ENERCON	CALCULATION COVER SHEET	CALC. NO. TXUT-001-FSAR-2.4.3-CALC-013
		REV. 3
		PAGE NO. 1 of 23

Title:	Coincident Wind Wave Analysis for Comanche Peak Nuclear Power Plant Units 3 and 4.	Client: Luminant Project: MITS116 – Luminant COLA

Item	Cover Sheet Items	Yes	No
1	Does this calculation contain any open assumptions that require confirmation? (If **YES**, identify the assumptions)________		X
2	Does this calculation serve as an "Alternate Calculation"? (If **YES**, identify the design verified calculation.) **Design Verified Calculation No.**________		X
3	Does this calculation supersede an existing calculation? (If **YES**, identify the superseded calculation.) **Superseded Calculation No.**________		X

Scope of Revision: The calculation was updated to utilize the revised PMF elevation from TXUT-001-FSAR 2.4.3-CALC-012 for the coincident wind wave analysis. The calculation was updated to utilize the 2007 Texas Water Development Board volumetric survey for Squaw Creek Reservoir. The calculation was also revised to include a discussion for the datum shift of NAVD 88 – NGVD 29 and some minor editorial changes of a non technical nature.

Revision Impact on Results: The maximum water surface elevation of the PMF coincident with wind wave activity due to revision 3 increased by 2.77 ft. to 810.64 ft. (NAVD 88).

Study Calculation	☐	**Final Calculation**	☒
Safety-Related	☒	**Non-safety-Related**	☐

(Print Name and Sign)

Originator: Suraj Balan		**Date:** 6/11/10
Design Verifier: Dr. Randall Kolar **Dr. Kendra Dresback**	Randall Kolar Kendra Dresback	**Date:** 6/11/10
Approver: **Joe Mancinelli**	J. Mancinelli	**Date:** 6/24/10

ENERCON	CALCULATION REVISION STATUS SHEET	CALC. NO. TXUT-001-FSAR-2.4.3-CALC-013 REV. 3 PAGE NO. 2 of 23

CALCULATION REVISION STATUS

REVISION	DATE	DESCRIPTION
0	June 27, 2008	Original Calculation
1	August 14, 2009	Revision accounts for increased water surface elevation due to the revisions to the coefficient of peaking (Cp) and lag coefficient (Ct) for the Snyder's unit hydrograph. To be consistent with the Coastal Engineering Manual, the surf similarity parameter was revised to utilize the significant wave height instead of the maximum wave height.
2	November 20, 2009	Page revision status was updated to indicate the corresponding revision number.
3		Updated to utilize the revised PMF elevation from TXUT-001-FSAR 2.4.3-CALC-012 and Texas Water Development Board, 2007 volumetric survey for Squaw Creek Reservoir for the analysis and included a discussion for the datum shift of NAVD 88 – NGVD 29.

PAGE REVISION STATUS

PAGE NO.	REVISION	PAGE NO.	REVISION
ALL	3		

APPENDIX REVISION STATUS

APPENDIX NO.	PAGE NO.	REVISION NO.	APPENDIX NO.	PAGE NO.	REVISION NO.
N/A					

ENERCON	CALCULATION DESIGN VERIFICATION PLAN AND SUMMARY SHEET	CALC. NO. TXUT-001-FSAR-2.4.3-CALC-013 REV. 3 PAGE NO. 3 of 23

Calculation Design Verification Plan:

Apply CSP Number 3.01 Revision 6, Section 4.5a Design Review Methods and to include at a minimum:

1. Review the changes due to Revision 3 and determine if calculation provides a reasonable estimate of the coincident wind wave activity and the resulting water surface elevation.
2. Review design methodology and determine if it is appropriate, correctly applied, and accurate.

(Print Name and Sign for Approval – mark "N/A" if not required)

Approver:	Date:
Joe Mancinelli JPMancinelli	6/24/10

Calculation Design Verification Summary:

After reviewing the Comanche Peak Coincident Wind Wave calculation, Revision 3, we have come to the following conclusions:

1. Revision 3 addresses changes from the Comanche Peak PMF calculation; additional volumetric survey information for Squaw Creek Reservoir watershed from the Texas Water Development Board and datum conversion;
2. The methodology used on this set of calculations is appropriate and has been applied correctly;
3. The calculation provides a reasonable estimate of the coincident wind wave activity for Comanche Peak plant and was done in accordance with USACE coastal engineering reports;
4. The Originator has considered all recommendations given during the review process and has made appropriate revisions;
5. The calculations were independently checked and any errors that were discovered have been corrected in the final version of the calculation sheets;
6. The Revision 3 calculation methodology, assumptions and inputs applied are reasonable and are in accordance with CSP Number 3.01 Revision 6.

Based on the above summary, the calculation is determined to be acceptable.

(Print Name and Sign)

Design Verifier: Dr. Randall Kolar Randall Kolar **Dr. Kendra Dresback** Kendra Dresback	**Date:** 6/11/10
Others:	**Date:**

Item	Cover Sheet Items	Yes	No	N/A
1	Design Inputs - Were the design inputs correctly selected, referenced (latest revision), consistent with the design basis and incorporated in the calculation?	X		
2	Assumptions – Were the assumptions reasonable and adequately described, justified and/or verified, and documented?	X		
3	Quality Assurance – Were the appropriate QA classification and requirements assigned to the calculation?	X		
4	Codes, Standard and Regulatory Requirements – Were the applicable codes, standards and regulatory requirements, including issue and addenda, properly identified and their requirements satisfied?	X		
5	Construction and Operating Experience – Have applicable construction and operating experience been considered?			X
6	Interfaces – Have the design interface requirements been satisfied, including interactions with other calculations?	X		
7	Methods – Was the calculation methodology appropriate and properly applied to satisfy the calculation objective?	X		
8	Design Outputs – Was the conclusion of the calculation clearly stated, did it correspond directly with the objectives and are the results reasonable compared to the inputs?	X		
9	Radiation Exposure – Has the calculation properly considered radiation exposure to the public and plant personnel?			X
10	Acceptance Criteria – Are the acceptance criteria incorporated in the calculation sufficient to allow verification that the design requirements have been satisfactorily accomplished?	X		
11	Computer Software – Is a computer program or software used, and if so, are the requirements of CSP 3.02 met?	X		

COMMENTS:

(Print Name and Sign)	
Design Verifier: Dr. Randall Kolar Randall Kolar **Dr. Kendra Dresback** Kendra Dresback	**Date:** 6/11/10
Others:	**Date:**

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1.0 Purpose and Scope

Determine coincident wind wave activity to be added to the water surface elevation of the probable maximum flood (PMF) for Comanche Peak Nuclear Power Plant (CPNPP) Units 3 and 4.

