Enclosure 1

LaSalle County Nuclear Generating Station
Flood Hazard Reevaluation Report
Revision 0

(55 pages)

FLOOD HAZARD REEVALUATION REPORT

IN RESPONSE TO THE 50.54(f) INFORMATION REQUEST REGARDING NEAR-TERM TASK FORCE RECOMMENDATION 2.1: FLOODING

for the

LaSalle County Nuclear Generating Station

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Acronyms and Abbreviations

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
APM	available physical margin
CEM	Coastal Engineering Manual
cfs	cubic feet per second
CLB	Current Licensing Basis
DEM	Digital Elevation Model
FFT	Fast Fourier Transform
EM	Engineer Manual
ESP	Early Site Permit
ESRI	Environmental Systems Research Institute
ft	foot, feet
GIS	Geographic Information System
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center River Analysis System
HHA	Hierarchical hazard assessment
HMR	Hydrometeorological Report
hr	hour(s)
in	inch (inches)
LiDAR	Light Detection and Ranging
LIP	Local Intense Precipitation
mi	mile(s)
min	minute(s)
MSL	mean sea level
NAVD	North American Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resources Conservation Service
NTTF	Near-Term Task Force
NWS	National Weather Service
PMF	probable maximum flood
PMP	probable maximum precipitation
PMS	probable maximum seiche
PMSS	probable maximum storm surge
PMWS	probable maximum wind storm
sq.mi.	square mile(s)
SPF	standard project flood
SSCs	structures, systems, and components
UFSAR	Updated Final Safety Analysis Report
UHS	Ultimate Heat Sink
USACE	Unites States Army Corps of Engineers
USGS	Unites States Geological Survey

1. PURPOSE

1.1 Background

In response to the nuclear fuel damage at the Fukushima-Dai-ichi power plant due to the March 11, 2011, earthquake and subsequent tsunami, the United States Nuclear Regulatory Commission (NRC) established the Near Term Task Force (NTTF) to conduct a systematic review of NRC processes and regulations, and to make recommendations to the NRC for its policy direction. The NTTF reported a set of recommendations that were intended to clarify and strengthen the regulatory framework for protection against natural phenomena.

On March 12, 2012, the NRC issued an information request pursuant to Title 10 of the Code of Federal Regulations, Section 50.54 (f) (10 CFR 50.54(f) or 50.54(f) letter) (NRC March 2012) which included six (6) enclosures:

1. [NTTF] Recommendation 2.1: Seismic
2. [NTTF] Recommendation 2.1: Flooding
3. [NTTF] Recommendation 2.3: Seismic
4. [NTTF] Recommendation 2.3: Flooding
5. [NTTF] Recommendation 9.3: EP
6. Licensees and Holders of Construction Permits

In Enclosure 2 of the NRC issued information request (NRC March 2012), the NRC requested that licensees 'reevaluate the flooding hazards at their sites against present-day regulatory guidance and methodologies being used for early site permits (ESP) and combined operating license reviews'.

On behalf of Exelon Generation Co. (Exelon) for the LaSalle County Nuclear Generating Station (LSCS), this Flood Hazard Reevaluation Report (Report) provides the information requested in the March 12, 50.54(f) letter; specifically, the information listed under the 'Requested Information' section of Enclosure 2, paragraph 1 ('a' through 'e'). The 'Requested Information' section of Enclosure 2, paragraph 2 ('a' through 'd'), Integrated Assessment Report, will be addressed separately if the current design basis floods do not bound the reevaluated hazard for all flood causing mechanisms.

1.2 Requested Actions

Per Enclosure 2 of the NRC issued information request, 50.54(f) letter, Exelon is requested to perform a reevaluation of all appropriate external flooding sources for LSCS, including the effects from local intense precipitation (LIP) on the site, probable maximum flood (PMF) on streams and rivers, storm surges, seiches, tsunami, and dam failures. It is requested that the reevaluation apply present-day regulatory guidance and methodologies being used for ESP and calculation reviews including current techniques, software, and methods used in present-day standard engineering practice to develop the flood hazard. The requested information will be gathered in Phase 1 of the NRC staff's two phase process to implement Recommendation 2.1, and will be used to identify potential 'vulnerabilities' (See definition below).

For the sites where the reevaluated flood exceeds the design basis, addressees are requested to submit an interim action plan that documents actions planned or taken to address the reevaluated hazard with the hazard evaluation.

Subsequently, addressees should perform an integrated assessment of the plant to identify vulnerabilities and actions to address them. The scope of the integrated assessment report will include full power operations and other plant configurations that could be susceptible due to the status of the flood protection features. The scope also includes those features of the ultimate heat sinks (UHS) that could be adversely affected by the flood conditions and lead to degradation of the flood protection (the loss of UHS from non-flood associated causes are not included). It is also requested that the integrated assessment address the entire duration of the flood conditions.

A definition of vulnerability in the context of [Enclosure 2] is as follows: *Plant-specific vulnerabilities are those features important to safety that when subject to an increased demand due to the newly calculated hazard evaluation have not been shown to be capable of performing their intended functions.*

1.3 Requested Information

Per Enclosure 2 of NRC issued information request 50.54(f) letter, the Report should provide documented results, as well as pertinent information and detailed analysis, and include the following:

a. Site information related to the flood hazard. Relevant structure, systems and components (SSCs) important to safety and the UHS are included in the scope of this reevaluation, and pertinent data concerning these SSCs should be included. Other relevant site data includes the following:

    i. Detailed site information (both designed and as-built), including present-day site layout, elevation of pertinent SSCs important to safety, site topography, as well as pertinent spatial and temporal data sets;
    ii. Current design basis flood elevations for all flood causing mechanisms;
    iii. Flood-related changes to the licensing basis and any flood protection changes (including mitigation) since license issuance;
    iv. Changes to the watershed and local area since license issuance;
    v. Current licensing basis flood protection and pertinent flood mitigation features at the site;
    vi. Additional site details, as necessary, to assess the flood hazard (i.e., bathymetry, walkdown results, etc.)

b. Evaluation of the flood hazard for each flood causing mechanism, based on present-day methodologies and regulatory guidance. Provide an analysis of each flood causing mechanism that may impact the site including LIP and site drainage, flooding in streams and rivers, dam breaches and failures, storm surge and seiche, tsunami, channel migration or diversion, and combined effects. Mechanisms that are not applicable at the site may be screened-out; however, a justification should be provided. Provide a basis for inputs and assumptions, methodologies and models used including input and output files, and other pertinent data.

c. Comparison of current and reevaluated flood causing mechanisms at the site. Provide an assessment of the current design basis flood elevation to the reevaluated flood elevation for each flood causing mechanism. Include how the findings from Enclosure 2 of the 50.54(f) letter (i.e., Recommendation 2.1 flood hazard reevaluations) support this determination. If the current design basis flood bounds the reevaluated hazard for all flood causing mechanisms, include how this finding was determined.

d. Interim evaluation and actions taken or planned to address any higher flooding hazards relative to the design basis, prior to completion of the integrated assessment described below, if necessary.

e. Additional actions beyond Requested Information item 1.d taken or planned to address flooding hazards, if any.

