Greg Gibson
Senior Vice President, Regulatory Affairs

750 East Pratt Street, Suite 1600
Baltimore, Maryland 21202

UniStar
NUCLEAR ENERGY

10 CFR 50.4
10 CFR 52.79

April 18, 2011

UN#11-129

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the
Calvert Cliffs Nuclear Power Plant, Unit 3,
RAI 289, Probable Maximum Surge and Seiche Flooding

References:
1) Surinder Arora (NRC) to Robert Poche (UniStar Nuclear Energy), "FINAL RAI 289 RHEB 5328" email dated January 07, 2011

2) UniStar Nuclear Energy Letter UN#11-072, from Greg Gibson to Document Control Desk, U.S. NRC, Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 288, Low Water Considerations, and RAI No. 289, Probable Maximum Surge and Seiche Flooding, dated February 4, 2011.

The purpose of this letter is to respond to the request for additional information (RAI) identified in the NRC e-mail correspondence to UniStar Nuclear Energy, dated January 07, 2011 (Reference 1). This RAI addresses the Probable Maximum Surge and Seiche Flooding, as discussed in Section 2.4.5 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 Combined License Application (COLA), Revision 7.

Reference 2 provided an April 18, 2011 date for the response to RAI No. 289, Question 02.04.05-7. The Enclosure provides our response to RAI No. 289, Question 02.04.05-7. Our

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response does not include any new regulatory commitments and does not impact COLA content. This letter does not contain any sensitive or proprietary information.

If there are any questions regarding this transmittal, please contact me at (410) 470-4205, or Mr. Wayne A. Massie at (410) 470-5503.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on April 18, 2011

Greg Gibson

Enclosures: 1) Response to Request for Additional Information, RAI No. 289, Probable Maximum Surge and Seiche Flooding, Calvert Cliffs Nuclear Power Plant Unit 3

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn, NRC Environmental Project Manager, U.S. EPR COL Application
Getachew Tesfaye, NRC Project Manager, U.S. EPR DC Application (w/o enclosure)
Charles Casto, Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
U.S. NRC Region I Office

GTG/SJS/mdf

Enclosure

Response to Request for Additional Information

RAI No. 289, Question 02.04.05-7, Probable Maximum Surge and Seiche Flooding

Calvert Cliffs Nuclear Power Plant Unit 3

RAI No 289

Question 02.04.05-7

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, estimates of the probable maximum hurricane (PMH) and the probable maximum storm surge are needed. The storm surge induced by the PMH should be estimated as recommended by Regulatory Guide 1.59, supplemented by current best practices. In RAI 249 Question 02.04.05-6, the staff asked the applicant to provide an analysis of the PMSS event using a conservative approach such as those predicted by a storm surge model (e.g., SLOSH) with input from appropriate PMH scenarios. In a response dated June 30, 2010, the applicant provided revisions to FSAR Sections 2.4.5.1 through 2.4.5.6. Upon further review of the applicant's submittal, the staff has identified that the applicant needs to provide the following additional information regarding the PMSS estimate.

(a) More details regarding the various PMH tracks and their associated PMH parameters simulated by the applicant are needed. Provide a table of PHM tracks and associated parameters that were used in SLOSH simulations. Provide a description of the simulated PMSS characteristics and list the simulated PMSS water surface elevations for these simulations near the Unit 3 intake.

(b) The antecedent water level has the potential to significantly affect the SLOSH simulations because of complex hydrodynamic interactions. Provide PMSS water surface elevation estimates that directly accounts for the antecedent water level in the SLOSH simulations.

(c) Provide an updated estimate of wind wave effects.

Response

Part (a)

The parameters defining the probable maximum hurricane (PMH) at the open coast near the Calvert Cliffs site were obtained from National Weather Service (NWS) Technical Report NWS-23 (Reference 1) as recommended in Regulatory Guide 1.206, Section C.I.2.4 (Reference 2). The PMH parameters at mile post 2300 nautical miles near the Calvert Cliffs site were obtained as below (page 42, Reference 1):

Peripheral pressure = 30.12 inch Hg,
Central pressure = 26.49 inch Hg,
Lower and upper limit for the radius of maximum wind (RMW) = 10 - 26 nautical miles,
Lower and upper limit for PMH forward speed = 17 - 38 knots.

The difference between the peripheral and central pressures is Δp = 3.63 inch Hg (30.12 inch Hg - 26.49 inch Hg) or 123 milibars.

Probable maximum storm surge (PMSS) at the site is estimated by running the SLOSH Chesapeake Bay basin model for the PMH conditions. A total of 59 SLOSH runs simulating the range of PMH parameters at the Calvert Cliffs site were made to obtain

the PMSS. The selection of input conditions for these 59 simulation cases are discussed below. Initial water level for SLOSH model simulations is calculated by adding 10% exceedance high tide, sea level anomaly and long term sea level rise which add up to approximately 4.3 feet NGVD29.