Calculation is to support the CPNPP Units 3 and 4 Final Safety Analysis Report Section 2.4.3 addressing the requirements of the Nuclear Regulatory Commission Regulatory Guide 1.206 (Reference 9) and NUREG-0800 (Reference 7).

2.0 Summary of Results and Conclusions

An adjusted wind speed of 49.91 mph for an optimal duration of 53 min. over the 2.7 mi. fetch will create 4.59 ft. maximum waves (crest to trough) and 2.76 ft. significant waves with a period of 2.6 sec. The maximum water surface elevation of the PMF coincident with wind wave activity is determined by adding the wind setup and wind wave runup, which includes wave setup, to the PMF water surface elevation (PMF elevation + wind setup + runup). The wind setup is determined to be 0.08 ft.

- For the sloped areas adjacent to the site with 10:1 (horizontal: vertical) slopes, the maximum water surface elevation of the PMF coincident with wind wave activity will be 795.93 ft. (793 ft. + 0.08 ft. + 2.85 ft.).
- For the sloped areas adjacent to the site with 3:1 (horizontal: vertical) slopes, the maximum water surface elevation of the PMF coincident with wind wave activity will be 800.07 ft. (793 ft. + 0.08 ft. + 6.99 ft.).
- The water surface elevation at the vertical retaining wall will reach 809.98 ft. (793 ft. + 0.08 ft. + 16.9 ft.).

The plant grade for safety related structures at CPNPP Units 3 and 4 is 822 ft (NAVD 88) and the highest water surface elevation of the PMF coincident with wind wave activity, as summarized above, is 809.98 ft (NGVD 29). The PMF water surface elevation of the Squaw Creek dam is increased by 0.66 ft (+20 cm) to account for datum differences. Hence the highest water surface elevation of the PMF coincident with wind wave activity is 810.64 ft (NAVD 88), allowing over 11 ft of freeboard under worst case conditions.

3.0 References

1. American Nuclear Society, "Determining Design Basis Flooding at Power Reactor Sites," ANSI/ANS-2.8-1992, July 28, 1992.
2. Autodesk, AutoCAD Civil 3D 2009, software.
3. Enercon Calculation TXUT-001-FSAR-2.4.3-CALC-012, "Probable Maximum Flood Calculation for Comanche Peak Nuclear Power Plant Units 3 and 4. Rev. 2."
4. Luminant / Comanche Units 3 & 4 MNES US APWR, Grading and Drainage Plan, Drawing Number CVL-12-11-101-001- Rev. G, by Washington Group of URS, February 9, 2010.
5. Luminant/Comanche Peak Units 3 & 4 MNES US APWR, Site Plan, Drawing - GAS-05-11-100-002 Rev. D, by Washington Group International, July 10, 2008.

6. National Geodetic Survey, Website, http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html, accessed May 2010.

7. NRC, NUREG-0800, “Standard Review Plan, 2.4.3 Probable Maximum Flood (PMF) on Streams and Rivers,” Revision 4, March, 2007.

8. NRC, Regulatory Guide 1.59, “Design Basis Floods for Nuclear Power Plants,” Revision 2, August, 1977.

9. NRC, Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition),” Regulatory Guide 1.206, June 2007.

10. Texas Water Development Board, Volumetric and Sedimentation Survey of Squaw Creek Reservoir, December 2007.

11. U.S. Army Corps of Engineers, “Coastal Engineering Manual,” EM 1110-2-1100, April 30, 2002 (Change 2: June 1, 2006).

12. U.S. Army Corps of Engineers, “Hydrologic Engineering Requirements for Reservoirs,” EM 1110-2-1420, October 31, 1997.

13. U.S. Department of the Interior, Bureau of Reclamation, Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams, ACER Technical Memorandum No. 2, December 1981.

14. U.S. Geological Survey, Quadrangles, Website, http://www.topozone.com, data extracted February, 2008.

15. U.S. Geological Survey, Quadrangles, Website, http://www.usgs.gov, data extracted February, 2008.

16. U.S. Nuclear Regulatory Commission, “Flood Protection for Nuclear Power Plants,” Regulatory Guide 1.102, September 1976.

17. U.S. Nuclear Regulatory Commission, “Early Site Permits; Standard design Certifications; and Combined Licenses for Nuclear Power Plants,” 10 CFR Part 52, August 2007.

18. U.S. Nuclear Regulatory Commission, “Industry Guidelines for Combined License Applicants under 10 CFR Part 52,” NEI 04-05, October 2005.

19. U.S. Nuclear Regulatory Commission, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants,” Regulatory Guide 1.70, November 1978.

4.0 Assumptions

Equations utilized from the U.S. Army Corps of Engineers (USACE) Coastal Engineering Manual (CEM) (Reference 11) assume linear wave theory.

The predominant wind direction was not considered in determining the fetch length. It is assumed that the strongest wind is perfectly aligned with the longest fetch for the worst case condition.

The retaining wall area on the northeast side is assumed to extend vertically to determine the worst case runup; this would be conservative because the runup considering the slope would be less.

5.0 Design Inputs

The probable maximum flood elevation for Squaw Creek Reservoir (SCR) is 793 feet (NGVD 29) (Reference 3).

U.S. Geological Survey topography from USGS 7.5 minute quadrangles (Reference 15) was used in generating Figures 7-1 and 7-3:

Hill City, Texas
Nemo, Texas

The CPNPP Units 3 and 4 location, as shown in Figure 5-1, is approximated using USGS Hill City, Texas quadrangle NAD83 (Reference 15):

32°18'10" N
97°47'30" W

The CPNPP Units 3 and 4 Site Plan (Reference 5) was used to determine the site grade elevation of 822 ft.(NAVD 88) and the approach slopes at the site. The approach slopes vary from about 3:1 to 10:1 (horizontal: vertical), up to a minimum elevation of 810 ft. Above 810 ft., the site consists of large flat areas and steeper 2:1 (horizontal: vertical) slopes up to site grade elevation. Additionally, one area contains a nearly 200 ft. long vertical retaining wall with a bottom elevation of 780 ft. and a top elevation of 795 ft. Above the wall, the site is graded at 2:1 (horizontal: vertical).

