HOUSTON LIGHTING & POWER COMPANY
ALLENS CREEK NUCLEAR GENERATING STATION - UNIT NO. 1
PRELIMINARY SAFETY ANALYSIS REPORT
AMENDMENT NO. 58
INSTRUCTION SHEET

This amendment contains information pertaining to PSAR Update. Each revised page bears the notation Am. No. 58, (5/81) at the bottom of the page. Vertical bars with the number 58 representing Amendment No. 58 have been used in the margins of the revised pages to indicate the location of the revision on the page.

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applicable, the horizontal (0.1g) and vertical (0.067g) components of the design basis earthquake are input.

To find the worst possible radius and center of rotation yielding the circle with the lowest factor of safety, a search routine is built into the program by which a trial center of rotation is selected. The program will investigate different radii from that center of rotation computing and recording the safety factor for each radius. It then moves the center of rotation at a prescribed increment to a different trial location and the above process is repeated until the lowest safety factor is reached.

The simplified Bishop solution yields results that are conservative in that shear resistance between slices, which would tend to raise the factor of safety against sliding, is neglected. When the simplified Bishop solution is used to compute a factor of safety under dynamic loading additional conservatism is built into the program in that the computed safety factor is calculated assuming the components of the design earthquake acceleration act only in one direction, neglecting any back and forth motion, and the magnitude of the acceleration of the design earthquake is taken to be a constant over the entire slope for an infinite length of time. 50 361.4

In performing the sliding wedge method the Ebasco computer program was also used. The sliding wedge method consists of an active wedge being mobilized against a neutral horizontal block and a passive resisting wedge. The factor of safety is calculated as the ratio of the sum of the resisting forces in the horizontal direction to the sum of the driving forces in the horizontal direction. In applying the sliding wedge method to the two cross-sections the input data and search routine is similar to that of the slip circle analysis previously discussed. This method also includes a seismic loading in the analyses. This was done by including the product of the weights of the wedges and the neutral block with the horizontal acceleration factor of 0.1g. This force was then considered to act in the direction of the postulated slide as a driving force. The vertical component of the seismic loading is also incorporated into the solution tending to reduce frictional resistance between the sliding wedges. This vertical seismic force is computed as the product of the weights of the neutral block and the wedges with the vertical acceleration factor of 0.067g.

The results of each of these analyses are presented on the tables on Figure M2. In all cases the actual safety factor exceeds the recommended minimum safety factor from Table M5, indicating that the slopes are safe. 58

The above described detailed investigation has accurately established the soil conditions in the area of the ultimate heat sink at Allens Creek. The continuous sampling in the upper soils and careful undisturbed sampling of clays and sand establishes a sound basis for the selection of lower bound strength samples. Selection of design strength parameters incorporated the use of lower bound strength parameters from the test results, using very conservative test procedures. Results of the analyses indicated

satisfactory safety factors. Reflected in the analyses are the changes required to obtain the required safety factors. In order to maintain the 1 vertical to 3 horizontal slope of the causeway it was necessary to excavate the surface clays from beneath the causeway. Additionally the slopes of the ultimate heat sink basin have been flattened to 1 vertical 50
to 8 horizontal from the original 1 vertical to 3 horizontal. These 361.4
changes are the result of using the $\phi = 9^{o}$ from the consolidated drained repeated direct shear tests.

M8 UHS CAUSEWAY SLOPE STABILITY

In accordance with the design parameters and loading criteria outlined in Figure M-2, studies were performed to verify the design and the validity of the slope stability of the UHS Causeway. Directly underneath the Causeway there exists an approximate 50 foot thick layer of dense sand. This dense sand layer will act as a firm foundation and provide adequate support and sufficient stability for the Causeway. An analysis simulating a potential failure was conducted and postulated that the potential failure plane would occur within the recompacted material, i.e. the man-made Causeway. For this failure a minimum safety factor of 1.46 against seismic loading conditions as shown in Table M6 would result.

A parametric study was also performed using the Seismic Wedge Method, considering side friction along the potential failure plane. The failure plane was allowed to cut through 50 feet of dense sand, and to penetrate into the under lying clay layer. This study yielded a minimum safety
factor of 1.34 and approximated the results obtained from the Simplified 58
Bishop Method. Either method is considered acceptable and adequate for the Causeway design.

It should be noted that the constant excitation forces utilized in both Wedge and Simplified Bishop Method slope stability analyses provide an extremely conservative approach in the case of an instantaneously back and forth earthquake motion of 10 second duration. This conservatism was also coupled with an unrealistic large amount of driving mass in the Wedge Method as indicated in Figure M-2. A comparison of these parametric study results is presented in Table M6.

In summary, the slope stability results as presented in Figure M-2 are extremely conservative, since they neglect all side friction forces along the failure planes, are coupled with unrealistically large amounts of driving mass, and neglect the low average soil design parameters. The minimum safety factors for the Causeway design are well within acceptable limits for different loading conditions as established by U.S. Army Corps of Engineers. (See PSAR Section 2.5 Appendix M Table M5.)

Furthermore, in accordance with the NRC Regulatory Guide 1.27, an analysis postulating the failure of the man-made Causeway was performed. A cross section taken at the lake front area was investigated for the potential blockage of the waterway should the Causeway be postulated to fail in this area. The results of the slope stability analysis along with postulated failure plane are presented in Figure M-2a.

The movement of the postulated failure plane was examined using Newmark's method (1) with a safety factor equal to 1, i.e. an impending failure of the Causeway slope. This yielded a conservative soil movement of less than 4 inches. This soil movement would produce a very minor bulging type of deformation which would be experienced in the Causeway along the lake front area (see Figure M-2a). As an additional conservatism and in order to provide a positive stoppage of soil movement, a concrete retaining wing wall structure will be provided at the Causeway/lake front area (see Figure M-1) to assure a continuous passage of cooling water into the forebay canal of the Ultimate Heat Sink Intake Structure. 58

Embedded piping and electric cabling within the Causeway embankment has been designed to ensure physical independence and redundancy following postulated failure of the Causeway. Figures M-2 and M-2a contain Causeway cross sections illustrating piping and electric cabling corridors.

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(1) "Effects of Earthquake on Dams and Embankment", Fifth Rankine Lecture by N.M. Newmark, Geotechnique, London, England, 1965. 58

TABLE M6

COMPARISON OF THE RESULTS OF THE PARAMETRIC STUDY

Methods and Conditions	Factor of Safety	Remark
Seismic Simplified Bishop Slip Circle	1.35	
Seismic Wedge Method using average low test results	1.46	Failure plane occurs within causeway
Seismic Wedge Method with friction resistance along failure plane	1.34	Failure plane cutting through 50 ft dense sand and penetrating into under clay
Seismic Wedge Method, using average low test result and neglecting friction resistance	1.15	Failure plane cutting through 50 ft dense sand and penetrating into under clay

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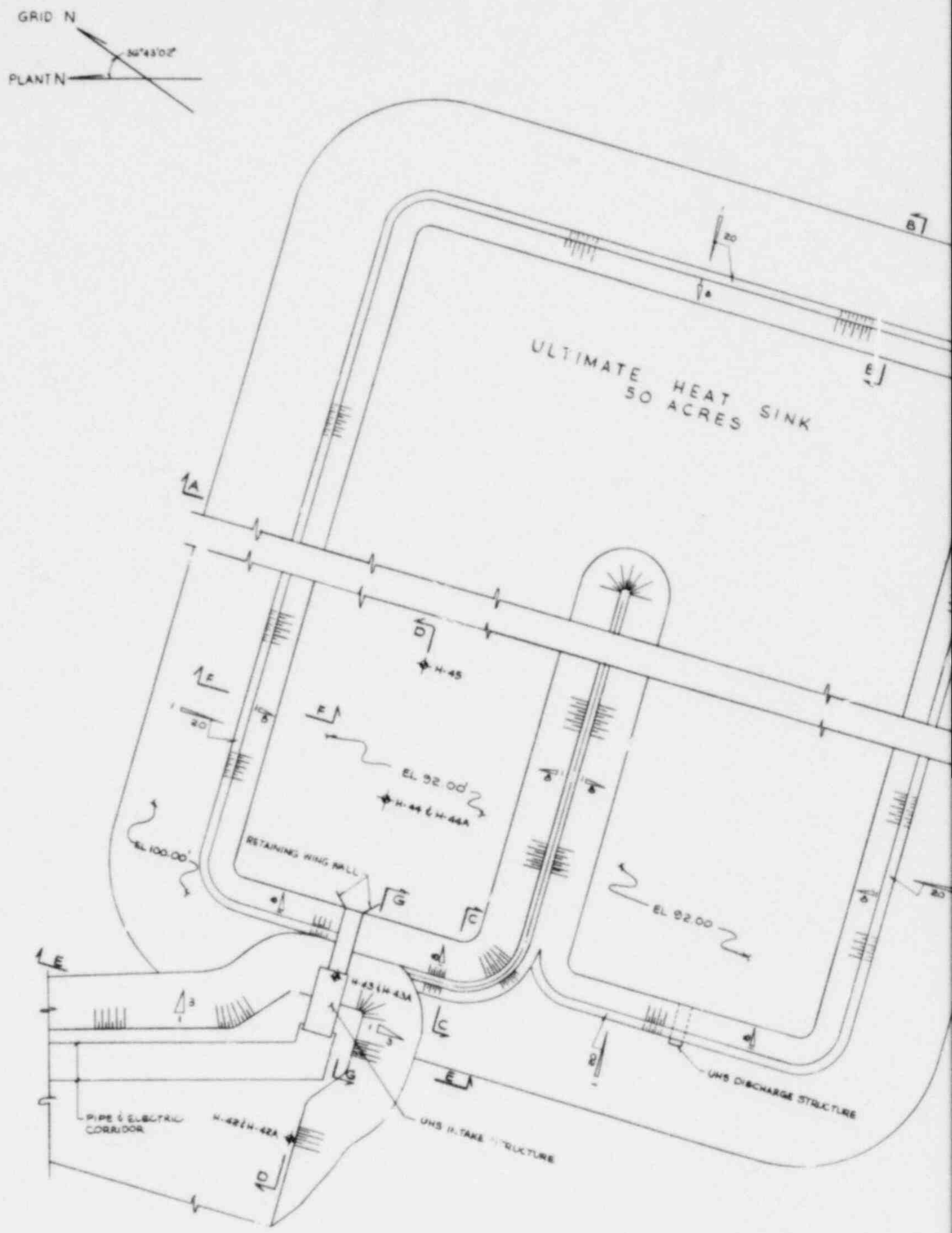
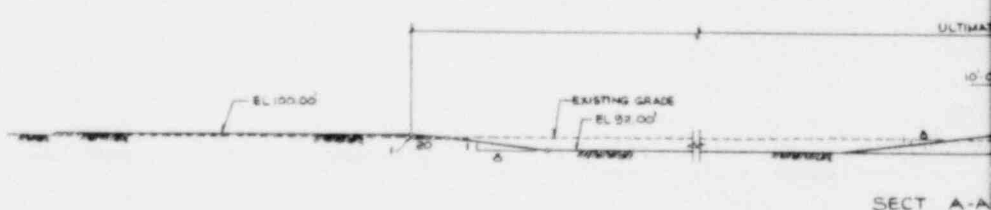
Design parameters: C = 1000 psf for clay, $\phi = 38^\circ$ for sand
Loading Criteria: SSE and full reservoir WL = EL 118 ft

