is removed from service, and closing the bypass valves when the water supply temperature increases to ~~78°F~~**a predetermined value** so that the cooling section is returned to service.

The cooling towers must have a source of makeup water to compensate for drift losses, evaporation, and blowdown. The normal supply of makeup water comes from the Category II circulating water system. An emergency source of makeup water is provided by the Category I diesel driven makeup pumps. These are described in Subsection 9.2.5.2.2. An additional source of makeup water is provided by the Category II onsite deep well pumps, which are described in Subsection 9.2.5.2.3.

The blowdown system for the essential **service water cooling** tower is Safety Category II since return of the blowdown water to the Rock River is not essential to the operation of the ultimate heat sink.

9.2.5.2.2 Category I Essential Service Water Makeup System

The essential service water makeup pumps, which are active components required for safe shutdown, are ASME Section III Safety Category I Quality Class C components.

Under ~~emergency~~ low levels in the Byron essential service water cooling towers, each tower is provided with a Category I diesel engine-driven makeup pump which automatically starts on low water level signal. These pumps are located in the river screen house and take suction from behind bar grilles and traveling screens located therein. Each essential service water cooling tower is supplied by a separate makeup train consisting of a pump and Safety Category I supply line.

Each makeup train is capable of supplying ~~a volume of water equivalent to~~sufficient water to compensate for auxiliary feedwater supply and/or for drift, evaporation and blowdown losses resulting from **design basis** ~~post~~-LOCA conditions in one unit concurrent with the safe shutdown of the other unit~~.~~**, low river level, a single active failure, and the concurrent occurrence of the safe shutdown seismic event.**

Each diesel-driven essential service water makeup pump located in the river screen house is provided with a dedicated Seismic Category I fuel oil supply. This fuel oil supply is discussed in Subsection 9.5.4.

Therefore, Category I makeup water can be supplied to the basins of both towers by either of the two lines from the river screen house. Similarly, the system can return water to one tower while deriving water from the other tower's basin, by way of the overflow~~ trough~~.

The river screen house is shown in Figure 1.2-16. A detailed cross section of the river intake structure is shown in Figure 9.2-28. The rating curve for low flows on the Rock River at the structure is shown in Figure 9.2-29.

The top of the base mat is at elevation 663 feet ~~5~~6 inches MSL, and the screens are recessed within the base mat so that essential service water makeup can be provided. A sump is provided for each essential service water makoup pump, having a bottom of sump elevation of 660 feet 6 inches MSL.

Minimum pump submergence requirement is 22-1/2 inches. The pump intake is about 15-1/2 inches above the bottom of the sump.

The essential service water makeup pumps may be started manually from the control room, locally at the river screen house, or automatically on level controls of the cooling tower basins. Once started~~ automatically~~, they continue to operate until the fuel supply to each engine drive (approximate fuel consumption is 10 gallons per hour) is exhausted or until the engines are manually stopped from the control room or locally. The engines and pumps are capable of meeting makeup requirements for the actual **design basis** ~~post~~-LOCA heat rejection rates under worst case evaporative loss conditions. A minimum of 36% of the 2000-gallon tank will ensure 72 hours of makeup pump operation before refueling is required.

The Category I makeup pumps are designed for the combined event flood, but not for the probable maximum flood.

9.2.5.2.3 Category II Deep Well Pumps

The Category II, Quality Group D onsite deep wells provide a source of makeup water to the essential service cooling tower basins in the event of a flood more severe than the combined event flood on the Rock River. Since the onsite wells are located approximately 200 feet above the river at plant grade elevation, they will not be affected by flooding on the Rock River.

The onsite wells at Byron are powered by ESF buses E11 and E12. The well pumps will, therefore, be capable of supplying makeup water to the essential service water cooling towers in the event of the loss of the river screen house coupled with the loss of offsite power. The wells supply the required amount of water for tower consumptive makeup for a minimum of 30 days. An aquifer pumping test was performed in the Byron water wells in July 1980. The test verified that the wells are capable of satisfying the requirement for essential service water makeup. Test results indicated that the total drawdown in each well after 30 days of continuous pumping at 800 gpm will be approximately 85 feet. This is substantially less than 125 feet of available drawdown in each well and demonstrates the adequacy of the wells.

The deep wells and portions of the well water system, which are an alternate source of water to the essential service water cooling towers, have been qualified for the safe shutdown earthquake.

9.2.5.3 Safety Evaluation

9.2.5.3.1 Ultimate Heat Sink Design Basis

The ultimate heat sink is designed to withstand either the safe shutdown earthquake or the probable maximum flood of the Rock River occurring separately, consistent with the philosophy for ultimate heat sinks for nuclear power plants. The system withstands a single active failure, ~~either active or passive, without impairing its~~ while maintaining the system's ability to perform its safety function. ~~Additionally, due to the manner in which emergency power may be supplied to the cooling towers from the diesels, the system functions unimpaired with one active diesel failure.~~Tables 9.2-7 and 9.2-16 present a failure analysis.

The review of the ultimate heat sink for single active electrical failures was based on guidance from IEEE standards, the Byron Safety Evaluation Report (1983), and the Standard Review Plan. Passive failures in fluid systems do not represent a challenge to the heat removal capability of the ultimate heat sink because of the cross-tie and bypass capabilities in the cooling water system. Passive failures (i.e. loss of a tower) were analyzed for Byron but were limited to non-accident conditions. Acceptability was based on the ability of the system to perform its safety function in the presence of such a failure.

The Safety Category I river screen house is designed for the combined event flood as discussed in Subsection 2.4.3.7, thus, should a flood more severe than the combined event flood occur, the Safety Category I makeup systems would be unavailable. In this event, the onsite wells would provide makeup.

The ultimate heat sink is designed to withstand a design-basis tornado. The design basis of the cooling towers is discussed in Subsection 9.2.5.2.1. An analysis of the effect of a tornado more severe than the design-basis tornado on the cooling towers is presented in Subsection 9.2.5.3.2. For the case of a tornado impacting the river screen house, which is not protected against such missiles, the onsite wells will provide makeup.

The Category I structures and components of the ultimate heat sink are designed to withstand the SSE. In the event of failure of the Oregon Dam downstream of the river screen house, concurrent with a low river discharge condition, the water level of the Rock River would be 664 feet 4 inches MSL, which is above the base mat elevation of the river screen house. Thus the Category I makeup pumps would have adequate submergence. In addition, under these conditions, an alternate source of makeup water is available from the seismically qualified deep wells.

9.2.5.3.1.1 Design Basis Reconstitution

A design basis reconstitution of the Byron ultimate heat sink was performed (Reference 10) to verify the design of the ultimate heat sink. The design basis event for the Byron ultimate heat sink is a loss-of-coolant accident (LOCA) coincident with a loss-of-offsite power (LOOP) in one unit and the concurrent orderly shutdown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures. The accident scenarios analyzed various single active failures and assumed that two essential service water cooling tower cells were initially out-of-service. These scenarios maximized heat supplied to the essential service water cooling towers and minimized tower heat removal capability.

The design heat load from the non-accident unit is conservatively calculated as the energy required to reduce the unit from maximum to zero power, and reduce the reactor coolant temperature to cold shutdown conditions (<200°F). Additional heat load is placed on the essential service water system and ultimate heat sink once residual heat removal is placed in operation (at approximately 350°F). Under normal conditions the minimum time to reach this condition, assuming an orderly shutdown and cooldown from maximum power using normal operating procedures, would be eight hours.

9.2.5.3.1.1.1 Containment Heat Load Calculations

The containment integrity calculations contained in Subsection 6.2.2 were reviewed to determine the scenario where the highest containment heat load would occur. The greatest heat load occurs as a result of a reactor coolant system double ended pump suction (DEPS) break with maximum safety injection. This case is a scenario in which all emergency core cooling systems inject with two diesel generators in operation. The DEPS case with three reactor containment fan coolers (RCFCs) and one containment spray (CS) pump running was originally used for the design of the ultimate heat sink. This was conservative in the sense that it combined a maximum energy release assumption with a coincident loss of heat dissipation capability (i.e., the failure of two essential service water cooling tower fans to operate). Since no single active failure could result in three RCFCs running and two disabled essential service water fans, new containment heat load calculations were performed to further examine the impact of containment heat removal equipment availability on the ultimate heat sink.

The containment heat loads consist of loads from the RCFCs and the residual heat removal (RHR) system. The RCFC loads were calculated using the CONTEMPT4/MOD5 computer code. The analysis examined various LOCA scenarios with respect to equipment availability to generate a series of RCFC heat removal rates versus time. The sump water temperature results from these runs were combined with system performance data to develop RHR loads.

The mass/energy release data utilized in the new containment heat load calculations was taken from the DEPS LOCA containment integrity calculations (maximum and minimum safety injection). However, the new containment heat load calculations are different in that the heat removal rates via the RCFCs and the RHR system were maximized to determine the limiting heat load on the ultimate heat sink. The performance of the RCFCs was recalculated to bound maximum expected essential service water flow rates and air flow rates. The mass and energy release rates were adjusted to incorporate RHR heat removal rates during recirculation.

The design basis reconstitution maximized the accident unit containment heat load to the UHS by:

- Postulating scenarios with four RCFCs and either one or two CS pump(s) operating
- Assuming higher essential service water flowrates to the RCFCs
- Assuming higher air flowrates to the RCFCs
- Assuming earlier switchover to Containment Recirculation phase and correspondingly earlier RHR heat loads with two CS Pumps operating, consistent with the design of ECCS recirculation.

The four RCFCs/two CS pump case, in combination with the other changes, results in greater LOCA unit Containment integrated heat loads of approximately 25% for the first two hours after accident initiation and an increase in LOCA unit Containment peak heat load from 513 to 830.8 MBTU/hr. This case results in the maximum integrated heat load during the critical period for base temperature. These increased heat loads were used for conservatively evaluating UHS Tower performance and do not affect previous UFSAR Chapter 6 containment analyses. The four RCFCs/ one CS pump case also results in greater LOCA unit containment integrated heat loads of approximately 25% and an increase in LOCA unit containment peak heat load from 513 to 841.6 MBTU/hr. Although the integrated heat loads for this case were slightly lower than for the 4 RCFC/2 CS pump case, this case results in the highest peak heat load. See Figures 9.2-30 and 9.2-31 for the containment response for the 4 RCFC/2 CS pump case.

9.2.5.3.1.1.2 Steady State Tower Performance Analysis

Essential service water cooling tower performance was calculated based on essential service water flow values, heat loads, and ambient wet-bulb temperature. Results of this calculation give thermal performance as a function of temperature input and flow and then provide an essential service water output temperature. An essential service water cooling tower performance curve is then generated from the temperature parameters. This curve is an input to the basin calculation which develops a basin temperature profile as a function of time.

9.2.5.3.1.1.3 Time Dependent Basin Temperature Calculations

These calculations predicted the basin temperature using a time dependent two cooling tower model.

The time dependent feature of the model was developed to account for the transient nature of the LOCA heat load. For example, the containment analysis for the 4 RCFC/2 CS pump case showed a LOCA unit containment peak heat load of 830.8 MBTU/hr at 45 seconds and an average heat load of approximately 450 MBTU/hr for the first hour after the accident. At two hours into the LOCA the heat load has decreased to approximately 260 MBTU/hr and continued to decrease. The calculations used the time dependent total heat loads to determine the amount of heat added to the essential service water system.

The two cooling tower models were developed to provide the capability to model different flow and energy (heat load) going to each of the cooling towers. The flow to each of the cooling towers could be significantly different under different accident scenarios. Depending on the scenario, the energy transport also considered the distribution of miscellaneous heat loads. Cooling was assumed to occur only for cells with fans running at high speed.

9.2.5.3.1.1.4 Conclusion

The ultimate heat sink design basis reconstitution concluded that the design accident analyses and operation have been determined to be consistent with all relevant Regulatory Guides and standards committed to in the UFSAR. The capability of the ultimate heat sink to perform its safety functions has been verified. The analyses performed have shown that essential service water cold water basin temperature does not exceed 100°F during normal and potential accident conditions.

9.2.5.3.1.2 Combination of Seismic Event and Drought

The ultimate heat sink can withstand combinations of events less severe than the design-basis events discussed ~~above~~in Subsection 9.2.5.3.1.1. The simultaneous occurrence of a 500-year seismic event with the 100-year 30-day duration drought is discussed below.

The 30-day 100-year recurrence drought flow at the intake is 739 cfs (Table 2.4-15). The corresponding water surface elevation at the intake with the Oregon Dam in place is 670.6 feet. The invert of the intake is at elevation 663.5 feet; thus, a water depth of 7.1 feet is available.

A 500-year seismic event at the site corresponds to a maximum horizontal ground acceleration of 0.05 g. The assumption of a failure of the Oregon Dam subject to this level of seismic loading is extremely conservative. However, if such a failure is postulated coincident with a 30-day 100-year recurrence drought, the water surface elevation at the intake would be 665 feet providing a depth of 1.5 feet of water on the floor of the intake.

A simplified evaluation of the seismic resistance of the Oregon Dam was made using data from Reference 1. The lateral resistance of sheet piling, liquefaction potential of the subsurface sand (Reference 2), and the stability of the dam were evaluated. On a conservative basis, it was determined that the dam can sustain a maximum horizontal ground acceleration of at least 0.1 g without failure.

From data presented in a recent study by Dames and Moore (Reference 3), it is estimated that an earthquake having a maximum acceleration equal to or greater than 0.1 g is about 0.3×10^{-3} per year. Hence, the probability of occurrence of an earthquake causing failure of the Oregon Dam is much less than 1/500.

It is estimated that the Rock River water temperature would be low enough for ice formation and accumulation, at most, for 2 months of the year. Therefore, the probability of not having the Rock River provide makeup water during a 30-day 100-year drought coincident with an earthquake having a maximum acceleration of 0.1 g would be no greater than:

$$P = (0.3 \times 10^{-3})\ (1/100)\ (2/12)$$

$$= 5.0 \times 10^{-7} \text{ occurrences/year}$$

Blockage of the intake structure by sedimentation is not expected to be a concern as discussed below.

The Rock River is a stable river and past experience (see Subsection 2.4.2) of nearby industries along the river indicates that sedimentation and blockage of intake with sediment is not a concern. The intake is located about [illegible] miles upstream of the Oregon Dam and any significant sediment deposition takes place near the dam and not at the intake.

The Iowa Institute of Hydraulic Research measured sediment concentration at the intake (Reference 4). The bed load at the intake mainly consists of fine sands. The particle size distribution is fairly uniform with a d_{50} = 0.4 mm. The suspended sediments are entirely in the fine silt to clay particles size range. Ninety percent of the suspended sediment is finer than 0.062 mm Table 9.2-14 provides suspended sediment concentration at the intake.

The U.S. Geological Survey (USGS) has published suspended sediment data for the Rock River at Joslin for the water years 1975-1979. The drainage area of the Rock River at Joslin is 9549 square miles.

About 90% of the sediment carried by the river constitutes suspended sediment and it is kept in suspension due to the turbulence of the river and thus will not deposit and cause blockage of the intake. Since the Rock River is considered to be stable and does not meander in the vicinity of the intake, blockage of the intake with bed load is not probable.

9.2.5.3.1.3 <u>Ice Buildup</u>

Estimates of ice buildups on the Rock River are discussed below.