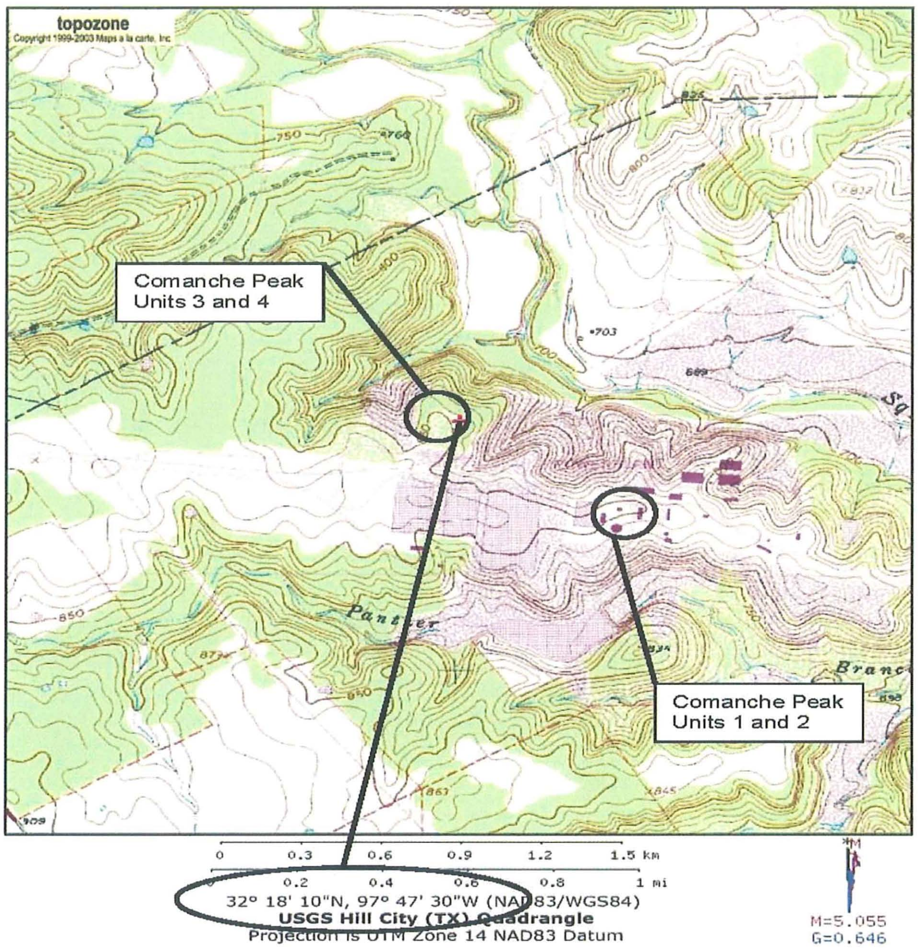

Figure 5-1, CPNPP Units 3 and 4 Site Location (Note Squaw Creek Reservoir not shown on USGS 7.5 minute quadrangles)

6.0 Methodology

Reference to and compliance with the following listed design guides were considered in evaluating the coincident wind wave activity. All other procedures, instructions and design guides listed in Section 5.4 of Project Planning Document (PPD No. TXUT-001, Rev. 3) are not applicable specifically in evaluating the coincident wind wave activity.

- American Nuclear Society, "Determining Design Basis Flooding at Power Reactor Sites," ANSI/ANS-2.8-1992, July 28, 1992, (Reference 1).
- U.S. Nuclear Regulatory Commission, "Combined License Applications for Nuclear Power Plants (LWR Edition)," Regulatory Guide 1.206, June 2007, (Reference 9).

- U.S. Nuclear Regulatory Commission, "Standard Review Plan," NUREG-0800, March 2007, (Reference 7).
- U.S. Nuclear Regulatory Commission, "Design Basis Floods for Nuclear Power Plants, Appendix B, Alternative Methods of Estimating Probable Maximum Floods," Regulatory Guide 1.59, August 1977, (Reference 8).
- U.S. Nuclear Regulatory Commission, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Regulatory Guide 1.70, November 1978, (Reference 19).
- U.S. Nuclear Regulatory Commission, "Flood Protection for Nuclear Power Plants," Regulatory Guide 1.102, September 1976, (Reference 16).
- U.S. Nuclear Regulatory Commission, "Early Site Permits; Standard design Certifications; and Combined Licenses for Nuclear Power Plants," 10 CFR Part 52, August 2007, (Reference 17).
- NEI 04-01 - U.S. Nuclear Regulatory Commission, "Industry Guidelines for Combined License Applicants under 10 CFR Part 52," (Reference 18).

Wind speed was determined using the ANSI/ANS-2.8-1992 (Reference 1) standard. Wind speed was then adjusted according to the USACE CEM (Reference 11). The Nuclear Regulatory Commission (NRC) Regulatory Guide 1.59 (Reference 8) refers to guidance in ANSI N170 1976 for calculating wind wave activity. However, ANSI/ANS-2.8-1992 has superseded ANSI N170 1976. ANSI/ANS-2.8-1992 has since been withdrawn, but remains a historical technical reference according to NRC NUREG-0800 SRP 2.4.3 (Reference 7).

USGS digital quadrangles for Figures 7-1 and 7-3 were extracted from the USGS website (Reference 15). USGS digital quadrangles for Figure 5-1 were extracted from Topozone website (Reference 14). The USGS topography was imported into AutoCAD drafting software (Reference 2) and the topographic image was scaled to 1 foot on USGS Topo = 1 foot in AutoCAD drawing space. Fetch length distances were then determined using standard AutoCAD functions.

Calculations for wind wave generation, setup, and runup follow guidelines provided in the USACE CEM. The ANSI/ANS-2.8-1992 standard refers to the use of the USACE Shore Protection Manual (SPM). However, the CEM has superseded the SPM that has traditionally been used to determine wind wave generation, setup, and runup.

Maximum wave height is determined in accordance with the ANSI/ANS-2.8-1992 standard as referenced by the NRC Regulatory Guide 1.59 and was calculated in accordance with the USACE CEM.

Wind setup is determined in accordance with USACE EM 1110-2-1420 (Reference 12).

USGS quadrangles and other locations and elevations discussed herein are relative to the Texas State Plane coordinate system, North American Datum of 1927 (NAD 27), and National Geodetic Vertical Datum of 1929 (NGVD 29) unless noted otherwise. The plant site grading plan is based on the Texas State Plane coordinate system, North American Datum of 1983 (NAD 83), and North American Vertical Datum of 1988 (NAVD 88).

According to the National Geodetic Survey (Reference 6), and as shown in Figure 6-1, the datum shift of NAVD 88 – NGVD 29 is between 0 and +20 cm for the CPNPP Site. Therefore, it is conservative to account for the maximum conversion when comparing water surface elevations determined from USGS quadrangles (NGVD 29) to elevations at the site (NAVD 88). The PMF water surface elevation of the Squaw Creek dam is increased by 0.66 ft (+20 cm) to account for datum differences.