2. SITE INFORMATION

2.1 Detailed Site Information

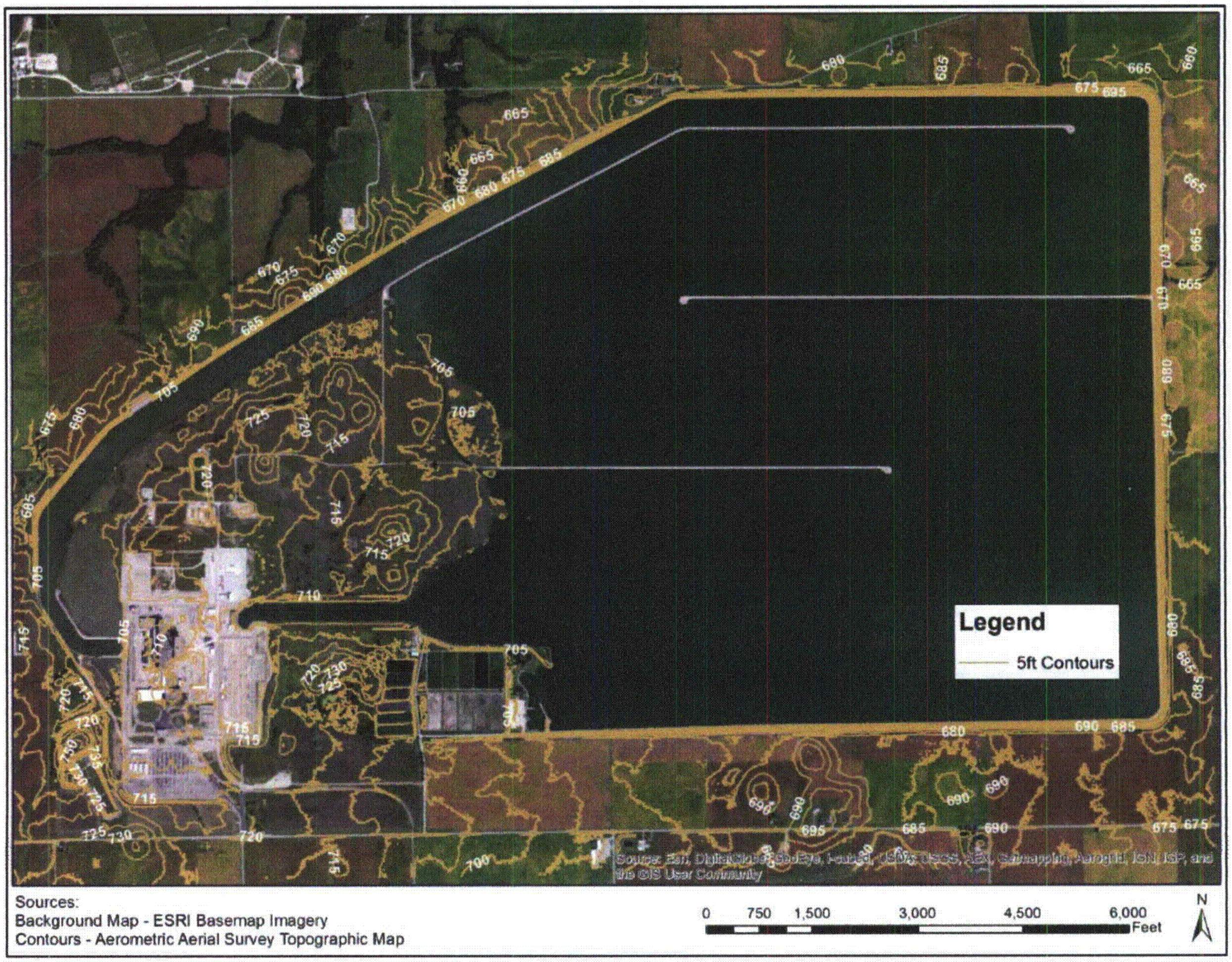
The LaSalle County Station is located in the southeastern part of LaSalle County, 6 miles southeast of Marseilles, Illinois.

Condenser water is cooled by a cooling lake forming a part of the closed cooling system. The surface area of the cooling lake at its normal pool elevation of 700 ft mean sea level (MSL) is 2,058 acres (UFSAR Section 2.4.1.1). The lake is impounded by constructed dikes with the top of the dike elevation varying from 705.0 ft to 706.6 ft MSL. The elevation of the top of the road located on top of the dike, which is provided to be higher than the wave runup elevation all around the lake and to prevent wave overtopping, varies from 705.7 ft to 707.3 ft MSL (UFSAR 2.4.8.2.8). Makeup water for the cooling lake is pumped from the Illinois River. In the unlikely event of a breach of the peripheral dike, emergency shutdown water supply would be obtained from the UHS, which is an excavated pond inside the Cooling Lake.

The terrain around the plant site is gently rolling, with ground surface elevations varying from 700 ft to 724 ft MSL. The plant grade and floor elevations are 710.0 ft and 710.5 ft MSL respectively (UFSAR Section 2.4.1.1). All the safety related SSCs are protected from external flooding to a plant floor elevation of 710.5 ft MSL. Some safety related SSCs are located internally in the safety related structures below the plant floor elevation 710.5 ft MSL.

The plant grade elevation (710.0 ft MSL) is 227 ft above the normal pool elevation in the Illinois River equal to 482.8 ft MSL (UFSAR). The site ground surface elevation is 131 ft above the mean water level in Lake Michigan equal to approximately 579 ft MSL (USACE 2014).

The plants present-day general site map and topography is presented in Figure 2.1.1. The detailed present-day site layout is presented in Figure 2.1.2.



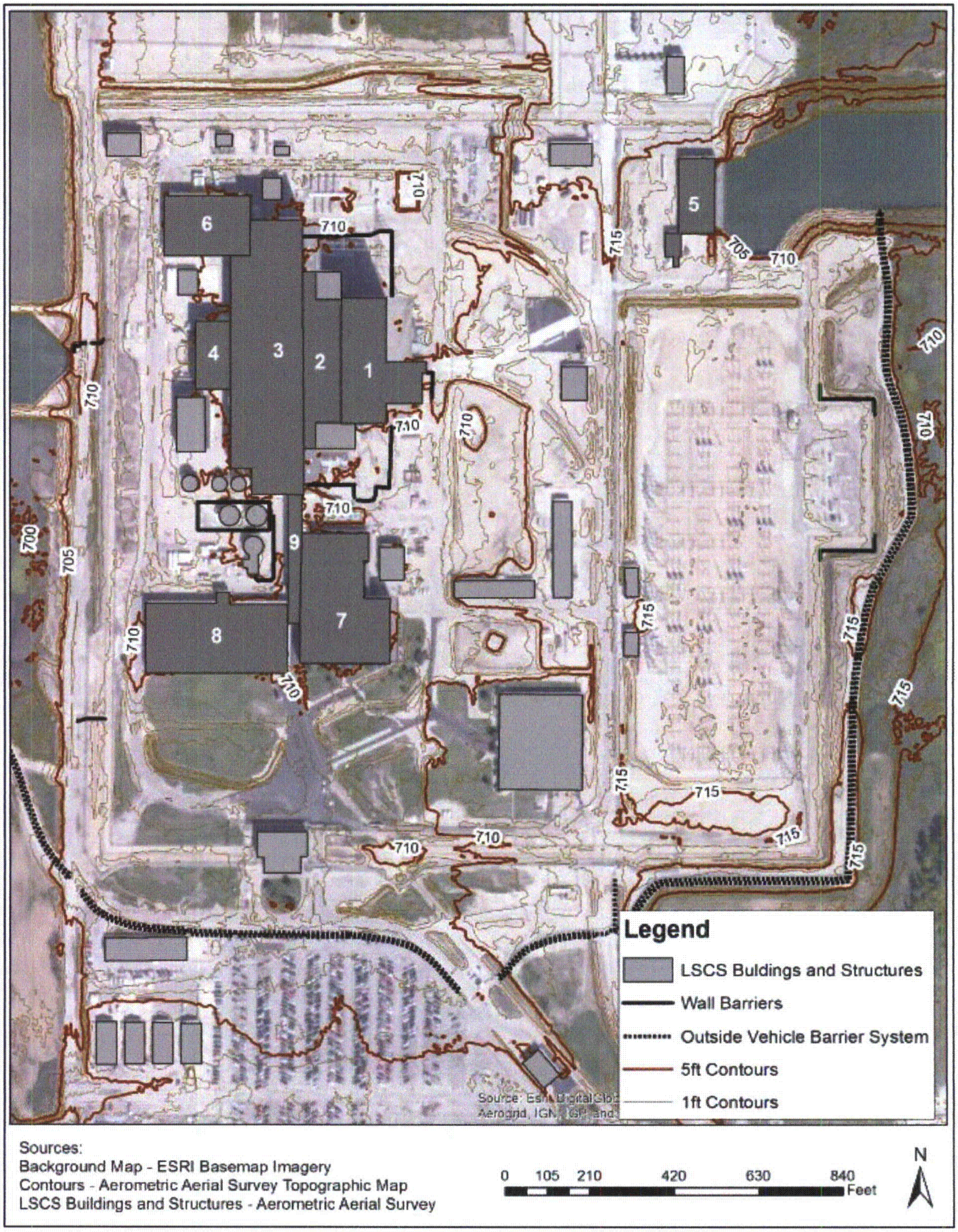
Sources:
Background Map - ESRI Basemap Imagery
Contours - Aerometric Aerial Survey Topographic Map

Figure 2.1.1 – Present-Day General Site Map and Topography

The main plant buildings are shown in Figure 2.1.2 and are identified in Table 2.1.1.

Table 2.1.1 – LSCS Main Buildings

No.	Building Name
1	Reactor Building
2	Auxiliary Building
3	Turbine Building
4	Radwaste Building
5	Lake Screen House
6	Old Service Building
7	New Service Building
8	New Store Warehouse
9	Trackway Building



Sources:
Background Map - ESRI Basemap Imagery
Contours - Aerometric Aerial Survey Topographic Map
LSCS Buildings and Structures - Aerometric Aerial Survey

Figure 2.1.2 – Present-Day Site Layout

2.2 Current Design Basis

The following is a list of flood causing mechanisms and their associated water surface elevations that are considered in the LSCS current licensing basis (CLB).

2.2.1 Effects of Local Intense Precipitation

The 24-hour PMP at the site equal to 32.1 inches is used as the LIP at the CLB. The 1-hour LIP is equal to 14.8 inches with the peak 5-minute intensity rainfall equal to 4.3 inches. The CLB assumes that infiltration losses are negligible and the site drainage system is not functioning. Rational method is used to convert rainfall to runoff with time of concentration accounted for. The flows over the peripheral roads are calculated using broad crested weir formula with a coefficient of discharge equal to 2.64. The water surface elevations at the site are determined by step backwater calculation performed using the U.S. Army Corps of Engineers (USACE) HEC-RAS model (UFSAR).

