Progress Energy

Serial: NPD-NRC-2010-061 10CFR52.79
July 19, 2010

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555-0001

LEVY NUCLEAR PLANT, UNITS 1 AND 2
DOCKET NOS. 52-029 AND 52-030
SUPPLEMENT 1 TO RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 080 RELATED TO PROBABLE MAXIMUM TSUNAMI FLOODING

References:
1. Letter from Brian C. Anderson (NRC) to Garry Miller (PEF), dated February 16, 2010, "Request for Additional Information Letter No. 080 Related to SRP Section 2.4.6 for the Levy County Nuclear Plant, Units 1 and 2 Combined License Application"

2. Letter from John Elnitsky (PEF) to U.S. Nuclear Regulatory Commission (NRC), dated March 25, 2010, "Response to Request for Additional Information Letter No. 080 Related to Probable Maximum Tsunami Flooding", Serial: NPD-NRC-2010-025

Ladies and Gentlemen:

Progress Energy Florida, Inc. (PEF) hereby submits a supplemental response to the Nuclear Regulatory Commission's (NRC) request for additional information provided in Reference 1.

A revised response to one of the NRC questions (02.04.06-15) is addressed in the enclosure. The enclosure also identifies changes that will be made in a future revision of the Levy Nuclear Plant Units 1 and 2 application.

If you have any further questions, or need additional information, please contact Bob Kitchen at (919) 546-6992, or me at (727) 820-4481.

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

Executed on July 19, 2010.

Sincerely,

John Elnitsky
Vice President
New Generation Programs & Projects

Enclosure/Attachment

Progress Energy Florida, Inc.
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NRO

cc : U.S. NRC Region II, Regional Administrator
Mr. Brian C. Anderson, U.S. NRC Project Manager

Levy Nuclear Plant Units 1 and 2
Supplement 1 to Response to NRC Request for Additional Information Letter No. 080
Related to SRP Section 2.4.6 for the Combined License Application,
Dated February 16, 2010

NRC RAI #	Progress Energy RAI #	Progress Energy Response
02.04.06-11	L-0692	March 25, 1010; Serial: NPD-NRC-2010-025
02.04.06-12	L-0693	March 25, 1010; Serial: NPD-NRC-2010-025
02.04.06-13	L-0694	March 25, 1010; Serial: NPD-NRC-2010-025
02.04.06-14	L-0695	March 25, 1010; Serial: NPD-NRC-2010-025
02.04.06-15	L-0841	Revised response enclosed – see following pages

NCR Letter No.: LNP-RAI-LTR-080

NRC Letter Date: February 16, 2010

NRC Review of Final Safety Analysis Report

NRC RAI #: 02.04.06-15

Text of NRC RAI:

To meet the requirements of GDC 2, 10 CFR 52.17, and 10 CFR Part 100, the applicant must provide an assessment of the Probable Maximum Tsunami (PMT) for the proposed Levy County site. Section C.I.2.4.6.4 of Regulatory Guide 1.206 (RG 1.206) provides specific guidance with respect to tsunami analysis. This includes providing a complete description of the analysis procedure used to calculate tsunami wave height and period at the site, including the theoretical bases of the models, their verification and the conservatism of all input parameters. Provide additional details regarding new methodology for tsunami analysis described in response to RAI 2.4.6-08. This discussion should specifically include (1) the basis for source amplitude formulae (they are not contain in Silver et al., 2009); (2) clarify what is meant by "wave amplitude onshore cannot exceed its estimated runup height at shore" (statement is incorrect using standard tsunami terminology); (3) definition of variable Co in equations 17 and 18.

PGN RAI ID #: L-0841

PGN Response to NRC RAI:

Subsequent to Progress Energy's initial response to this RAI, a follow-up conference call was requested by NRC to facilitate a better understanding of NRC's request concerning the clarification of the PMT runup estimate. The conference call was held on June 25, 2010, and attended by representatives of Progress Energy and NRC. During the call, Progress Energy summarized the methodology and approach that was used for the development of the PMT runup and run-in estimates for the LNP site and described why those estimates were considered to be conservative. As a result of the call, Progress Energy has revised the PMT analysis to include further clarification of the runup and run-in estimates used in the determination of a tsunami hazard zone. The information provided in this response is intended to supersede and replace our previous response to this RAI, which was submitted to NRC by letter dated March 25, 2010 (Serial NPD-NRC-2010-025).