Effect of PMH Forward Speed and Radius of Maximum Wind

The effect of PMH forward speed on the storm surge elevation at the site is tested for the lower and upper bounds of forward speed, 17 knots (19.6 miles per hour) and 38 knots (43.7 miles per hour), respectively. Three Radius of Maximum Wind (RMW) values, i.e., 10 nautical miles (11.5 miles), 18 nautical miles (20.7 miles) and 26 nautical miles (29.9 miles), corresponding to the lower bound, average and upper bound of the RMW respectively, were selected to study the effect of RMW. The hurricane track was selected such that Calvert Cliffs site is located at the edge of RMW while the PMH eye passes by the west of the site. For the test runs to study the effect of PMH forward speed and RMW (Cases N1 to N6), hurricane direction is set to be from south to north (Approach angle = 360 degrees). The resulting PMH surge levels are given in Table 1.

In Table 1 and following tables:

R = track distance to site,
^{0} = degrees,
kt = knots,
mph = miles per hour,
nm = nautical miles,
sm = statue miles or miles,
ft = feet.

Table 1: Effects of PMH Forward Speed and Radius of Maximum Wind (RMW) on Surge Levels at the Calvert Cliffs Site. Site is Located at the Edge of RMW.

Case	Specific Direction	Forward Speed		RMW		Hurricane Track Normal Dist. To Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. Ft, NGVD29
N1	360° N	17	19.6	10	11.5	11.5	1.00	12.7
N2	360° N	17	19.6	18	20.7	20.7	1.00	14.1
N3	360° N	17	19.6	26	29.9	29.9	1.00	14.2
N4	360° N	38	43.7	10	11.5	11.5	1.00	7.8
N5	360° N	38	43.7	18	20.7	20.7	1.00	8.5
N6	360° N	38	43.7	26	29.9	29.9	1.00	9.5

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

For both upper bound and lower bound forward speeds the highest surge levels are achieved when the RMW of 26 nautical miles (29.9 miles) is selected. The lower bound forward speed of 17 knots (19.6 miles per hour) generated higher surge levels than the

upper bound forward speed. In Table 1 the highest surge level at the Calvert Cliffs site is 14.2 feet NGVD29, obtained for Case N3.

Effects of PMH Direction and Track Distance to Site

The previous section showed that a forward speed of 17 knots (19.6 miles per hour, lower bound) combined with a RMW of 26 nautical miles (29.9 miles, upper bound) caused the highest surge at the site. Keeping these two parameters constant, 5 different hurricane directions, i.e., Approach angle = 315 degrees (NW), Approach angle = 337.5 degrees (NNW), Approach angle = 360 degrees (N), Approach angle = 22.5 degrees (NNE) and Approach angle = 45 degrees (NE) were studied. Various distances from the hurricane track to the site were tested to get the maximum surge level for each direction. The resulting surge levels are given in Tables 2 to 6. The highest surge level of 16.6 feet NGVD29 is achieved for a hurricane directed toward north (Approach angle = 360 degrees), passes by about 7.5 miles (R /Upper Bound RMW = 0.25) west of the site (See Case N11 in Table 4). Note that in Tables 2 to 6 positive R/RMW values correspond to hurricanes passing west of site and negative R/RMW values correspond to hurricanes passing east of site.

Table 2: Effects of Track Distance to Site on the Surge Level at the Site for Hurricanes Directed toward NW (315 degrees).

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NW4	315° NW	17	19.6	26	29.9	89.7	3.00	11.8
NW3	315° NW	17	19.6	26	29.9	59.8	2.00	12.5
NW1	315° NW	17	19.6	26	29.9	29.9	1.00	10.2
NW2	315° NW	17	19.6	26	29.9	0	0.00	4.4

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 3: Effects of Track Distance to Site on the Surge Level at the Site for Hurricanes Directed toward NNW (337.5 degrees).

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NNW7	337.5° NNW	17	19.6	26	29.9	59.8	2.00	12.5
NNW4	337.5° NNW	17	19.6	26	29.9	44.9	1.50	14.6
NNW6	337.5° NNW	17	19.6	26	29.9	37.4	1.25	15.5
NNW1	337.5° NNW	17	19.6	26	29.9	29.9	1.00	15.9
NNW5	337.5° NNW	17	19.6	26	29.9	22.4	0.75	15.3
NNW2	337.5° NNW	17	19.6	26	29.9	15.0	0.50	13.7
NNW3	337.5° NNW	17	19.6	26	29.9	0.0	0.00	7.0

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 4: Effects of Track Distance to Site on the Surge Level at the Site for Hurricanes Directed toward N (360 degrees).

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
N7	360° N	17	19.6	26	29.9	59.8	2.00	10.1
N8	360° N	17	19.6	26	29.9	44.9	1.50	11.7
N3	360° N	17	19.6	26	29.9	29.9	1.00	14.2
N9	360° N	17	19.6	26	29.9	22.4	0.75	15.5
N10	360° N	17	19.6	26	29.9	15.0	0.50	16.5
N11	360° N	17	19.6	26	29.9	7.5	0.25	16.6
N12	360° N	17	19.6	26	29.9	0.0	0.00	15.5
N13	360° N	17	19.6	26	29.9	-15.0	-0.50	10.7
N14	360° N	17	19.6	26	29.9	-29.9	-1.00	5.5

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 5: Effects of Track Distance to Site on the Surge Level at the Site for Hurricanes Directed toward NNE (22.5 degrees).