There is no data available regarding ice thickness on the Rock River. USGS indicated that the maximum thickness of ice observed at the discharge measuring stations at Rockton, Byron, and Como was 1.9 feet during the 1978-79 winter which is one of the severest winters of record.

The thickness of ice on lakes can be predicted by using the following equation (Reference 5):

$$h_i = L\ (1.06\ \ \sqrt{S})$$

where:

h_i = the ice thickness in inches,

L = the coefficient of snow cover and location conditions

S = the accumulated degree-days since freezeup, based on °F below freezing.

L = 0.75 to 0.65 for medium size lakes with moderate snow cover. Average annual snowfall at the Byron site is about 28 inches. Hence, L is taken at 0.65. The average annual freezing degree-days at Rockford, Illinois are 1123°F-day. The winter year 1976-1977 was the coldest year on record in Northern Illinois. The corresponding freezing degree-days at Rockford were 1727°F-day. The above equation gives the thickness of ice cover for a lake at 23 inches during an average year and 29 inches for the coldest year (1976-1977). However, these values are for a lake and not directly applicable to rivers. For rivers, the flow resistance reduces the thickness of the ice. Freezeup starts in late November and reaches a maximum in March. Based on historic flow data, minimum flow occurs during August-September. During winter, the flow gradually increases from November to March. The minimum monthly flows and the average monthly flows at the intake based on the recorded flow data at Como gauging station are given in Table 9.2-15.

From the above discussion, it is clear that ice (maximum thickness is 29 inches) does not block the intake since the depth of water available is 7.1 feet under 30-day 100-year low flow conditions.

9.2.5.3.1.4 Frazzle Ice

Frazzle ice is a term referring to small ice particles which may form at the water surface if the air temperature is quite low and the mixing and conductivity of the water is insufficient to prevent ~~a slight supercooling of~~freezing at the water surface. Based on operating experience, frazzle ice is not expected to affect the operation of the river intake at the Byron Station. If ice forms on the intake bars, the trash rake may be operated to remove the ice.

Ice and sediment cannot block the intake because of the availability of the 7.1 foot depth of water. The probability of the dam failure during the 30-day 100-year recurrence drought and in the winter months is very low. Even in the case of no flow in the Rock River, the Oregon Dam will maintain a water depth of 6.75 feet over the invert of intake (the crest of the Oregon Dam is at 670.25 feet and the invert of intake is at 663.50 feet).

9.2.5.3.2 Essential Service Water Cooling Towers

An analysis of the effect of multiple tornado missiles on the essential service water cooling towers has been performed.

The following components of the essential service water cooling towers are unprotected from tornado missiles:

a. fans,

b. fan motors, and

c. fan drives.

An analysis of cooling tower capacity without fans has been made. Using the most conservative design conditions, it is predicted if the plant is shut down under non-LOCA conditions with loss of offsite power, the temperature of the service water supplied to the plant will not exceed 110°F. Although this exceeds the normal maximum temperature of 100°F, no adverse impact on safety equipment will result.

If all fans are inoperable, additional cooling can be achieved by blowing down service water using the strainer backflush system and introducing makeup water (approximately 55°F) from the onsite wells which are provided with a safety-related power supply. This would reduce the predicted maximum supplied service water temperature to approximately 105°F.

The analysis assumed no wind, 78°F wet bulb temperature, conservative plant cooling loads (normal shutdown loads for both units plus diesel cooling loads), and a maximum initial service water temperature. In reality, the wind velocities and reduced wet bulb temperature which could be expected in conjunction with weather conditions which produce tornados would insure that the service water temperature would remain below 100°F.

Tornado protection has been provided for the exposed supply piping to the cooling towers.

Ice formation on the fill during cold weather operation is analyzed below:

A Category I temperature controller is provided to actuate each of two bypass valves per tower during winter operation. When the temperature of water in the basin drops to ~~52°F~~**a predetermined value**, the bypass valves open, diverting water from the cooling section to the cold water basin. When the temperature of water in the basin increases to ~~78°F~~**a predetermined value**, the bypass valves close.

Computer code TODTBM was utilized to verify that the basin temperature does increase from 50°F to 80°F. Under -25°F ambient conditions, the length of time required is 12.7 hours maximum under minimum refueling heat load conditions of 11.0 x 10^6 Btu/hr. Under extended bypass operating conditions, the greatest potential exists for vapor rising from the cold water basin and condensing on the fill. The maximum ice formation rate would be 0.1019 lb/sec for one tower, which would over a 13-hour period, result in an ice thickness of 0.15 inch on the lowest row of fill. However, each pound of ice that forms on the tile fill releases 144 Btu which tends to increase the temperature of the tile, and in addition the tile absorbs heat by radiation from the ~~52°F to 78°F~~water in the basin. It is, therefore, doubtful that any ice will form on the tile fill.

The wind speed across the basin was assumed to be at an ambient average of 10.7 mph in arriving at 12.7 hours of continuous bypass operation. By comparison, a 4.2-mph wind speed results from operation of the fans at half speed. It is, therefore, concluded that if the fans are inadvertently left operating under minimum ambient temperature conditions concurrent with minimum refueling heat load, 12.7 hours of operation in the bypass mode is not exceeded.

When the fans are operated at half speed, air flow into the tower (i.e., across the basin) is 391,475 cfm per cell which results in a velocity across the basin of 4.2 mph. At full speed, the airflow is 782,950 cfm resulting in a velocity across the basin of 8.4 mph. The average ambient wind speed of 10.7 mph is therefore greater than the velocity produced by running the fans at rated speed. The critical wind speed derived from Ryan's equations is the wind speed at which the heat dissipated is equal to the heat added. The critical wind speed for -25°F ambient air and 0 psia ambient vapor pressure was found to be 137 mph at 40°F basin water temperature and 109 mph at 50°F basin water temperature The maximum wind speed recorded at Rockford airport for the 1950-1970 period is 46 mph.

Inasmuch as the fans occupy only 36% of the total projected area above the drift eliminators, it is concluded that adequate cooling can be obtained from the remainder of the tower should a heavy snowfall occur. Moreover, a maximum snowfall of record, 44.8 inches during December 1909 through January 1910, would produce a loading of 70 lb/ft^2 which is well within the load carrying capability of the drift eliminator and its supports.

The design snow load of 104 lb/ft^2 from Subsection 2.3.1 is clearly for roofs of safety-related structures. A roof is a relatively flat receptacle for falling precipitation whereas the plastic angular drift eliminators are sheltered by 11 fan blades per cell, and to a lesser extent by the velocity recovery stacks. Thus, 70 lb/ft^2 is a conservative design snow load for the drift eliminators.

Failure of the nonseismic blowdown line would not affect the ability of the cooling towers to perform their safety function.

The portion of the line that is nonseismic delivers blowdown from the essential service water cooling towers to the natural draft cooling tower cold water flume. The valve ~~is locked~~remains in a position to maintain water chemistry during normal operation so that scale does not form on heat transfer surfaces. The expected setting would be for approximately 250 gpm of blowdown from each tower. In the event of failure of the downstream piping, no significant increase in blowdown will occur. ~~Under post-LOCA evaporative conditions, the blowdown from each tower would be increased somewhat due to the higher heat load on the tower.~~

~~Under worst case evaporative loss conditions of 76°F wet bulb, 110°F dry bulb for a 3-hour period (July 14, 1954) and 73°F average wet bulb, 90.5°F average dry bulb for a 24-hour period (July 18, 1954), the postaccident evaporation, blowdown, and~~

~~makeup rates are as follows based on 10.4 gpm of drift losses, 1000 ppm total dissolved solids in the cold water basin and heat rejection continuously at the post-LOCA rate of 580 x 10^6 Btu/hr:~~

	~~Worst 24-Hour Period~~	~~Worst 3-Hour Period~~
~~evaporation rate, gpm~~	~~970.4~~	~~1092.4~~
~~blowdown rate, gpm~~	~~563.8~~	~~636.0~~
~~makeup rate, gpm~~	~~1544.6~~	~~1738.8~~

~~The worst case evaporative loss for a 30-day period is 303.3 gpm.~~

~~The worst case heat transfer for an atmospheric condition of 82°F wet bulb for 3 hours on July 30, 1961 would have resulted in a cold water outlet temperature of 94.6°F at a heat rejection rate of 580 x 10^6 Btu/hr based upon predicted tower performance curves.~~

Meteorological data for worst case conditions is presented in Subsection 2.3.1.

The cooling tower~~, therefore,~~ is adequate for all worst case meteorological conditions concurrent with a loss-of-cooling accident ~~in one unit while the other unit is being safely shut down.~~coincident with a loss of offsite power of one unit and the concurrent orderly shutdown and cooldown from maximum power to cold shutdown of the other unit using normal shutdown operating procedures. The accident scenario also includes a single active failure.

9.2.5.3.3 Category I Essential Service Water Makeup System

The capability of the essential service water makeup pumps to function under low Rock River level conditions is discussed in Subsection 9.2.5.2.2. An analysis of the ability of the ultimate heat sink to function during flood conditions coincident with a loss of offsite power has been performed.

The combined event flood coincident with maximum wave runup will have an elevation of 703.39 and an annual probability of 1.0 x 10^{-6}. The engine is mounted on its subbase at elevation 703 feet 8-1/2 inches and the engine shaft centerline elevation is 705 feet 4 inches. It is anticipated that the latter elevation would be limiting under flood conditions. There is approximately 2 feet of margin between the combined event plus maximum wave run up elevation and the elevation at which the engine would stop. Battery and engine starter elevations will be approximately 705 feet 4 inches.

The engine-driven essential service water makeup pumps will automatically start and continue to operate regardless of whether offsite power is available or not.

9.2.5 Ultimate Heat Sink

9.2.5.1 Design Basis

The condenser water cooling facility at Braidwood Station is referred to as a cooling pond rather than as a cooling lake. This is consistent with the definition of "pond" in EPA Effluent Guidelines and Standards for Steam Electric Power Generation, 40 CFR 423, Section 432.11, which became effective in 1974.

The Braidwood Station's ultimate heat sink consists of an excavated essential cooling pond integral with the main Braidwood cooling pond. The excavation is made such that the essential pond remains intact in the event of failure of the Category II retaining dikes impounding the main cooling pond. Thus, the essential pond does not depend upon man-made structural features for retention so that redundancy, per criteria, for ultimate heat sinks for nuclear power plants is not required.

~~The heat rejection rate versus time is shown in Table 9.2-6 for the unit undergoing post-LOCA cooldown. Figure 9.2-5 shows energy heat input to the containment under equilibrium fuel cycle and worst case loss-of-coolant accident conditions as a function of time. Figure 9.2-6 shows the heat removal rates of one reactor containment fan cooler and one residual heat removal heat exchanger as a function of time.~~ Figure 9.2-7 shows the combined heat rejection rate versus time for the unit undergoing post-LOCA cooldown, plus heat rejection rate versus time for the unit undergoing safe shutdown. **The LOCA unit containment heat load was maximized to determine the limiting heat load to the ultimate heat sink. Refer to Byron Section 9.2.5.3.1.1.1 for additional discussions of the containment heat load calculations.** Figure 9.2-8 shows area and volume versus surface elevation in feet for the essential cooling pond. The maximum operating level of the essential cooling pond is assumed to be 590 feet above mean sea level, at which point it loses communication with the main cooling pond.

9.2.5.2 System Description

Under normal circumstances, the essential cooling pond is indistinguishable from the remainder of the Braidwood cooling pond. The essential cooling water intakes and discharges are arranged, however, to extract water from and return water to the cooling pond in that portion which would become the essential cooling pond, should failure of the Category II cooling pond retaining dikes occur.

The substructure of the lake screen house, which houses the essential service water intakes, is designed as a seismic structure. Postulated failure of nonseismic portions of the structure and equipment will not affect the intakes due to the location of the intakes away from any such structures and equipment. In addition, the intakes are protected by concrete enclosures protruding above the top of the mat. The three

5. Flow balancing valves are provided to initially balance the system. Pressure indicators are provided on the suction and discharge lines of the heat exchange coils. Temperature wells are provided at many points of the system to measure the water temperature, if desired.

9.2.8.3 Safety Evaluation

The station heating system is a non-safety-related system. See Table 9.2-10 for system failure analysis.

9.2.8.4 Testing and Inspection

All equipment is factory inspected and tested in accordance with the applicable specifications and codes. During various stages of construction, field inspections are made of the equipment. Component demonstration tests are performed on the system.

The equipment manufacturer's recommendations and station practices are considered in determining required maintenance.

9.2.9 References

1. Schumaker and Svoboda, Inc., "Oregon Dam Inspection and Evaluation," report prepared for the Dept. of Conservation, State of Illinois, January 1979.

2. H. B. Seed and J. M. Idriss, "Simplified Procedure for Evaluating Soil Liquefaction Potential," Journal of Soil Mechanics and Foundations Division, ASCE, Vol. 97, No. SM9, September 1971.

3. Dames & Moore, "Seismic Ground Motion Hazard at Zion Nuclear Power Plant Site," July 1980.

4. R. Ettema and T. Nakato, "Sediments in the Byron Power Plant," IIHR Report No. 82, Iowa Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa, January 1981.

5. V. T. Chow, Handbook of Applied Hydrology, Chapter 23, McGraw Hill Co., New York, 1964.

6. P. J. Ryan and D. Harleman, "An Analytical and Experimental Study of Transient Cooling Pond Behavior," Report No. 161, R. M. Parsons Laboratory for Water Resources and Hydrodynamics, M.I.T.