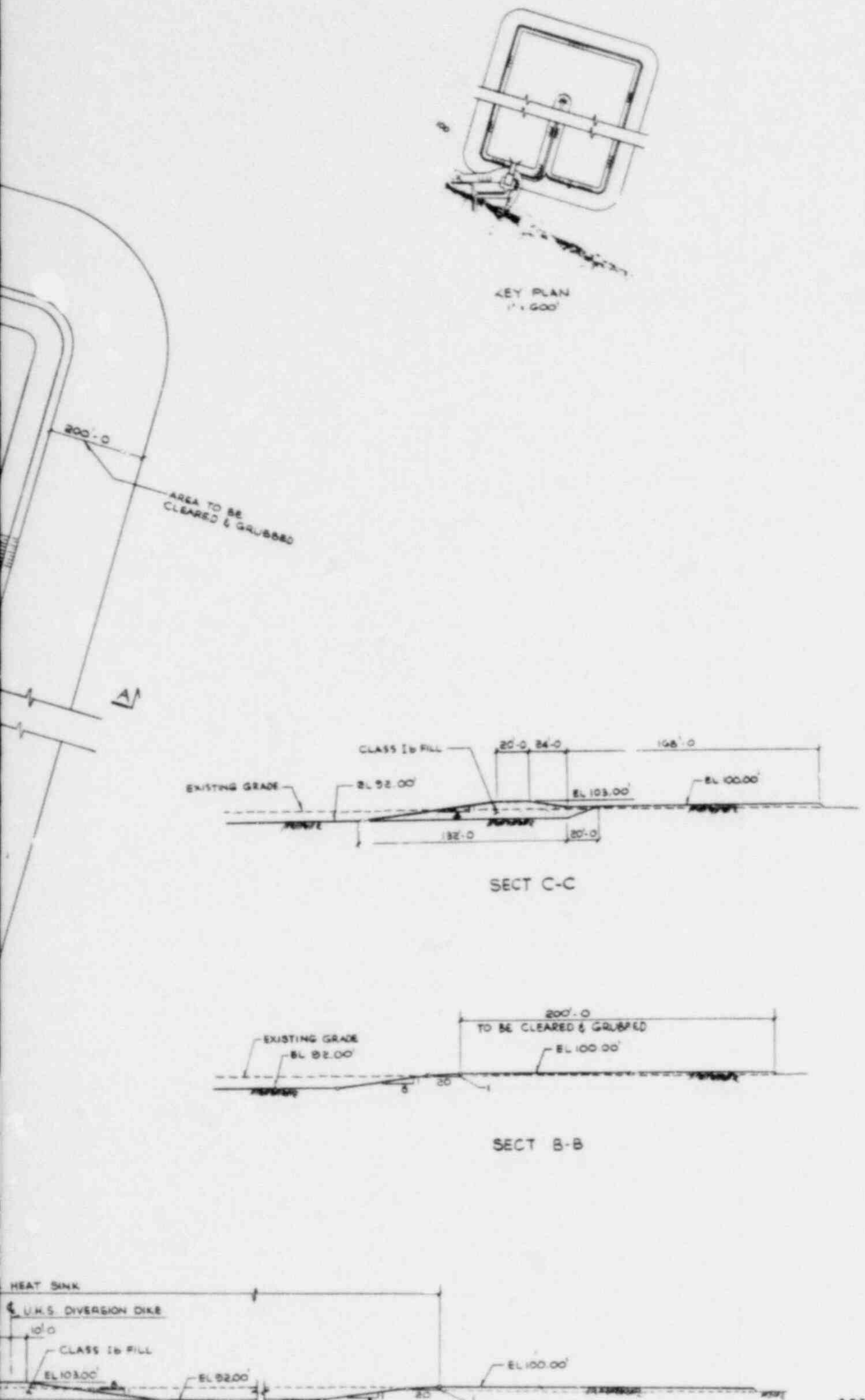


PLAN & BORING LOCATION



SECT A-A

POOR ORIGINAL



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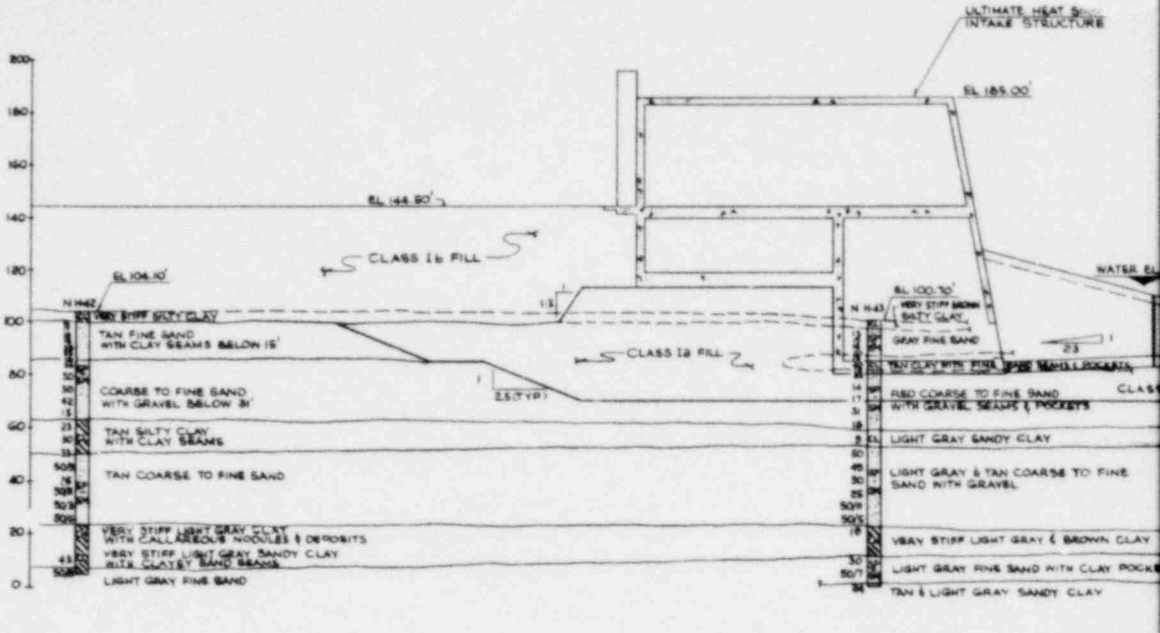
Allens Creek Nuclear Generating Station
Unit 1