The CLB maximum water surface elevation at the site due to the LIP event is equal to 710.1 ft MSL in Zone I and 710.3 ft MSL in Zone II (LUCR-272). The zones for the CLB LIP analysis are obtained from the UFSAR Figure 2.4-6 and presented in Figure 2.1.1.1.

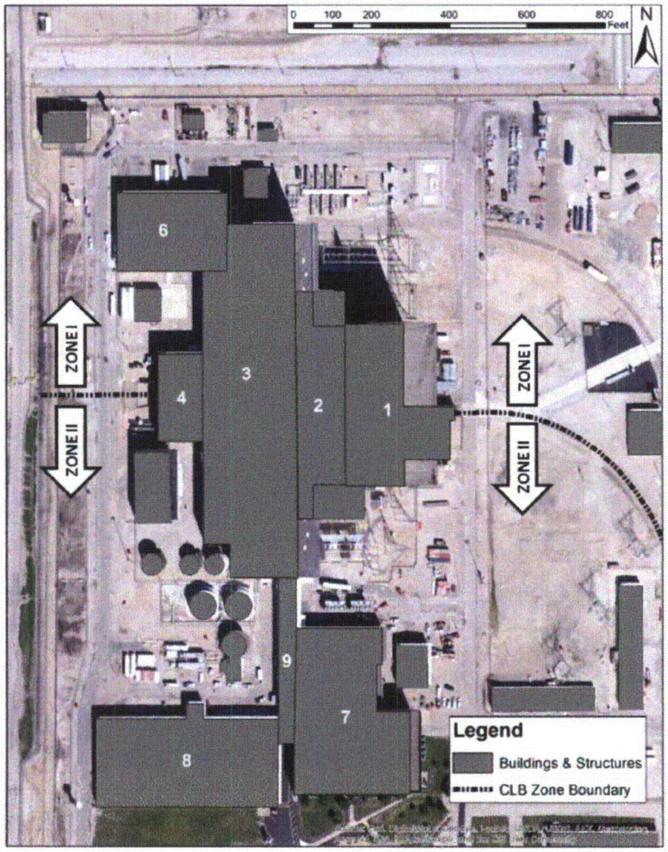


Figure 2.1.1.1 – Zones for CLB LIP

The roof loads due to the LIP are determined assuming that the roof drains are clogged at the time of the LIP. The maximum water accumulation on structures is limited by the height of parapet walls, which is equal to 16 inches (UFSAR).

2.2.2 Flooding in Streams and Rivers

The station is "floodproof" or "dry" with regard to a postulated PMF in the Illinois River, since the plant floor elevation 710.5 ft MSL is 188 ft higher that the PMF plus wave runup elevation of 522.5 ft MSL (UFSAR Section 2.4.3).

2.2.3 Dam Breaches and Failures

The station is "floodproof" or "dry". In the event of a seismically-induced dam failure, it is unlikely that the resulting flood stage would exceed the Illinois River PMF stage at the site (UFSAR Section 2.4.4).

Breaching of the peripheral dikes of the cooling lake at the time of postulated seismic event would cause the impounded water to discharge directly into local creeks that meet the Illinois River. The plant floor elevation is at least 3 ft above the top of the dike elevation. Therefore, there is no likelihood of flooding of the plant facilities due to this phenomenon (UFSAR Section 2.4.4). Hydrologically-induced dam failure is not considered in LSCS CLB.

Since the cooling lake is used as the cooling source and not the Illinois River, plant safety is not affected by postulated blockage or by any other concurrent flooding condition on the Illinois River. Failure of cooling lake dikes would not affect the UHS because storage for the UHS is contained in the excavated portion of the cooling lake (UFSAR Section 2.4.4).

2.2.4 Probable Maximum Flood on Cooling Lake

At normal pool, the lake has a water surface elevation of 700 ft MSL and a surface area of 2,058 acres. The drainage area of the lake is 1,200 acres (UFSAR Section 2.4.3).

The design precipitation consists of standard project flood (SPF) of 48-hour duration followed by three dry days and then PMP of 48-hour duration. The cumulative SPF is equal to 15.30 inches and cumulative PMP is equal to 33.35 in (UFSAR Table 2.4-6). Initial loss is considered for the SPF rainfall. No initial losses are applied to the PMP event. Infiltration losses are considered for both the SPF and the PMP events. The rainfall is transformed into runoff using Snyder's unit hydrograph (UFSAR).

The water surface elevation at the lake is determined using reservoir elevation-storage routing. The discharge from the lake occurs through both service spillway and auxiliary spillway. The maximum still-water surface elevation due to the PMF is equal to 704.3 ft MSL. The wave activity (wave runup and setup) due to PMF and the coincident 40-mph wind increases the maximum water surface elevation in the lake to 707.2 ft MSL at the dike, 705.6 ft MSL at the site, and 706.11 ft MSL at the lake screen house (UFSAR).

2.2.5 Storm Surge and Seiche

The LSCS CLB considers flooding due to surges or seiches as not applicable for the site (UFSAR Section 2.4.5)

2.2.6 Tsunami

The LSCS CLB considers flooding due to tsunami as not applicable for the site (UFSAR Section 2.4.6)

2.2.7 Ice Induced Flooding

The flooding caused by ice jams is considered in the CLB. For the Illinois River the ice induced flooding is determined to be not applicable near the site as the river is wide and kept navigable. The lake screen house is protected against icing in the cooling lake by provision of warming lines near the screen house (UFSAR Section 2.4.7).

2.2.8 Channel Migration or Diversion

The site is located approximately 5 miles south of the Illinois River. The cooling lake is approximately 2 miles south of the Illinois River at its closest point. Due to the distance to the Illinois River, its considerable width, and the well-developed flood plain there is little likelihood that any event would completely divert the flow from the existing location (UFSAR Section 2.4.9).

The migration of the small creeks near the site in not considered in the LSCS CLB.

2.2.9 Low water Considerations

The postulated droughts in the Illinois River do not affect the makeup pumping to the cooling lake. The source of the normal water supply is the cooling lake. In the unlikely event of a breach of the peripheral dikes, emergency shutdown water supply would be obtained from the ultimate heat sink (UHS), which is an excavated pond within the cooling lake. There are no retaining structures for the UHS. The intake flume is a part of the excavated UHS. Loss of the cooling lake has no effect on the UHS.

2.2.10 Combined Effect Flood

Floods due to combinations of flooding events and their effects are not considered in the LSCS CLB (UFSAR).

2.3 Flood Related Changes to the Licensing Basis and any Flood Protection Changes (Including Mitigation) since Licensing Issuance

The only flooding-related changes that have been made deal only with the effects of the local intense precipitation (LIP). Some small buildings have been added and removed, which have caused revisions to the design basis calculations. In one instance, some re-grading of the site was performed in conjunction with the added buildings to help drainage. All the changes have been captured in the design basis effects of LIP analysis.

2.4 Changes to the Watershed and Local Area since License Issuance

The LSCS watershed has a total area of 3,258 acres which includes the area of the cooling lake equal to 2,058 acres as described in the UFSAR. The watershed area delineated for the reevaluation analysis is equal to 5.066 square miles or 3,242 acres. Therefore, the watershed area is approximately the same as in the current licensing basis. The land portion of the watershed consists of the site area, open land area between the lake and the site and a small portion of land used for agricultural purposes. There are no noticeable changes applied to the watershed and local site area.

2.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

The flood protection features credited in the CLB for LSCS are considered incorporated passive. The features are located in the Auxiliary, Diesel Generator, Reactor, Turbine, Off-gas, Lake Screen House and Radioactive Waste Buildings. The features include:

1. Site drainage plan / flow paths;
2. Exterior walls below grade. Exterior walls to grade level are sealed with a waterproof; membrane. Exterior construction joins are sealed with waterstops to grade level
3. Exterior wall penetration seals below grade;
4. Roofs;
5. Basement floor slabs;
6. Ground floor exterior excess doors, openings, and removable wall panel thresholds.

Exterior walls and penetration seals are designed to protect against groundwater ingress. DBD-LS-M11 Rev B (Exelon DBD-LS-M11) states that external walls below grade elevation are required to be covered with a waterproof membrane. In addition, all exterior construction joints are sealed with waterstops to grade level and pipe penetrations in exterior walls have watertight penetration sleeves. The CLB does not specifically credit floor slabs for providing protection from groundwater ingress, although they are designed to resist full hydrostatic uplift pressures (Exelon 2012a).

The Lake Screen House is affected by static and dynamic consequences of wave activity. The walls of the Lake Screen House are designed to withstand hydrodynamic forces caused by wind wave runup superimposed on hydrostatic forces (Exelon 2012a).