7. Calculation RSA-B-91-03, Rev. 0, dated August 28, 1991, "Byron Station Containment Response for Ultimate Heat Sink Requirements"

8. Calculation NED-M-MSD-9, Rev. 0, dated October 21, 1991, "Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation: Part IV"

9. Calculation NED-M-MSD-11, Rev. 0, dated December 17, 1991, "Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation: Part V (Bypass Operation)"

10. Letter from T. K. Schuster (Commonwealth Edison Company) to T. E. Murley (Nuclear Regulatory Commission) dated January 9, 1992, transmitting the "Byron Station UHS Design Basis Reconstitution Final Report"

11. Calculation UHS-01, Rev. 1, dated August 5, 1991, "Ultimate Heat Sink Design Basis LOCA Single Failure Scenarios"

12. Calculation ATD-0063, Rev. 1, dated April 1, 1992, "Heat Load to the Ultimate Heat Sink During a Loss of Coolant Accident"

13. Calculation ATD-0109, Rev. 1, dated April 27, 1992, "Thermal Performance of UHS During Postulated Loss of Coolant Accident"

14. Calculation NED-M-MSD-19, Rev. 0, dated March 2, 1992, "Byron Ultimate Heat Sink Cooling Tower Basin Temperature Calculation: Part VII (Initial Basin Temperature at 96°F)"

TABLE 9.2-1

ESSENTIAL SERVICE WATER HEAT LOADS

ITEM	NORMAL	LOCA	LOSS-OF-OFFSITE POWER OR SHUTDOWN
Diesel-generator coolers		X	X
Containment fan coolers	X ~~(2)~~	X ~~(4/2)*~~	X ~~(2)~~
Component cooling heat exchangers	X ~~(1)~~	X ~~(1)~~	X ~~(1-2)~~
Diesel- and Motor-driven auxiliary feedwater pump lube oil coolers		X ~~or 0~~	X ~~or 0~~
Diesel-driven auxiliary feedwater pump cubicle coolers		X ~~or 0~~	X ~~or 0~~
Diesel-driven auxiliary feedwater pump diesel coolers		X ~~or 0~~	X ~~or 0~~
Essential service water pump lube oil coolers	X	X	X
Essential service water pump cubicle coolers	X	X	X
Centrifugal charging pump cubicle coolers	X	X	X
Centrifugal charging pump oil coolers	X	X	X
Positive displacement charging pump cubicle cooler	X		
Safety injection pump cubicle coolers		X	
Safety injection pump oil coolers		X	
Containment spray pump cubicle coolers		X	

~~*Four for first 20 minutes then 2.~~

TABLE 9.2-6 HAS BEEN INTENTIONALLY DELETED

~~TABLE 9.2-11~~

~~ESSENTIAL SERVICE WATER~~
~~CUBICLE COOLER DESIGN FLOW RATES~~

~~CUBICLE COOLER~~	~~1A PUMP~~	~~1B PUMP~~
~~Safety Injection Pump~~	~~45 gpm~~	~~45 gpm~~
~~Centr[illegible]. Charging Pump~~	~~60 gpm~~	~~60 gpm~~
~~PD Charging Pump~~	~~25 gpm~~	
~~RHR Pump~~	~~45 gpm~~	~~45 gpm~~
~~Containment Spray Pump~~	~~70 gpm~~	~~70 gpm~~
~~Spent Fuel Pool Pump~~		~~45 gpm~~
~~Essential SW Pump~~	~~105 gpm~~	~~105 gpm~~
~~Total Flow~~	~~350 gpm~~	~~370 gpm~~

TABLE 9.2-11

ESSENTIAL SERVICE WATER
COMPONENT NOMINAL DESIGN FLOW RATES

Component	Equipment No.	Nominal Flow (gpm)
CC Heat Exchangers	0,1,2CC01A	8,000 (Note 1)
SX Pump Lube Oil Coolers	1,2SX01AA,B	10
SX Pump Cubicle Coolers	1,2VA01SA,B	105
AF Pump (Motor Driven) Lube Oil Coolers	1,2AF01AA,B	14
AF Pumps (Diesel Driven)		
- Closed Cycle HX	1,2SX01K	250
- Lube Oil Coolers	1,2AF02A	14
- Gear Oil Coolers	1,2AF01AB	20
- Right Angle Gear Lube Oil Coolers	1,2SX02K	20
- Cubicle Coolers	1,2VA08S	150
CV Pump Lube Oil Coolers	1,2CV03SA,B	15
CV Pump Gear Oil Coolers	1,2CV02SA,B	25
CV Pump Cubicle Coolers	1,2VA06SA,B	60
D/G Jacket Water Coolers	1,2DG01KA,B	1650
Spent Fuel Pit Pump Cubicle Coolers (Note 2)	1,2VA07S	45
SI Pump Bearing Oil Coolers	1,2SI01SA,B	33
SI Pump Cubicle Coolers	1,2VA04SA,B	45
CS Pump Cubicle Coolers	1,2VA03SA,B	70
Pos. Disp. Pump Cubicle Coolers (Note 3)	1,2VA05S	25
Control Room Refrigeration Units	0WO01CA,B	950 (Note 4)
RHR Pump Cubicle Coolers	1,2VA02SA,B	45
RCFC SX Water Coils	1,2VP01AA-D	2660
Primary Containment Refrigeration Units	1,2WO01CA,B	4160 (Note 5)

TABLE 9.2-11 (Cont'd)

Notes:

1. SX flow to the CC Heat Exchanger is manually throttled between 5,000 to 20,000 gpm.
2. The Spent Fuel Pit Pump Cubicle Cooler is served by the "B" SX train.
3. The Pos. Disp. Pump Cubicle Cooler is served by the "A" SX train.
4. Control Room Refrigeration Unit flow varies automatically in response to condenser load. The Control Room Refrigeration Units are served by the Unit 1 SX system.
5. The Primary Containment Regrigeration Units are in series with the RCFC SX water coils. Flow varies automatically in response to condenser load.

TABLE 9.2-12

~~ESSENTIAL SERVICE WATER~~
~~NORMAL OPERATING AND COLD SHUTDOWN DESIGN FLOW RATES~~

~~EQUIPMENT*~~	~~1A PUMP~~	~~1B PUMP~~
~~Cubicle Coolers**~~	~~350 gpm~~	~~370 gpm~~
~~RC Fan Coolers~~	~~5320 gpm~~	~~5320 gpm~~
~~Control Room HVAC~~	~~950 gpm~~	~~950 gpm~~
~~Component Cooling~~	~~16,000 gpm~~	~~16,000 gpm~~
~~Total Flow~~	~~22,620 gpm~~	~~22,640 gpm~~

This table has been intentionally deleted.

~~*Strainers backwash of 1200 gpm is intermittent. Also miscellaneous pump lube oil coolers not included in the above will require approximately 150 gpm per ESF Division.~~

~~*This is the total flow rate for all cubicle coolers listed in Table 9.2-11. See Table 9.2-1 for pumps which are operating during this plant condition to obtain the actual cubicle cooler flow rates.~~

TABLE 9.2-13

~~ESSENTIAL SERVICE WATER~~
~~POST-LOCA DESIGN FLOW RATES~~

~~EQUIPMENT*~~	~~1A PUMP~~	~~1B PUMP~~
~~Cubicle Coolers**~~	~~350 gpm~~	~~370 gpm~~
~~RC Fan Coolers~~	~~5,320 gpm~~	~~5,320 gpm~~
~~Control Room HVAC~~	~~950 gpm~~	~~950 gpm~~
~~Component Cooling~~	~~13,600 gpm~~	~~13,600 gpm~~
~~Diesel Generator~~	~~1,650 gpm~~	~~1,650 gpm~~
~~Auxiliary Feedwater Diesel-Driven Cubicle and Engine Coolers~~		~~350 gpm~~
~~Total Flow~~	~~21,870 gpm~~	~~22,240 gpm~~

This table has been intentionally deleted.

~~*Strainer backwash of 1200 gpm is intermittent. Also miscellaneous pump lube oil coolers not included in the above will require approximately 150 gpm per ESF Division.~~

~~**This is the total flow rate for all cubicle coolers listed in Table 9.2-11. See Table 9.2-1 for pumps which are operating during this plant condition to obtain the actual cubicle cooler flow rates.~~

TABLE 9.2-16

SINGLE FAILURE ANALYSIS OF THE ULTIMATE HEAT SINK

Component	Failure	Comments and Consequences
Containment spray pump (accident unit)	Failure to operate	A minimum of six cells will remain available to limit tower basin temperature below 100°F.
Essential service water tower fan	Failure to start	A minimum of five cells will remain available to limit tower basin temperature below 100°F.
Emergency diesel generator	Failure to start	Diesel generator failure results in a reduced rate of heat input to the ultimate heat sink. A minimum of four cells will remain available to limit tower basin temperature below 100°F.
Essential service water pump (accident unit)	Failure to operate	A minimum of six cells will remain available to limit tower basin temperature below 100°F.

Note: All single failure analysis cases conservatively assume two cells initially out of service in addition to the subject single failure.

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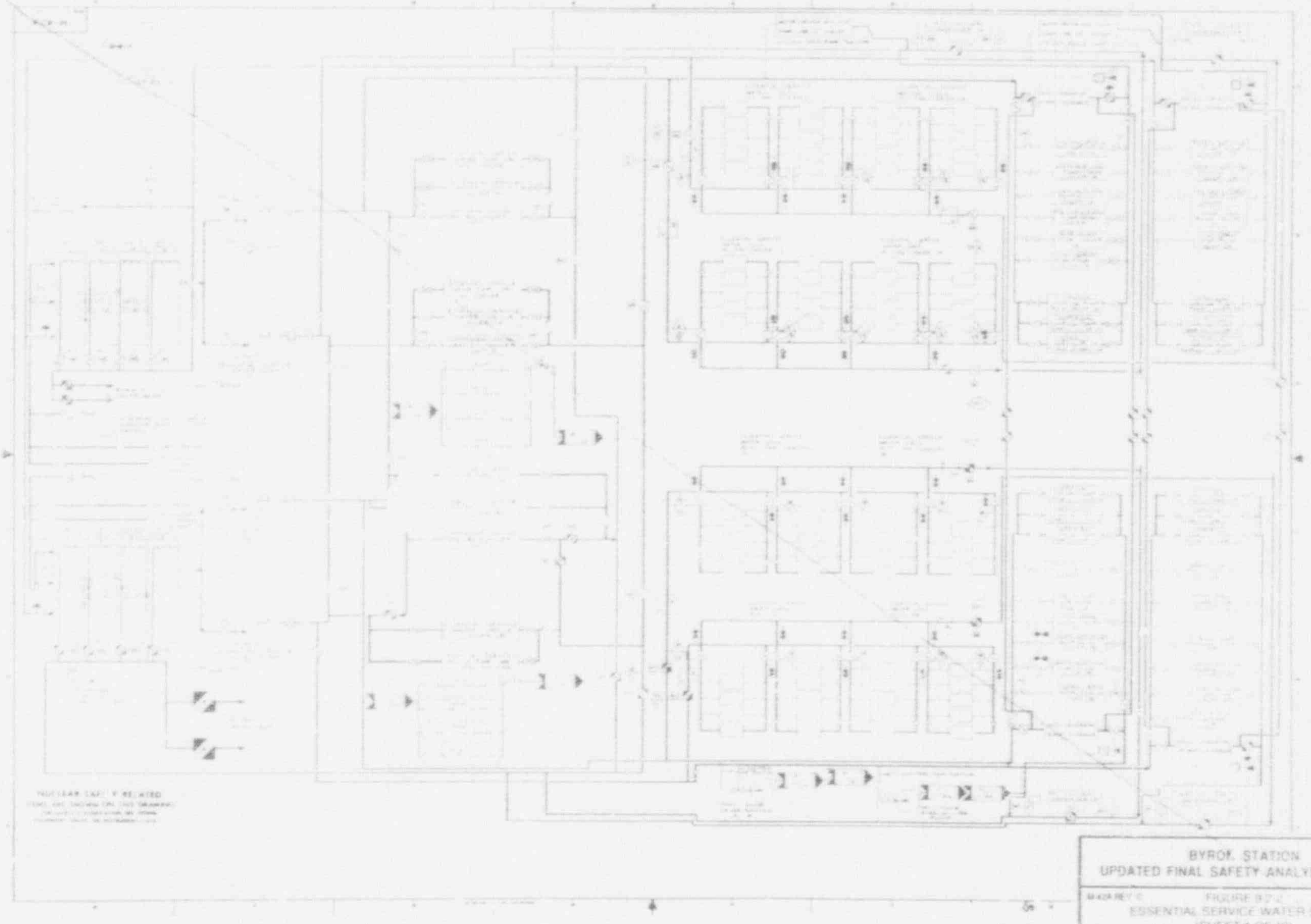

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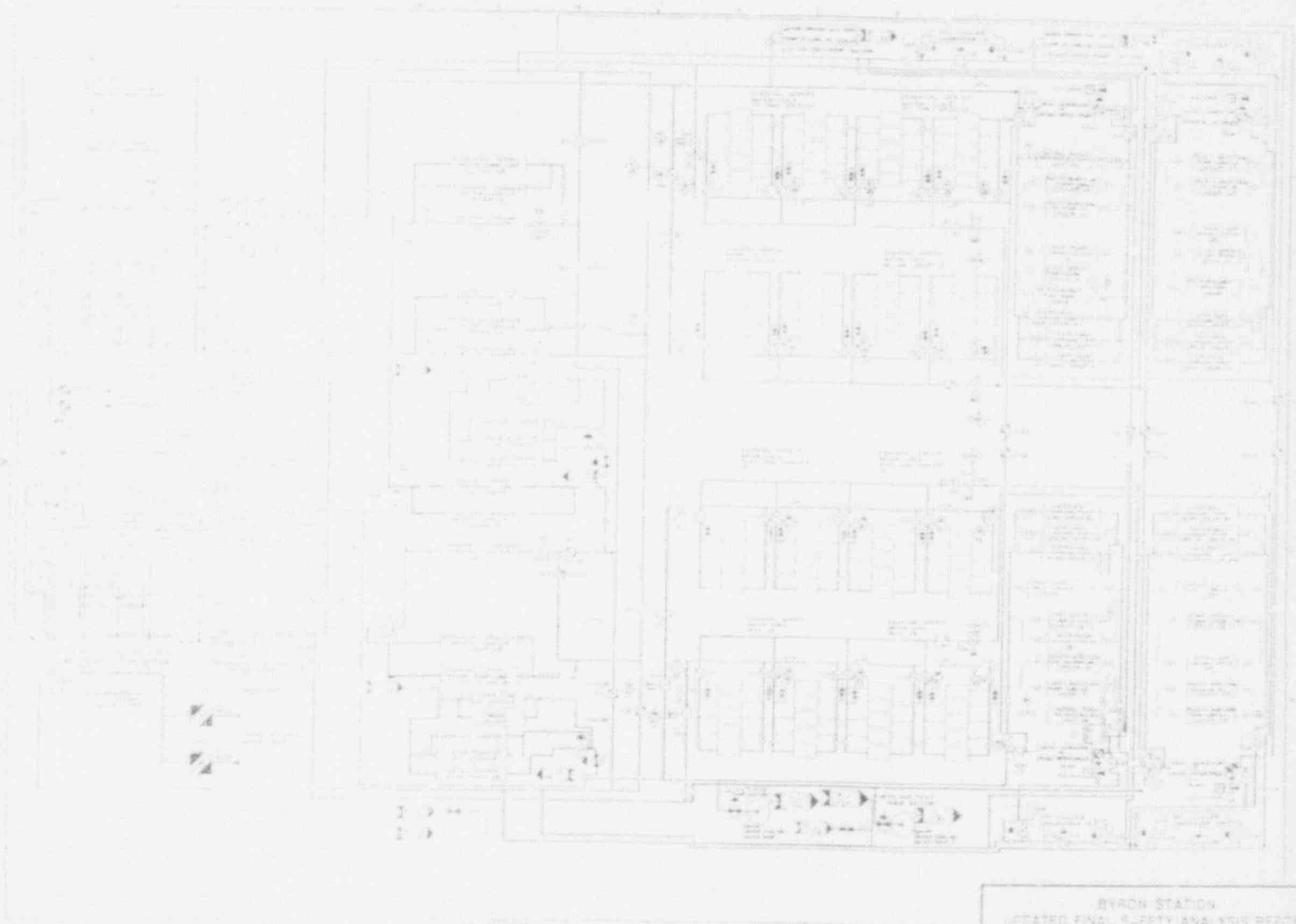
FIGURE 9.2-1
ESSENTIAL SERVICE WATER SYSTEM
(SHEET 1 OF 13)