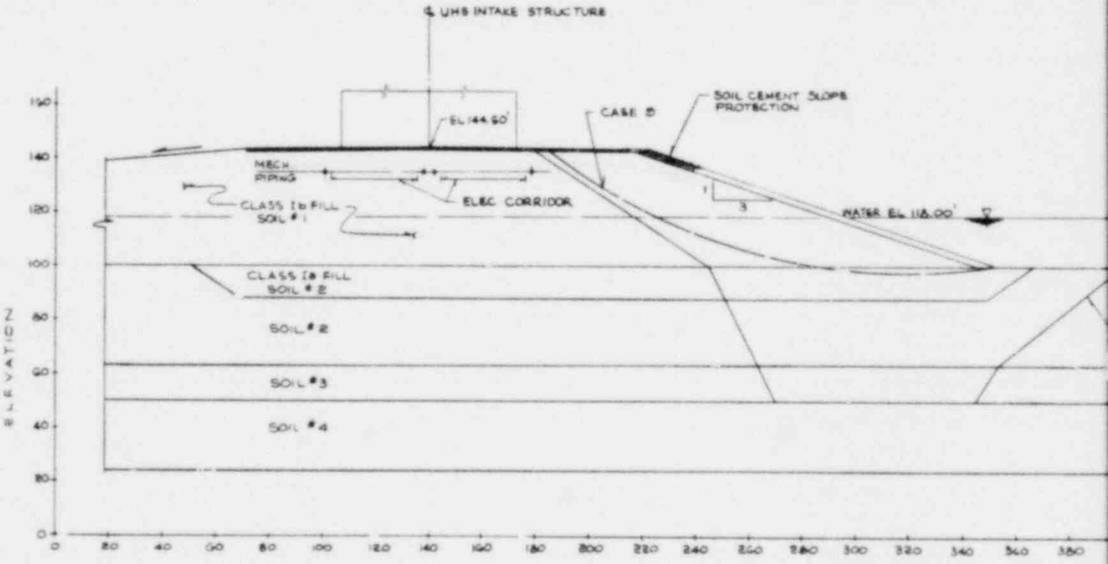
ULTIMATE HEAT SINK
PLAN AND SECTIONS

FIGURE M-1



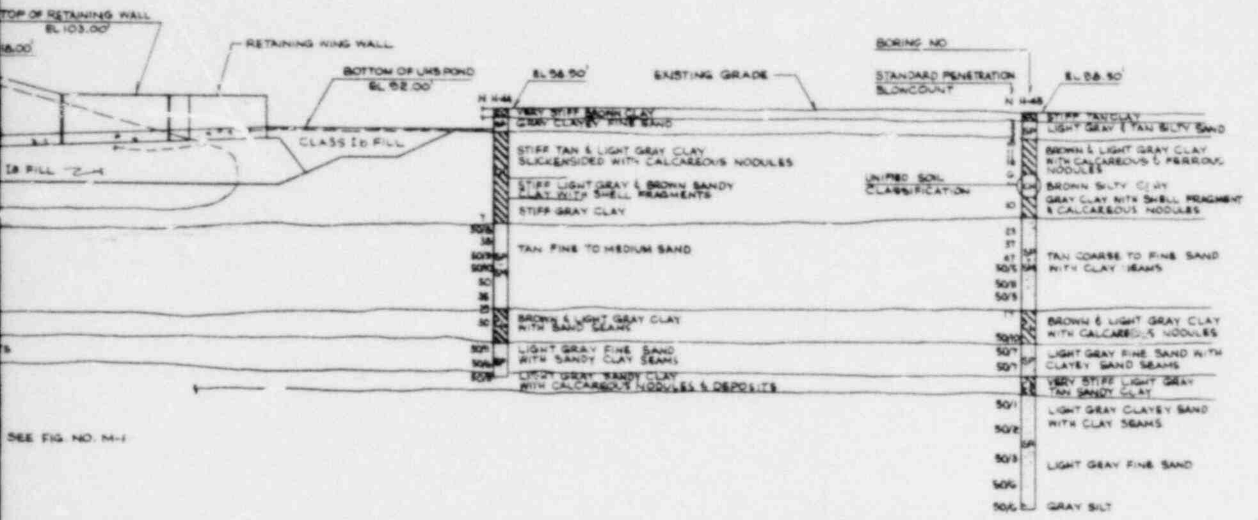
SECT D-D

CASE NO	STRUCTURE	ANALYSIS TYPE	FAILURE PLANE	GROUND WATER LEVEL	SOIL PROPERTIES	SUGGESTED MIN SAFETY FACTOR	ACTUAL MIN SAFETY FACTOR
1	UHS CAUSEWAY	STATIC	CIRCLE	NORMAL (EL 118.00')	#1 C=1000 PSF, #2 φ=38°, #3 C=1000 PSF, #4 φ=38°	1.5	1.56
2			WEDGE		" " " "	1.5	1.76
3			CIRCLE		#1 φ=21°, C=300 PSF, #2 φ=38°, #3 φ=21°, C=300 PSF, #4 φ=38°	1.3	1.52
4			WEDGE		" " " " " "	1.3	2.24
5			CIRCLE		#1 φ=21°, C=300 PSF, #2 φ=38°, #3 φ=5°, #4 φ=38°	1.25	1.52
6		STATIC	WEDGE	NORMAL (EL 118.00')	" " " " "	1.25	1.62
7		RAPID DRAWDOWN	CIRCLE	NORMAL TO EL 111.00'	#1 C=1000 PSF, #2 φ=38°, #3 C=1000 PSF, #4 φ=38°	1.2	2.10
8		RAPID DRAWDOWN	WEDGE	NORMAL TO EL 111.00'	" " " "	1.2	1.54
9		EARTHQUAKE	CIRCLE	NORMAL	#1 C=1000 PSF, #2 φ=38°, #3 C=1000 PSF, #4 φ=38°	1.15	1.35
10	UHS CAUSEWAY	EARTHQUAKE	WEDGE	NORMAL	" " " "	1.15	1.15

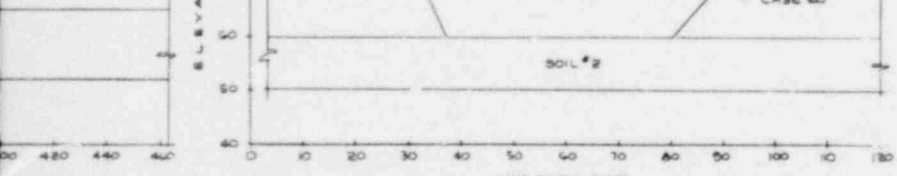


UHS CAUSEWAY
SECT E-E SEE FIG NO. M-1

POOR ORIGINAL



CASE NO	STRUCTURE	ANALYSIS TYPE	FAILURE PLANE	GROUND WATER LEVEL	SOIL PROPERTIES	SUGGESTED MIN. SAFETY FACTOR	ACTUAL MIN. SAFETY FACTOR
11	UHS BASIN SLOPE	STATIC	CIRCLE	NORMAL (EL 118.00')	#1 C=1000 PSF , #2 φ=38°	1.5	13.29
12			WEDGE		" "	1.5	12.31
13			CIRCLE		#1 φ=21°, C=300 PSF, #2 φ=38°	1.5	9.35
14			WEDGE		" " "	1.3	9.28
15			CIRCLE		#1 φ=8° , #2 φ=38°	1.25	1.25
16		STATIC	WEDGE	NORMAL (EL 118.00')	" "	1.25	2.25
17		RAPID DRAWDOWN	CIRCLE	NORMAL TO EL 100.00'	#1 C=1000 PSF , #2 φ=38°	1.2	13.26
18		RAPID DRAWDOWN	WEDGE	NORMAL TO EL 100.00'	" "	1.2	12.37
19		EARTHQUAKE	CIRCLE	NORMAL	#1 C=1000 PSF , #2 φ=38°	1.15	3.52
20	UHS BASIN SLOPE	EARTHQUAKE	WEDGE	NORMAL	" "	1.15	4.29



UHS BASIN SLOPE
SECT F-F SEE FIG NO. M-1

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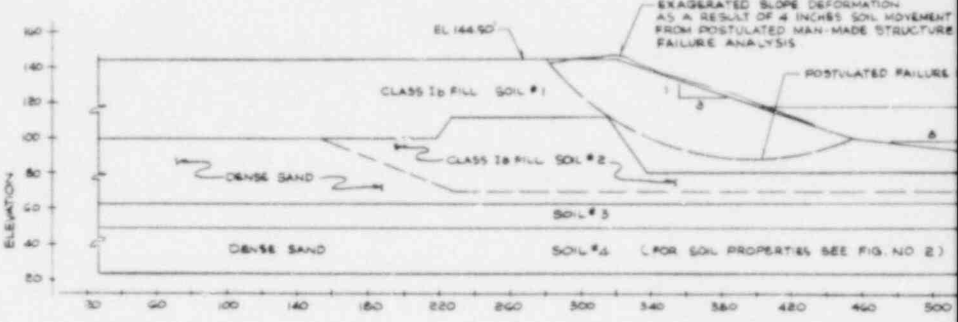
Allens Creek Nuclear Generating Station
Unit 1

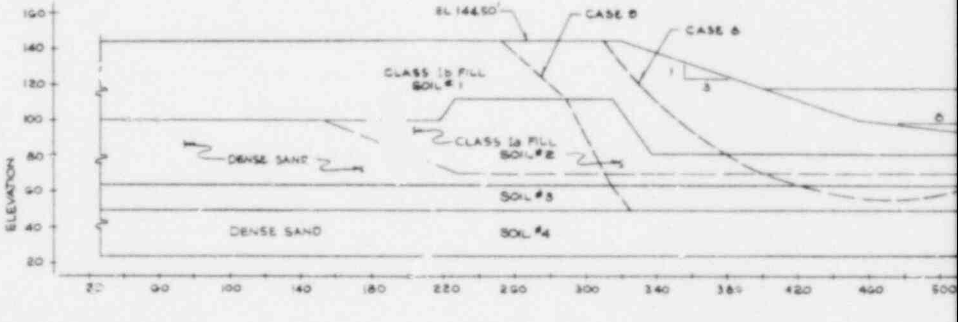
U.H.S. CAUSEWAY – STABILITY ANALYSES

FIGURE M-2

CASE NO	STRUCTURE	ANALYSIS TYPES	LOADING CRITERIA	GROUND WATER (ELEV)	SOIL PROPE
1	UHS CAUSEWAY	SB CIRCLE	STATIC UNDRAINED	118.00'	#1 C=1000 PSF, #2 φ=38°, #
2		SB CIRCLE	STATIC UNDRAINED	110.00'	" "
3		WEDGE	STATIC UNDRAINED	118.00'	" "
4		SB CIRCLE	STATIC DRAINED	118.00'	#1 φ=21° C=300PSF, #2 φ=38°, #3 φ
5		WEDGE	STATIC DRAINED	118.00'	" " "
6		SB CIRCLE	STATIC RESIDUAL	118.00'	#1 φ=21° C=300PSF, #2 φ=38°,
7		SB CIRCLE	STATIC RESIDUAL	118.00'	" " "
8		SB CIRCLE	SIESMIC UNDRAINED	118.00'	#1 C=1000PSF, #2 φ=38°, #
9	UHS CAUSEWAY	WEDGE	SEISMIC UNDRAINED	118.00'	" "