Section 2.4.13.5 of the LSCS UFSAR states that the groundwater level assumed for calculation of hydrostatic loading on the power plant foundations is elevation 700.00 feet MSL, which is equivalent to the design cooling lake level. The design groundwater level is based on the assumption that granular fill around the plant foundations will be hydraulically connected with the cooling lake through the granular fill around the intake pipelines. The groundwater level in the granular fill around the plant foundations would reflect the cooling lake level.

3. SUMMARY OF FLOOD HAZARD REEVALUATION

Flooding hazards from various flood-causing mechanisms are evaluated for LSCS in accordance with Enclosure 2 of the NRC's March 12, 2012, 50.54(f) Request for Information Letter (NRC March 2012).

Following the guidance outlined in NUREG/CR-7046 *Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America* (NUREG/CR-7046), the Hierarchical Hazard Assessment (HHA) approach is utilized in the reevaluation study. The HHA approach is a progressively refined, stepwise estimation of site-specific hazards that evaluates the safety of SSCs with the most conservative plausible assumptions consistent with available data. Consistent with the HHA approach, flooding mechanisms that are determined to be not applicable for the site are screened out using qualitative and quantitative assessments with conservative, simplified assumptions and/or physical reasoning based on physical, hydrological and geological characteristics of the site. For the flooding mechanisms that can potentially affect the design basis, detailed analyses are performed based on present-day methodologies, standards and available data.

This section describes in detail the reevaluation analysis performed for each plausible flooding mechanism: flooding due to local intense precipitation, flooding on the cooling lake, storm surge and seiche, ice induced flooding and channel migration, and combined effects flood. Bases for screening-out other flood-causing mechanisms are also provided.

The methodology used in the flooding reevaluation study performed for LSCS is consistent with the following standards and guidance documents:

- NRC Standard Review Plan, NUREG-0800, revised March 2007 (NRC NUREG-0800);
- NRC Office of Standards Development, Regulatory Guides, RG 1.102 – Flood Protection for Nuclear Power Plants, Revision 1, dated September 1976 (NRC RG 1.102);
- RG 1.59 – Design Basis Floods for Nuclear Power Plants, Revision 2, dated August 1977 (NRC RG 1.59);
- NUREG/CR-7046 "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," dated November 2011 (NRC NUREG/CR-7046);
- NUREG/CR-6966 "Tsunami Hazard Assessment at Nuclear Power Plant Sites in the United States of America" dated March 2009 (NRC NUREG/CR-6966);
- American National Standard for Determining Design Basis Flooding at Power Reactor Sites (ANSI/ANS-2.8-1992), dated July 28, 1992;
- NRC JLD-ISG-2012-06, "Guidance for Performing a Tsunami, Surge and Seiche Flooding Safety Analysis", Japan Lessons-Learned Project Directorate Interim Staff Guidance, Revision 0

3.1 Effects of Local Intense Precipitation

Local intense precipitation is an extreme precipitation event at the site location. The LIP is equivalent to the 1-hour, 1-sq.mi. PMP as described in the NUREG/CR-7046.

The LIP at LSCS is determined in the Calculation L-003859, Beyond Design Basis Site-Specific Local Intense Precipitation Analysis (Fukushima), (Exelon 2014g).

The effects of the LIP are the water surface elevations, flow depths and impact loads. The effects of the LIP are computed for the safety-related structures at LSCS. The effects of LIP are determined in Calculation L-003856, Beyond Design Basis Effects of Local Intense Precipitation Analysis (Fukushima), (Exelon 2014d).

For assumptions applied to the analysis see Calculation L-003856, Beyond Design Basis Effects of Local Intense Precipitation Analysis (Fukushima), (Exelon 2014d).

3.1.1 Inputs

The inputs for the analysis are described below.

3.1.1.1 Local Intense Precipitation

The site-specific study for the LIP at LSCS is performed the Calculation L-003859 (Exelon 2014g). The LIP estimates are first derived using the generalized hydrometeorological study (HMR No. 52). Following the HHA approach, since the results showed water surface elevation above plant entrances, the LIP estimates are refined by using a site-specific hydrometeorological study in lieu of the generalized hydrometeorological study. The approach and methodology utilized in the site-specific hydrometeorological study is outlined in detail in Calculation L-003859 (Exelon 2014g).

3.1.1.2 Ground Surface Topography

The ground surface elevations are collected via Light Detection and Ranging (LiDAR) data acquisition performed in October 2013 (Aerometric 2013a). The pertinent features at the site, including buildings, structures, roads, railroad tracks, parking lots, and wall barriers, and the land features, including water, areas with trees and shrubbery, are also depicted from the LiDAR data. Additional ground features at the site are collected during a site ground survey performed by Aerometric in October 2013 (Aerometric 2013b). The ground survey collected additional information for the relevant features at the site including survey benchmarks, door locations and elevations, additional wall barriers, and storm drain culverts. The LiDAR data is processed to produce data in various required formats using ESRI ArcGIS software in Calculation L-003857 (Exelon 2014e).

3.1.1.3 Manning's Roughness Coefficients

For surface roughness coefficients the Manning's n-values are used in the analysis. The roughness coefficients are selected based on the land cover type identified using aerial topographical survey information (Aerometric 2013a), and available aerial imagery. The Manning's n-values are selected following the suggested range for the overland flow runoff provided in the FLO-2D Reference Manual (FLO-2D Manual).

3.1.2 Methodology

The Effects of LIP analysis uses a two-dimensional (2D) hydrodynamic model, the FLO-2D model (FLO-2D). FLO-2D is a volume conservation model. The FLO-2D model simulates open channel flow through a numerical approximation of the shallow water equations. Flood wave progression over the flow domain is controlled by topography and resistance to flow. Flood routing in two dimensions is accomplished through a numerical integration of the equations of motion and the conservation of fluid volume.

A two-dimensional model is appropriate and better suitable model compared to a one-dimensional model to simulate the overland flow conditions at the site, which are sheet flow and shallow open channel flow. The two-dimensional model determines the flow direction based on the ground topography when in the one-dimensional model the flow direction has to be assigned. The one-dimensional models, such as unsteady-state HEC-RAS model, are capable to utilize similar computational approaches as the FLO-2D model (equations of motion and volume conservation). However, because the flow direction is initially assigned, the model forces water flows in the assigned general direction rather than determining the direction. Additionally, the flow path in the one-dimensional model is represented by cross sections along the assumed flow direction and the averaged cross sections are utilized for the computational processes. On the other hand, the two-dimensional model uses a grid to represent the ground surface. Each grid element is treated as a computational cell and the hydraulic relationships are determined for each cell depending on the hydrologic and hydraulic properties of the cell itself and the surrounding cells. The ground is closely represented in the two-dimensional model because each grid element is assigned a corresponding ground surface elevation, roughness coefficient, and, when applicable, reduction factor(s) to account for obstructions (buildings, walls, etc.).

The steps applied to model the LIP event at LSCS in the FLO-2D are described as follows:

- Create a grid system using ground surface topographical data;
- Assign properties and pertinent conditions such as computational boundary and outflow elements;
- Specify roughness coefficients (Manning's coefficients) corresponding to the site's land cover type (e.g. concrete, grass, water);
- Identify obstructions completely blocking water flow (i.e. buildings and/or structures);
- Identify obstructions diverting water flow (i.e. security wall barriers);
- Assign precipitation inflow to the model;
- Perform the FLO-2D computation;
- Analyze the results produced by the FLO-2D.

Following the guidance outlined in NUREG/CR-7046 the runoff losses are ignored. The roof rainfall is assumed to be contributing to the overland runoff. The drainage system at the site is assumed to be non-functional at the time of the LIP event.

The site specific 1-hour, 1-sq.mi. LIP is equal to 13.8 inches, the peak intensity 5-minute LIP is equal to 4.7 inches for LSCS (Exelon 2014g).

The upstream areas around the site are included in the computational boundary to ensure all the runoff possibly contributing to the runoff at the site is accounted for.