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NNE3	22.5° NNE	17	19.6	26	29.9	29.9	1.00	11.4
NNE2	22.5° NNE	17	19.6	26	29.9	15	0.50	13.8
NNE1	22.5° NNE	17	19.6	26	29.9	0	0.00	15.8
NNE6	22.5° NNE	17	19.6	26	29.9	-7.5	-0.25	15.9
NNE4	22.5° NNE	17	19.6	26	29.9	-15	-0.50	15.4
NNE5	22.5° NNE	17	19.6	26	29.9	-29.9	-1.00	11.8

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 6: Effects of Track Distance to Site on the Surge Level at the Site for Hurricanes Directed toward NE (45 degrees).

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Hurricane Track Normal Dist. To Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NE3	45° NE	17	19.6	26	29.9	15	0.50	11.2
NE1	45° NE	17	19.6	26	29.9	0	0.00	14.1
NE5	45° NE	17	19.6	26	29.9	-7.5	-0.25	15.0
NE2	45° NE	17	19.6	26	29.9	-15	-0.50	15.3
NE6	45° NE	17	19.6	26	29.9	-22.4	-0.75	15.0
NE4	45° NE	17	19.6	26	29.9	-29.9	-1.00	14.1

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Effects of Hurricane Direction at Chesapeake Bay Entrance

The previous section showed that a hurricane directed toward the north generates the highest surge at the site. For hurricanes directed from the south to north and passing near the site, the landfall location is in the Outer Banks, NC. The surge level at the site is also affected by the surge level generated at the Chesapeake Bay Entrance. In this section, hurricanes that landfall near the Chesapeake Bay Entrance are simulated. After landfall near the bay entrance it is postulated that the hurricanes change direction towards the north to provide the maximum surge elevation at the site, based on the previous section. Four incoming hurricane directions, i.e., northwest, north-northwest, west-northwest and west are studied. The PMH is then postulated to move toward north by the west of the site to provide maximum surge elevation at the site. For each track

with composite directions, i.e., NW to N, NNW to N, WNW to N and W to N, various track distances to the site are simulated to obtain the maximum surge value. Definitions and results for the composite direction cases are summarized in Tables 7 to 10. As seen in Table 10, the highest surge achieved is 18.6 feet NGVD29 for a direction composite of west to north and with the hurricane passing by about 7.5 miles (R/Upper Bound RMW = 0.25) west of the site (Case WTON5).

Table 7: Effects of Composite Direction and Track Distance to Site for Hurricanes Directed NW to N.

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NWTON3	NW to N	17	19.6	26	29.9	29.9	1.00	15.4
NWTON4	NW to N	17	19.6	26	29.9	22.4	0.75	16.6
NWTON1	NW to N	17	19.6	26	29.9	15.0	0.50	17.6
NWTON5	NW to N	17	19.6	26	29.9	7.5	0.25	17.2
NWTON2	NW to N	17	19.6	26	29.9	0.0	0.00	16.1

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 8: Effects of Composite Direction and Track Distance to Site for Hurricanes Directed NNW to N.

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
NNWTON2	NNW to N	17	19.6	26	29.9	29.9	1.00	14.5
NNWTON3	NNW to N	17	19.6	26	29.9	15.0	0.50	16.6
NNWTON1	NNW to N	17	19.6	26	29.9	0.0	0.00	15.8

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 9: Effects of Composite Direction and Track Distance to Site for Hurricanes Directed WNW to N.

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
WNWTON3	WNW to N	17	19.6	26	29.9	29.9	1.00	16.5
WNWTON2	WNW to N	17	19.6	26	29.9	15.0	0.50	18.2
WNWTON4	WNW to N	17	19.6	26	29.9	7.5	0.25	18.2
WNWTON1	WNW to N	17	19.6	26	29.9	0.0	0.00	16.8

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Table 10: Effects of Composite Direction and Track Distance to Site for Hurricanes Directed W to N.

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	El. ft, NGVD29
WTON3	W to N	17	19.6	26	29.9	29.9	1.00	17.1
WTON4	W to N	17	19.6	26	29.9	22.4	0.75	18.4
WTON2	W to N	17	19.6	26	29.9	15.0	0.50	18.5
WTON5	W to N	17	19.6	26	29.9	7.5	0.25	18.6
WTON1	W to N	17	19.6	26	29.9	0.0	0.00	17.1

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.

Effects of Hurricane Track Distance to Chesapeake Bay Entrance

A maximum surge level can be achieved by moving the hurricane in the north-south direction by changing the distance of the track from the Chesapeake Bay Entrance. Six test cases (See Table 11) are simulated for the direction composite of west to north which gave the highest surge level as seen in Table 10. Table 11 summarizes the change in surge level as the distance (in the north-south direction) from the Chesapeake Bay Entrance of the east-west track of the hurricane changes. The highest surge level, 18.8 feet NGVD 29 is achieved when the east-west track of the hurricane is about 44.9 miles (R'/Upper Bound RMW = 1.5) south of the Chesapeake Bay Entrance (the distance to the bay entrance is measured from the south tip of the entrance) and when the hurricane passes about 7.5 miles (R/Upper Bound RMW = 0.25) west of the site (Case WTON9).