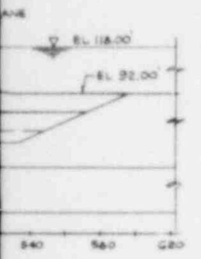
SECT G-G SEE FIG NO M-1

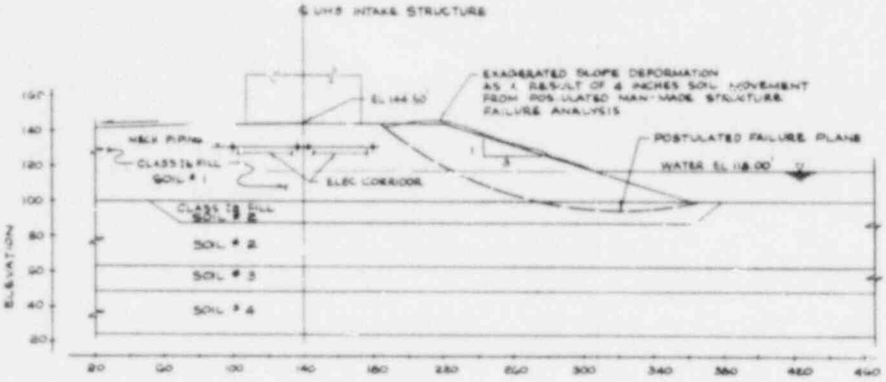


SECT G-G SEE FIG NO M-1

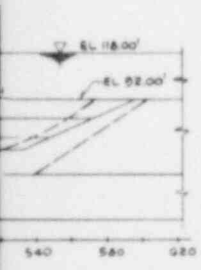
POOR ORIGINAL

TIES	SUGGESTED MIN. SAFETY FACTOR	ACTUAL MIN. SAFETY FACTOR	REMARKS
=1000 PSF, #4 φ=38°	1.5	1.75	H/L. RESERVOIR
" "	1.2	1.75	RAPID DRAWDOWN
" "	1.5	2.15	
C=300 PSF #4 φ=38°	1.5	1.77	
" "	1.5	2.10	
φ=0°, #4 φ=38°	1.5	1.65	SLICKENSIDED CLAY CONDITION
" "	1.5	1.73	SLICKENSIDED CLAY CONDITION
=1000 PSF, #4 φ=38°	1.15	1.31	EARTHQUAKE CONDITION
" "	1.15	1.20	EARTHQUAKE CONDITION





SECT E-E SEE FIG NO. M-1



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Allens Creek Nuclear Generating Station
Unit 1

U.H.S. CAUSEWAY – STABILITY ANALYSES

FIGURE M-2A

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* All Figures whether labelled "Unit 1" or "Units 1 & 2" are to be considered applicable to Unit No. 1.

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from turbining of the driven end of the equipment due to blowdown of the system pressure upon rupture of the system pressure boundary.

The most substantial piece of rotating equipment is the recirculation pump and motor which, in the event of a major recirculation line break, and under certain system blowdown conditions, can theoretically reach overspeed beyond practical design limitations and result in ejection of various parts of the pump and motor. This hypothetical situation is currently the topic of discussions between GE and the NRC. The Applicant will implement the generic resolution of these discussions. 49

3.5.2.2 Turbine Missiles

3.5.2.2.1 Introduction

The potential for damage to safety related structures, systems and components due to turbine failure has been evaluated to determine whether additional protection, beyond that inherently provided by plant building orientation and existing structural shielding, need be provided to further reduce the probability of damage.

The probability of damage was calculated for the vital plant structures by evaluating the product of the probability of missile generation, the probability of impact on the structure and the probability of damage to the structures. 58

The evaluation of the individual probability components and a summary of the overall damage probability is discussed in the following sections.

testing techniques, are now better able to discover surface and internal defects. In addition, a thorough inspection program will be
used to inspect the critical bore and keyway regions to minimize the
possibility of stress corrosion cracking. An ultrasonic test has
been developed to detect stress corrosion cracks in these regions 58
well before cracks would grow to critical size necessary to cause
turbine wheel failure. Laboratory investigation has revealed some
of the basic relationships among structure strength, material
strength, FATT, and defect size and location, so that the reliability of the rotor as a structure has been significantly improved
during the past few years.

New starting and loading equipment and instructions reduce the severity of surface and bore thermal cycles incurred during service. The improvements include: better temperature sensors; better guidance for station operators in the control of speed, acceleration, and loading rates to minimize rotor stresses.

Progress in design, better materials and quality control, more rigorous acceptance criteria, and improved machine operation have substantially reduced the likelihood of burst failures of turbine-generator rotors operating near rated speed.

d) Turbine-Generator Overspeed Protection

The improvements of rotor quality discussed above reduce the chance of failures at operating speed, but they do tend to increase the hazard level associated with unlimited overspeed, because of the greater missile energy associated with higher bursting speed. Therefore, it is pertinent to examine the Turbine Overspeed Protection Systems. For condensing units, the devices to control the flow of steam into the turbine are discussed in the following paragraphs.

e) Main and Secondary Steam Inlets

Main and secondary steam inlets have valves in series. These valves are:

1) Control valves, or throttle valves, controlled by the speed governor and tripped closed by emergency governor and backup overspeed trip. 35(U)

2) Stop valves or trip valves, actuated by the emergency governor and backup overspeed trip. 35(U)

Emergency main stop valves of the steam sealed design have been used 17
on General Electric steam turbines of 10,000 KW and larger since
1948. More than 650 turbines have been shipped and placed in
service during this period, and there has been no report of the main 1
stop valve failing to close when required to protect the turbine.
Impending sticking is disclosed by the full closed test feature so
that a planned shutdown could be made to permit the necessary correction. Such correction almost always requires removal of the

oxide layer that builds up in the stem and bushing, which would not occur on a low temperature nuclear application.

Steam-driven auxiliary turbines, like the main units, include two complete lines of defense: control and stop valves, speed and emergency governors against destructive overspeed. 35(U) have less stored energy than corresponding parts of the low-pressure turbine. These turbines are totally enclosed in a shielded compartment on upper mezzanine floor of the Turbine Building. 35(U)

4) High-pressure turbine rotor

This rotor would not be expected to fail at runaway speed. 35(U)
But, even if failure did occur, the fragments should be retained by the heavy-section, bolted high-pressure shells.

5) Couplings

Couplings are designed to withstand overspeed higher than the maximum speed at runaway.

The following components could produce high energy missiles:

1) Low-pressure turbine wheels

The wheel capable of producing the most dangerous missile is the last stage. Using the analysis techniques described in Reference 3.5-3, it has been shown that a 120 degree fragment is the most dangerous in terms of a concrete slab that can be perforated after leaving the turbine casing.

2) Bucket vane

The last stage bucket is both the heaviest and most energetic of the vanes capable of escape from the turbine casing. Favorably oriented, i.e., head-on, the vane could conceivably penetrate approximately 10 inches of steel. Such orientation is unlikely, as the tip of the bucket would quickly strike the outer diaphragm ring tangentially. Interference with the other buckets could also be expected. In the ensuing tangle, the inner casing and hood structure would probably contain the blade.