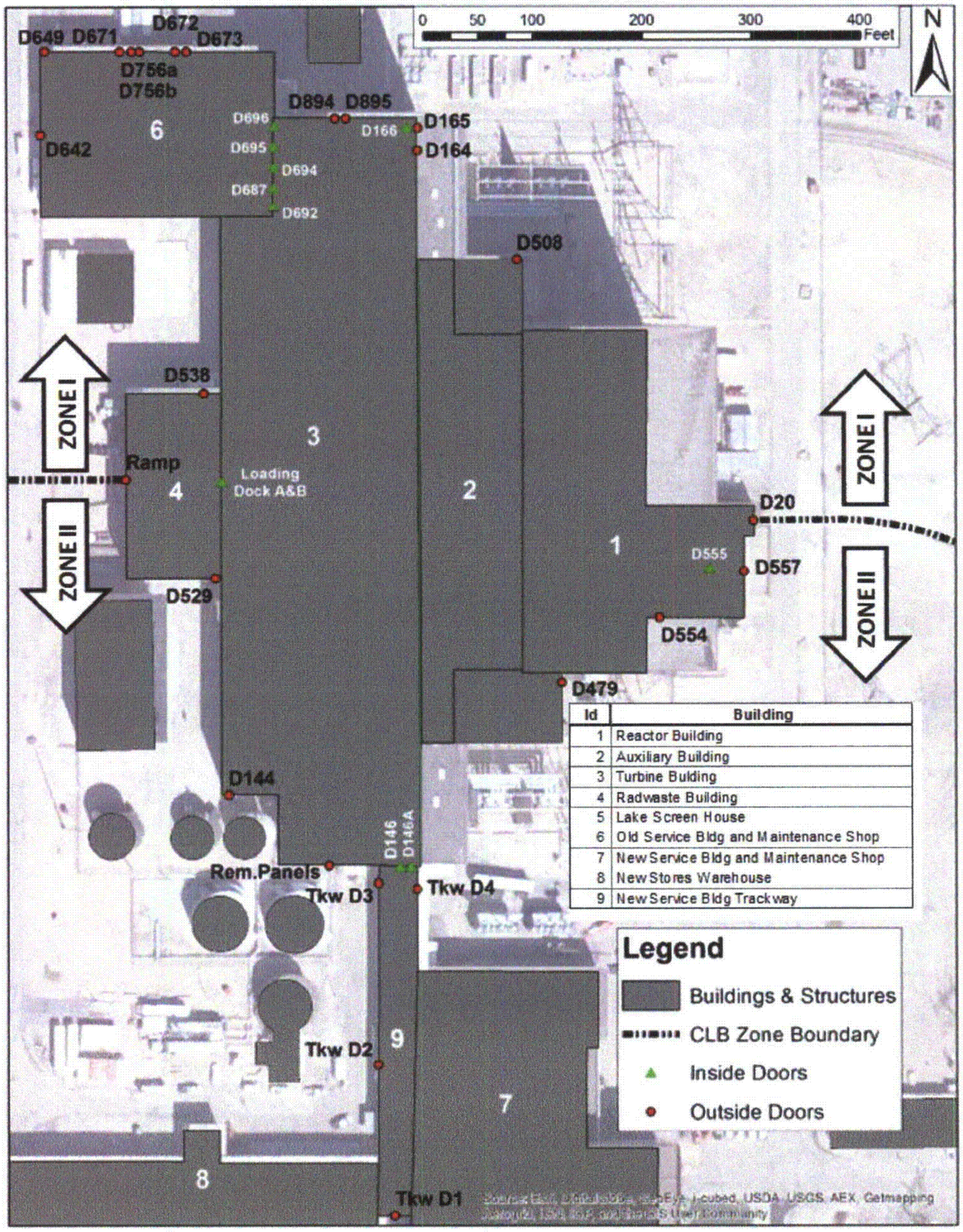
The elevations at LSCS are referenced to MSL vertical datum as stated in the UFSAR. The ground surface topography and the site-related features are referenced to North American

Vertical Datum of 1988 (NAVD88). The vertical datum difference between NAVD88 and MSL is obtained from Survey Control Report (Aerometric 2013b). From the Survey Control Report, the vertical datum difference is equal to NAVD88 – MSL = 0.22 ft.

3.1.3 Results

3.1.3.1 Maximum Water Surface Elevations

The power block buildings and the location of the doors that could potentially provide a pathway for the floodwaters are shown in Figure 3.1.3.1.



Id	Building
1	Reactor Building
2	Auxiliary Building
3	Turbine Bulding
4	Radwaste Building
5	Lake Screen House
6	Old Service Bldg and Maintenance Shop
7	New Service Bldg and Maintenance Shop
8	New Stores Warehouse
9	New Service Bldg Trackway

Figure 3.1.3.1 – LSCS Door Location Map

The resulting water surface elevations at the doors potentially leading to the safety-related areas are presented in Table 3.1.3.1.

Table 3.1.3.1 – Results from LIP Flood at Door Locations

Door Number	Grid Number	Building	Max WSE		CLB Zone	CLB Max WSE
			ft, NAVD88	ft, MSL		ft, MSL
D20	61638	Reactor Building	710.83	710.61	I	710.10
D557	65659	Reactor Building	710.67	710.45	II	710.30
D554	69666	Reactor Building	710.67	710.45	II	710.30
D479	74466	Auxiliary Building	710.65	710.43	II	710.30
D508	40229	Auxiliary Building	710.51	710.29	I	710.10
D894	29305	Turbine Building	710.54	710.32	I	710.10
D895	29307	Turbine Building	710.31	710.09	I	710.10
D165	30128	Turbine Building	710.63	710.41	I	710.10
D164	31752	Turbine Building	710.76	710.54	I	710.10
Removable Panels	89145	Turbine Building	710.74	710.52	II	710.30
D144	83497	Turbine Building	710.60	710.38	II	710.30
D642	30464	Old Service Building	710.62	710.40	I	710.10
D649	24436	Old Service Building	710.44	710.22	I	710.10
D671	24450	Old Service Building	710.03	709.81	I	710.10
D756a	24452	Old Service Building	710.07	709.85	I	710.10
D756b	24453	Old Service Building	710.10	709.88	I	710.10
D672	24460	Old Service Building	710.67	710.45	I	710.10
D673	24462	Old Service Building	710.55	710.33	I	710.10
Tkw.D1	116609	Trackway Building	711.03	710.81	II	710.30
Tkw.D2	104721	Trackway Building	710.65	710.43	II	710.30
Tkw.D3	90452	Trackway Building	710.78	710.56	II	710.30
Tkw.D4	90893	Trackway Building	710.65	710.43	II	710.30
Ramp	57946	Radwaste Building	709.57	709.35	I	710.10
D529	66009	Radwaste Building	710.63	710.41	II	710.30
D538	50809	Radwaste Building	710.63	710.41	I	710.10

3.1.3.2 Hydrostatic / Hydrodynamic Loads

The hydrostatic and hydrodynamic loads are determined as part of the FLO-2D computation as force per unit length of structure (lb/ft) for the safety-related buildings and are presented in Table 3.1.3.2.

Table 3.1.3.2 – Hydrodynamic and Hydrostatic Loads on Safety-Related Buildings

Building	Max Hydrodynamic Load (lb/ft)	Max Hydrostatic Load (lb/ft)
Reactor Building	3.94	27.72
Auxiliary Building	0.84	26.66
Turbine Building	0.60	19.65
Lake Screen House	2.32	23.52

3.1.3.3 Flood Duration

The duration of the flooding at each door is presented in Table 3.1.3.3.

Table 3.1.3.3 – Flood Duration above CLB LIP Elevation

Door Number	Building	Flood Beginning**	Flood Duration*		Notes
		(min)	(hours)	(min)	
D20	Reactor Building	0	1.1	66	Flood above const. D = 0.05 ft*
D557	Reactor Building	48	0.5	30	Flood above CLB max WSE
D554	Reactor Building	48	0.5	30	Flood above CLB max WSE
D479	Auxiliary Building	48	0.5	30	Flood above CLB max WSE
D508	Auxiliary Building	18	1.0	60	Flood above CLB max WSE
D894	Turbine Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
D895	Turbine Building	n/a	n/a	n/a	Water level below CLB max WSE
D165	Turbine Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
D164	Turbine Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
Rem. Panels	Turbine Building	0	1.10	66	Flood above CLB max WSE
D144	Turbine Building	0	0.3	16	Flood above CLB max WSE
D642	Old Service Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
D649	Old Service Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
D671	Old Service Building	n/a	n/a	n/a	Water level below CLB
D756a	Old Service Building	n/a	n/a	n/a	Water level below CLB
D756b	Old Service Building	n/a	n/a	n/a	Water level below CLB
D672	Old Service Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
D673	Old Service Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
Tkw.D1	Trackway Building	0	1.10	66	Flood above const. D = 0.05 ft*
Tkw.D2	Trackway Building	n/a	n/a	n/a	Water level below const. D = 0.05 ft*
Tkw.D3	Trackway Building	0	1.10	66	Flood above const. D = 0.05 ft*
Tkw.D4	Trackway Building	48	0.6	36	Flood above CLB max WSE
Ramp	Radwaste Building	n/a	n/a	n/a	Water level below CLB
D529	Radwaste Building	0	0.3	18	Flood above const. D = 0.05 ft*
D538	Radwaste Building	0	1.1	66	Flood above CLB max WSE

* FLO-2D accounts for surface detention and the minimum computer water depth (0.05 ft) is due to the surface detention. Therefore, the time of flooding with a constant minimum computed water depth D is not considered and is not included in the computed flood duration.

** Flood beginning is the time, in minutes, from the beginning of the rainfall to the time when the CLB maximum water surface elevation is first exceeded. The rain begins at minute zero.

3.1.3.4 Warning Time

A local intense precipitation event has no appreciable warning time except those provided by a weather (precipitation) forecast.