Table 11: Effect of Track Distance to Chesapeake Bay Entrance

Case	Specified Direction	Lower Bound Forward Speed		Upper Bound RMW		Track Distance to Site		Track Distance To Chesapeake Bay Entrance (**)		Maximum Surge Level (*)
		kt	mph	nm	sm	sm	R/RMW	sm	R'/RMW	El. ft. NGVD29
WTON10	W to N	17	19.6	26	29.9	7.5	0.25	59.8	2.00	18.4
WTON8	W to N	17	19.6	26	29.9	7.5	0.25	52.3	1.75	18.6
WTON9	W to N	17	19.6	26	29.9	7.5	0.25	44.9	1.50	18.8
WTON5	W to N	17	19.6	26	29.9	7.5	0.25	37.4	1.25	18.6
WTON7	W to N	17	19.6	26	29.9	7.5	0.25	22.4	0.75	17.0
WTON6	W to N	17	19.6	26	29.9	7.5	0.25	7.5	0.25	14.0

(*) Surge elevations are the maximum values obtained at the site during the simulation of each case.
(**) Hurricane track distance (in the north-south direction) to Chesapeake Bay entrance (R') is measured from the south tip of the entrance

The coordinates of all 59 hurricane tracks as used in SLOSH simulations are shown in Table 12. Case WTON9 was used to generate the storm track in COLA Revision 7.

Table 12: Simulated Hurricane Tracks

	CASE N1		CASE N2		CASE N3		CASE N4		CASE N5		CASE N6		CASE N7		CASE N8	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	21.0851	76.6525	21.0851	76.8224	21.0451	76.9924	4.3532	76.6525	4.3532	76.8224	4.3132	76.9924	20.7851	77.5448	20.9551	77.2695
2	22.7870	76.6525	22.7870	76.8224	22.7470	76.9924	8.1466	76.6525	8.1466	76.8224	8.1066	76.9924	22.4870	77.5448	22.6570	77.2695
3	24.4888	76.6525	24.4888	76.8224	24.4488	76.9924	11.9399	76.6525	11.9399	76.8224	11.8999	76.9924	24.1888	77.5448	24.3589	77.2695
4	26.1907	76.6525	26.1907	76.8224	26.1507	76.9924	15.7333	76.6525	15.7333	76.8224	15.6933	76.9924	25.8907	77.5448	26.0607	77.2695
5	27.8926	76.6525	27.8926	76.8224	27.8526	76.9924	19.5266	76.6525	19.5266	76.8224	19.4866	76.9924	27.5926	77.5448	27.7626	77.2695
6	29.5944	76.6525	29.5944	76.8224	29.5544	76.9924	23.3200	76.6525	23.3200	76.8224	23.2800	76.9924	29.2944	77.5448	29.4644	77.2695
7	31.2963	76.6525	31.2963	76.8224	31.2563	76.9924	27.1133	76.6525	27.1133	76.8224	27.0733	76.9924	30.9963	77.5448	31.1663	77.2695
8	32.9981	76.6525	32.9981	76.8224	32.9581	76.9924	30.9067	76.6525	30.9067	76.8224	30.8667	76.9924	32.6981	77.5448	32.8681	77.2695
9	34.7000	76.6525	34.7000	76.8224	34.6600	76.9924	34.7000	76.6525	34.7000	76.8224	34.6600	76.9924	34.4000	77.5448	34.5700	77.2695
10	36.4019	76.6525	36.4019	76.8224	36.3619	76.9924	38.4933	76.6525	38.4933	76.8224	38.4533	76.9924	36.1019	77.5448	36.2719	77.2695
11	38.1037	76.6525	38.1037	76.8224	38.0637	76.9924	42.2867	76.6525	42.2867	76.8224	42.2467	76.9924	37.8037	77.5448	37.9737	77.2695
12	39.8056	76.6525	39.8056	76.8224	39.7656	76.9924	46.0800	76.6525	46.0800	76.8224	46.0400	76.9924	39.5056	77.5448	39.6756	77.2695
13	41.5074	76.6525	41.5074	76.8224	41.4674	76.9924	49.8734	76.6525	49.8734	76.8224	49.8334	76.9924	41.2074	77.5448	41.3774	77.2695