At worst, the vane could ricochet and escape through the 1-1/4 inch-thick plate toward the end of the hood. It is judged that in any case no more than half of the initial energy is retained.

i) Turbine Missiles - Probability Analysis

The present analysis utilizes the historical turbine failure probability value of $4X10^{-5}$ per year per unit for destructive overspeed failures (see Reference 3.5-22). Analyses have indicated that for destructive overspeed failure, the initial energy imparted to postulated last stage turbine missiles is $41X10^{6}$ ft-lb_f. The missile energy outside the turbine casing is $20.5X10^{6}$ ft-lb_f and the turbine casing absorbs $20.5X10^{6}$ ft-lb_f (see Table 3.5-3). 58

Studies of design overspeed failure when applied to a turbine having 38" last stage buckets, indicate that the initial energy imparted to a postulated turbine missile is approximately $16X10^6$ ft-lb_f. This energy is not sufficient to penetrate the turbine casing. and consequently, all missiles associated with a design overspeed failure would be contained. Alternatively, if missile should perforate the turbine casiing, their residual energy would be so low that they could not damage any safety-related structure. 58

3.5.2.2.3 Probability of Impact with Safety Related Structures

Figure 3.5-1 shows the relative location of low pressure elements of the turbines and the plant structures. Missiles may be ejected at any angle of the 360 degrees about the turbine axis. The missile ejection angles and directions are illustrated in Figure 3.5-2. 35(U) 58

Tests have indicated (Reference 3.5-5) that deflection angles (θ_2) of turbine generated missiles will be close to zero (+ 5 degrees) for interior discs and 0 to 25 degrees for the last stage disc. A uniform probability distribution is assumed within this range of angles. To calculate the impact probability it was also assumed that a missile would be ejected with equal probability in the 360 degrees around the rotor axis (θ_1). 58

Table 3.5-3 shows the characteristics of a typical turbine missile from the last stage wheel. 58

a) High Trajectory Turbine Missile Probabilities

A convenient means for estimating the probability of strikes from high trajectory missiles lies in calculating the overall extent of the region which the missiles can reach. Because of the plant arrangement, the striking of all the vital plant structures with high trajectory missiles requires that these missiles be ejected at angles bounded by $85 < 0, < 90$. 58

Figure 3.5-3, which is based on information contained in References 3.5-5 and 3.5-16, is a map of the x-y ground plane locations into which the missile indicated in Table 3.5-3 would fall. The turbine wheel is shown at the intersection of the x and y-axis. 35(U) 58

θ_1 is the angle between the velocity vectors' projection onto the Y-Z plane (the plane of the turbine wheel) and the Y direction measured in the Y-Z plane.

θ_2 is the angle between the velocity vectors' projection onto the Y-X plane (the horizontal plane) and the Y direction measured in the Y-X plane. 1 03.7

Φ is the true angle between the velocity vector and the Y-X plane (the horizontal plane) measured in the plane normal to the horizontal plane in which the vector lies.

See Figures 3.5-1 through 3.5-4 for a graphical representation of these angles.

The maximum range achievable neglecting air resistance (air resistance changes range probability distribution but its impact is not significant) is with Φ equal to 45 degrees. 35(U) Locations were calculated by varying θ_1 from 0 to 90 degrees. 58 A mirror image plot 37(U) around the x-axis would result for values from 90 to 180 degrees. Values from 180 to 360 degrees would be meaningless, for these missiles are ejected below the ground. Calculations were made for values of θ_2 from 0 to 25 degrees which encompasses the maximum postulated turbine missile deflection angle.

The curves in the lower half of Figure 3.5-3 show landing zones for missiles released at values of θ_1 up to 45 degrees. The curves above the y-axis define landing zones for high trajectory missiles, for which θ_1 lies between 45 and 90 degrees. The two patterns are actually coincident in each of the four quadrants of the x-y plane. The dotted curves and arrowheads in the lower half of Fig- 1 ure 3.5-3 represent an overlay of the high trajectory curves on the 03.7 low trajectory solid curves. The dotted curves and arrowheads in the upper half represent an overlay of the low trajectory curves on the high trajectory solid curves.

The significance of this figure lies in the uniform distribution of the angles θ_1 and θ_2. Because of this, and because the lines are calculated at uniform subdivisions of those distributions, each landing zone defined by a pair of θ_1 lines and a pair of θ_2 lines has an equal probability of being struck. Further, locations outside of the region bounded by r = 6,900 feet and the appropriate 37(U) limiting value of θ_2 cannot be reached by the missile.

All of the vital plant structures lie within the region bounded by $85 < \theta_1 < 90$ and $0 < \theta_2 < 5$ degrees. Thus the probability of striking any particular plant structure is only related to the plane (horizontal) area of the structure, and is given by the ratio of that area to the area of the region which can be struck by the missile. The latter in turn is conservatively estimated to be the area of half the ellipse having a major axis equal to the maximum range of the missile ejected with $\theta_2 = 0$ degree and a minor axis 58 with θ_1, = 90 degrees and any specified θ_2. The probability of impact from high trajectory missiles on the safety related structures is given in Table 3.5-4 together with the aggregate total damage probability.

b) Low Trajectory Missiles

Due to the plant arrangement, orientation of the turbine generators, and the relative elevations of the turbine operating deck and the other structures, no safety related structure is exposed to impact damage by low trajectory missiles. As shown on Figure 3.5-1 only the Radwaste Building is located within the 25 degrees deflection limit.

35(U)

The Radwaste Building is located below the turbine operating deck level. In order to impact directly on the roof of this structure, it would be necessary to penetrate the operating floor at an impact angle of five to fourteen degrees from horizontal. The operating floor is composed of reinforced concrete three feet thick. (See Figure 1.2-22). At these angles of impact, the missile would not penetrate the operating floor. 35(U)

To impact the walls of the Radwaste Building adjacent to the Turbine Building, it would be necessary for the missile to penetrate the reinforced concrete turbine pedestal and several reinforced concrete internal walls at the mezzanine level. Therefore, the missile would not have sufficient energy to reach these walls. 35(U)

35(U)

Summary and Conclusion

The high trajectory turbine missiles are characterized by their nearly vertical trajectories. The total damage probability of a high trajectory turbine missile striking the safety related structures is less than 10^{-7} per unit year as listed in Table 3.5-4. In addition, the vulnerable safety related equipment area which is exposed to the potential turbine missile is redundant and physically well separated. Consequently the risk from high trajectory turbine missiles is insignificant.

The ACNGS turbine generator has been arranged in a peninsula orientation. With the exception of the Radwaste Building, this configuration excludes all major systems important to safety from the low trajectory turbine missile strike zones. The Radwaste Building does not contain any essential systems required for safe shutdown and is located below the turbine operating deck level. The location of the Radwaste System components relative to the turbine is such that they are adequately protected by the presence of the reinforced concrete pedestal, internal building walls and the turbine operating deck floor. Thus, the plant configuration complies with the guidelines of Regulatory Guide 1.115, "Protection Against Low Trajectory Turbine Missiles." 58

In addition to the above, due to the redundancy and testing features of the turbine overspeed protection, quality control manufacturing processes, materials, and inspection program, the hypothetical turbine missiles are considered very remote. Consequently the risk of potential turbine missile damage to safety related plant structures, systems, and components for the facility is acceptably low.

SECTION 3.5 REFERENCES (Cont'd)

3.5-15 DELETED 58

3.5-16 DELETED

3.5-17 DELETED

3.5-18 D. R. Miller and W. A. Williams, "Tornado Protection for the Spent Fuel Storage Pool" APED 5696 of General Electric, November, 1968.

3.5-19 W. F. Houghes and J. A. Brighton, "Theory and Problems of Fluid Dynamics," Schaum's Outline Series, Schaum Publishing Co., 1967. 21

3.5-20 M. A. Suarez, "Missile Generation by Fluid Propulsion," presented at ASCE, New York Metropolitan Chapter, March 26, 1974.

3.5-21 Electric Power Research Institute, "Full-Scale Tornado-Missile Impact Tests," NP-148, Interim Report, April, 1976. 35(D)

3.5-22 U. S. Nuclear Regulatory Commission Standard Review Plan Section 3.5.1.3. 58

TABLE 3.5-2 HAS BEEN INTENTIONALLY DELETED 58

TABLE 3.5-3

TURBINE MISSILE CHARACTERISTICS
(TYPICAL, FOR 38" WHEEL)

Fragment Angle, Deg.	120
Fragment Weight, Lb.	5944
Radius of CG, ft.	2.093
Polar Inertia, lb-ft-sec ^{2}	462
Min. Proj. Area, ft.^{2}	3.657
Max. Proj. Area, ft.^{2}	8.368
Failure Speed, Percent of 1800 RPM	169
Initial Velocity, ft/sec.	666.8
Energies, Million Ft-lb.	
Initial, Translation	41.0
Initial, Rotation	23.5
Outside Turbine Casing, Maximum Translation	20.5
After Air Drag, (Vertical Trajectory), Maximum	16.3