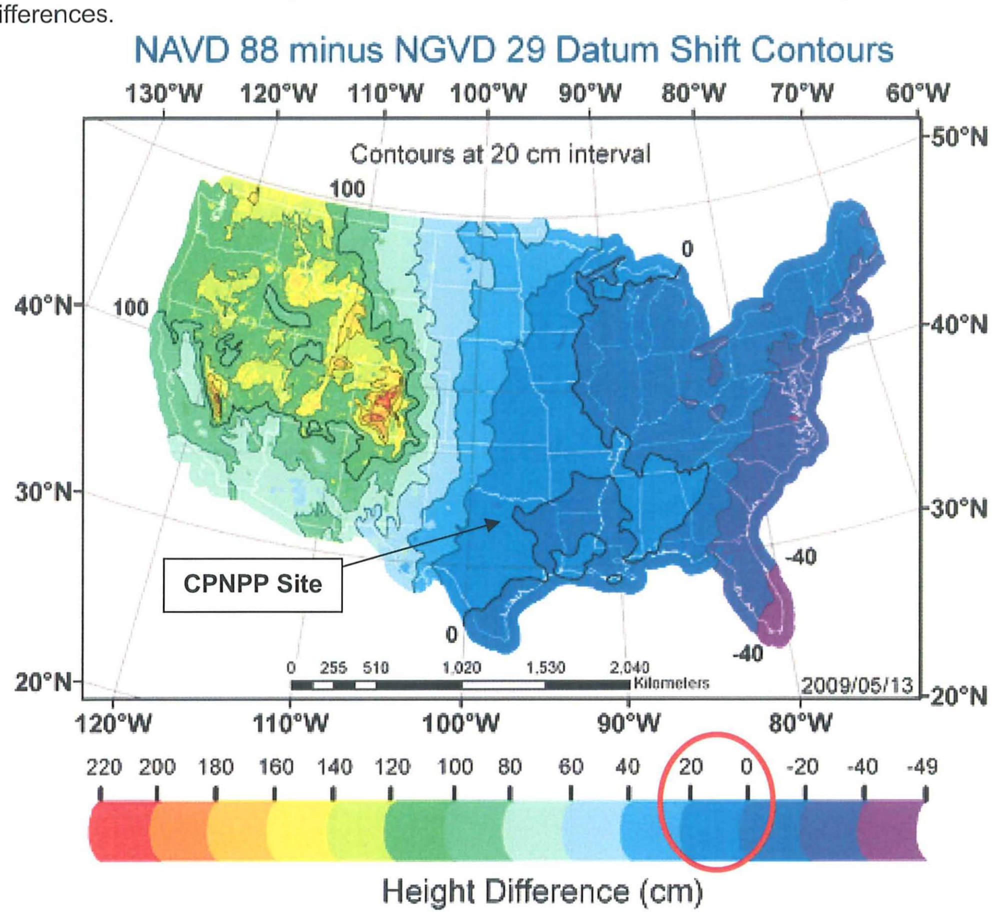

Figure 6-1. NAVD 88 Minus NGVD 29 Datum Shift Contour

AutoCAD Civil 3D 2009 software has been verified and validated in accordance with CSP 3.02, Revision 5. The verification and validation documents are maintained by Enercon as part of the Quality Assurance program.

7.0 Calculations

The results from any intermediate calculations are rounded for subsequent computations. The USACE CEM is formatted for metric units. Input data is available in English units. In general, input data is converted to metric units, and the calculations are performed using metric units. The results are then converted back to English units.

Conversions Used:
1 foot = 0.3048 meter
1 mph = 0.44704 m/s

Abbreviations and definitions of symbols are identified at the conclusion of the calculation.

Fetch Length

According to the USACE CEM (Reference 11, pg. II-2-45), a straight line fetch is recommended to define fetch length. Figure 7-1 identifies the Squaw Creek Reservoir using USGS topographic quadrangles. Based on the PMF water surface elevation of 793 ft. (NGVD 29), and to represent a conservative approach, the 795 ft. contour from the grading plan in AutoCAD format (Reference 4) was used as the reference contour for the maximum water surface elevation. The 795 ft contour on the opposite bank of Squaw Creek Reservoir was estimated based on the distance between the 790 ft. and 800 ft. contour from the USGS quadrangles.

The longest straight line that could be drawn from the slopes northeast of the units, to an opposite bank of SCR was found to be 14,251 ft. (2.7 mi. or 4.34 km). This longest straight line distance of 2.7 mi. is the critical fetch length extending from the retaining wall on the northeast side of CPNPP Units 3 and 4 to the opposite bank of SCR. The critical fetch is identified in Figure 7-1. The SCR side slopes are generally uniform and steep. The average slope at the fetch location is approximately 44 percent up to the plant finished floor elevation of 822 ft., which corresponds to a slope less than 2:1 (horizontal: vertical) with a total runup distance of approximately 67 ft. (Reference 4). The retaining wall area on the northeast side is assumed to extend vertically to determine the worst case runup; this would be conservative because the runup considering the slope would be less.

Converting critical fetch length to metric units:
Fetch length = 14,251 ft. * (0.3048 m / 1 ft.) * (1 km / 1000 m) = 4.34 km