	CASE N9		CASE N10		CASE N11		CASE N12		CASE N13		CASE N14		CASE NW1		CASE NW2	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	21.0848	76.8538	21.0848	76.7171	21.0351	76.5786	21.0851	76.4400	21.3851	76.1629	21.4851	75.8876	28.4184	64.7882	28.7241	64.3507
2	22.7867	76.8538	22.7867	76.7171	22.7370	76.5786	22.7870	76.4400	23.0870	76.1629	23.1870	75.8876	29.6315	66.2933	29.9374	65.8618
3	24.4886	76.8538	24.4886	76.7171	24.4388	76.5786	24.4888	76.4400	24.7888	76.1629	24.8888	75.8876	30.8446	67.7984	31.1506	67.3730
4	26.1905	76.8538	26.1905	76.7171	26.1407	76.5786	26.1907	76.4400	26.4907	76.1629	26.5907	75.8876	32.0578	69.3035	32.3638	68.8842
5	27.8924	76.8538	27.8924	76.7171	27.8426	76.5786	27.8926	76.4400	28.1926	76.1629	28.2925	75.8876	33.2709	70.8086	33.5771	70.3953
6	29.5943	76.8538	29.5943	76.7171	29.5444	76.5786	29.5944	76.4400	29.8944	76.1629	29.9944	75.8876	34.4840	72.3136	34.7903	71.9065
7	31.2962	76.8538	31.2962	76.7171	31.2463	76.5786	31.2963	76.4400	31.5963	76.1629	31.6963	75.8876	35.6971	73.8187	36.0035	73.4177
8	32.9981	76.8538	32.9981	76.7171	32.9481	76.5786	32.9981	76.4400	33.2981	76.1629	33.3981	75.8876	36.9103	75.3238	37.2168	74.9288
9	34.7000	76.8538	34.7000	76.7171	34.6500	76.5786	34.7000	76.4400	35.0000	76.1629	35.1000	75.8876	38.1234	76.8289	38.4300	76.4400
10	36.4019	76.8538	36.4019	76.7171	36.3519	76.5786	36.4019	76.4400	36.7019	76.1629	36.8019	75.8876	39.3365	78.3340	39.6432	77.9512
11	38.1038	76.8538	38.1038	76.7171	38.0537	76.5786	38.1037	76.4400	38.4037	76.1629	38.5037	75.8876	40.5497	79.8391	40.8565	79.4623
12	39.8057	76.8538	39.8057	76.7171	39.7556	76.5786	39.8056	76.4400	40.1056	76.1629	40.2056	75.8876	41.7628	81.3442	42.0697	80.9735
13	41.5076	76.8538	41.5076	76.7171	41.4574	76.5786	41.5074	76.4400	41.8074	76.1629	41.9075	75.8876	42.9759	82.8493	43.2829	82.4847

Table 12: Simulated Hurricane Tracks (continued)

	CASE NW3		CASE NW4		CASE NNW1		CASE NNW2		CASE NNW3		CASE NNW4		CASE NNW5		CASE NNW6	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	28.1114	65.2221	27.8030	65.6525	25.6632	70.4542	25.7464	70.1926	25.8297	69.9297	25.5788	70.7150	25.7047	70.3220	25.6211	70.5854
2	29.3244	66.7212	29.0159	67.1455	27.2382	71.2661	27.3215	71.0055	27.4047	70.7434	27.1538	71.5261	27.2798	71.1344	27.1961	71.3967
3	30.5374	68.2202	30.2288	68.6386	28.8132	72.0779	28.8965	71.8184	28.9798	71.5572	28.7288	72.3372	28.8549	71.9469	28.7711	72.2081
4	31.7505	69.7193	31.4417	70.1317	30.3883	72.8898	30.4715	72.6313	30.5548	72.3710	30.3038	73.1483	30.4299	72.7593	30.3461	73.0195
5	32.9635	71.2183	32.6546	71.6248	31.9633	73.7017	32.0465	73.4442	32.1299	73.1848	31.8788	73.9594	32.0050	73.5718	31.9211	73.8309
6	34.1765	72.7174	33.8676	73.1179	33.5383	74.5135	33.6216	74.2571	33.7049	73.9986	33.4538	74.7704	33.5801	74.3842	33.4961	74.6423
7	35.3895	74.2164	35.0805	74.6110	35.1133	75.3254	35.1966	75.0700	35.2799	74.8124	35.0289	75.5815	35.1552	75.1967	35.0711	75.4537
8	36.6026	75.7155	36.2934	76.1041	36.6883	76.1372	36.7716	75.8829	36.8550	75.6262	36.6039	76.3926	36.7303	76.0091	36.6462	76.2651
9	37.8156	77.2146	37.5063	77.5971	38.2633	76.9491	38.3466	76.6958	38.4300	76.4400	38.1789	77.2037	38.3054	76.8216	38.2212	77.0765
10	39.0286	78.7136	38.7192	79.0902	39.8384	77.7610	39.9217	77.5087	40.0050	77.2538	39.7539	78.0148	39.8804	77.6340	39.7962	77.8879
11	40.2416	80.2127	39.9322	80.5833	41.4134	78.5728	41.4967	78.3216	41.5801	78.0676	41.3289	78.8259	41.4555	78.4465	41.3712	78.6993
12	41.4547	81.7117	41.1451	82.0764	42.9884	79.3847	43.0717	79.1344	43.1551	78.8814	42.9039	79.6369	43.0306	79.2589	42.9462	79.5106
13	42.6677	83.2108	42.3580	83.5695	44.5634	80.1965	44.6468	79.9473	44.7301	79.6952	44.4789	80.4480	44.6057	80.0714	44.5212	80.3220