3.1.3.5 Groundwater Ingress

Section 2.4.13.5 of the UFSAR states that the groundwater level assumed for calculation of hydrostatic loading on the power plant foundations is elevation 700.00 ft MSL, which is equivalent to the normal pool of the cooling lake. The design groundwater level is based on the assumption that granular fill around the plant foundations will be hydraulically connected with the cooling lake through the granular fill around the intake pipelines. The groundwater level in the granular fill around the plant foundations would reflect the cooling lake level.
The UFSAR states that the granular fill around the plant foundations is covered with 20 feet of essentially impermeable, compacted clay. In addition, the surrounding clayey till is also essentially impermeable. Due to the compacted clay cover and clayey till, it is expected that infiltration of precipitation and groundwater seepage would likely be minimal.

3.1.3.6 Erosion and Sediment Deposition

The flow velocities due to the LIP event are determined to be below the suggested velocities (USACE 1984) at the plant area. Therefore, the erosion is not expected during a LIP event.

There are no mechanisms that could generate or transport significant sediment loads to the site during a LIP flood. Therefore, sediment deposition is not expected to affect the LIP flood.

3.1.3.7 Error and Uncertainties

The errors and uncertainties potentially affecting the results determined from the LIP flooding are analyzed in Calculation L-003862, Beyond Design Basis External Flooding Error/Uncertainty Analysis (Exelon 2014j).

It is determined that the calculated water surface elevations resulting from the LIP flooding at LSCS can be potentially affected by the errors and/or uncertainties associated with the following:

- Ground surface topography data
- Approximation of the ground surface topography by FLO-2D computational software
- Surface roughness coefficients (Manning's n-values)

The results of determined errors/uncertainties are presented in Table 3.1.3.4.

Table 3.1.3.4 – Errors/Uncertainties for LIP Flooding Results

Parameter	Associated Error
Ground Surface Topography (LiDAR Data)	0.083 ft
Ground Surface Approximation by FLO-2D	0.063 ft
Manning's Surface Roughness Coefficients	0.052 ft

3.1.4 Conclusions

The CLB maximum water surface elevation due to the LIP is equal to 710.1 ft MSL and 710.3 ft MSL at different plant zones as described in Section 2.1.1. The reevaluated maximum water surface elevations at the majority of the doors potentially leading to the safety-related areas of the plant exceed the CLB maximum water surface elevations as shown in Table 3.1.3.1.

3.2 Probable Maximum Flood on Cooling Lake

The probable maximum flood is the hypothetical flood (peak discharge, volume and hydrograph shape) that is considered to be the most severe reasonably possible, based on comprehensive hydrometeorological application of probable maximum precipitation and other hydrologic factors favorable for maximum flood runoff such as sequential storms and snowmelt.

As outlined in the guidance provided in ANSI/ANS-2.8-1992 and in NUREG/CR-7046, Appendix H, the design basis from flood hazards should include several flood-causing mechanisms and combinations of these mechanisms. For the floods caused by precipitation events, the following should be examined:

Flooding in Rivers and Streams

Alternative 1 – Combination of:

- Mean monthly base flow
- Median soil moisture
- Antecedent or subsequent rain: the lesser of 1) rainfall equal to 40% PMP and 2) a 500-year rainfall
- The PMP
- Waves induced by 2-year wind speed applied along the critical direction.

Alternative 2 – Combination of:

- Mean monthly base flow
- Probable maximum snowpack
- A 100-year, snow-season rainfall
- Waves induced by 2-year wind speed applied along the critical direction.

Alternative 3 – Combination of:

- Mean monthly base flow
- A 100-year snowpack
- Snow-season PMP
- Waves induced by 2-year wind speed applied along the critical direction.

The precipitation input for Alternative 1, the all-season PMF, is determined in Calculation L-003853, Beyond Design Basis Probable Maximum Precipitation Analysis (Fukushima), (Exelon 2014a).

The precipitation input, including snowmelt, for Alternatives 2 and 3, the cool-season PMF, are determined in Calculation L-003854, Beyond Design Basis Cool-Season Precipitation and Snowmelt Analysis on Lake (Fukushima), (Exelon 2014b).

The PMF on the cooling lake and in the small unnamed creek contributing to the cooling lake is determined in Calculation L-003855, Beyond Design Basis Probable Maximum Flood Analysis for Lake (Fukushima), (Exelon 2014c). The results of the PMF are the water surface elevations that could result in the flooding of the safety-related Structures, Systems and Components (SSCs) at LSCS.

The results of the wind wave activity coincident with the PMF on the cooling lake are addressed in Section 3.4.

For assumptions applied to the PMF on the lake analysis see Calculation L-003855, Beyond Design Basis Probable Maximum Flood Analysis for Lake (Fukushima), (Exelon 2014c).

3.2.1 Inputs

The inputs for the analysis are described below.

3.2.1.1 All-Season PMP

The all-season PMP estimates for LSCS are derived from the charts presented in the generalized hydrometeorological reports (HMR No.51 and HMR No.52). The PMP estimates are derived based on the site location and site watershed area.

3.2.1.2 500-Year Rainfall

The 500-year rainfall estimates are obtained from NOAA Precipitation Frequency Data Server (NOAA 2013b) for the LSCS location.

3.2.1.3 100-Year Rainfall

The 100-year rainfall estimates are obtained from NOAA Precipitation Frequency Data Server (NOAA 2013b) for the LSCS location.

3.2.1.4 Maximum Dew Point Temperatures

The dew point temperatures are used as an input to the energy budget equation to calculate snowmelt rate. The dew point temperatures are obtained from the meteorological stations in close proximity to LSCS (NOAA 2013d). The hourly data is processed in Microsoft Excel and the maximum dew point temperatures for three consecutive days observed at a general location of LSCS are identified.

3.2.1.5 Maximum Wind Speeds

The wind speeds are used as an input to the energy budget equation to calculate snowmelt rate. The wind speeds are obtained from the meteorological stations in close proximity to LSCS (NOAA 2013d). The hourly data is processed in Microsoft Excel and the maximum wind speeds for three consecutive days observed at a general location of LSCS are identified.

3.2.1.6 Typical Regional Wind Speed

The wind speed typical for the region is obtained from NOAA Climate Maps of the United States (NOAA 2013f).

3.2.1.7 Snow Data

The historical snow depth data are obtained from the meteorological stations located in close proximity to LSCS (NOAA 2013c). The snow density data for the LSCS location is obtained from NOAA Interactive Snow Information website (NOAA 2013e).

3.2.1.8 Mean Monthly Baseflow

The LSCS watershed does not have streamflow gages that could be used to determine the base flows. Additionally, there is no available methodology for the state of Illinois to determine the baseflow arithmetically. Therefore, the baseflow is determined based on the records at the stream flow gages located in close proximity to LSCS.

3.2.1.9 Soil Data

The Natural Resources Conservation Service (NRCS) data is used (NRCS 2013a).

3.2.1.10 Land Use Land Cover Data

The National Land Cover Database 2006 is used (NLCD 2006).

3.2.1.11 Surface Roughness Coefficients

Manning's roughness coefficients are obtained based on the topographical survey and available aerial imagery for LSCS using the guidelines outlined in the Open-Channel Hydraulics (Chow 1959).

3.2.1.12 Ground Surface Topography

The ground surface elevations are collected via LiDAR data acquisition performed in October 2013 (Aerometric 2013a). The pertinent features in the watershed, including buildings, structures, roads, railroad tracks, parking lots, and wall barriers, and the land features, including water, areas with trees and shrubbery, are also depicted from the LiDAR data. Additional ground features at the site are collected during a site ground survey performed by Aerometric in October 2013 (Aerometric 2013b).

3.2.2 Methodology

The maximum water surface elevation in the cooling lake is determined using reservoir-storage routing method using USACE HEC-HMS computer software. The PMF inflow hydrograph for the small unnamed creek (Unnamed Creek) contributing runoff for the cooling lake is derived also using the USACE HEC-HMS computer software. The maximum water surface elevations in the Unnamed Creek are determined using the USACE HEC-RAS computer software. The detailed description of the methods utilized in the PMF analyses is presented below.

3.2.2.1 Alternative 1 Precipitation Input

As described above the precipitation input for the Alternative 1 PMF, the all-season PMF consists of the all-season PMP and an antecedent storm (lesser of 40% PMP or 500-year rainfall).

The all-season PMP estimates for LSCS are derived from the charts presented in the generalized hydrometeorological reports (HMR No.51 and HMR No.52). The PMP estimates are derived based on the site location and site watershed area.

The 500-year rainfall estimates are obtained from NOAA Precipitation Frequency Data Server (NOAA 2013b) for the LSCS location. The estimates of 40% PMP and 500-year rainfall are compared and the 500-year rainfall is a smaller rainfall event and is used for the Alternative 1 PMF.

As a summary, the Alternative 1 precipitation event consists of a 72-hour 500-year rainfall, followed by 3 rainless days and then 72-hour all-season PMP.

3.2.2.2 Alternative 2 Precipitation Input

The precipitation input for Alternative 2 PMF consists of 100-year, snow-season rainfall and coincident snowmelt from the probable maximum snowpack.