<u>Response to RAI Item No. 1:</u>

For landslides, the initial tsunami amplitude (Equation 1, response to RAI 02.04.06-08) at the source is approximated as:

$$A_0 = 3.5T\left(\frac{V_s}{\sqrt{gH_0}}\right)^{1.8} \qquad (1)$$

where, T is the thickness of the landslide unit, Vs is the landslide speed, g = 9.8 m/s^2 (32.2 ft/s^2), and H_0 is the water depth at the slide. The above equation is applicable for all landslide velocities satisfying $0<V_s<\sqrt{gH_0}$.

Whereas, the initial tsunami amplitude approximated by Silver et al., 2009 (Reference RAI 02.04.06-15 001) is:

$$A_0 = T \qquad (2)$$

It is clear from these two expressions (Equations 1 and 2) that, for the initial tsunami amplitude, Equation 1 (response to RAI 02.04.06-08) is more complicated than Equation 2 (Reference RAI 02.04.06-15 001) as the former tries to account for the effect of landslide velocity whereas the latter does not. Equation 1 (response to RAI 02.04.06-08) was derived by fitting the results from many numerical landslide tsunami experiments in Ward (Reference RAI 02.04.06-15 002). It can be noted that for nominal landslide speeds (V_s~$0.5\sqrt{gH_0}$), both approximations (Equations 1 and 2) for the initial tsunami amplitude give nearly equal results. The range of V_s values used in Equation 1 above can be estimated from the "terminal velocity" of low basal friction slides $V_{term} = \sqrt{\frac{g\sin\Theta}{Cd}}$ where Θ is slope of the surface, and Cd the coefficient of dynamic friction. For underwater landslides, Ward (References RAI 02.04.06-15 003 and RAI 02.04.06-15 005) used values of Cd = (2 to 20)x10^{-4}/m ([6.6 to 66]x10^{-4}/ft). Regardless of the value of Cd selected, the important feature is that the plausible range of V_s used in Equation 1 is lower for slides on shallow slopes and larger for slides on steep slopes.

For earthquakes, the initial tsunami amplitude at the source (Equation 3, response to RAI 02.04.06-08) was approximated as simply the vertical component of uplift in the earthquake. Certainly the uplift of the sea surface will not be any larger than the uplift at the sea floor. In the case of deep water, sea surface uplift is even less than the sea floor uplift so this is a conservative assumption. Equation 4 in the response to RAI 02.04.06-08 quantifies the vertical uplift as a function of the dip and rake angle of the fault. Ward (Reference RAI 02.04.06-15 004) developed a similar relationship for initial tsunami magnitude in terms of fraction of earthquake slip, and values of fault area, length and mean slip as a function of earthquake magnitude using data from typical tsunami-generating earthquakes.

Response to RAI Item No. 2:

The statement, "Wave Amplitude onshore cannot exceed its maximum runup height at shore," is clarified with the following discussion. To clarify terminology, the following terms and symbols are defined:

Runup height, η, is the maximum elevation that a tsunami reaches. Runup height can either be an actual observed value η_{obs} or an estimated value η_{est}.

Run-in distance, X, is the maximum distance inland that a tsunami reaches. Run-in distance can either be an actual observed value X_{obs} or an estimated value X_{est}. The topographic elevation at the run-in distance X_{obs} equals the runup height η_{obs}.

Flow Depth, $F_d(x)$, is the depth of the flowing water at various places X onshore. Flow depth goes from its maximum value, $F_d(0)$, at the shoreline to $F_d(X_{obs}) = 0$ at the run-in distance X_{obs}.

Attachment 02.04.06-15A shows both the terms above and the terms used in Equation 11 of the response to RAI 02.04.06-08.

In order to clarify the estimation of runup height and run-in distance, Equations 12 through 18 of the response to RAI 02.04.06-08 have been modified as given below:

Estimation of Runup Height

Runup height, η_{est}, is estimated using the following empirical formula given by Chesley and Ward (Reference 02.04.06-15 006):

$$\eta_{est} = A(S)^{4/5} H_S^{1/5} \tag{12}$$

Using Equation 12, one can estimate wave runup from offshore shoaled wave height. Combining Equation 11 from the response to RAI 02.04.06-08 and Equation 12, the estimated runup can be calculated using the following relationship:

$$\eta_{est} = A(R)^{4/5} H_0^{1/5} \tag{13}$$

Using Equation 13, one can estimate runup using offshore wave height A(R) and source water depth H_0.