58

TABLE 3.5-4

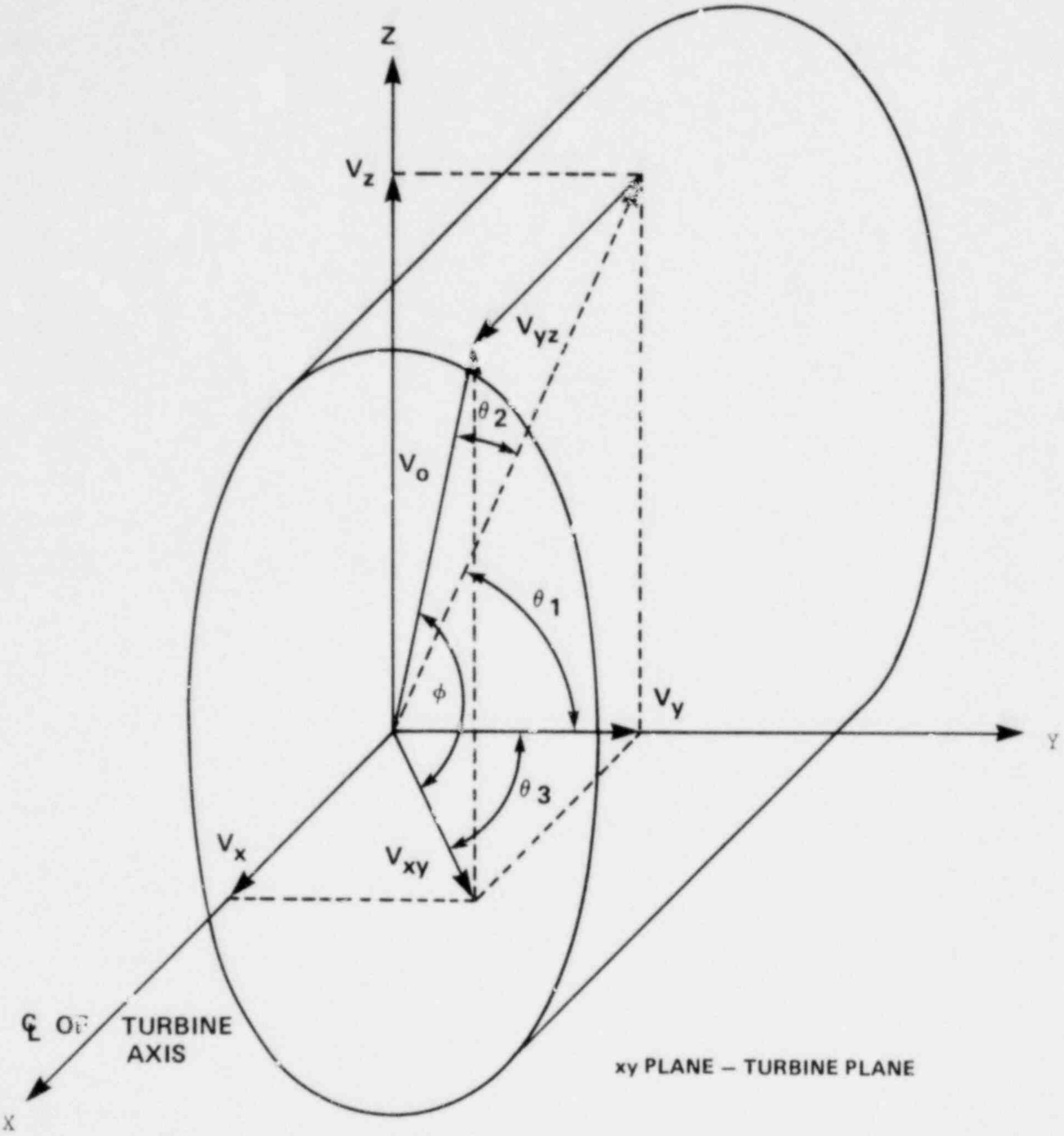
PROBABILITY OF A TURBINE MISSILE IMPACTING PLANT SAFETY RELATED STRUCTURES

Structure	High Trajectory Missile Impact Probability (1)	Total Damage (2) Probability (yr^{-1})
Reactor Building	2.5×10^{-4}	1.0×10^{-8}
Control Building	3.5×10^{-4}	1.4×10^{-8}
Fuel Handling Building	4.3×10^{-4}	1.7×10^{-8}
DG Building	1.7×10^{-4}	6.9×10^{-9}
Reactor Auxiliary Building	5.3×10^{-4}	2.1×10^{-8}
UHS Intake Structure	1.6×10^{-4}	6.4×10^{-9}
		7.5×10^{-8}

58

1. Based on missile deflection angle (θ_2) of $\pm$ 25 and air resistance is neglected.

2. Based on missile generation probability of 4.0×10^{-5} per unit per year.



V_o : INITIAL VELOCITY

θ_1 : ANGLE FROM y AXIS TO V_{yz}

θ_2 : ANGLE FROM yz PLANE TO V_o

θ_3 : ANGLE ON THE GROUND

ϕ : ANGLE FROM GROUND TO V_o

AM.NO. 58, (5/81)

HOUSTON LIGHTING & POWER COMPANY
Allens Creek Nuclear Generating Station
Unit 1

ILLUSTRATION OF VARIABLES USED IN THE TURBINE MISSILE ANALYSIS

FIGURE 3.5-2

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TABLE 6.2-14

COMPARISON OF SAFETY RELATED AIR FILTRATION SYSTEMS WITH REGULATORY POSITION OF REGULATORY GUIDE 1.52

Regulatory Position Item	Standby Gas Treatment System	ECCS Area Filtered Exhaust System	Control Room Emergency Filtration System
1a-e	All systems will comply with regulatory position.		System complies with regulatory positions except:
2a	System complies with regulatory position.	System complies with regulatory position	1) System does not include demisters. Within this system there is no source of entrained water droplets and therefore demisters are not required. 2) Electric heating coil is provided for humidity control.
2b	Physical separation will be provided between redundant components of all systems.		
2c	All systems will be designed as seimic Category I.		
2d	Not applicable. All systems are located outside Containment and therefore not subject to accident pressure surges.		
2e	All systems will comply with regulatory position and radiation levels given in Table 3.11-3.		
2f	All systems will comply with regulatory position. Flow rates are less than 30,000 cfm. HEPA filter arrangements will be limited to three high.		
2g	Pressure differential indicators will be provided locally for the demister, medium efficiency filter, pre-HEPA, after HEPA and across each ESF filtration train. Remotely located pressure differential indicators for the pre-HEPA and across each ESF filtration train will be provided in the Control Room. In addition, high limit alarm across the medium efficiency filter, pre-HEPA and across each ESF filtration train will be provided in the Control Room.		

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TABLE 6.2-14 (Cont'd)

<table>
<tr><th>Regulatory Position Item</th><th>Standby Gas Treatment System</th><th>ECCS Area Filtered Exhaust System</th><th>Control Room Emergency Filtration System</th></tr>
<tr><td></td><td colspan="3">Each ESF filtration train will be provided with a low flow indicator and low flow alarm in the Control Room.</td></tr>
<tr><td></td><td colspan="3">Temperature indicators will be provided locally at the inlet of the electric heating coil and the charcoal adsorber. These temperatures will be indicated in the Control Room. High charcoal adsorber bed temperature will be indicated and alarmed in the Control Room.</td></tr>
<tr><td>2h</td><td colspan="3">Systems will comply with applicable IEEE standards (see Section 7.1).</td></tr>
<tr><td>2i</td><td colspan="3">Systems will be automatically activated upon the occurrence of a DBA by a redundant ESF signal.</td></tr>
<tr><td>2j-1</td><td colspan="3">All systems will comply with regulatory position.</td></tr>
<tr><td>3a-j</td><td colspan="3">All systems will comply with regulatory positions.</td></tr>
<tr><td>3k</td><td colspan="3">System design includes provisions for preventing adsorber fires by ensuring continued cooling of adsorbers by air flow even in the event of a single failure. This is accomplished by providing cross connections between redundant fans and filter trains. In addition, system design includes provisions to apply water to the adsorber section, from the plant Fire Protection System, in the event of a fire in the adsorber beds.</td></tr>
<tr><td>3l-p</td><td colspan="3">All systems will comply with regulatory position.</td></tr>
<tr><td>4a-e</td><td colspan="3">All systems will comply with regulatory position.</td></tr>
<tr><td>5a-d</td><td colspan="3">All systems will comply with regulatory positions.</td></tr>
<tr><td>6a-b</td><td colspan="3">All systems will comply with regulatory positions.</td></tr>
</table>

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FIGURES 6.2-27a & 6.2-27b HAVE BEEN
INTENTIONALLY DELETED 58

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The submerged evaporative pond is located to the south of the plant area with a diversion dike perpendicular to the 4,800 acre cooling lake shore. The submerged pond serves as the UHS. The normal source of essential services cooling water is the 4,800 acre cooling lake since water will be supplied from this heat sink whenever it is available. When using the 4,800 acre lake as the heat sink for essential services cooling the essential services, cooling water will be discharged from a seismic Category I structure located at the lake edge south of the UHS. The 50 acre submerged pond will perform its function as the Ultimate Heat Sink in the unlikely event of a loss of water from the 4,800 acre cooling lake. Switchover from the normal ESCWS mode of operation to the UHS mode of operation will be manual. 37(U)

A minimum level of 8 ft will be maintained in the 4,800 acre cooling lake at all times by creek inflows and by pumping from the Brazos River. In the event of a total loss of cooling water in the lake, the submerged pond will be more than adequate to permit emergency shutdown and cooldown for 4 months or in the event of an accident, to permit control of the accident for 4 months.

The intake is situated approximately 500 feet from the lake shore. The intake canal starts at the UHS bottom elevation 92 feet sloping downward continuously to the foot of the sill on UHS intake structure at elevation 86 feet. This corresponds to a 6 foot drop over a 139 foot horizontal run (approximately a 1:23 slope). The one foot sill will be provided as a barrier to limit the amount of silt which might enter UHS intake structure. 58

37(U)

A causeway will provide access from the plant area to the intake structure. The crest of the UHS Causeway is established at EL 145.5 ft. The Causeway is designed for the Brazos River Probable Maximum Flood (PMF) at EL 135.4 ft, coupled with a wind set up of 0.7 ft and a wave run up of 8.2 ft generated by a 52 MPH Wind Velocity overwater (see PSAR Section 2.4 Appendix D, Table D4) This design flood consideration conservatively yields a design flood elevation of EL 144.3 ft, which will provide an adequate safe margin for the UHS Causeway.