	CASE NNW7		CASE NNE1		CASE NNE2		CASE NNE3		CASE NNE4		CASE NNE5		CASE NNE6		CASE NE1	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	25.4945	70.9739	25.8297	82.9502	25.9124	83.2133	25.9962	83.4757	25.7464	82.6864	25.6632	82.4270	25.7881	82.8188	28.7241	88.5294
2	27.0695	71.7842	27.4047	82.1364	27.4875	82.3986	27.5710	82.6602	27.3215	81.8736	27.2382	81.6150	27.3632	82.0054	29.9374	87.0182
3	28.6445	72.5944	28.9798	81.3227	29.0625	81.5840	29.1458	81.8447	28.8965	81.0608	28.8133	80.8030	28.9382	81.1921	31.1506	85.5070
4	30.2195	73.4047	30.5548	80.5089	30.6376	80.7694	30.7206	81.0291	30.4715	80.2481	30.3883	79.9909	30.5132	80.3788	32.3638	83.9959
5	31.7945	74.2150	32.1299	79.6951	32.2126	79.9548	32.2953	80.2136	32.0466	79.4353	31.9633	79.1789	32.0883	79.5654	33.5771	82.4847
6	33.3695	75.0252	33.7049	78.8813	33.7877	79.1402	33.8701	79.3981	33.6216	78.6225	33.5383	78.3669	33.6633	78.7521	34.7903	80.9735
7	34.9445	75.8355	35.2799	78.0676	35.3627	78.3256	35.4449	78.5825	35.1966	77.8098	35.1133	77.5549	35.2383	77.9387	36.0035	79.4623
8	36.5195	76.6458	36.8550	77.2538	36.9377	77.5110	37.0197	77.7670	36.7716	76.9970	36.6883	76.7429	36.8134	77.1254	37.2168	77.9512
9	38.0945	77.4560	38.4300	76.4400	38.5128	76.6964	38.5944	76.9514	38.3467	76.1842	38.2634	75.9309	38.3884	76.3120	38.4300	76.4400
10	39.6695	78.2663	40.0050	75.6262	40.0878	75.8817	40.1692	76.1359	39.9217	75.3715	39.8384	75.1189	39.9634	75.4987	39.6432	74.9288
11	41.2445	79.0766	41.5801	74.8124	41.6629	75.0671	41.7440	75.3204	41.4967	74.5587	41.4134	74.3069	41.5385	74.6854	40.8565	73.4177
12	42.8195	79.8868	43.1551	73.9987	43.2379	74.2525	43.3188	74.5048	43.0717	73.7459	42.9884	73.4949	43.1135	73.8720	42.0697	71.9065
13	44.3945	80.6971	44.7301	73.1849	44.8130	73.4379	44.8935	73.6893	44.6468	72.9332	44.5634	72.6829	44.6885	73.0587	43.2829	70.3953

Table 12: Simulated Hurricane Tracks (continued)

	CASE NE2		CASE NE3		CASE NE4		CASE NE5		CASE NE6		CASE NWTON1		CASE NWTON2		CASE NWTON3	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	28.5710	88.3095	28.8769	88.7503	28.4182	88.0917	28.6476	88.4193	28.4957	88.2018	27.0391	64.6529	27.0391	64.3758	27.0391	64.9282
2	29.7842	86.8014	30.0902	87.2360	29.6314	86.5866	29.8608	86.9096	29.7089	86.6952	28.2516	66.1316	28.2516	65.8545	28.2516	66.4069
3	30.9973	85.2933	31.3035	85.7218	30.8445	85.0815	31.0740	85.4000	30.9220	85.1886	29.4642	67.6103	29.4642	67.3332	29.4642	67.8856
4	32.2105	83.7851	32.5168	84.2075	32.0577	83.5764	32.2872	83.8904	32.1352	83.6820	30.6767	69.0890	30.6767	68.8118	30.6767	69.3643
5	33.4237	82.2770	33.7301	82.6933	33.2708	82.0714	33.5004	82.3807	33.3483	82.1754	31.8893	70.5676	31.8893	70.2905	31.8893	70.8429
6	34.6369	80.7689	34.9434	81.1790	34.4840	80.5663	34.7136	80.8711	34.5615	80.6688	33.1018	72.0463	33.1018	71.7692	33.1018	72.3216
7	35.8501	79.2608	36.1567	79.6648	35.6971	79.0612	35.9268	79.3615	35.7747	79.1622	34.3144	73.5250	34.3144	73.2479	34.3144	73.8003
8	37.0633	77.7527	37.3700	78.1505	36.9103	77.5562	37.1400	77.8518	36.9878	77.6556	35.5269	75.0037	35.5269	74.7266	35.5269	75.2790
9	38.2764	76.2446	38.5832	76.6363	38.1234	76.0511	38.3533	76.3422	38.2010	76.1490	36.7395	76.4824	36.7395	76.2053	36.7395	76.7577
10	39.4896	74.7365	39.7965	75.1220	39.3366	74.5460	39.5665	74.8325	39.4141	74.6424	38.4300	76.7171	38.4300	76.4400	38.4300	76.9924
11	40.7028	73.2284	41.0098	73.6077	40.5497	73.0409	40.7797	73.3229	40.6273	73.1358	40.1319	76.7171	40.1319	76.4400	40.1319	76.9924
12	41.9160	71.7202	42.2231	72.0935	41.7629	71.5359	41.9929	71.8133	41.8405	71.6292	41.8337	76.7171	41.8337	76.4400	41.8337	76.9924
13	43.1292	70.2121	43.4364	70.5792	42.9760	70.0308	43.2061	70.3036	43.0536	70.1226	43.5356	76.7171	43.5356	76.4400	43.5356	76.9924