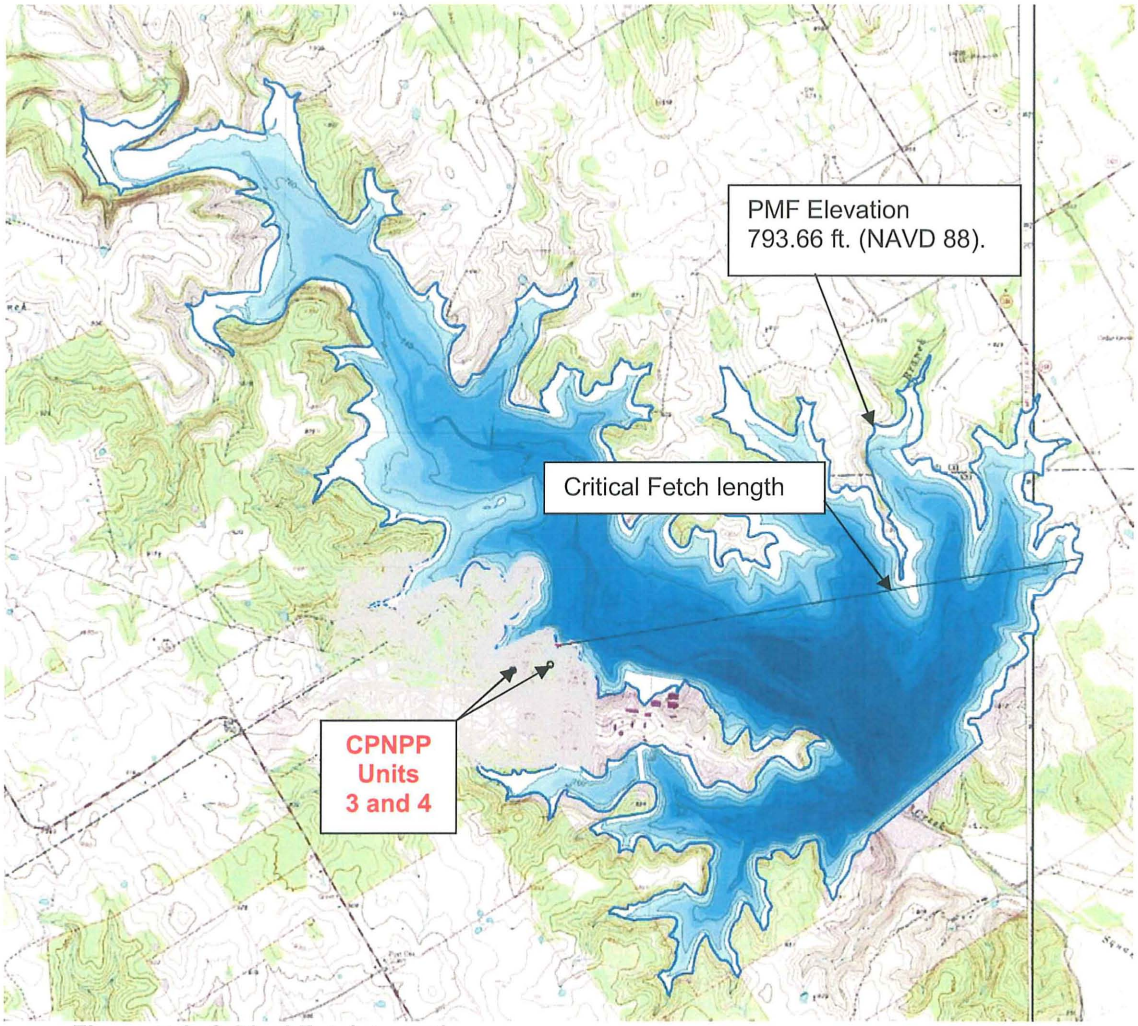

Figure 7-1, Critical Fetch Length.

Wind Speed

As referred to by regulatory guidance, ANSI/ANS-2.8-1992 (Reference 1, Section 9.2.1.1) indicates use of the 2-year wind speed applied in the critical direction for a combined probable maximum precipitation and coincident wind event. ANSI/ANS-2.8-1992 (Reference 1, Section 9.1.4) allows the use of Figure 7-2 to determine the 2-year wind speed in lieu of site specific studies.

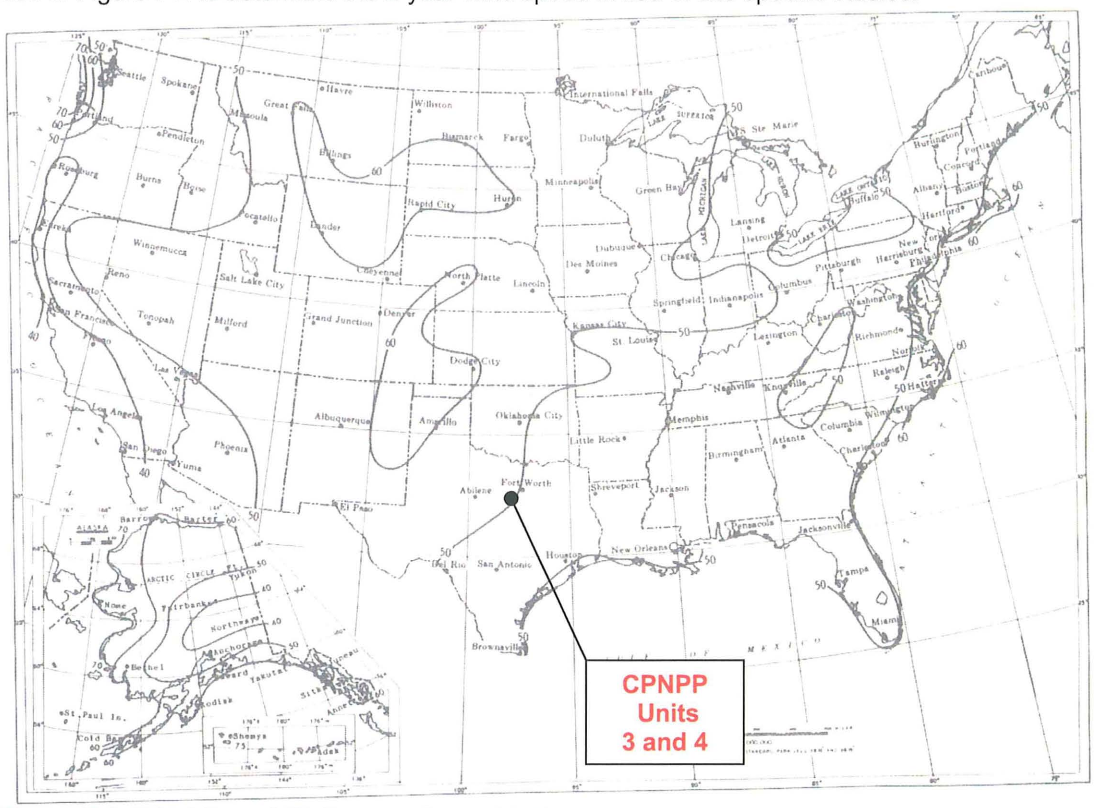

Figure 7-2, Wind Speed (Reference 1, pg. 31, Figure 1)

From Figure 7-2, the Annual Extreme-Mile, 30 ft. Above Ground, 2-yr Mean Recurrence Interval is 50 mph for the CPNPP Units 3 and 4 site.

Converting wind speed to metric units:
Wind speed = 50 mph * (0.44704 m/s / 1 mph) = 22.35 m/s

Wind Speed Adjustments

CEM (Reference 11, Section II-2-1.i.3) wind speed adjustments are performed in metric units.

a) Level adjustment – adjust to 10 m

From above, wind speed is defined at 30 ft. Converting to metric units:
30 ft. * (0.3048 m / 1 ft.) = 9.144 m

For the case of winds at a level near 10 m (8-12m), guidance indicates using the following equation:
$U_{10} = U_z * (10/z) ^\wedge (1/7)$
Note the CEM contains two equations identified as Equation II-2-9. The equation used herein is identified in the CEM, Section II-2-1.f.1.a (Reference 11).
U_{10} = 22.35 m/s * (10 m /9.144 m) ^ (1/7) = 22.64 m/s

b) Duration adjustment uses the following equations and iterations:

$t = 1609 / U_f$ (Reference 11, Figure II-2-2)
$U_f = U_{10}$ = 22.64m/s
t = 1609 / 22.64 m/s = 71.1 sec.

Find the ratio for 1 hr. wind speed based on the following equations:
$U_t / U_{3600} = 1.277 + 0.296 \tanh (0.9 * \log_{10} (45/t))$ (Reference 11, Figure II-2-1)
for $t \leq 3600$ sec.
[Note: tanh(a) = hyperbolic tangent (a) = $(e^a - e^{-a}) / (e^a + e^{-a})$)]
or $U_t / U_{3600} = 1.5334 - 0.15 * \log_{10} (t)$ (Reference 11, Figure II-2-1)
For 3600< t <36,000 sec.