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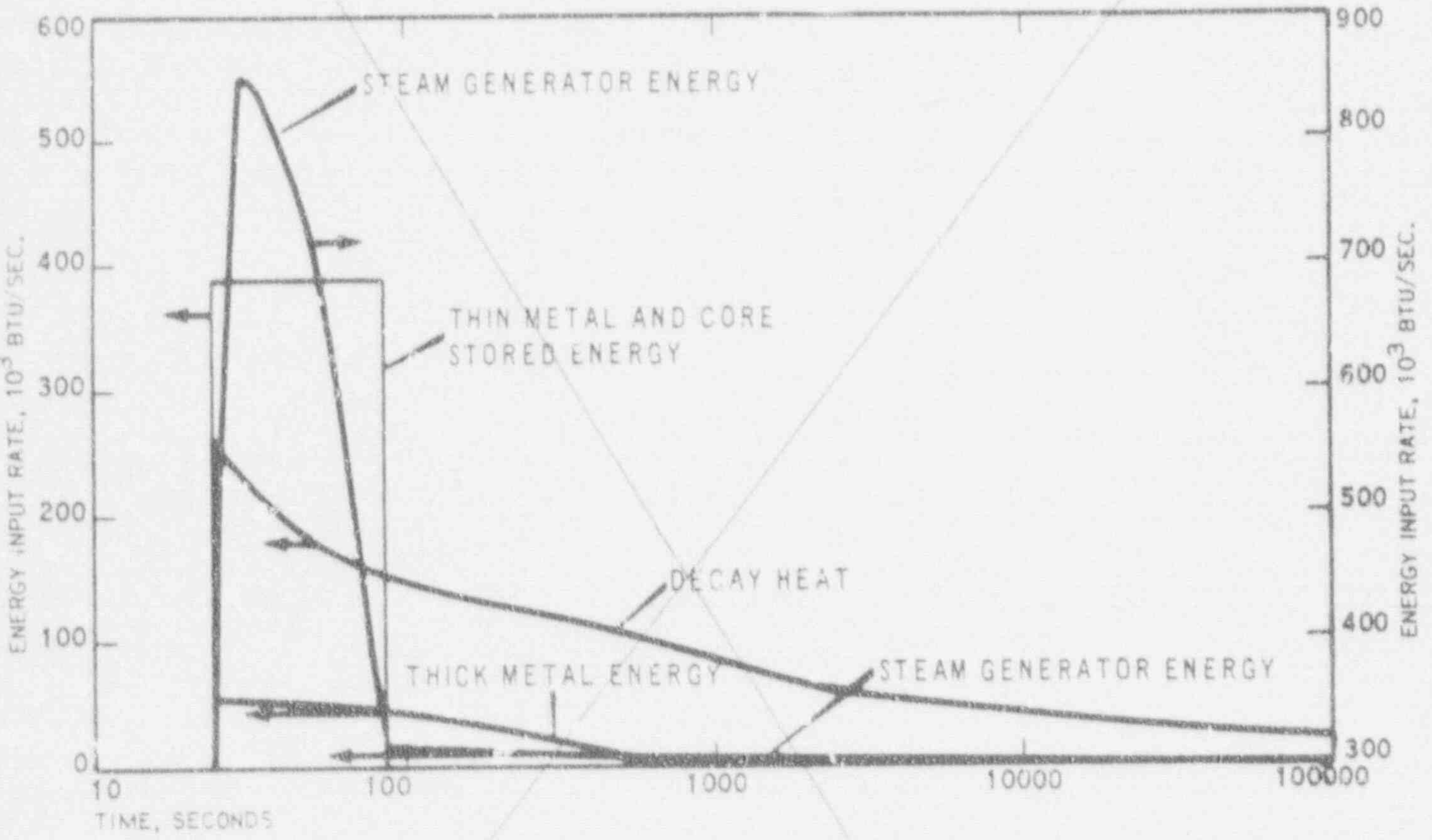

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FIGURE 9.2-5

ENERGY INPUT TO CONTAINMENT,
DOUBLE ENDED PUMP SUCTION RUPTURE

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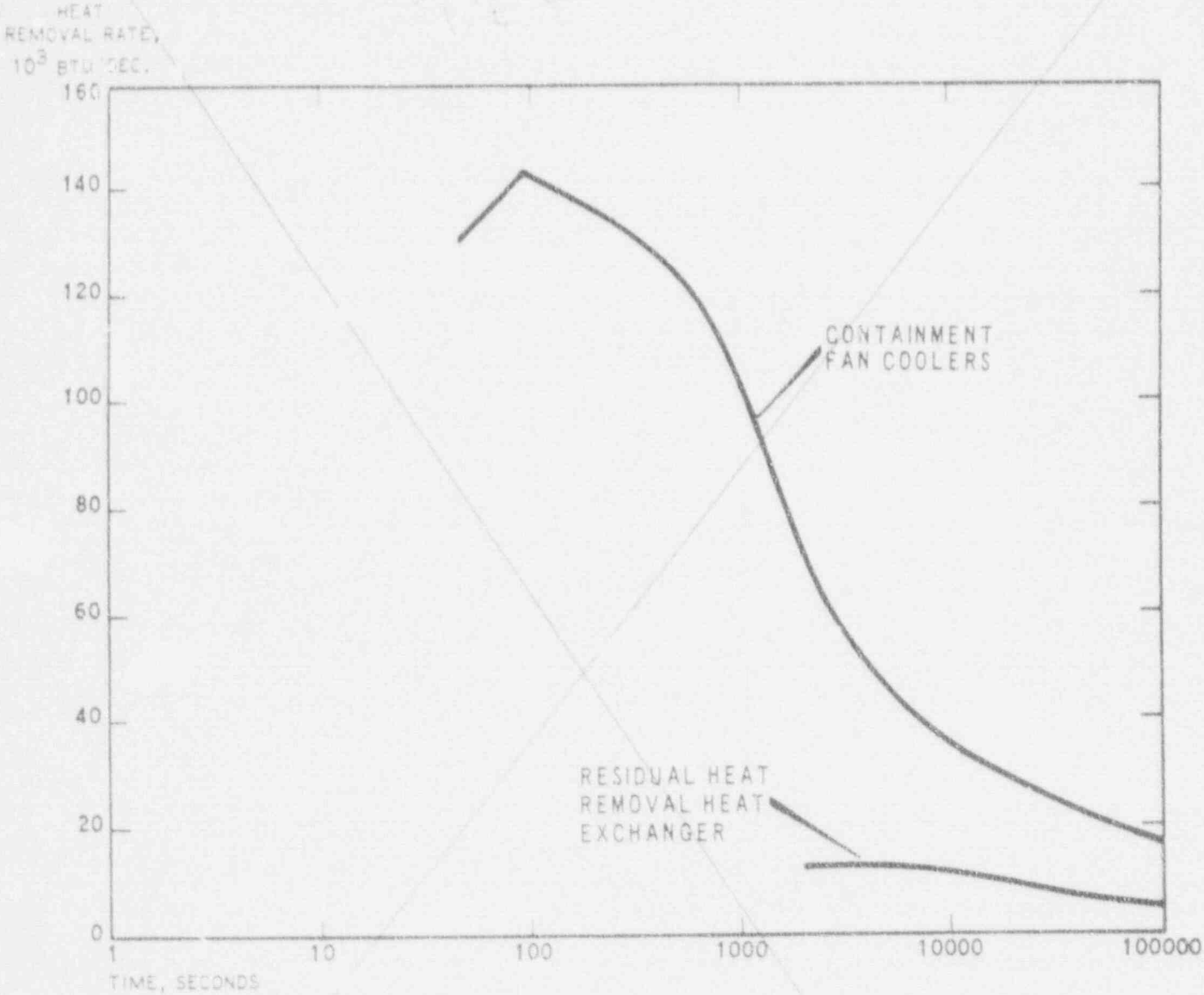

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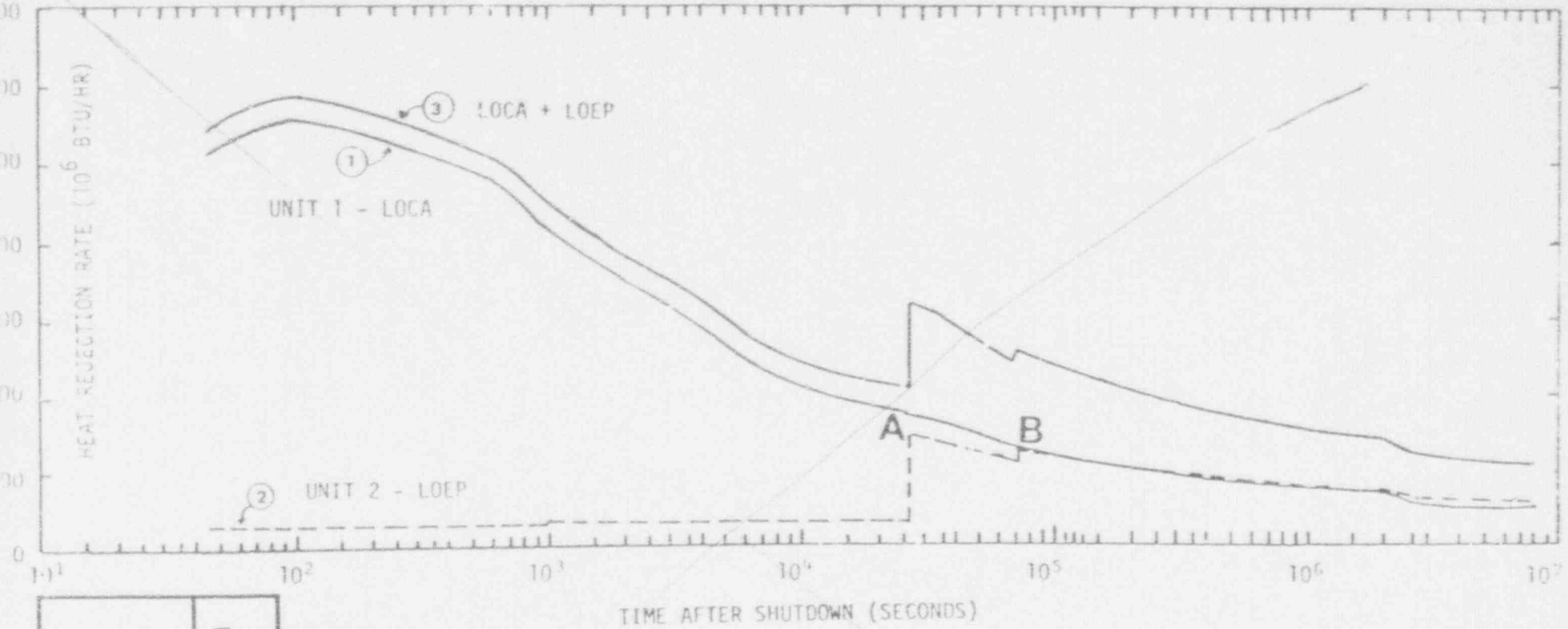
FIGURE 9.2-6

HEAT REMOVAL FROM CONTAINMENT

FIGURES 9.2-5 AND 9.2-6 HAVE BEEN INTENTIONALLY DELETED



UNIT 1 - UNDERGOING LOCA (LOSS OF COOLANT ACCIDENT)
UNIT 2 - UNDERGOING LOEP (COMPLETE LOSS OF EXTERNAL ELECTRICAL POWER)

REACTOR RESIDUAL DECAY HEAT BASED ON 102% OF THE ENGINEERED SAFEGUARDS. SYSTEMS DESIGN POWER RATING (102% OF 3579 MWt)
A - START OF RHRS HEAT EXCHANGER
B - START OF SPENT FUEL STORAGE POOL COOLING

Replace with a new figure

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FIGURE 9.2-7
HEAT REJECTION TO THE ULTIMATE HEAT SINK
FOR TWO 3411 MWT (GUARANTEED CORE
THERMAL POWER) PWR REACTORS
BROUGHT TO COLD SHUTDOWN

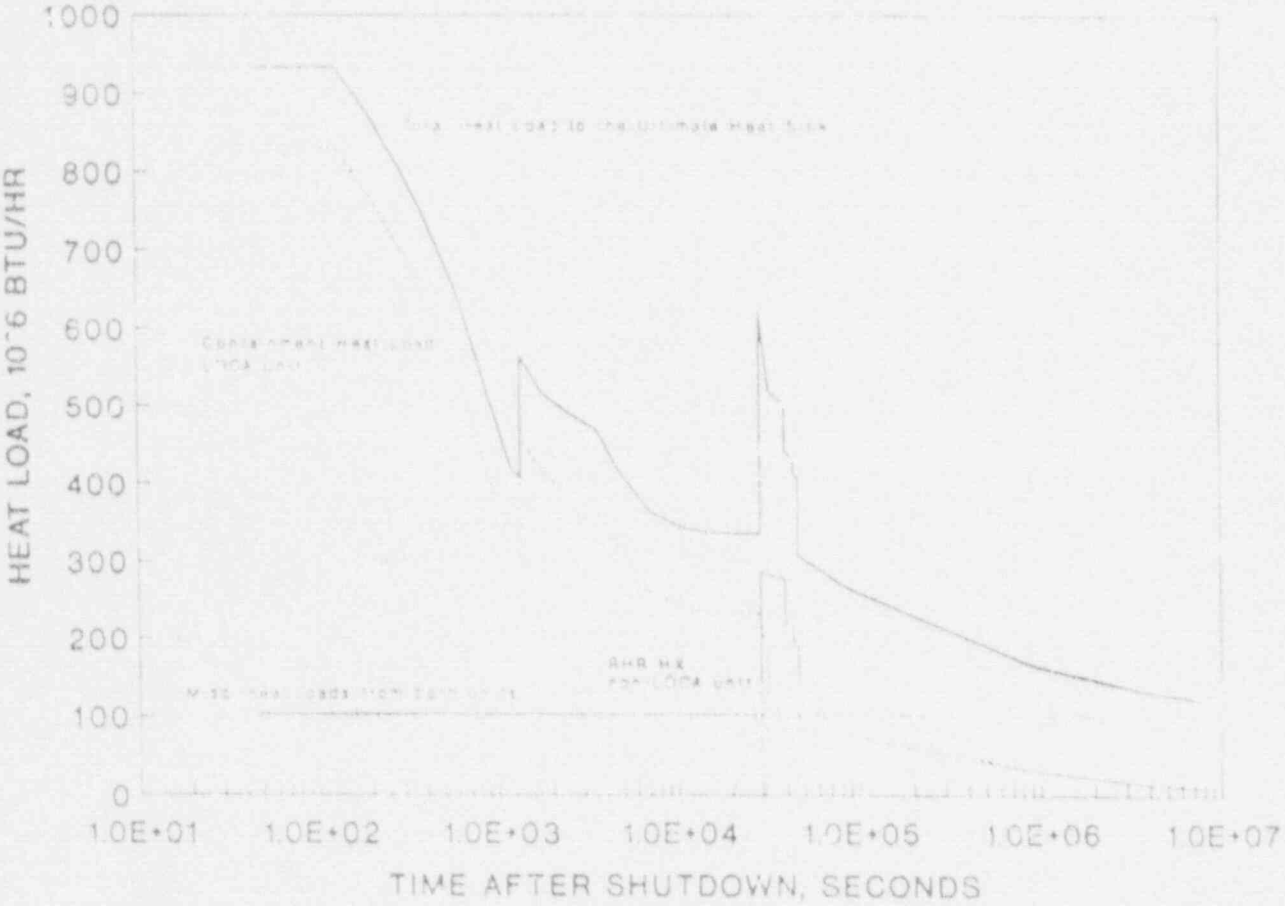

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FIGURE 9.2-7
HEAT REJECTION TO THE ULTIMATE HEAT SINK
FOR TWO 3411 MWT (GUARANTEED CORE
THERMAL POWER) PWR REACTORS
BROUGHT TO COLD SHUTDOWN