	CASE NWTON4		CASE NWTON5		CASE NNWTON1		CASE NNWTON2		CASE NNWTON3		CASE WNWTON1		CASE WNWTON2		CASE WNWTON3	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	27.0391	64.7896	27.0391	64.5144	24.1307	69.9784	24.1307	70.5308	24.1307	70.2556	31.4029	60.6435	31.4029	60.9207	31.4029	61.1959
2	28.2516	66.2683	28.2516	65.9930	25.7056	70.7748	25.7056	71.3272	25.7056	71.0520	32.0700	62.5887	32.0700	62.8659	32.0700	63.1412
3	29.4642	67.7470	29.4642	67.4717	27.2804	71.5713	27.2804	72.1237	27.2804	71.8484	32.7370	64.5340	32.7370	64.8111	32.7370	65.0864
4	30.6767	69.2257	30.6767	68.9504	28.8553	72.3677	28.8553	72.9201	28.8553	72.6448	33.4041	66.4792	33.4041	66.7563	33.4041	67.0316
5	31.8893	70.7044	31.8893	70.4291	30.4301	73.1641	30.4301	73.7165	30.4301	73.4412	34.0712	68.4244	34.0712	68.7015	34.0712	68.9768
6	33.1018	72.1831	33.1018	71.9078	32.0050	73.9605	32.0050	74.5129	32.0050	74.2376	34.7383	70.3696	34.7383	70.6467	34.7383	70.9220
7	34.3144	73.6617	34.3144	73.3865	33.5798	74.7569	33.5798	75.3093	33.5798	75.0340	35.4053	72.3148	35.4053	72.5919	35.4053	72.8672
8	35.5269	75.1404	35.5269	74.8651	35.1547	75.5533	35.1547	76.1057	35.1547	75.8304	36.0724	74.2600	36.0724	74.5372	36.0724	74.8124
9	36.7395	76.6191	36.7395	76.3438	36.7296	76.3497	36.7296	76.9021	36.7296	76.6269	36.7395	76.2053	36.7395	76.4824	36.7395	76.7577
10	38.4300	76.8539	38.4300	76.5786	38.4300	76.4400	38.4300	76.9924	38.4300	76.7171	38.4300	76.4400	38.4300	76.7171	38.4300	76.9924
11	40.1319	76.8539	40.1319	76.5786	40.1319	76.4400	40.1319	76.9924	40.1319	76.7171	40.1319	76.4400	40.1319	76.7171	40.1319	76.9924
12	41.8337	76.8539	41.8337	76.5786	41.8337	76.4400	41.8337	76.9924	41.8337	76.7171	41.8337	76.4400	41.8337	76.7171	41.8337	76.9924
13	43.5356	76.8539	43.5356	76.5786	43.5356	76.4400	43.5356	76.9924	43.5356	76.7171	43.5356	76.4400	43.5356	76.7171	43.5356	76.9924

Table 12: Simulated Hurricane Tracks (continued)

	CASE WNWTON4		CASE WTON1		CASE WTON2		CASE WTON3		CASE WTON4		CASE WTON5		CASE WTON6		CASE WTON7	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	31.4029	60.7821	36.3777	59.3370	36.3777	59.6141	36.3777	59.8894	36.3777	59.7509	36.3777	59.4756	36.8104	59.4756	36.5948	59.4756
2	32.0700	62.7273	36.3777	61.4510	36.3777	61.7281	36.3777	62.0034	36.3777	61.8648	36.3777	61.5895	36.8104	61.5895	36.5948	61.5895
3	32.7370	64.6725	36.3777	63.5649	36.3777	63.8420	36.3777	64.1173	36.3777	63.9788	36.3777	63.7035	36.8104	63.7035	36.5948	63.7035
4	33.4041	66.6177	36.3777	65.6789	36.3777	65.9560	36.3777	66.2313	36.3777	66.0927	36.3777	65.8174	36.8104	65.8174	36.5948	65.8174
5	34.0712	68.5630	36.3777	67.7928	36.3777	68.0699	36.3777	68.3452	36.3777	68.2067	36.3777	67.9314	36.8104	67.9314	36.5948	67.9314
6	34.7383	70.5082	36.3777	69.9068	36.3777	70.1839	36.3777	70.4592	36.3777	70.3206	36.3777	70.0454	36.8104	70.0454	36.5948	70.0454
7	35.4053	72.4534	36.3777	72.0207	36.3777	72.2979	36.3777	72.5731	36.3777	72.4346	36.3777	72.1593	36.8104	72.1593	36.5948	72.1593
8	36.0724	74.3986	36.3777	74.1347	36.3777	74.4118	36.3777	74.6871	36.3777	74.5485	36.3777	74.2733	36.8104	74.2733	36.5948	74.2733
9	36.7395	76.3438	36.7395	76.2053	36.7395	76.4824	36.7395	76.7577	36.7395	76.6191	36.7395	76.3438	37.1722	76.3438	36.9566	76.3438
10	38.4300	76.5786	38.4300	76.4400	38.4300	76.7171	38.4300	76.9924	38.4300	76.8539	38.4300	76.5786	38.8627	76.5786	38.6471	76.5786
11	40.1319	76.5786	40.1319	76.4400	40.1319	76.7171	40.1319	76.9924	40.1319	76.8539	40.1319	76.5786	40.5646	76.5786	40.3490	76.5786
12	41.8337	76.5786	41.8337	76.4400	41.8337	76.7171	41.8337	76.9924	41.8337	76.8539	41.8337	76.5786	42.2665	76.5786	42.0508	76.5786
13	43.5356	76.5786	43.5356	76.4400	43.5356	76.7171	43.5356	76.9924	43.5356	76.8539	43.5356	76.5786	43.9683	76.5786	43.7527	76.5786