The 100-year rainfall estimates are obtained from NOAA Precipitation Frequency Data Server (NOAA 2013b) for the LSCS location. The all-season rainfall values are adjusted to represent the cold-season rainfall values using the methodology outlined in the Rainfall Frequency Atlas of the Midwest (Huff 1992).

The snowmelt rate is calculated using the energy budget equation for the rain-on-snow condition following the guidance outlined in USACE EM 1110-2-1406, Runoff from Snowmelt (USACE 1998). The dew point temperatures used as the input to the energy budget equation are determined from the historical data obtained from the meteorological stations in close proximity to LSCS. The dew point temperatures are determined for the all cool-season months (October to April) and the most conservative values are utilized in the energy-budget equation. The wind speed typical for the region during the cool-season period is used as an input for the energy-budget equation to determine the snowmelt rates from the probable maximum snowpack.

The probable maximum snowpack is assumed to be equal to an unlimited snowpack depth during the entire coincident 72-hour rainfall. While the snowpack can be determined directly from the snow depth, there is not adequate data to reliably extrapolate from the historical observations to the magnitude of the probable maximum event. Any estimated probable maximum snowpack would have an associated physical limit, i.e., maximum snow depth; therefore an unlimited snow depth is a conservative assumption.

As a summary, the Alternative 2 precipitation event consists of a 72-hour 100-year, cool-season rainfall coincident with the snowmelt from the probable maximum snowpack.

3.2.2.3 Alternative 3 Precipitation Input

The precipitation input for Alternative 3 PMF consists of the cool-season PMF coincident with the snowmelt from a 100-year snowpack.

The cool-season PMP estimates for the LSCS location are determined using the charts provided in the Hydrometeorological Report No.53 (HMR No.53) for each cool-season month (October to April).

The snowmelt rate is also determined for each cool-season month using the energy budget equation for the rain-on-snow condition (USACE 1998). The meteorological parameters used as the input to the energy budget equation, dew point temperatures and wind speeds, are determined from the historical data obtained from the meteorological stations in close proximity to LSCS. The maximum dew point temperatures and maximum wind speeds observed at each cool-season months are used as an input to the energy budget to determine the snowmelt rates from a 100-year snowpack.

The snowmelt for the Alternative 3 PMF is limited by a 100-year snowpack. The 100-year snow depth is determined using statistical analysis based on the historical data for snow depth obtained from the meteorological stations in close proximity to LSCS.

As a summary, the Alternative 3 precipitation event consists of a 72-hour cool-season PMP coincident with the snowmelt from a 100-year snowpack.

3.2.2.4 Watershed Delineation

The LSCS watershed is delineated using the ground surface topography (Aerometric 2013a). The subbasins are delineated for the Unnamed Creek, tributary stream for the Unnamed Creek, the drainage area of the cooling lake and the lake area itself.

3.2.2.5 Infiltration Loss Rate

The NRCS Curve Number (CN) method described by Technical Release 55 (TR-55) (NRCS 1986) is used to estimate the losses due to infiltration. The land use / land cover and hydrologic soil group data are used to develop the area-weighted CN values for each sub-basin. No losses are applied to the lake subbasin. The infiltration loss rates are applied only to the all-season PMF. The infiltration losses are ignored for the cool-season PMF alternatives due to an assumption of frozen ground.

3.2.2.6 Unit Hydrograph

The NRCS synthetic unit hydrograph defined in the National Engineering Handbook (NRCS 2007, Chapter 16) is used as the basis to transform rainfall to runoff. For the lake subbasin an instantaneous rainfall to runoff transformation is used. Due to a small size of the subbasin the 5-min unit hydrographs are developed to ensure that the peak runoff is properly represented. For the same reason, the precipitation input is also derived with the 5-minute time step interval to capture the peak runoff. The derived NRCS unit hydrographs are adjusted to account for the non-linear basin response by increasing the peak discharge of the unit hydrograph by one-fifth and decreasing the time to peak by one-third following the guidance outlined in NUREG/CR-7046.

3.2.2.7 Time of Concentration

The time of concentration is a required parameter to determine the lag time for the NRCS unit hydrograph. The time of concentration for each sub-basin is determined following the guidelines outlined in the NRCS TR-55 (NRCS 1986) based on the travel times. Time of concentration is the sum of the travel times for consecutive flow segments of sheet flow, shallow concentrated flow, and channel flow.

3.2.2.8 Lake Modeling

The lake is modeled using the reservoir routing method in the HEC-HMS software. The elevation-storage data is derived from the topographical survey (Aerometric 2013a). The discharge from the lake occurs through the uncontrolled auxiliary spillway, which is a trapezoidal cut in the lake dike. A broad crested weir discharge coefficient equal to 2.6 is utilized. The gate-controlled service spillway, used to discharge water from the cooling lake to the Illinois River, is assumed to be non-functional during the entire PMF event (including the antecedent storm).

3.2.2.9 Temporal Distribution

The temporal distributions evaluated are: front (hour 1), one-third (hour 24), center (hour 36), two-thirds (hour 48) and end (hour 72) peaking events.

3.2.2.10 Hydrologic Modeling

Hydrologic modeling is performed using USACE HEC-HMS computer software. The various precipitation estimates are applied to the basin models using time series precipitation gages. Base flow is applied as a constant flow rate. The NRCS Curve Number loss method is used. A user-specified unit hydrograph rainfall-runoff transform method is used by applying the modified unit hydrographs that account for the effects of nonlinear basin response. The cooling lake is modeled using reservoir storage routing. The HEC-HMS model produces results for the water surface elevation in the lake and flow hydrograph in the Unnamed Creek for future use in the hydraulic model.

3.2.2.11 Hydraulic Modeling

Hydraulic modeling for the Unnamed Creek is performed using USACE HEC-RAS computer software. Cross sections are designated along the Unnamed Creek and the channel geometry is obtained using USACE HEC-GeoRAS computer software. The channel geometry is created using the ground surface topography developed via LiDAR data acquisition (Aerometric 2013a). The HEC-RAS unsteady-state model is used to analyze the flow hydrographs obtained from the HEC-HMS hydrologic model to determine the water surface elevation at each cross section.

3.2.2.12 Vertical Datum

The elevations at LSCS are referenced to MSL vertical datum as stated in the UFSAR. The ground surface topography and the site-related features are referenced to North American Vertical Datum of 1988 (NAVD88). The vertical datum difference between NAVD88 and MSL is obtained from Survey Control Report (Aerometric 2013b). From the Survey Control Report, the vertical datum difference is equal to NAVD88 – MSL = 0.22 ft.

3.2.3 Results

The three PMF alternatives (all-season and cool-season) are analyzed. The Alternative 1, the all-season PMF, results in the highest water surface elevation in the cooling lake and in the largest flow hydrograph for the Unnamed Creek.

The maximum water surface elevation in the LaSalle Cooling Lake due to the PMF event at LSCS watershed is determined to be equal to 705.90 ft NAVD88 or 705.68 ft MSL. The maximum water surface elevation in the Unnamed Creek due to the PMF event at LSCS watershed is determined to be equal to 706.67 ft NAVD88 or 706.45 ft MSL.

3.2.3.1 Groundwater Ingress

Section 2.4.13.5 of the UFSAR states that the groundwater level assumed for calculation of hydrostatic loading on the power plant foundations is elevation 700.00 ft MSL, which is equivalent to the normal pool elevation of the cooling lake. The design groundwater level is based on the assumption that granular fill around the plant foundations will be hydraulically connected with the cooling lake through the granular fill around the intake pipelines. The groundwater level in the granular fill around the plant foundations would reflect the cooling lake level.

The UFSAR states that the granular fill around the plant foundations is covered with 20 feet of essentially impermeable, compacted clay. In addition, the surrounding clayey till is also essentially impermeable. Due to the compacted clay cover and clayey till, it is expected that infiltration of precipitation during the H.1 combination would likely be minimal.

Due to the fact that the granular fill around the plant foundation is hydraulically connected with the cooling lake, the groundwater level might be expected to be equivalent to the still-water level in the lake. The maximum still-water level in the lake is equal to 705.68 ft MSL due to the all-season PMF.

3.2.4 Conclusions

The maximum water surface elevation in the Cooling Lake is 4.32 ft below the plant grade elevation and 4.82 ft below the finished floor elevation. Therefore, the PMF event in the Cooling Lake does not result in the flooding hazard for LSCS. The maximum water surface elevation in the Unnamed Creek is 3.55 ft below the plant grade elevation and 4.05 ft below the finished floor elevation. Therefore, the PMF in the Unnamed Creek does not result in a flooding hazard for LSCS.

The CLB maximum still-water surface elevation in the cooling lake due to the PMF is equal to 704.3 ft MSL (UFSAR). The reevaluated maximum still-water surface elevation in the cooling lake due to the PMF exceeds the CLB maximum water surface elevation. Note that the mentioned above still-water surface elevations do not include the wind-generated wave activities. The effects from the wind-generated waves are described in Section 3.4.