The Causeway slopes are protected against wave action by the placement of two (2) foot thick layers of soil-cement, measured perpendicular to the slope. The causeway slope stability analysis is described in Section 2.5 Appendix M Subsection M8. The design and placement of soil-cement will be in accordance with the ACNGS specifications, and subject to a strict construction quality control program. 58

9.2.5.3 Safety Evaluation

9.2.5.3.1 Consumptive Use

9.2.5.3.1.1 Methodology

In order to select an UHS design and to evaluate its expected performance, the following process has been used: 26

I. Selection of Design Basis Accident (Section 9.2.5.3.1.2)

II. Selection of Design Meteorological Conditions (Section 9.2.5.3.1.3)

a. Maximum water temperature conditions 26
b. Maximum evaporation rate conditions

III. Simulation of the Design Basis Accident (Section 9.2.5.3.1.4) 37(C)

a. Determination of the maximum Essential Services Cooling Water System (ESCWS) intake temperature.

b. Determination of the adequacy of a submerged 50 acre pond to provide four months supply of ESCWS water. 37(D)

9.2.5.3.1.2 Selection of Design Basis Accident

The Ultimate Heat Sink was evaluated for the following events: 26

1. Safe shutdown

2. LOCA 37(U)

These events were assumed to occur coincidently with the loss of the cooling lake.

A comparison of these alternatives is presented in the following:

Table 9.2-5 indicates that the maximum instantaneous heat rejected to the Essential Services Cooling Water System for safe shutdown conditions without Fuel Pool Cooling is 286 x 10^6 Btu/hr. After 24 hours of cooldown operation, the total heat rejection would be reduced from 286 x 10^6 Btu/hr to approximately 100 x 10^6 Btu/hr. 37(D)

Figure 9.2-11 presents the instantaneous heat rejection rate to the ESCWS as a function of time for safe shutdown. 37(U)

Table 9.2-6 indicates that the maximum instantaneous heat rejected to the Essential Services Cooling Water System during and following a Design Basis LOCA is 230 x 10^6 Btu/hr without Fuel Pool Cooling. 37(D)

Under emergency shutdown conditions with the 4,800 acre lake available, the 37(D)
essential services cooling water discharge will be at the seismic Category I discharge structure located to the south of the UHS.

Access to the UHS Intake Structure is via a manmade earth causeway extending 37(D)
from the main plant area and abutting the UHS Intake Structure. The causeway will be designed to be stable following a Safe Shutdown Earthquake or any other severe natural phenomena. 58

Buried piping and conduit leading from the UHS Intake Structure, the UHS discharge structure and the ESCWS discharge structure will be designed to withstand the effects of the SSE and, in addition, will be designed to 37(C)
withstand a differential ground settlement of 3 inches per 1000 feet.

An investigation was conducted to evaluate the potential sediment build up in the Ultimate Heat Sink. This supposition being that if an unusually large sediment deposit is postulated and is allowed to go uncorrected that it might adversely affect the cooling capacity of the UHS for plant shutdown.

The principal sources of sediment deposits are identified as Allens Creek and the makeup water for the Cooling Lake derived from Brazos River after prior passage through a 190 acre sedimentation basin. In order for sediment to enter the Essential Service Cooling Water System pumps it must passover the one foot sill and then pass through trash bars and traveling water screens. The UHSIS has a flat floor at elevation 86 feet and the pumps are set back approximately 60 feet from the sill. The pump suction bells are 53 inches off the floor. This arrangement eliminates the possibility of degrading the pumps by the provision of sufficient clearance around pump suction areas.

Based upon the sediment deposit analysis and conservative engineering judgement, the sediments would most likely uniformly distribute over the entire cooling lake including the UHS. For such a uniform distribution, the study indicates that the total accumulated sediments in the UHS will most likely be less than one-half inch for 40 years of plant life. This is well 58
within the 1 foot maximum deposition considered in the plant design.

A 1 foot sediment deposit will have no significant effect on the total inventory of required cooling water for an emergency cool down for 4 months, in the event of a total loss of the Cooling Lake. Since the total consumptive use for an emergency cooldown, including seepage and evaporation, will be in the order of 4 feet of a total of 8 feet water depth from a net storage of 404 acre-ft UHS.

Consideration was given to any slumping effect from the sediment deposit along the Heat Sink slopes. It has been recognized by the U.S. Army Corps of Engineers that for a slope having a 1 vertical to 20 horizontal or flatter, sediment will remain stable and no slumping or sliding effect will take place. Per PSAR Section 9.2.5.2 the intake canal will have 1:23 slope. As a

(C)-Consistency
(D)-Design

preventive measure, provisions will be made to flatten the upper 1 foot of the UHS side slopes and the UHS intake forebay canal bottom floor to 1 vertical and 20 horizontal or flatter.

In addition, in order to safeguard all the above, a monitoring program will be designed and implemented to check on any potential sediment accumulation in the UHS. The sediment monitoring program will be comprised of:

(1) Establishing monument plates on the UHS floor. These plates will be located to provide representative indication of sediment deposition on flat and sloping surfaces in the Ultimate Heat Sink.

(2) Probing will be conducted once per quarter for the first year of plant operation, and at least annually thereafter or until the monitoring program results indicate probing at a lesser frequency would not cause a safety hazard. 58

(3) Probing operation will be performed in conjunction with the actual visual observation.

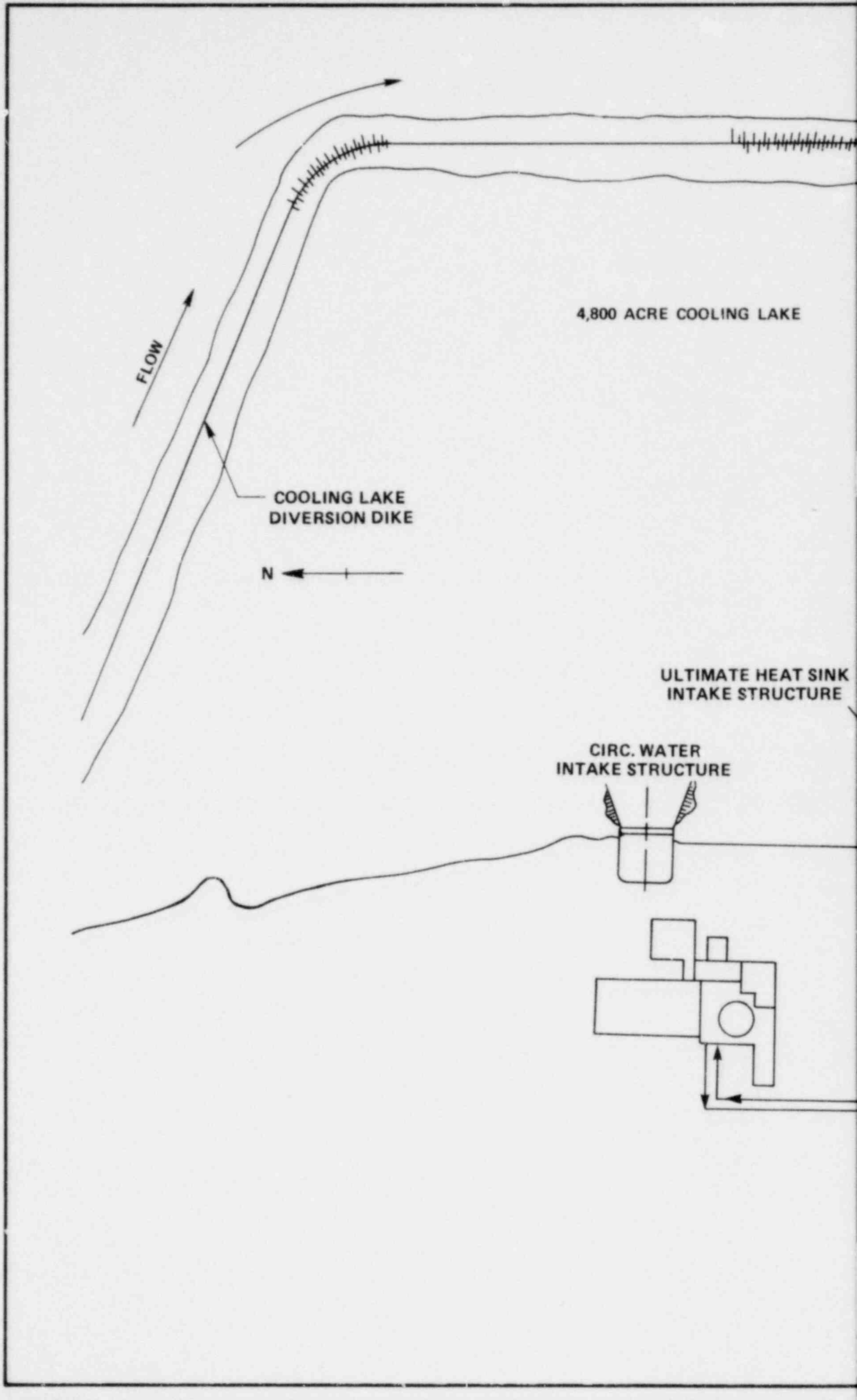
(4) Sediment removal frequency will be determined as required according to the actual monitoring results during plant operation. However, the upper bound of the allowable limit of sediment build up will not exceed 1 foot on the bottom floor within the confinement of the Ultimate Heat Sink in the vicinity of the embankment and 6 inches in the intake canal proper.