	CASE WTON8		CASE WTON9		CASE WTON10	
Hurricane Track Point	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees
1	36.1606	59.4756	36.2691	59.4756	36.0535	59.4756
2	36.1606	61.5895	36.2691	61.5895	36.0535	61.5895
3	36.1606	63.7035	36.2691	63.7035	36.0535	63.7035
4	36.1606	65.8174	36.2691	65.8174	36.0535	65.8174
5	36.1606	67.9314	36.2691	67.9314	36.0535	67.9314
6	36.1606	70.0454	36.2691	70.0454	36.0535	70.0454
7	36.1606	72.1593	36.2691	72.1593	36.0535	72.1593
8	36.1606	74.2733	36.2691	74.2733	36.0535	74.2733
9	36.5224	76.3438	36.6309	76.3438	36.4153	76.3438
10	38.2129	76.5786	38.3215	76.5786	38.1058	76.5786
11	39.9148	76.5786	40.0233	76.5786	39.8077	76.5786
12	41.6166	76.5786	41.7252	76.5786	41.5095	76.5786
13	43.3185	76.5786	43.4270	76.5786	43.2114	76.5786

Part (b)

The antecedent water level, including 10% exceedance high spring tide, initial rise (sea level anomaly) and long-term sea level rise was used to establish the initial Still Water Level (SWL).

SWL = (Initial Rise) + (10% Exceedance Tide + MSL) + (Long Term Rise) (1)

SWL = (1.1 ft) + (1.53 ft MSL + 0.64 ft) + (1.07ft) = 4.34 ft (1.32 m) NGVD29 (2)

For the analysis provided in COLA Revision 7, this value was rounded to 4.4 ft and added to the results of the SLOSH simulation, which was performed with an initial water level of 0.0 ft.

As requested in RAI 289 Question 02.04.05-7(b), a SLOSH simulation was performed with an initial SWL of 4.34 ft (1.32 m), NGVD29 datum. This SLOSH simulation estimated a PMSS water level of 15.1 ft (4.6 m) NGVD29.

The SLOSH PMSS final elevation result of 17.31 ft (5.27 m) NGVD29 takes into account the upper bound of the 20% margin associated with SLOSH model uncertainties as suggested in Technical Report NWS 48 (Reference 3). This accuracy multiplier was applied to the net increase in water level computed by SLOSH (i.e., 20% * [15.10 ft – 4.34 ft]). This final result is slightly smaller than the 17.6 ft provided in COLA Revision 7. This difference comes primarily from the conservative rounding applied to the original analysis. Consequently, it is concluded that the PMSS elevation obtained from the original SLOSH model is conservative when compared to incorporating the antecedent water level within SLOSH simulations. A comparison of the two approaches is provided in Table 13 below.

Table 13: Comparison of Surge Results

Scenarios	Initial Still Water Level	SLOSH Primary Surge elevation (NGVD29)	20% of SLOSH Primary Surge	Antecedent Water Level addition (NGVD 29)	Total PMSS (NGVD29)
Original [1]	0.00	11.00 ft (3.35 m)	2.20 ft (0.67 m)	4.4 ft (1.32 m)	17.6 ft (5.35 m)
This RAI Response [2]	4.34 ft (1.32 m)	15.10 ft (4.60 m)	2.15 ft (0.66 m)	0	17.3 ft (5.27m)

1 Antecedent water level not incorporated within SLOSH simulations. Upper bound determined by using 20% accuracy on computed Primary Surge.

2 Antecedent water level incorporated within SLOSH simulations. Upper bound determined by applying 20% accuracy on the net increase water level computed by SLOSH.

The probable maximum storm surge results presented in COLA Revision 7 are slightly higher (and therefore more conservative) than the calculations performed for this RAI response.

Part (c)

The revised PMSS value computed in RAI 289 Question 02.04.05-7(b) was utilized to empirically compute the wind setup and wave run-up on the intake structure of CCNPP Unit 3. The wave parameters, including the breaking wave height, significant wave height, and wave period based on the wind field analysis, were computed based on Shore Protection Manual (Reference 4) and Coastal Engineering Manual (Reference 5). As expected, this produced a slightly lower wave run-up of 33.1 ft (10.09 m).

The existing wave run-up results presented in COLA Revision 7 are slightly higher (and therefore more conservative) than the calculations performed for this RAI response.

References

1. NOAA/NWS, Meteorological Criteria for Standard Project Hurricane and Probable Maximum Hurricane Windfields, Gulf and East Coasts of the United States, NWS-23, 1979.
2. Nuclear Regulatory Commission, Combined License Application for Nuclear Power Plants, Regulatory Guide 1.206, Section C.I.2.4, June, 2007.
3. SLOSH: Sea, Lake, and Overland Surges from Hurricanes, Technical Report NWS 48, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Jelesnianski, C.P., et al., April 1992.
4. Shore Protection Manual, Volume 2, United States Army Corps of Engineers, 1984.
5. Coastal Engineering Manual, EM 1110-2-1100, U.S. Army Corps of Engineers, 2008.

COLA Impact

The CCNPP Unit 3 COLA will not be updated as a result of this response.