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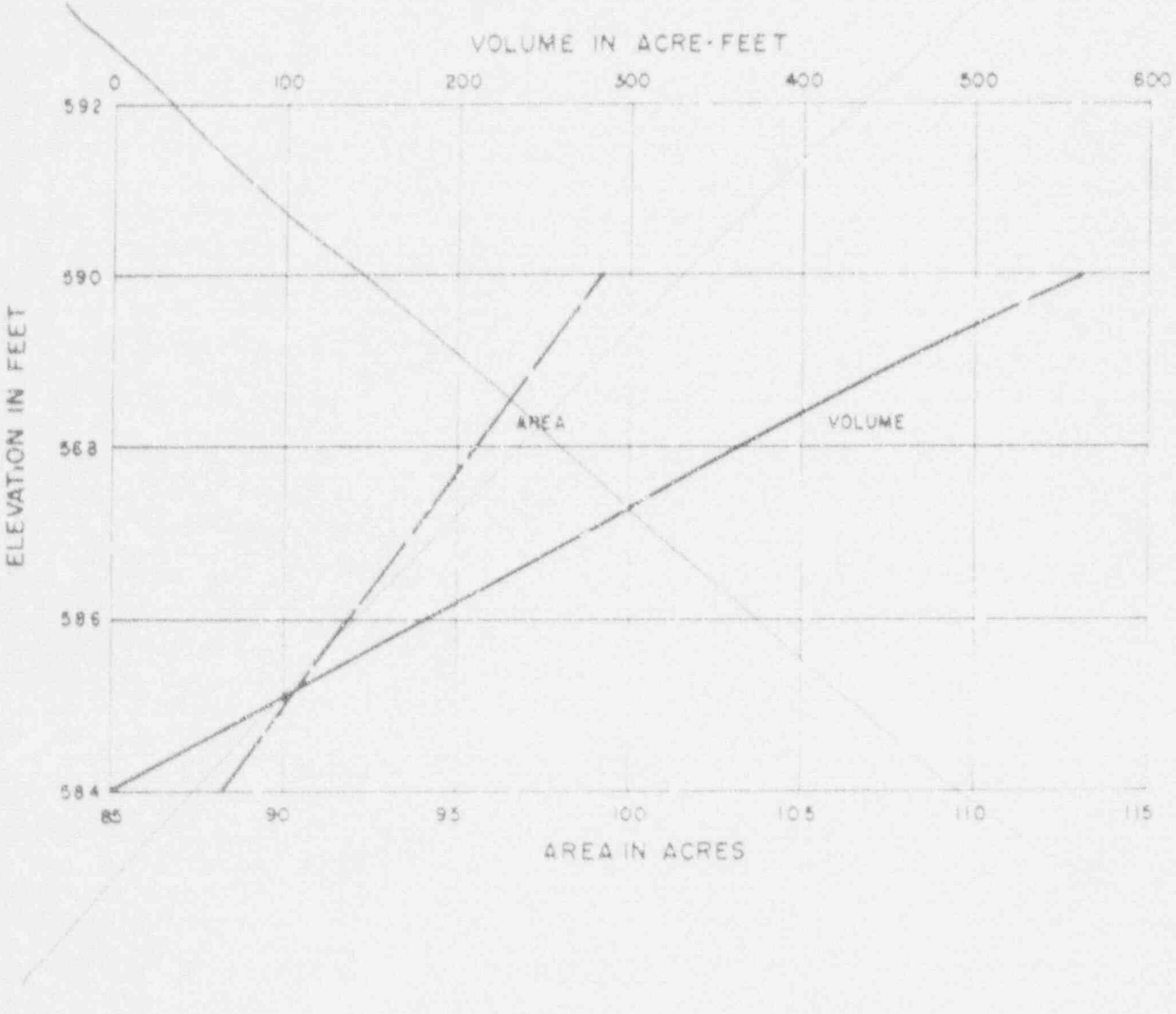

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FIGURE 9.2-8

ULTIMATE HEAT SINK AREA
VOLUME (CAPACITY) CURVES

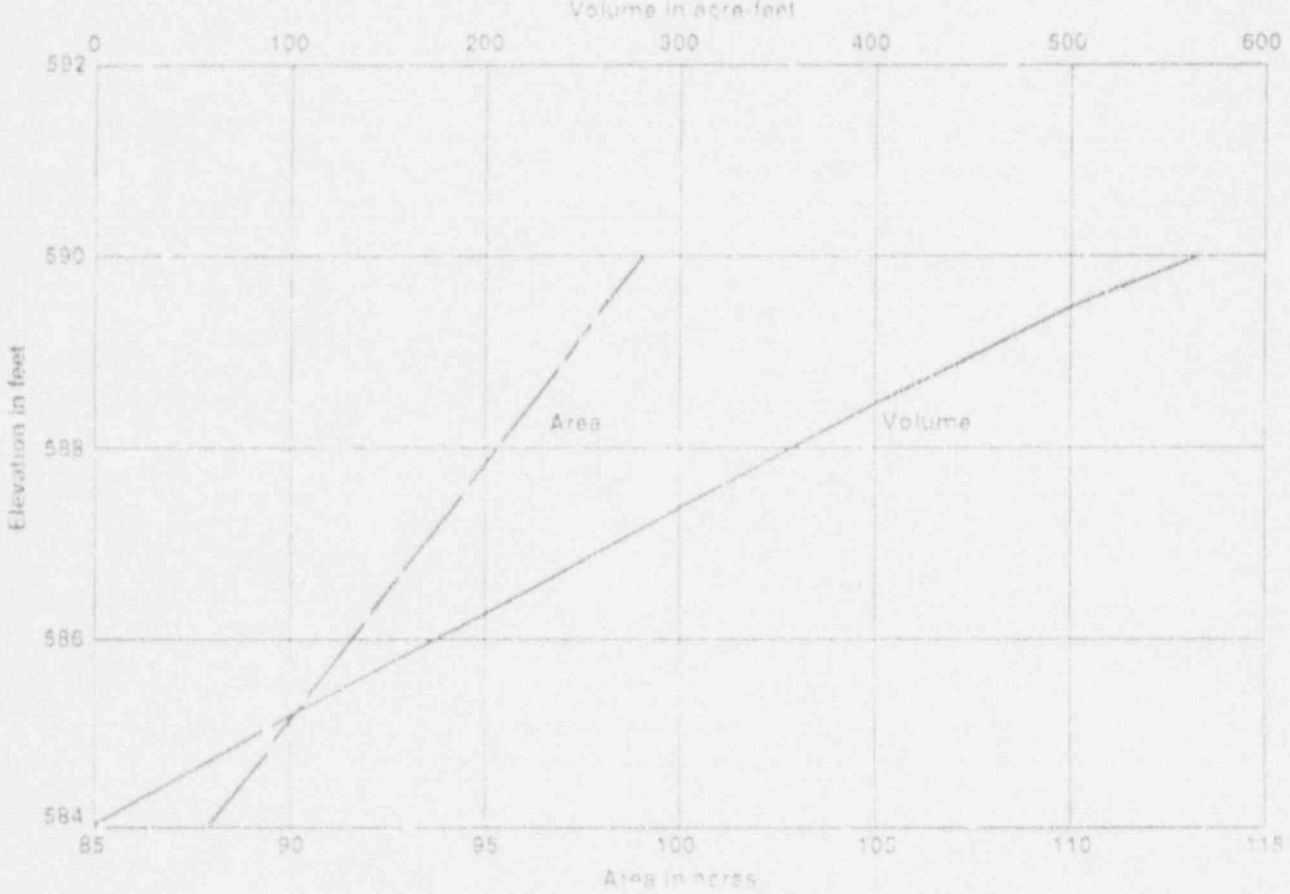

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FIGURE 9.2-8

ULTIMATE HEAT SINK AREA
VOLUME (CAPACITY) CURVES

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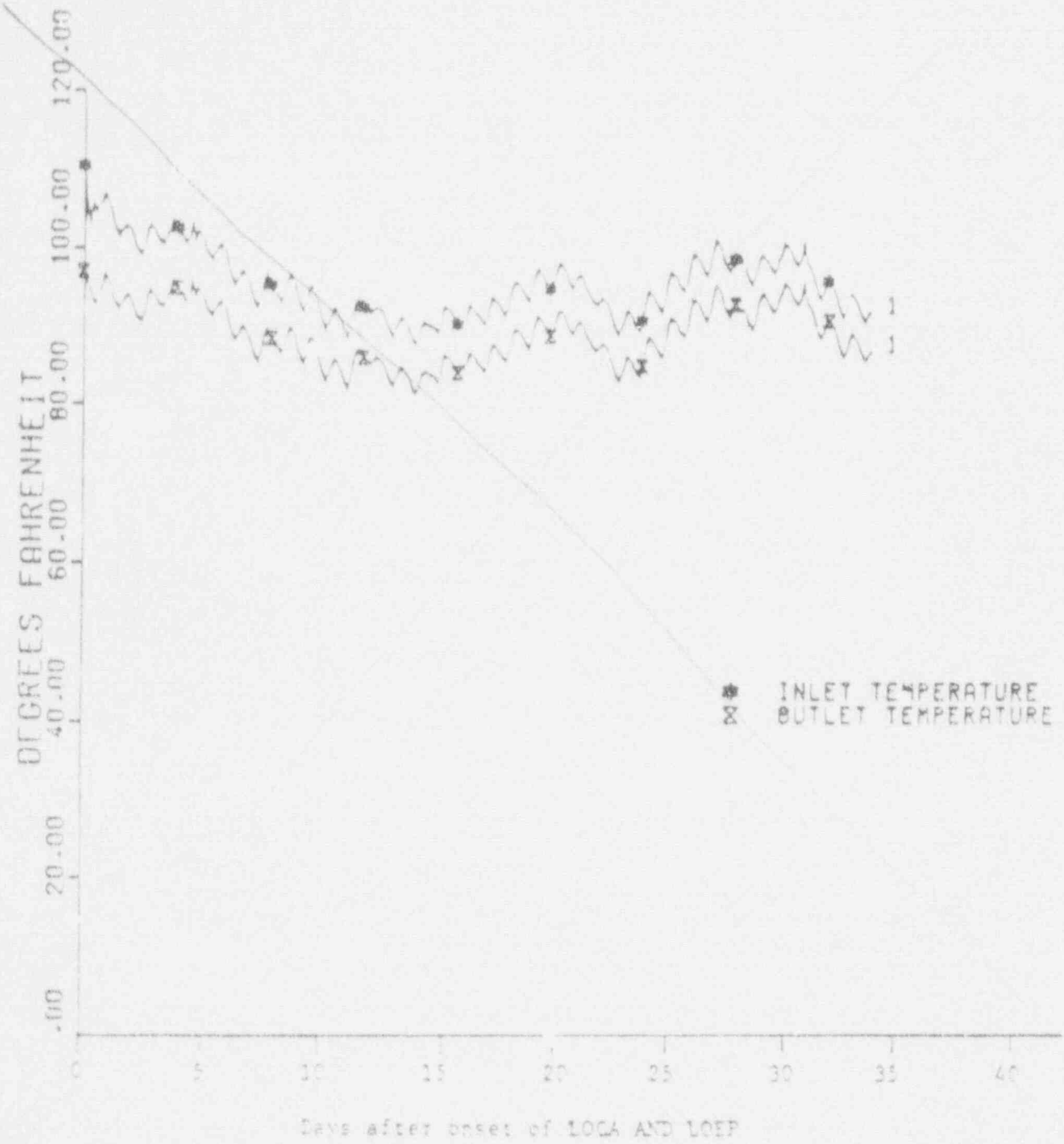