$t \leq 3600$ sec. therefore use $U_t / U_{3600} = 1.277 + 0.296 \tanh (0.9 * \log_{10} (45/71.1 \text{ sec.})) = 1.22$
The 1 hr wind speed is $U_{3600} = U_t$ / ratio = 22.64 m/s / 1.22 = 18.56 m/s

The CEM (Reference 11, Figure II-2-3) is used to determine the optimal duration. The optimal duration is the time needed to achieve fetch limited conditions.
For fetch length = 4.34 km and wind speed = 18.56 m/s, optimal duration time = 53 min.
(53 min. = 3180 sec.).

Determine new ratio of U_{3180} / U_{3600}
$U_{3180} / U_{3600} = 1.277 + 0.296 \tanh (0.9 * \log_{10} (45/3180 \text{ sec.})) = 1.0015$
U_{3180} = ratio * U_{3600} = 1.0015 * 18.56 m/s = 18.59 m/s

The CEM (Reference 11, Figure II-2-3) is used to determine a new optimal duration.
For fetch length = 4.34 km and wind speed = 18.59 m/s, optimal duration time = 53 min.
No further iteration is required.

c) Overland speed to over water speed adjustment uses the following equation:

$R_L = U_w / U_L$ (Reference 11, Figure II-2-7)
For fetches less than 16 km use R_L = 1.2.

Therefore, $U_w = R_L * U_L = 1.2 * 18.59$ m/s = 22.31 m/s

d) Stability adjustment (Reference 11, Figure II-2-8)
No stability adjustment for fetches less than 16 km

In summary, the total adjusted 10 m wind speed is 22.31 m/s (49.91 mph) and has an optimal duration time of 53 min.

Wave Calculations

According to CEM (Reference 11, Section II-2-2.b.1.a) simplified wave predictions can provide accurate estimates for deep water fetch limited conditions when the wind blows with essentially constant direction over a fetch for sufficient time to achieve steady-state, fetch limited values. The verification for the deep water classification of SCR is presented later in subsequent calculation steps of this analysis.

Using the equations for fetch limited wave growth (Reference 11, Equations II-2-36) the energy based wave height, Hm_o, and period, T, are determined. The coefficient of drag, C_D, for the adjusted wind speed is first calculated using the following equation:

$C_D = 0.001 * (1.1 + 0.035 * U) = 0.001 * (1.1 + 0.035 * 22.31 \text{ m/s}) = 0.0019$

The wind friction velocity, U_*, is then determined using the following equation:

$U_* = (C_D * U^2)^{1/2} = (0.0019 * (22.31 \text{ m/s})^2)^{1/2} = 0.97$ m/s.

The wave height is determined using the wind friction velocity and the fetch length as follows:

$Hm_o = 0.0413 * (g * F / U_*^2)^{1/2} * U_*^2 / g$
$Hm_o = 0.0413 * [9.81 \text{ m/s}^2 * 4340 \text{ m} / (0.97 \text{ m/s})^2]^{1/2} * (0.97 \text{ m/s})^2 / 9.81 \text{ m/s}^2 = 0.84$ m.

The wave period is also determined using the wind friction velocity and the fetch length as follows:

$T = 0.751 * (g * F / U_*^2)^{1/3} * U_* / g$
$T = 0.751 * [9.81 \text{ m/s}^2 * 4340 \text{ m} / (0.97 \text{ m/s})^2]^{1/3} * 0.97 \text{ m/s} / 9.81 \text{ m/s}^2 = 2.6$ sec.

According to the CEM (Reference 11, Section II-1-3.c.5.a), in deep water $H_{1/3}$ and Hm_o are very close and both are a good estimate of the significant wave height, H_s.

Based on ANSI/ANS-2.8-1992 (Reference 1, Section 7.4.3) guidance, the maximum wave height, H_{max}, is the 1 percent wave, where $H_{max} = 1.67 * H_s$.

According to CEM (Reference 11, Section II-1-3.b.7.b, Equation II-1-132),
$H_{1/100} = 1.67 * H_{1/3}$ (Note: $H_{1/3} = H_s$)
Therefore $H_{max} = H_{1/100}$ (Note: 1/100 is 1 percent).

The maximum wave height, $H_{max} = 1.67 * 0.84$ m = 1.4 m (crest to trough).

Converting to English units:
Hm_o = 0.84 m * (1 ft. / 0.3048 m) = 2.76 ft.
H_{max} = 1.4 m * (1 ft. / 0.3048 m) = 4.59 ft.

Wave Setup and Runup Calculations

The CEM (Reference 11, Section II-1-3.a) indicates that irregular waves are more descriptive of waves seen in nature. Therefore, the irregular wave estimates are used. Runup includes wave setup.
From above, the slopes approaching the site vary from 3:1 to 10:1 (horizontal: vertical). Additionally, there is a vertical retaining wall.

The surf similarity parameter is determined using the following equation:
$\xi_o = \tan\beta * (H_o / L_o)$^(-1/2) (Reference 11, Equation II-4-1)
Note for steep slopes, 1/10 to vertical, tanβ parameter is replaced by sinβ
$H_o = H_s$ = 0.84 m (from above)
The deep water wave length is determined using the following equation:
L_o = (g * T^2) / (2 * PI), (Reference 11, Equation II-1-15)
T = 2.6 sec (from above)
L_o = (9.81 m/sec^2 * (2.6 sec)^2) / (2 * PI) = 10.55 m

- Slopes 10:1 (horizontal: vertical)

β = arctan(1/10) = 5.7106 degrees
ξ_o = sin(5.7106) * (0.84 m / 10.55 m)^(-1/2) = 0.35

For irregular waves the maximum runup is determined using the following equation:
$R_{max} / H_o = 2.32\ \xi_o^{0.77}$ (Reference 11, Equation II-4-28)
$R_{max} = 2.32 * H_o \cdot \xi_o^{0.77}$
$R_{max} = 2.32 * 0.84\ m \cdot 0.35^{0.77}$
R_{max} = 0.87 m

Converting to English units:
R_{max} = 0.87 m * (1 ft/0.3048) = 2.85 ft.

- Slopes 3:1 (horizontal: vertical)

β = arctan(1/3) = 18.4349 degrees
ξ_o = sin(18.4349) * (0.84 m / 10.55 m)^(-1/2) = 1.12

For irregular waves the maximum runup is determined using the following equation:
$R_{max} / H_o = 2.32\ \xi_o^{0.77}$ (Reference 11, Equation II-4-28)
$R_{max} = 2.32 * H_o \cdot \xi_o^{0.77}$
$R_{max} = 2.32 * 0.84\ m \cdot 1.12^{0.77}$
R_{max} = 2.13 m

Converting to English units:
R_{max} = 2.13 m * (1 ft/0.3048) = 6.99 ft.