Estimation of Run-In Distance

Hills and Mader (Reference 02.04.06-15 007) estimated run-in distance as:

$$X_{est} = 0.06 F_d(0)^{1.33} n^{-2} \tag{14}$$

where, X_{est} is the estimated run-in distance in meters, $F_d(0)$ is the flow depth at the shoreline in meters, and n is Manning's roughness coefficient. This equation was modified by McSaveney and Rattenbury (Reference 02.04.06-15 008) to include a slope factor:

$$\frac{dF_d(X)}{dX} = -\left[\frac{16.7n^2}{F_d(0)^{0.33}} + 5Sin(\theta)\right] \tag{15}$$

where, $dF_d(X)/dX$ is the loss in flow depth per meter of run-in distance and θ is the beach slope. Integrating Equation 15 gives:

$$F_d(X) = F_d(0) - \left[\frac{16.7n^2}{F_d(0)^{0.33}} + 5Sin(\theta)\right]X \tag{16}$$

The maximum run-in distance can be estimated from Equation 16 by substituting $F_d(X)=0$, as:

$$X_{est} = \frac{F_d(0)^{1.33}}{16.7n^2 + 5F_d(0)^{0.33}Sin(\theta)} \tag{17}$$

Flow depths are difficult to measure after a tsunami event has occurred. In order to determine actual flow depths, water marks need to be measured on surviving telephone poles, posts, trees, or buildings. On open beaches, these items are not readily available. Moreover, to use Equation 17, flow depth at the shoreline must be known. For applications here, the estimated runup height η_{est} (Equation 13) is substituted for flow depth at the shoreline $F_d(0)$ (Equation 17) with the following result:

$$X_{est} = \frac{\eta_{est}^{1.33}}{16.7n^2 + 5\eta_{est}^{0.33}Sin(\theta)} \tag{18}$$

Estimated runup height η_{est} (Equation 13) should exceed $F_d(0)$ in most cases, so the substitution (Equation 18) is conservative.

Determination of Tsunami Hazard

Due to all of the uncertainties involved in an actual tsunami event, it is impossible to forecast the actual or observed tsunami runup η_{obs} or run-in X_{obs}. These quantities can only be estimated η_{est} (Equation 13) and X_{est} (Equation 18). In general, these estimates are conservative; in most real situations η_{est} and X_{est} will be greater than η_{obs} and X_{obs}.

Consider a facility at elevation E_{site} and distance D_{site} from the coast. For the facility to be in an estimated tsunami hazard zone, two conditions must be met:

- Condition-1: The site must have an elevation less than the estimated tsunami runup η_{est} (Equation 13).
- Condition-2: The site must be closer to the beach than the estimated run-in distance X_{est} (Equation 18).

Both $E_{site}<\eta_{est}$ and $D_{site}< X_{est}$ must be satisfied for the site to be considered within the estimated tsunami hazard zone. If one of the conditions is not met, then the site is considered outside of the estimated tsunami hazard zone.

RAI 02.04.06-15 Tables 1 and 2 present results for selected worst case tsunamis due to submarine landslides and earthquakes. Results indicate that both Condition-1 ($E_{site}<\eta_{est}$) and Condition-2 ($D_{site}< X_{est}$) are not met simultaneously for the LNP site. Therefore, tsunamis generated by worst case submarine landslides or earthquakes will not impact the LNP site.

Response to RAI Item No. 3:

Equations 17 and 18 from RAI 02.04.06-08 have been revised as shown above. The revised equations no longer contain the Cosec(θ) term.