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FIGURE 9.2-9

HEAT SINK TEMPERATURES FOR
MAXIMUM TEMPERATURE CONDITIONS

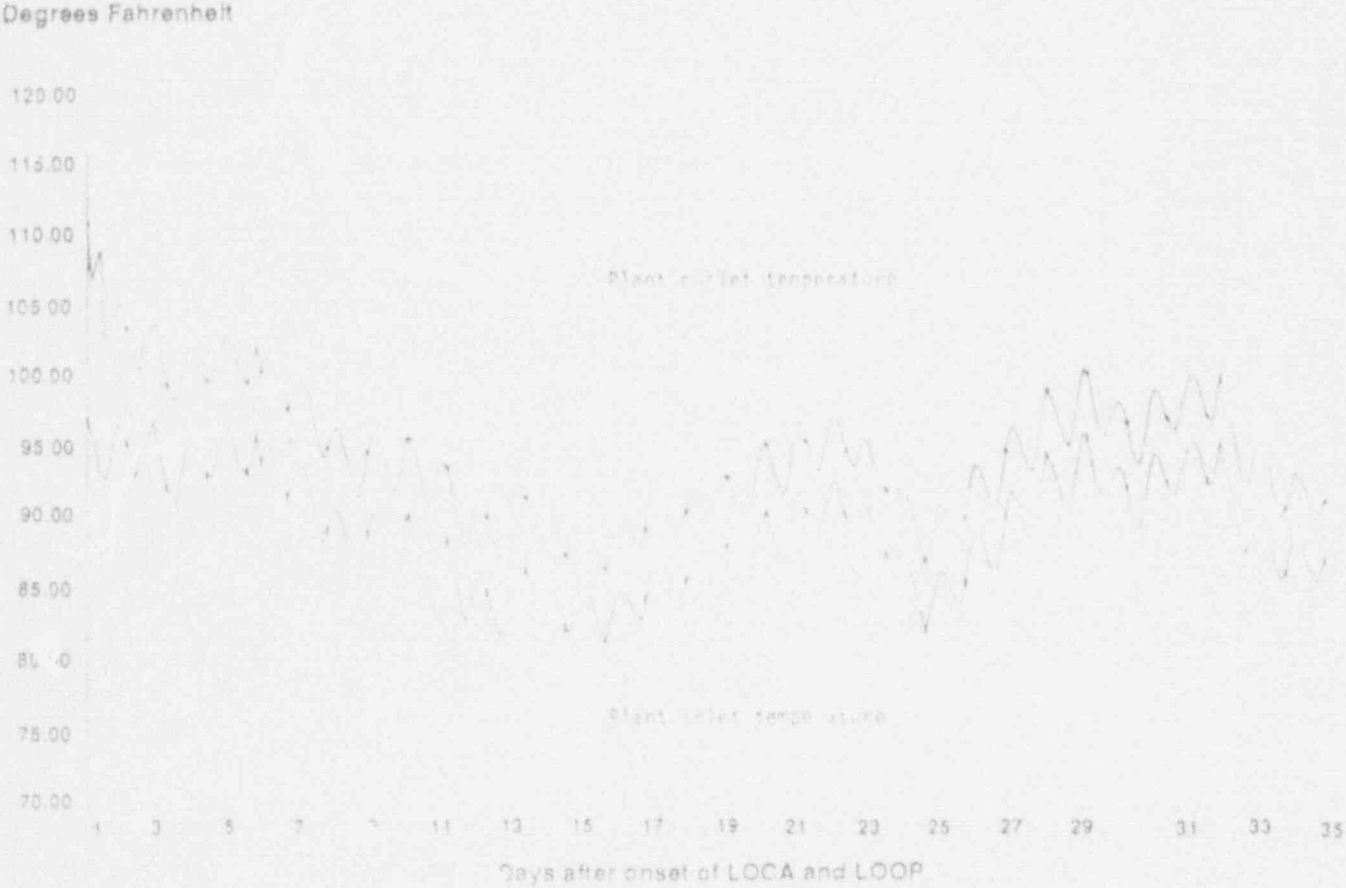

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FIGURE 9.2-9

HEAT SINK TEMPERATURES FOR
MAXIMUM TEMPERATURE CONDITIONS

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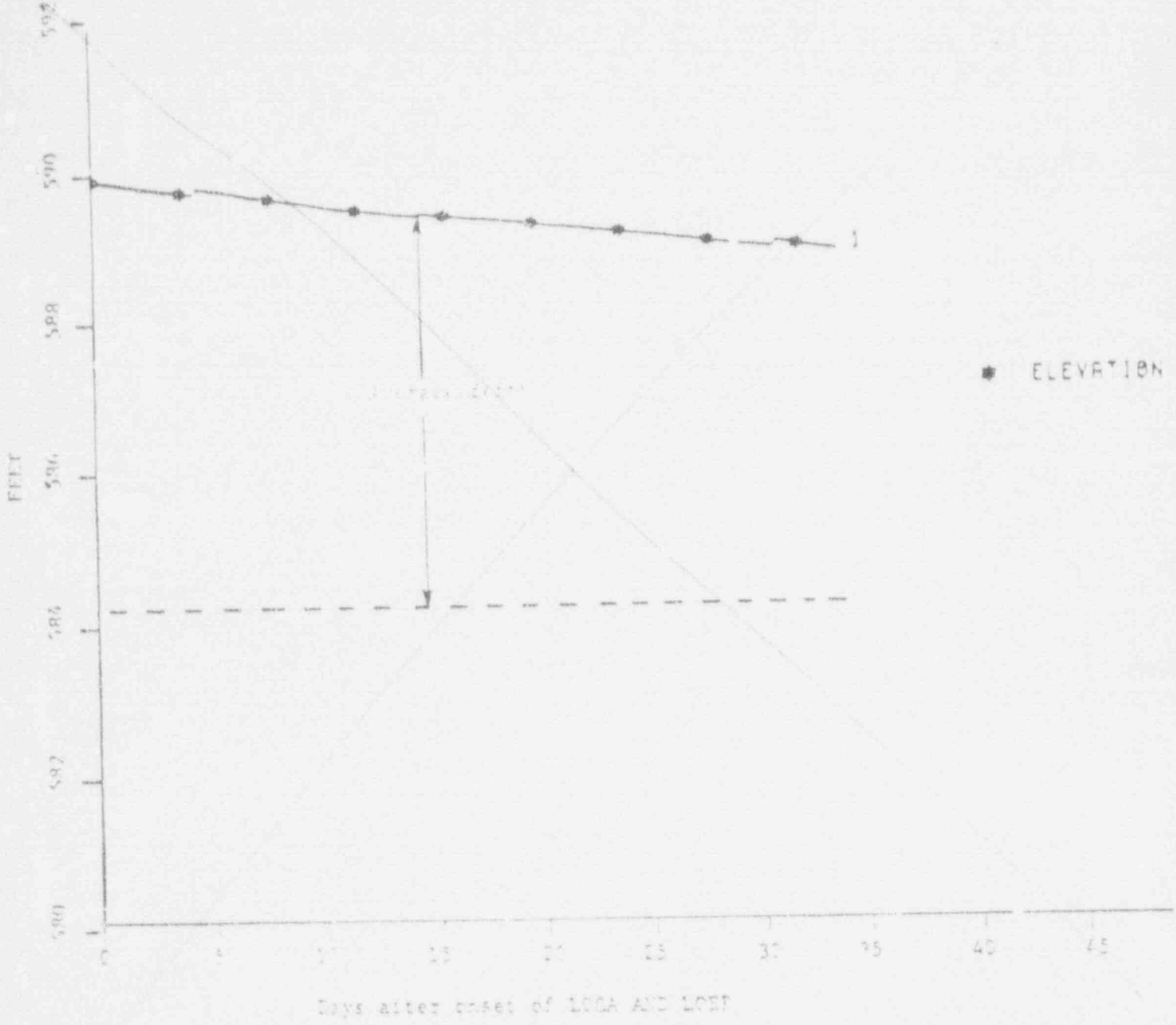

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FIGURE 9.2-10

DRAWDOWN FOR MAXIMUM
TEMPERATURE CONDITIONS

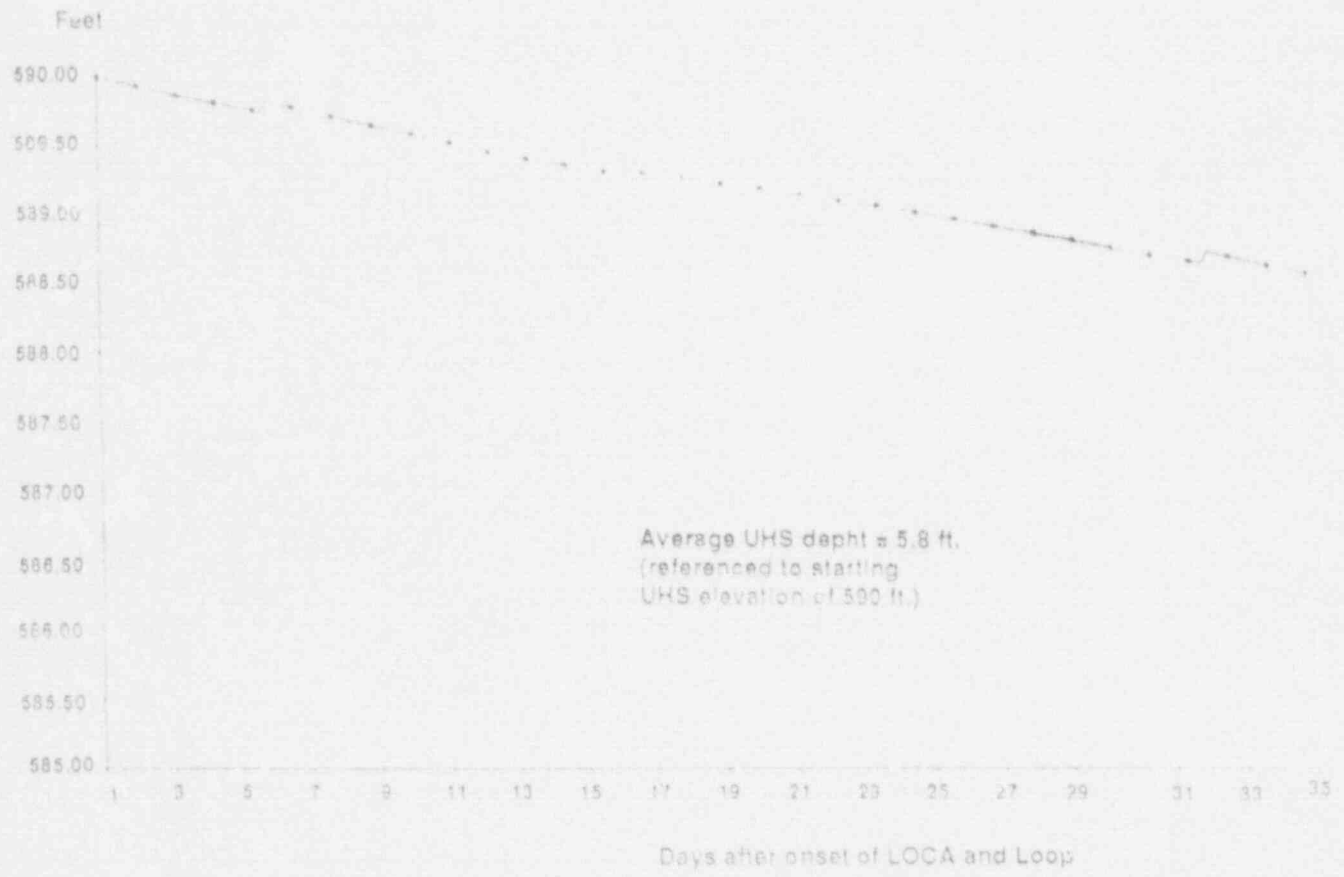

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FIGURE 9.2-10

DRAWDOWN FOR MAXIMUM
TEMPERATURE CONDITIONS

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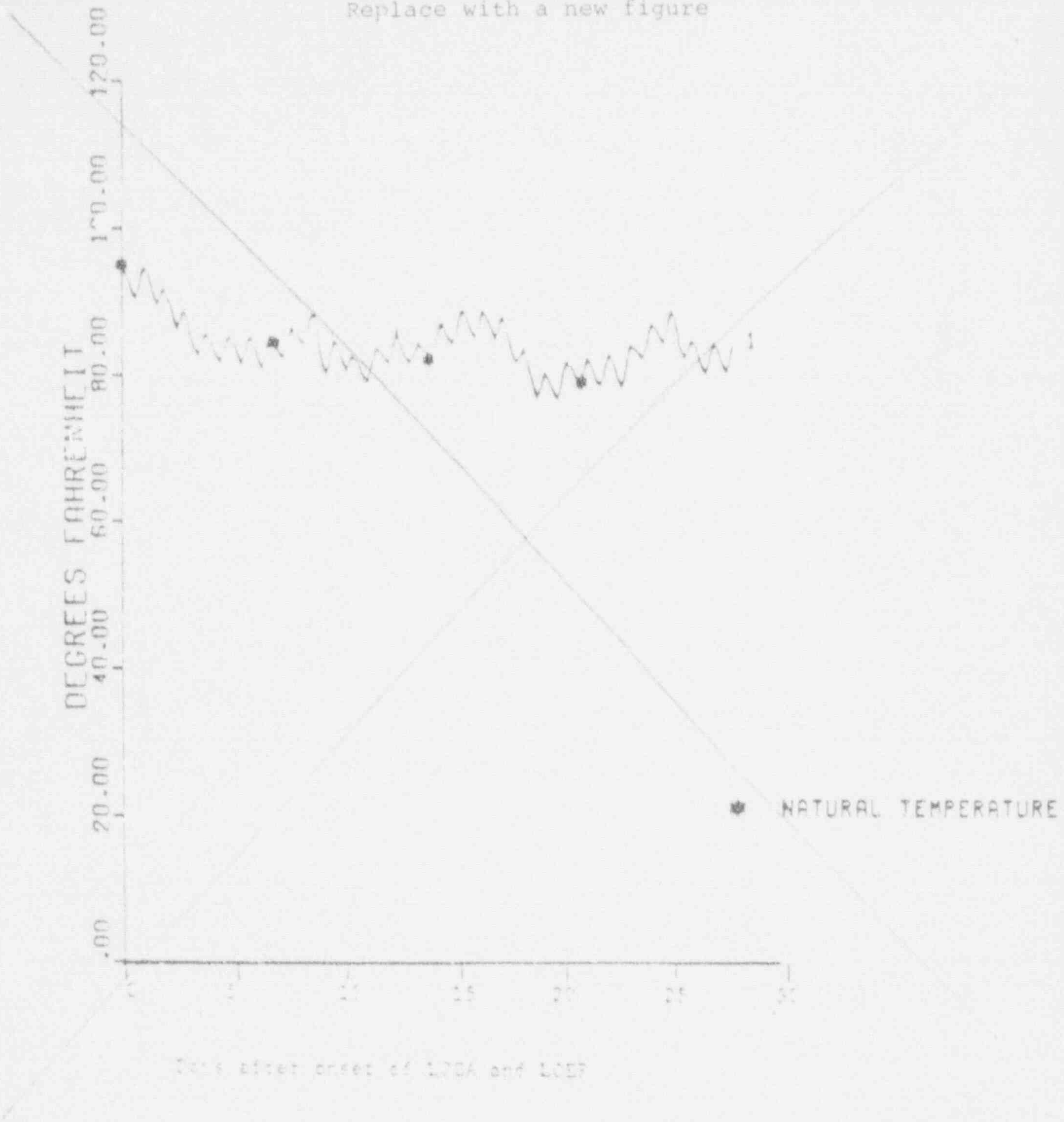