- Vertical retaining wall

β = vertical = 90 degrees
ξ_o = sin(90) * (0.84 m / 10.55 m)^(-1/2) = 3.54

For irregular waves the maximum runup is determined using the following equation:
$R_{max} / H_o = 2.32\ \xi_o^{0.77}$ (Reference 11, Equation II-4-28)
$R_{max} = 2.32 * H_o \cdot \xi_o^{0.77}$
$R_{max} = 2.32 * 0.84\text{ m} \cdot 3.54^{0.77}$
R_{max} = 5.15 m

Converting to English units:
R_{max} = 5.15 m * (1ft/0.3048) = 16.9 ft.

<u>Wind Setup</u>

According to USACE EM 1110-2-1420 (Reference 12) wind setup can be reasonably estimated for lakes and reservoirs using the following equation:

$S = U^2 * F / (1400 * D)$ (Reference 12, equation 15-1)

Where:
S = wind setup (ft.)
U = average wind velocity over fetch distance (mph)
F = fetch distance (mi.)
D = average depth of water generally along the fetch line (ft.)

Wind setup is calculated in English units. The units for fetch and depth are not provided in the USACE EM 1110-2-1420. However, in a technical memorandum by the U.S. Bureau of Reclamation (Reference 13), the same equation is referenced to determine wind setup. The units for fetch are indicated to be miles and the units for depth are indicated to be feet.

USACE EM 1110-2-1420 indicates that the fetch distance, F, is usually satisfactorily assumed to be two times the effective fetch distance. The fetch was estimated above using a maximum distance instead of an effective fetch. Therefore, the fetch distance previously determined is also used for the wind setup.

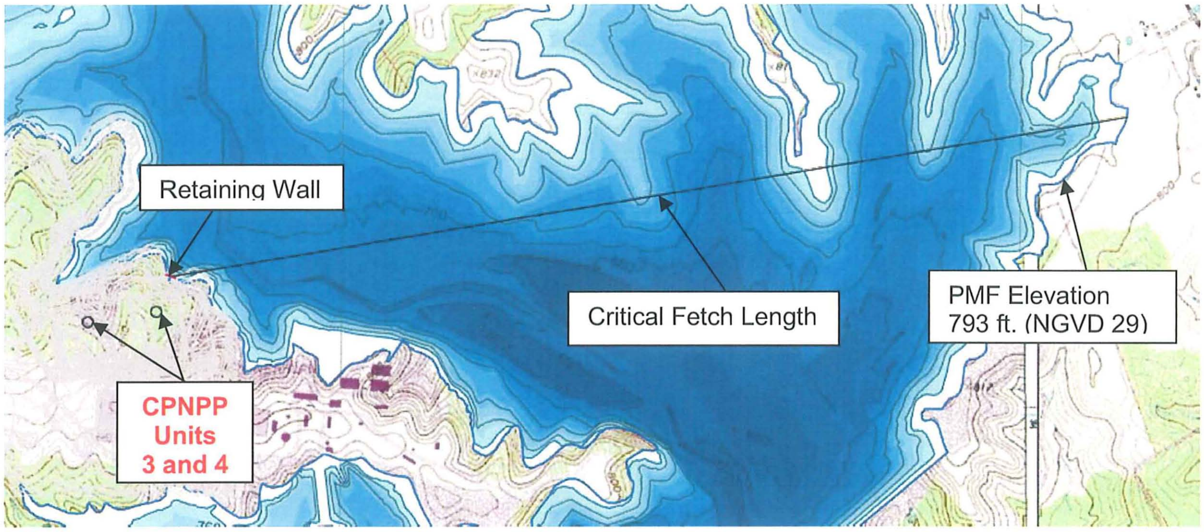

Figure 7-3, Critical Fetch Length for Profile

Using the USGS contours and the Texas Water Development Board Volumetric Survey for SCR (Reference 10), as shown in Figure 7-3, a profile along the fetch length was created. A simplified depiction of the profile is provided in Figure 7-4. Details for the profile are provided in Table 7-1. The average depth along the fetch length was determined to be 60.83 ft.

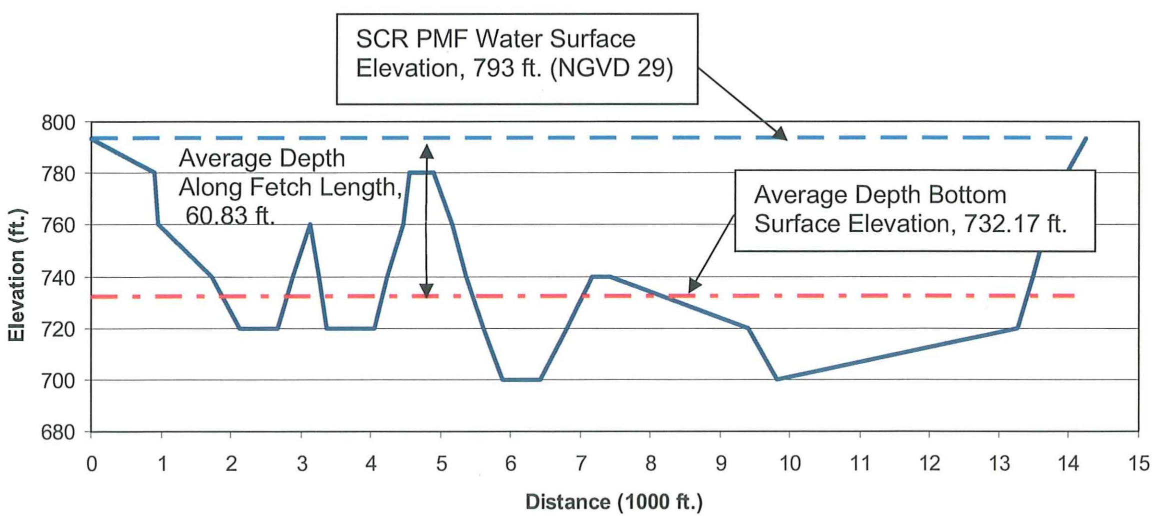

Figure 7-4, Profile of Critical Fetch

Table 7-1, Critical Fetch Length Profile Details

Elevation (ft.)	Distance (ft.)
0	793
907	780
957	760
1730	740
2120	720
2672	720
2877	740
3140	760
3260	740
3375	720
4060	720
4230	740
4470	760
4560	780
4895	780
5170	760
5370	740
5620	720
5880	700
6425	700
6805	720
7175	740
7410	740
9400	720
9820	700
13275	720
13490	740
13690	760
13970	780
14251	793

Note: Distance 0 ft. is at the east end of the fetch distance shown in Figure 7-3.