RAI 02.04.06-15 Table 1
Formula Based Results to Selected Worst Case Landslide Tsunamis

Landslide	Area A	Volume V	Thickness of the Unit T	Slide Speed V_s	Initial Wave Amplitude A_0	Water Depth of the Slide Event H_0	Diameter D	Distance of the Measurement Point from the Source R	Exponent φ	Offshore Wave Height at a Distance R from the Source A(R)	Estimated Runup η_{est}		Estimated Run-in Distance X_{est}	
											Without Correction	With Correction	Without Correction	With Correction
	(km^2)	(km^3)	(m)	(m/s)	(m)	(m)	(m)	(km)		(m)	(m)	(m)	(mi.)	(mi.)
East Breaks	520	22	42	25	7	1750	25,719	1000	0.94	0.12	0.8	1.9	0.02	0.07
	520	22	42	50	26	1750	25,719	1000	0.94	0.42	2.2	3.4	0.08	0.13
Mississippi Canyon	3720	428	115	25	21	1689	68,822	640	0.78	2.06	7.9	9.0	0.38	0.44
	3720	428	115	50	73	1689	68,822	640	0.78	7.17	21.4	22.5	1.22	1.29
Florida Escarpment	648	16.2	25	25	4	2000	28,724	275	0.95	0.23	1.4	2.5	0.05	0.10
	648	16.2	25	50	14	2000	28,724	275	0.95	0.80	3.8	4.9	0.16	0.21
Slope above the Florida Escarpment	648	16.2	25	7.0	1.2	600	28,724	325	0.75	0.11	0.6	1.7	0.02	0.06
	648	16.2	25	14.0	4.1	600	28,724	325	0.75	0.38	1.7	2.8	0.06	0.11

Notes:
V_s = slide velocity

km = kilometer; km^2 = square kilometer; km^3 = cubic kilometer; m = meter; mi. = mile; m/s = meters per second

Correction = consideration of correction factors for the 10 percent exceedance astronomical high tide, sea level anomaly, and expected long-term sea level rise.

RAI 02.04.06-15 Table 2
Formula Based Results to Selected Worst Case Earthquake Tsunamis

Earthquake Location	Magnitude Mw	Water Depth at the Source H_0	Diameter or Physical Size of Uplift D	Distance of the Measurement Point from the Source R	Exponent φ	Offshore Wave Height at a Distance R from the Source A(R)	Estimated Runup η_{est}		Estimated Run-in Distance X_{est}	
							Without Correction	With Correction	Without Correction	With Correction
	(Nm)	(m)	(m)	(km)		(m)	(m)	(m)	(mi.)	(mi.)
Mid Gulf	7.0	3121	36,500	450	0.96	0.02	0.3	1.4	0.01	0.04
Vera Cruz	8.2	2836	146,000	1500	0.73	0.22	1.5	2.6	0.05	0.10
Venezuela	9.0	1847	325,000	2400	0.53	1.33	5.7	6.8	0.25	0.31

Notes:
km = kilometer; m = meter; mi. = mile; Nm = Newton meter

Correction= consideration of correction factors for the 10 percent exceedance astronomical high tide, sea level anomaly, and expected long-term sea level rise.