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FIGURE 9.2-11

NATURAL TEMPERATURES FOR
MAXIMUM TEMPERATURE CONDITIONS

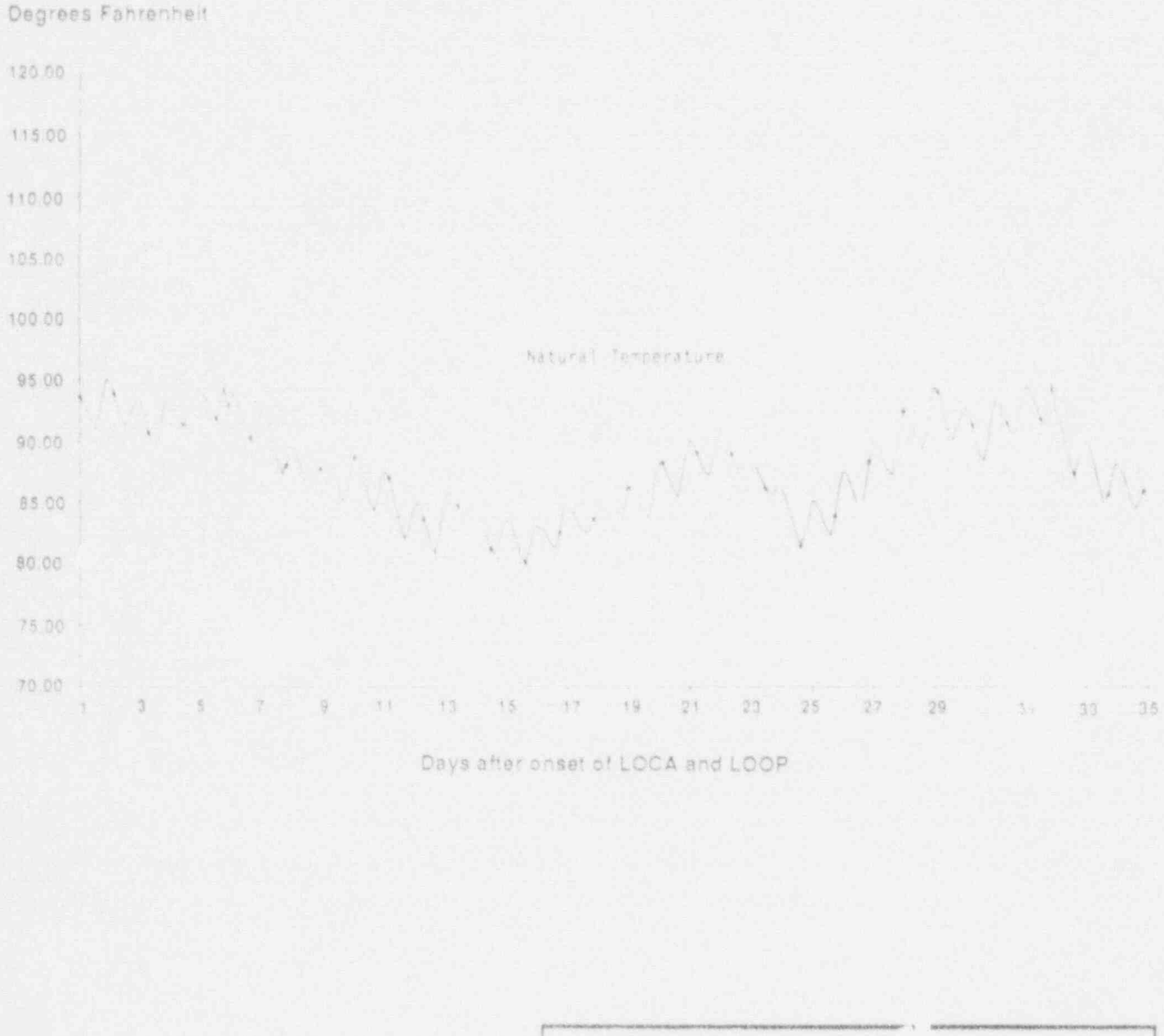

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FIGURE 9.2-11

NATURAL TEMPERATURES FOR
MAXIMUM TEMPERATURE CONDITIONS

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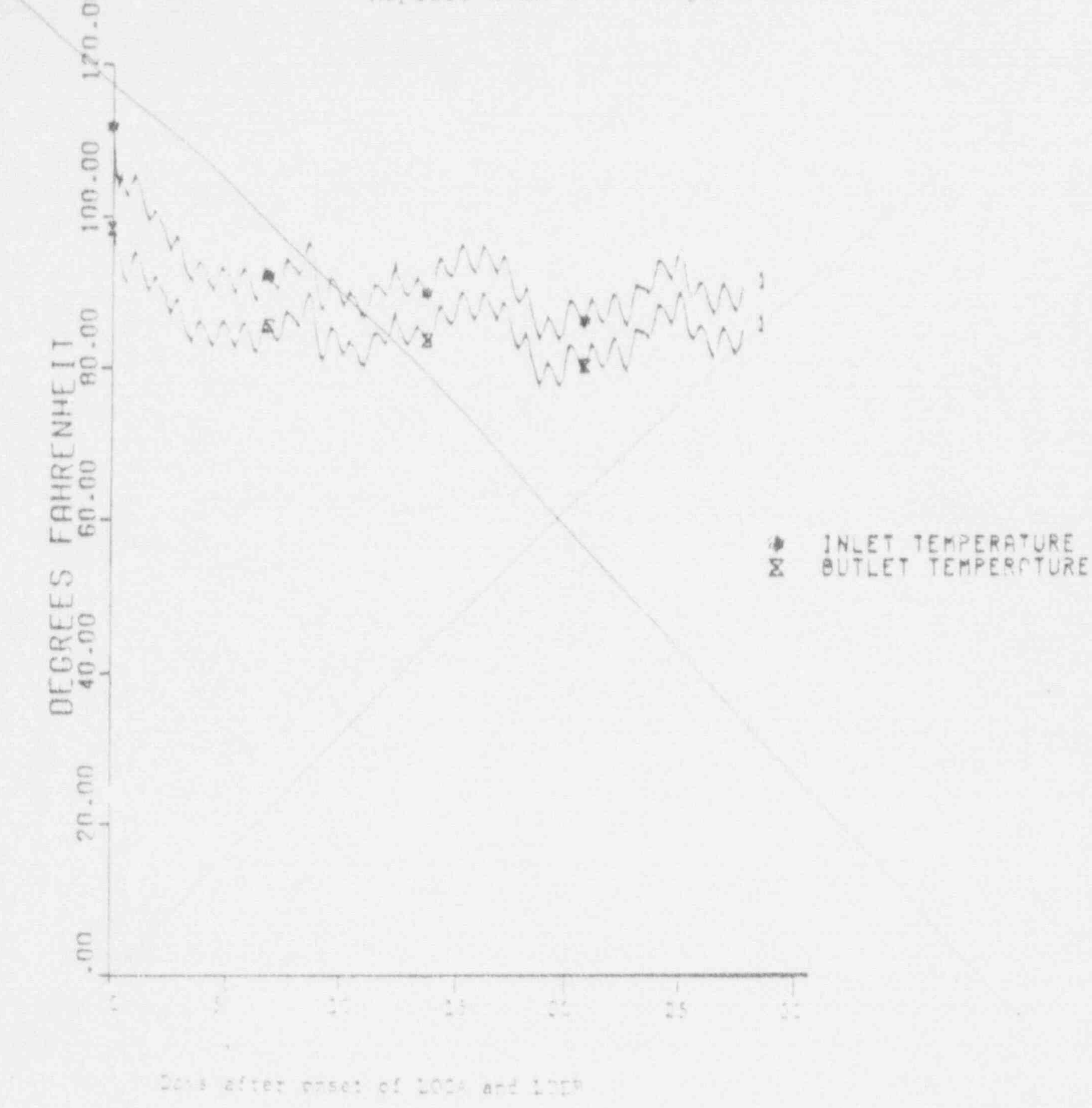

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FIGURE 9.2-12

HEAT SINK TEMPERATURES FOR
MAXIMUM EVAPORATION CONDITIONS

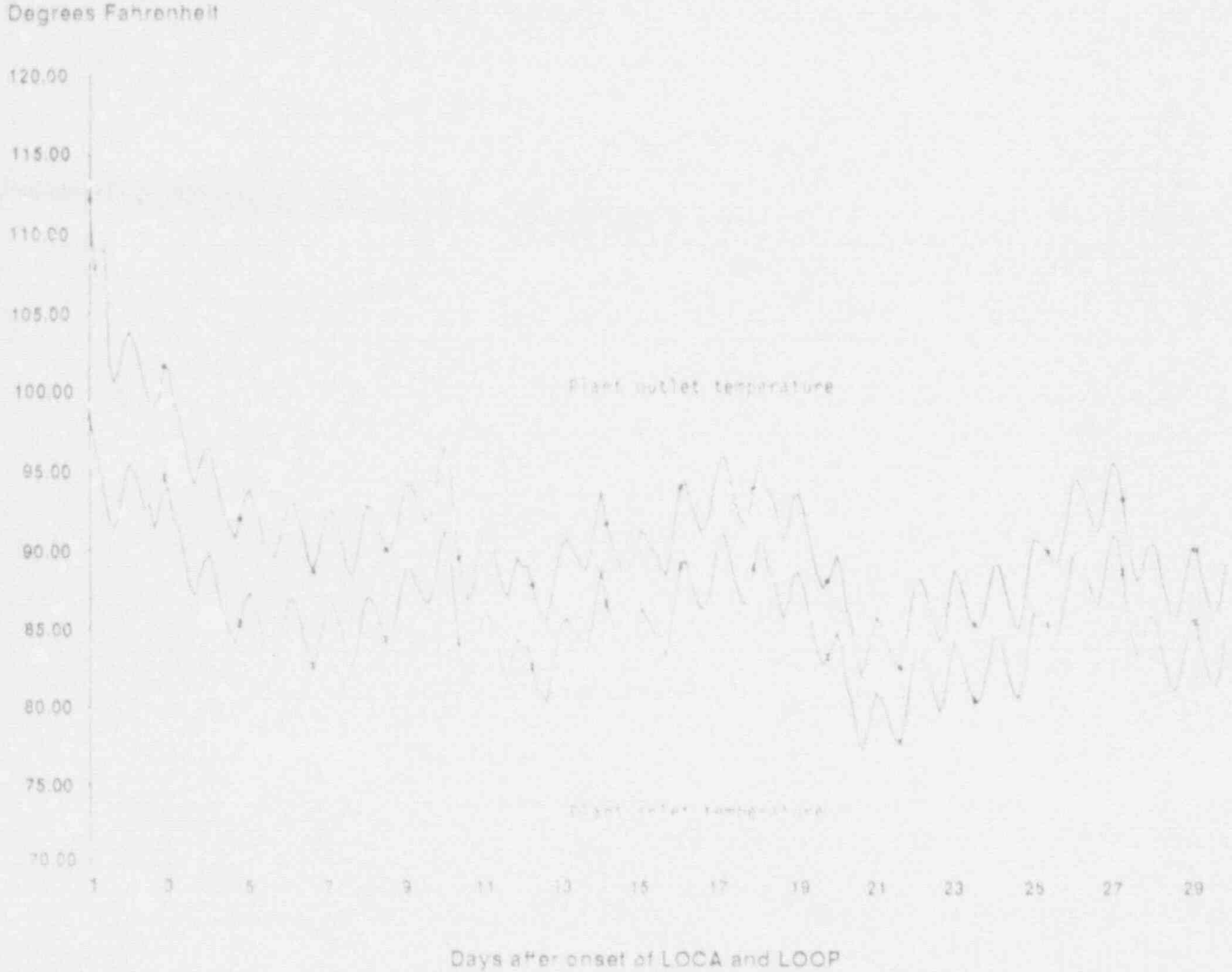

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FIGURE 9.2-12

HEAT SINK TEMPERATURES FOR
MAXIMUM EVAPORATION CONDITIONS

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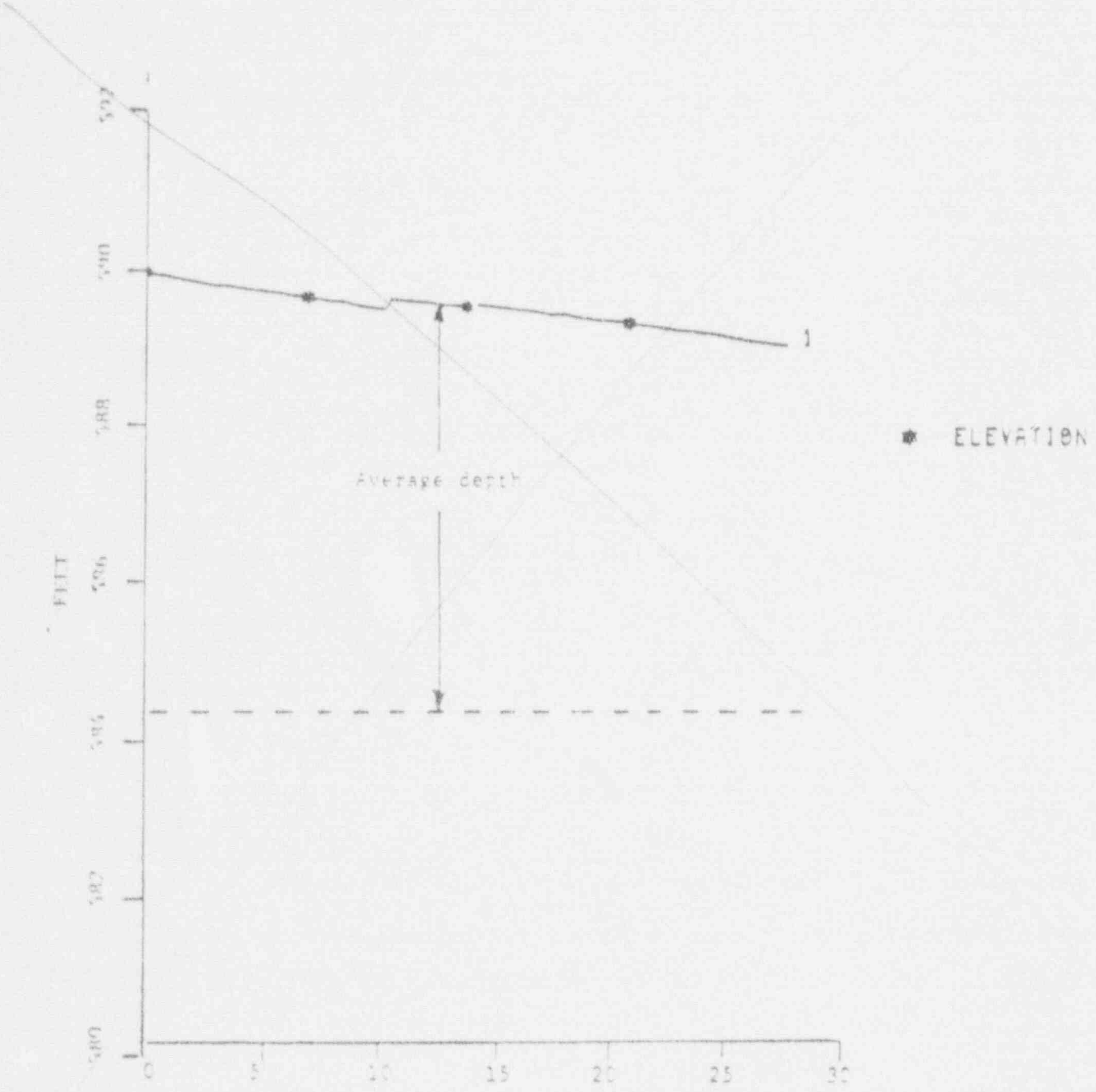