An average depth along the fetch length was determined using the data in Table 7-1 and the following formula for hydraulic depth.

$$E = \frac{\left(\frac{Y_1 + Y_2}{2}\right) * (X_2 - X_1) + \ldots + \left(\frac{Y_{n-1} + Y_n}{2}\right) * (X_n - X_{n-1})}{X_n - X_1}$$

Where:
E = average depth bottom surface elevation relative to PMF water surface elevation (ft.)
Y_1 = elevation of first point along fetch line (ft.)
Y_2 = elevation of second point along fetch line (ft.)
Y_{n-1} = elevation of next to last point along fetch line (ft.)

Y_n = elevation of last point along fetch line (ft.)
X_1 = distance of first point along fetch line (ft.)
X_2 = distance of second point along fetch line (ft.)
X_{n-1} = distance of next to last point along fetch line (ft.)
X_n = distance of last point along fetch line (ft.)

The average bottom elevation was calculated to be 732.17 ft. The PMF water surface elevation is 793 ft. (NGVD 29) (Reference 3). Therefore, the average depth along the fetch distance was found to be 793 ft. – 732.17 ft. = 60.83 ft.

From the above calculations, the wind speed is 49.91 mph (22.31 m/s) and the fetch distance is 2.7 mi. (4.34 km). Wind setup is calculated as follows:

$S = (49.91 \text{ mph})^2 * (2.7 \text{ mi.}) / (1400 * 60.83 \text{ ft.}) = 0.08 \text{ ft.}$

Deepwater classification

The assumption of deepwater wave conditions is verified in accordance with the CEM (Reference 11, Table II-1-1). For deepwater classification the ratio of water depth divided by the wave length, D/L, must be greater than or equal to 0.5. According to the CEM (Reference 11, Example II-1-1), the wave length can be substituted with the deepwater wave length if the ratio of water depth divided by the deepwater wavelength, D/L_o, is greater than 1.0. The D/L_o ratio is calculated in metric units. From the calculations above, D = 60.83 ft. (18.54 m) and L_o = 10.55 m.

D/L_o = 18.54 m / 10.55 m = 1.76, which is greater than 1.0. Therefore, it is permitted to substitute the wave length with the deepwater wave length to determine the ratio. Furthermore the ratio is greater than 0.5, so the assumption of deepwater wave classification is verified.

Wave, Setup, Runup Summary

Fetch = 2.7 mi.
Duration, t = 53 min.
Wind speed, U_t = 49.91 mph

Significant Wave Height, $Hm_o = H_{1/3} = H_s$ = 2.76 ft.
Period, T = 2.6 seconds
Max 1% Wave Height (crest to trough), $H_o = H_{max} = H_{1/100}$ = 4.59 ft.

Slopes 10:1 (horizontal:vertical)
Runup, R = 2.85 ft.

Slopes 3:1 (horizontal:vertical)
Runup, R = 6.99 ft.

Vertical Retaining Wall
Runup, R = 16.9 ft.

Wind setup = 0.08 ft.

The maximum water surface elevation of the PMF coincident with wind wave activity is determined by adding the wind setup and wind wave runup, including wave setup, to the PMF water surface elevation (PMF elevation + wind setup + runup).

- For the sloped areas adjacent to the site with 10:1 (horizontal: vertical) slopes, the maximum water surface elevation of the PMF coincident with wind wave activity will be 795.93 ft. (793 ft. + 0.08 ft. + 2.85 ft.).
- For the sloped areas adjacent to the site with 3:1 (horizontal: vertical) slopes, the maximum water surface elevation of the PMF coincident with wind wave activity will be 800.07 ft. (793 ft. + 0.08 ft. + 6.99 ft.).
- The water surface elevation at the vertical retaining wall will reach 809.98 ft. (793 ft. + 0.08 ft. + 16.9 ft.).

As indicated in Section 6.0, the datum shift of NAVD 88 – NGVD 29 is between 0 and +20 cm for the CPNPP Site. Therefore, The PMF water surface elevation of the Squaw Creek dam is conservatively increased by 0.66 ft (+20 cm) to account for datum differences. Hence the highest water surface elevation of the PMF coincident with wind wave activity is 810.64 ft (NAVD 88), allowing over 11 ft of freeboard to the finished plant grade for safety related structures under worst case conditions.

List of Abbreviations and Acronyms

ANSI – American National Standards Institute

ANSI/ANS – American National Standards Institute/American Nuclear Society

CEM – Coastal engineering manual

EM – Engineering manual

N – North

NAD83 – North American Datum of 1983

NRC – United States Nuclear Regulatory Commission

NUREG – United States Nuclear Regulatory Commission Regulation

PMF – Probable maximum flood

SPM – Shore protection manual

USACE – United States Army Corps of Engineers

USGS – United States Geological Survey

W – west

Definition of Symbols

a – hyperbolic tangent variable

β – Ground slope (angle)

ξ_o – Deep water surf similarity parameter indicating relative wave energy (dimensionless)

C_D – coefficient of drag (dimensionless)

D – Average depth of water generally on the fetch line (length)

e - mathematical constant, Euler's number, the base of the natural logarithm

E – average depth bottom surface elevation relative to PMF water surface elevation (ft.)

F – Fetch distance (length)

g – Gravitational acceleration constant (length per time squared)

$H_{1/3}$ – Significant wave height (length)

$H_{1/100}$ – Average of the highest 1 percent wave heights, also maximum wave height (length)

Hm_o – Energy based significant wave height (length)

H_{max} – Maximum wave height, also average of highest 1 percent wave height (length)

H_o – Deep water wave height (length)

H_s – Significant wave height (length)

L – wave length (length)

L_o – Deep water wave length (length)

PI – Constant ratio of a circle's circumference to its diameter (dimensionless)

R_L – Ratio adjustment factor of over water wind velocity, U_W, to overland wind velocity, U_L, as a function of overland wind speed (dimensionless)

R_{max} – Maximum wave runup (length)

S – Wind setup above the still water level (length)

t – Duration of wind velocity (time)

T – Wave period (time)

U – Average wind velocity over the fetch distance (length per time)

U_{10} – Wind velocity at 10 meters above the ground (length per time)

U_{3600} – Wind velocity at duration 3600 seconds (length per time)

U_f – Fastest mile wind velocity (length per time)

U_L – Wind velocity overland (length per time)

U_t – wind velocity at duration t seconds (length per time)

U_W – Wind velocity over water (length per time)

U_z – Wind velocity at height z above the surface (length per time)

U_* – wind friction velocity (length per time)

X – distance along fetch length (length)

z – Wind velocity height overland (length)

8.0 Appendices

N/A