References

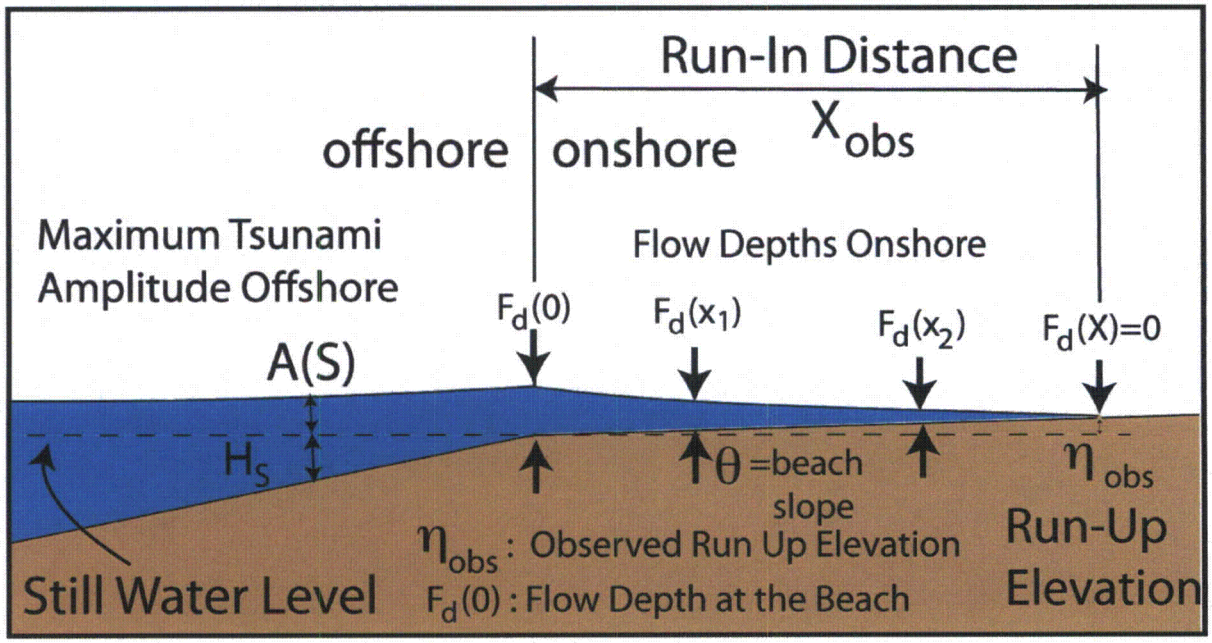
Reference RAI 02.04.06-15 001	Silver, Eli, S. Day, S. N. Ward, G. Hoffmann, P. Llanes, N. Driscoll, B. Applegate, S. Saunders., "Volcano Collapse and Tsunami Generation in the Bismarck Volcanic Arc, Papua New Guinea," *Journal of Volcanology and Geothermal Research,* in press, 2009.
Reference RAI 02.04.06-15 002	Ward, S. N., "Landslide Tsunami," *Journal of Geophysical. Research.*, pp. 106, B6, 11, 201-11, and 216, 2001.
Reference RAI 02.04.06-15 003	Ward, S. N., and S. Day, "The 1958 Lituya Bay Landslide and Tsunami: A Tsunami Ball Approach," *Journal of Earthquake and Tsunami*, accepted and in press, 2009. PDF available at: http://es.ucsc.edu/~ward/papers/lituya-R.pdf
Reference RAI 02.04.06-15 004	Ward, S. N., "Tsunami" in *The Encyclopedia of Solid Earth Geophysics*, ed. H. Gupta, Springer Press, accepted and in press., 2010a. PDF available at: http://es.ucsc.edu/~ward/papers/ency2.pdf
Reference RAI 02.04.06-15 005	Ward, S.N. and S. Day, "The 1963 Landslide and Flood at Vaiont Reservoir Italy – A tsunami ball simulation," in preparation., 2010b. PDF available at: http://es.ucsc.edu/~ward/papers/Vaiont.pdf
Reference RAI 02.04.06-15 006	Chesley, S. R., and Ward. S. N., "A Quantitative Assessment of the Human and Economic Hazard from Impact-generated Tsunami." *Natural Hazards*, 38, p 355-374. Springer, 2006.
Reference RAI 02.04.06-15 007	Gerardi. F., Barbano, M. S., De Martini, P. M., and Pantosti, P., "Discrimination of Tsunami Sources (Earthquake versus Landslide) on the Basis of Historical Data in Eastern Sicily and Southern Calabria," *Bulletin of the Seismological Society of America*, Vol. 98; no. 6; p. 2795-2805, December 2008.
Reference RAI 02.04.06-15 008	Institute of Geological & Nuclear Sciences, *Review of Tsunami Hazard and Risk in New Zealand*, Client Report Compiled by Kelvin Berryman, 2006.

Associated LNP COL Application Revisions:

LNP FSAR Subsection 2.4.6, Rev. 1 will be changed in a future revision of the LNP FSAR to incorporate the modified equations for the PMT analysis and results presented in this RAI response.

Attachments/Enclosures:

Attachment 02.04.06-15A Definition Sketch of Wave Shoaling and Runup [1 page]



SOURCE: Ward, S.N. and S. Day, 2010b. The 1963 Landslide and Flood at Vaiont Reservoir Italy – A tsunami ball simulation. In preparation. PDF available at http://es.ucsc.edu/~ward/papers/Vaiont.pdf

Progress Energy Florida

Levy Nuclear Plant
Units 1 and 2

Definition Sketch of Wave Shoaling and Runup

ATTACHMENT 02.04.06-15A