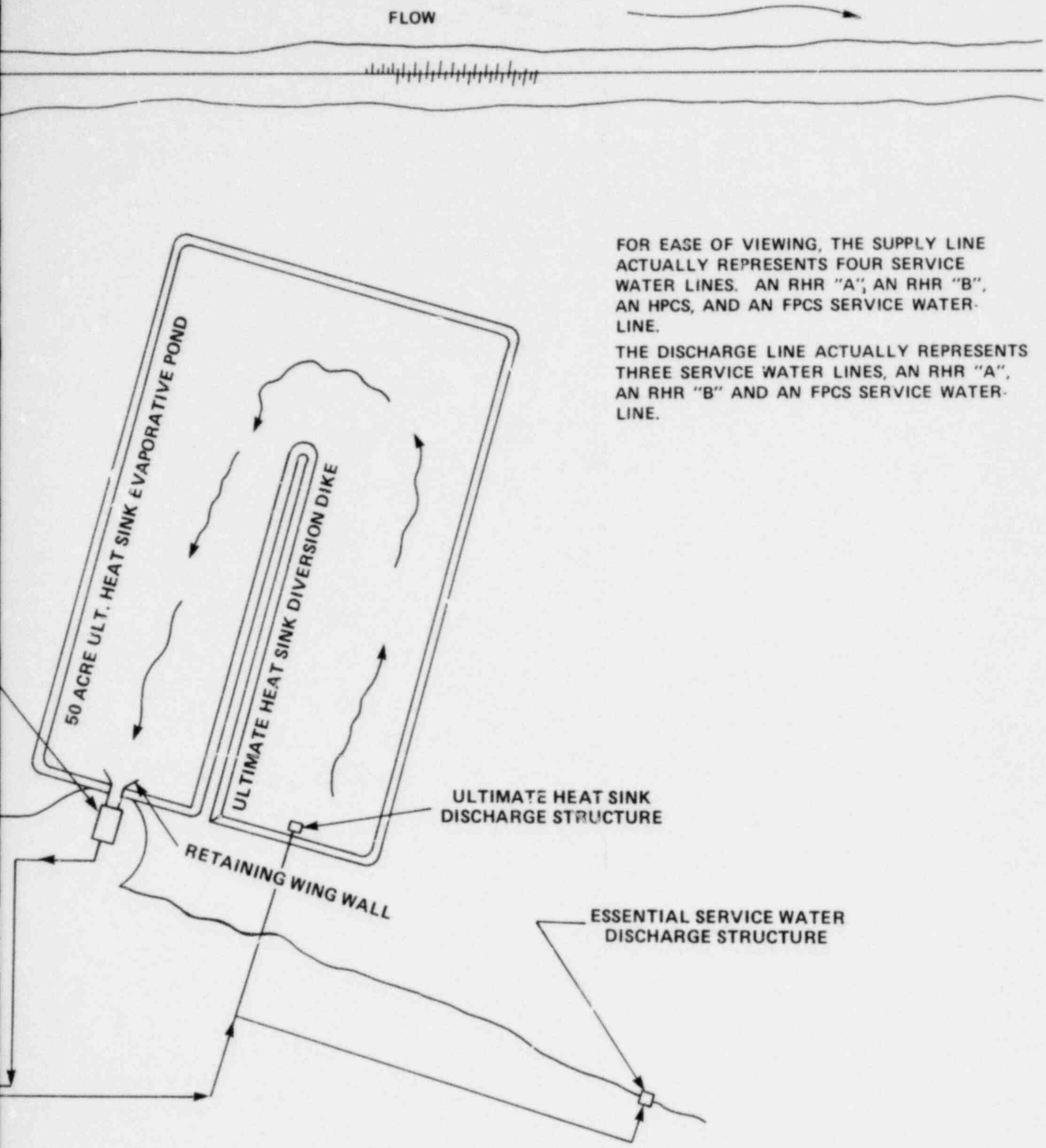
In conclusion, based upon the sediment analysis results, the conservative considerations for the design and the sediment monitoring program, sediment deposition will not contribute any adverse effect on the functional capability of the Ultimate Heat Sink.

9.2.5.3.3 Capability to Withstand a Single Failure

The UHS is designed to withstand the single failure of a manmade earthen structure or a single failure of any UHS active component.

In the event of failure of the cooling lake dam and complete loss of lake water, essential services cooling water will be drawn from the submerged pond. 37(D)


FLOW
4,800 ACRE COOLING LAKE
COOLING LAKE DIVERSION DIKE
N
ULTIMATE HEAT SINK INTAKE STRUCTURE
CIRC. WATER INTAKE STRUCTURE



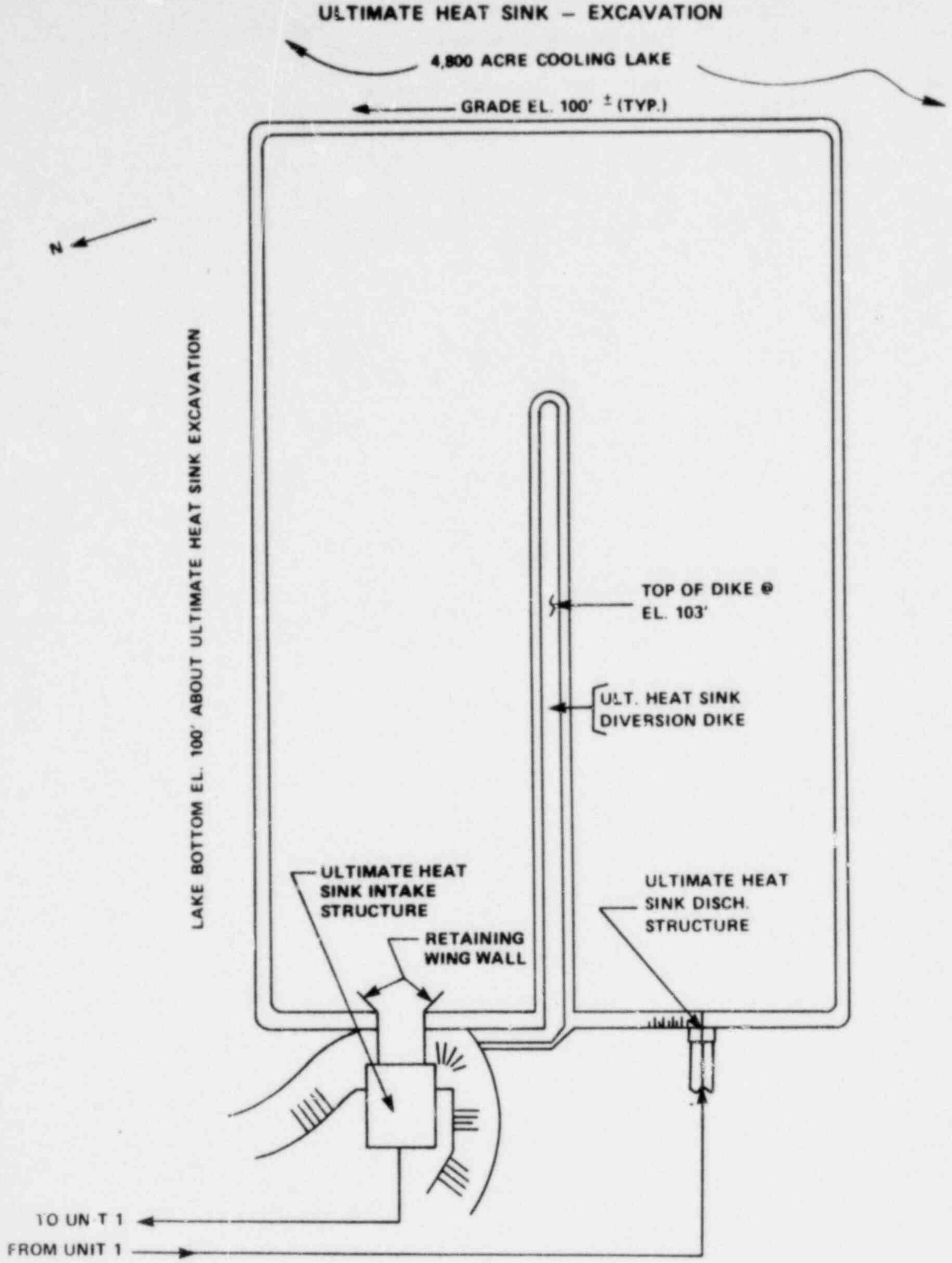
FOR EASE OF VIEWING, THE SUPPLY LINE ACTUALLY REPRESENTS FOUR SERVICE WATER LINES. AN RHR "A", AN RHR "B", AN HPCS, AND AN FPCS SERVICE WATER LINE.

THE DISCHARGE LINE ACTUALLY REPRESENTS THREE SERVICE WATER LINES, AN RHR "A", AN RHR "B" AND AN FPCS SERVICE WATER LINE.

AM. NO. 58, (5/81)

HOUSTON LIGHTING & POWER COMPANY
Allens Creek Nuclear Generating Station
Unit 1

ULTIMATE HEAT SINK SCHEMATIC
(SHEET 1)
FIGURE 9.2–13



AM. NO. 58, (5/81)

HOUSTON LIGHTING & POWER COMPANY
Allens Creek Nuclear Generating Station
Unit 1

ULTIMATE HEAT SINK SCHEMATIC
(SHEET 2)

FIGURE 9.2-14

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DESIGN, TESTING AND MAINTENANCE CRITERIA FOR ENGINEERED-SAFETY-FEATURE ATMOSPHERE CLEANUP SYSTEM AIR FILTRATION AND ADSORPTION UNITS OF LIGHT-WATER-COOLED NUCLEAR POWER PLANTS 35(D)

Applicant's Position:

A comparison of safety related air filtration systems with the requirements of this Regulatory Guide is given in Table 6.2-14 of the PSAR.