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FIGURE 9.2-13

DRAWDOWN FOR MAXIMUM
EVAPORATION CONDITIONS

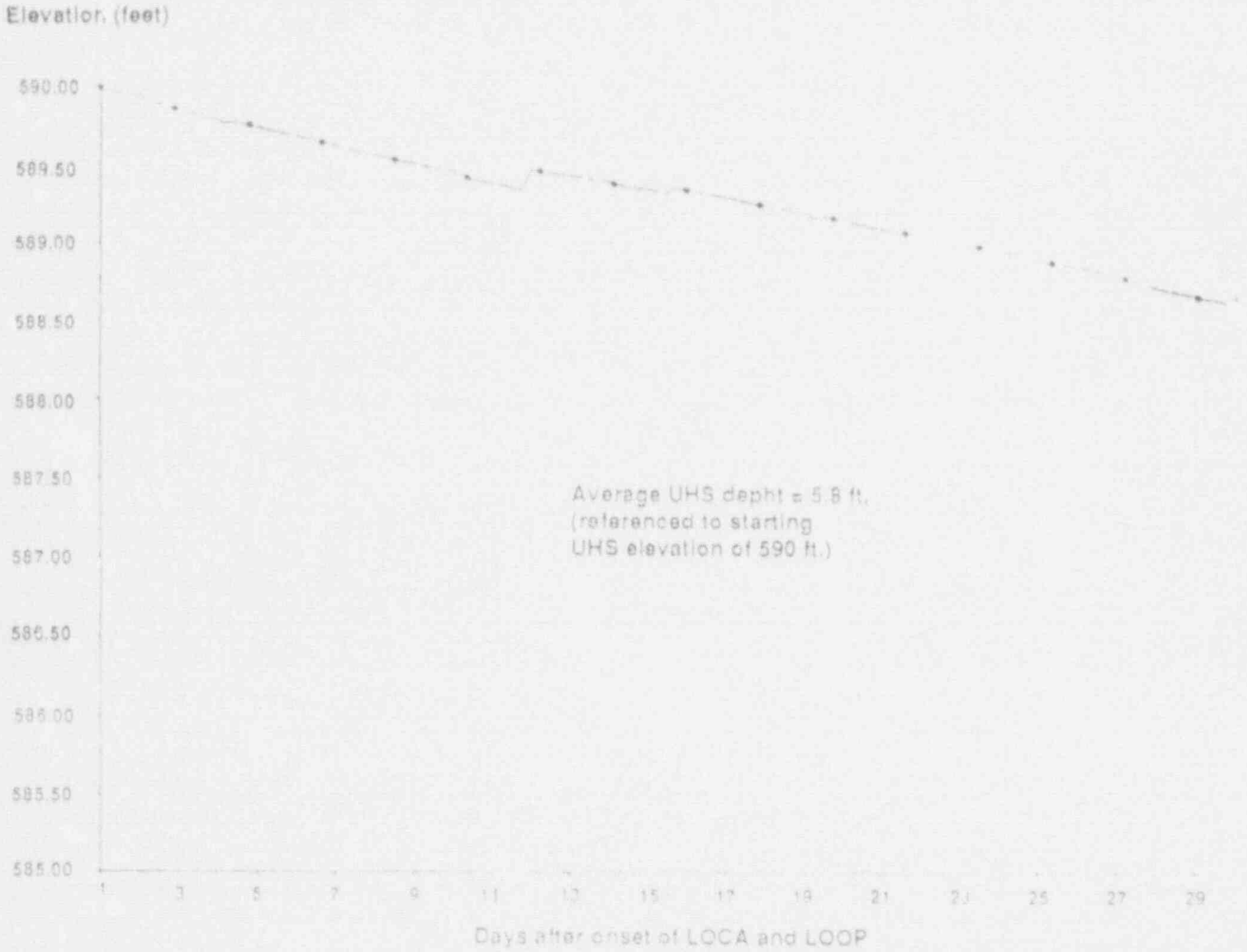

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FIGURE 9.2-13

DRAWDOWN FOR MAXIMUM
EVAPORATION CONDITIONS

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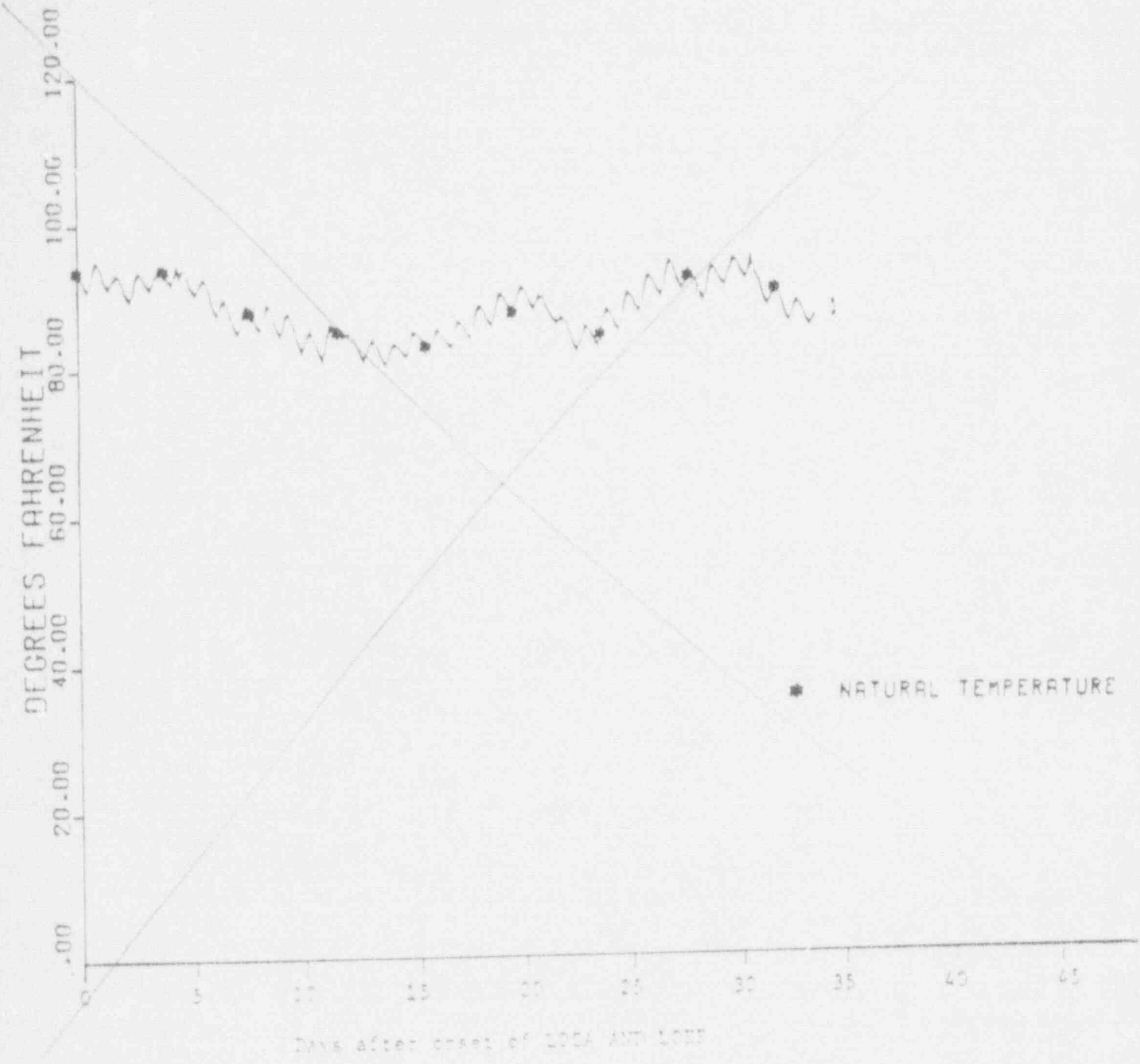

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FIGURE 9.2-14

NATURAL TEMPERATURES FOR
MAXIMUM EVAPORATION CONDITIONS

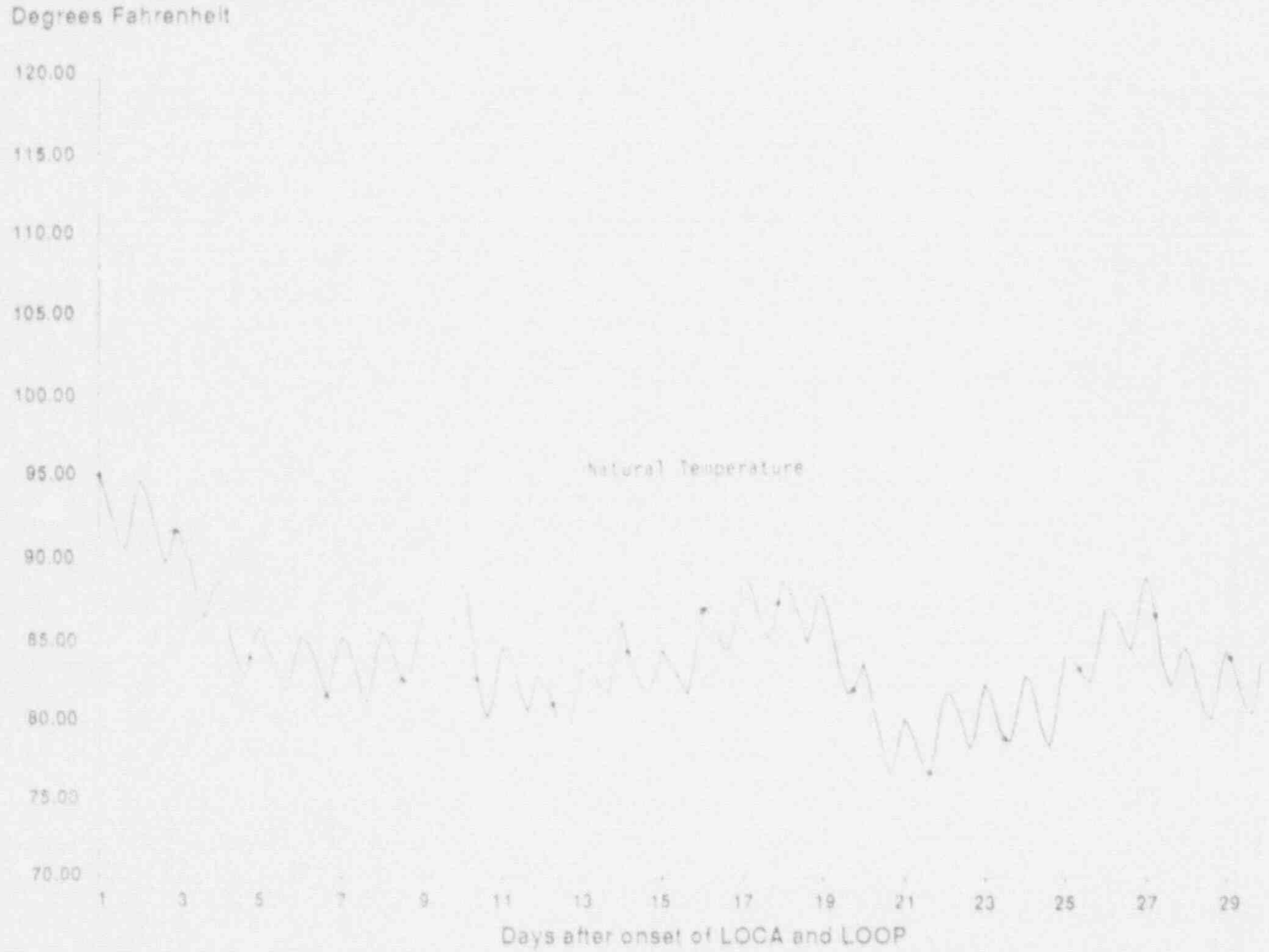

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FIGURE 9.2-14

NATURAL TEMPERATURES FOR
MAXIMUM EVAPORATION CONDITIONS

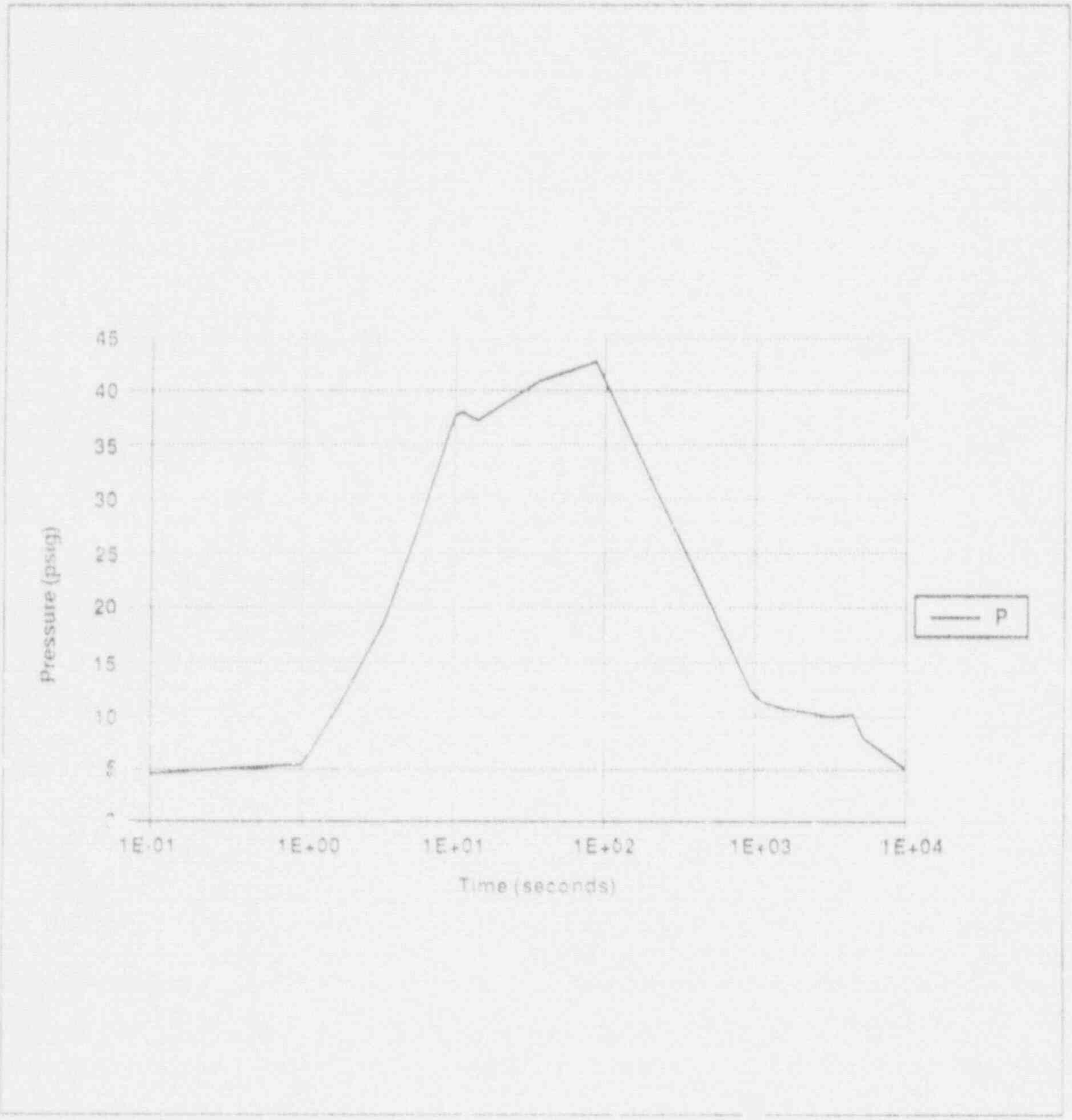

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FIGURE 9.2-30

CONTAINMENT PRESSURE
4 RCFC/2 CS PUMP CASE

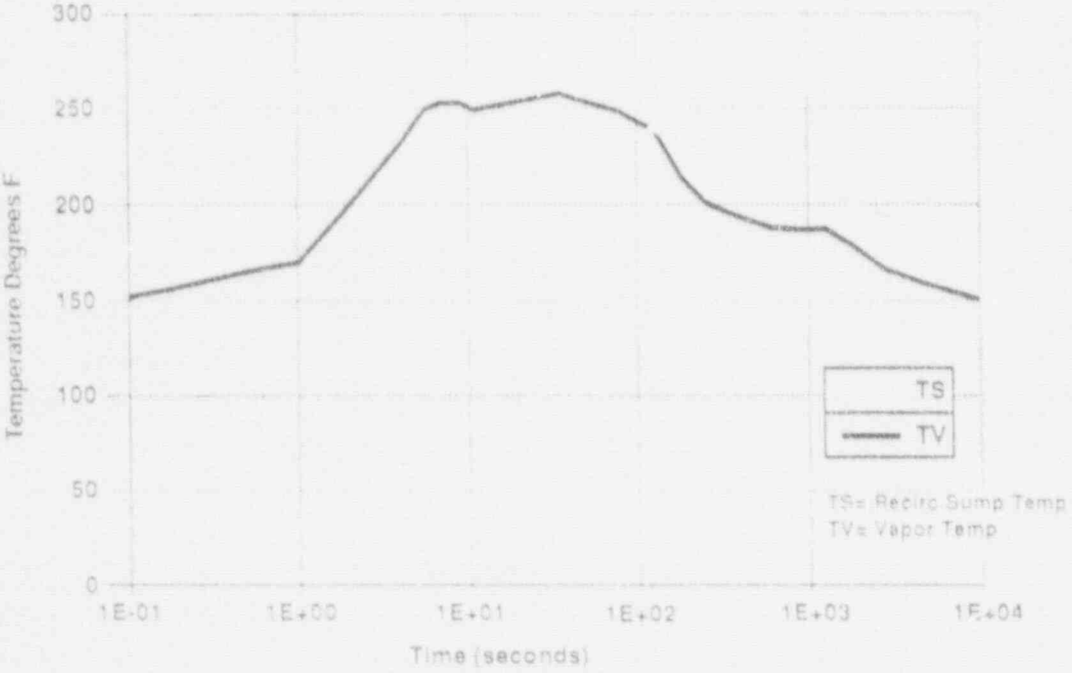

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FIGURE 9.2-31

CONTAINMENT TEMPERATURE
4 RCFC/2 CS PUMP CASE