3.3 Probable Maximum Storm Surge and Seiche

The probable maximum storm surge (PMSS) and probable maximum seiche (PMS) are analyzed in Calculation L-003858, Beyond Design Basis Storm Surge and Seiche & Tsunami Screening for Lake (Fukushima) (Exelon 2014f).

The storm surge analysis is performed following the guidance outlined in NUREG/CR-7046, ANSI/ANS-2.8-1992, JLD-ISG-2012-06 (NRC ISG-2012-06), and NUREG/CR-6966. NUREG/CR-7046, Appendix H.4 describes the combined events criteria for an enclosed body of water, which is appropriate for analyzing surge and seiche flooding at LSCS cooling pond. NRC JLD-ISG-2012-06 requires: "all coastal nuclear power plant sites and nuclear power plant sites located adjacent to cooling ponds or reservoirs subject to potential hurricanes, windstorms, and squall lines must consider the potential for inundation from storm surge and wind waves." The LSCS is not a coastal location; however, the LSCS cooling pond could be subjected to storm surge (wind setup and wave setup) due to severe wind storms.

For assumptions applied to the analysis see Calculation L-003858, Beyond Design Basis Storm Surge and Seiche & Tsunami Screening for Lake (Fukushima) (Exelon 2014f).

3.3.1 Inputs

The inputs for the analysis are described below.

3.3.1.1 Cooling Lake Bathymetry (Lake Bottom Topography)

The cooling lake bottom topography (bathymetry) in the format of a Digital Elevation Model (DEM) is created based on the Cooling Lake construction drawings (Exelon 2013a) using ArcGIS computer software in Calculation L-003857, Beyond Design Basis GIS Data Processing Calculation (Fukushima), (Exelon 2014e).

3.3.1.2 Ground Surface Topography

The ground surface elevations are collected via LiDAR data acquisition performed in October 2013 (Aerometric 2013a). The LiDAR data is processed to produce data in various required formats using ESRI ArcGIS software in Calculation L-003857 (Exelon 2014e).

3.3.1.3 Atmospheric Forcing (Wind)

A constant over-water wind speed equal to 100 mph is used to initiate a storm surge/seiche event at LSCS cooling lake. The wind speed is selected conservatively following the guidance outlined in the ANSI/ANS-2.8-1992.

3.3.1.4 Initial Lake Water Level

Based on NUREG/CR-7046, a 100-year or maximum controlled level in water body, whichever is less should be used as the water level for the probable maximum surge and seiche event analysis. The 100-year water level in LaSalle Cooling Lake is not available as no gage stations exist for this lake. Therefore, the maximum controlled water level equal to 700 ft MSL (UFSAR) is used as the initial water surface elevation at the beginning of the precipitation events.

3.3.1.5 Lake Bottom Roughness Coefficient

The Manning's roughness coefficient for dredged earth channels equal to 0.02 is used (Chow 1959).

3.3.1.6 Hourly wind data

The wind data is obtained from Chicago/Midway International Airport (NOAA 2013g). The data is used to calculate natural oscillation period of external forcing events (wind storms).

3.3.2 Methodology

The probable maximum storm surge on the LSCS cooling lake is simulated by applying the probable maximum wind storm caused by a 100-mph overland wind speed. The probable maximum seiche on the cooling lake is modeled by applying the forcing element, the wind speed, with amplitude close in magnitude to the amplitude of the cooling lake.

The wind speed is assumed to be perfectly aligned in the critical fetch direction.

3.3.2.1 Storm Surge

Storm surge is the rise in offshore water elevation caused principally by the shear force of the wind due to hurricanes, extra-tropical storms, or squall lines acting on the water surface. Storm surge is the product of four processes: pressure setup, wind setup, wave setup, and incident wave runup. The LSCS cooling pond is too small in size to be affected by moving pressure gradients; therefore, pressure term was not used. The incident wave runup is determined separately in Calculation L-003861, Beyond Design Basis External Flooding Combined Events Analysis (Fukushima), (Exelon 2014i).

The Probable Maximum Storm Surge (PMSS) is the surge that results from a combination of meteorological parameters of a probable maximum hurricane or probable maximum wind storm. According to ANSI/ANS-2.8-1992, for the area of the Great Lakes region, the probable maximum surge and seiche should be calculated from the Probable Maximum Winds Storm (PMWS). ANSI/ANS-2.8-1992 further indicates that parameters of the PMWS should be determined by a meteorological study. However, in lieu of a study for the Great Lakes, the following may be used:

1. Set maximum over-water wind speed at 100 mph (~ 45 m/s).
2. Set lowest pressure within the PMWS to 950 mbar.
3. Apply a most critical, constant translational speed during the life of the PMWS.
4. Assume the wind speeds over water vary diurnally from 1.3 (day) to 1.6 (night) times the overland speed.
5. Assume that all winds blow 10 degrees across the isobars over the water body.

The Delft3D computer model was used to evaluate the PMSS on LSCS cooling lake. The Delft3D model is set up following the ANSI/ANS-2.8-1992 guidance and is run to simulate 9-hours of real time computation with water level outputs at intervals of 1-minute. The model simulation time does not represent a storm duration time, rather the model simulation time (9-hours) extends long enough for the model to reach dynamic equilibrium at a "steady state" maximum wind and wave setup. As such, the storm surge still water level, and applied wind were held constant throughout the model simulation.

3.3.2.2 Storm Seiche

Seiches may originate from a number of different surface and atmospheric disturbances, of which wind is thought to be the most important. Enclosed basins have certain natural frequencies of seiche, depending on the geometry of the water boundaries and the bathymetry of water depths. NUREG/CR-7046 states that amplified seiche or resonance occurs when an atmospheric disturbance's period (mainly wind, seismic) matches the natural fundamental lake period.

JLD-ISG-2012-06 noted that "for water bodies with variable bathymetry and irregular shorelines, seiche periods and water surface elevation should be determined by numerical modeling." Due to the configuration of the Cooling Lake and the presence of berms located in the Cooling Lake, the storm surge and seiche evaluation was performed using the Delft3D numerical model.

The HHA approach described in NUREG/CR-7046 was used to determine whether a seiche can result in significant flooding at LSCS. This approach involves:

1) Determination of the natural oscillation periods of external forces such as extra-tropical storms
2) Evaluation of the natural period of the Cooling Lake,
3) Comparison of Step-1 and Step-2 oscillation periods to determine if resonance is possible
4) If resonance is possible, compute the potential seiche amplitude by applying the external forcing at the resonance period of the Cooling Lake.

3.3.2.3 Natural Oscillation Periods of External Forces (Wind Storm Frequency/Period)

Hourly wind speed, wind direction, and pressure data are available from Midway International Airport which lies approximately 100 miles east of LSCS. Spectral analyses for the three major historical non-convective wind storm events were performed by applying a Fast Fourier Transform (FFT) in Microsoft Excel to identify the fundamental frequencies in the wind record.

Due to lack of detailed wind and pressure data that captures isolated non-convective weather systems such as squall lines, natural frequencies for these types of storms are not calculated. Instead, a scenario is created such that the wind forcing (PMWS of 100 mph) is turned on and off in the Delft3D model at the resonance period of the Cooling Lake to induce a "forced oscillation" and to evaluate potential seiche due to these fast moving storm systems. Wind frequencies at the resonance period of the Cooling Lake are used to characterize the wind field of a non-convective weather system such as squall lines.

3.3.2.4 Natural Period of the LaSalle Cooling Lake

The natural period of a lake is primarily a function of its geometry and basin depth and is independent of external forcing mechanisms. Seiche periods can be extracted from observations, modeled, calculated by spectral analyses or by using Merian's formula. In this study spectral analyses are performed by applying a FFT (in Excel) to the Delft3D output water level time series data, similar to the spectral analyses of the wind speed time series, to identify the fundamental frequency or frequencies of the LSCS cooling lake.

Using the Delft3D simulation and then spectral analysis is a more suitable approach than Merian's formula because the 2D hydrodynamic model takes into account the 2D dimensionality of the Cooling Lake and variable bathymetry while the simplified approach that utilizes Merian's formula does not.

3.3.2.5 Probable Maximum Wind Storm for Seiche Evaluation: Free Oscillations

The basic theory of seiche oscillations is similar to the theory of free and forced oscillations of mechanical, electrical, and acoustical systems. The systems respond to an external forcing (e.g., wind) by developing a restoring force that re-establishes equilibrium in the system.

The maximum over-water wind speed used for seiche analysis is equal to 100 mph (~ 45 m/s in the Delft3D model). The cooling lake is too small in size to be affected by moving pressure gradients; therefore, a pressure term is not used for surge and seiche modeling. Based on the geometry of the cooling lake, winds from western and eastern directions provide longer fetches. Therefore, the critical wind directions for computing the seiche period and amplitude are from east to west (~ 90 degrees) and from west to east (~ 270 degrees) using the nautical convention of Delf3D.

3.3.2.6 Seiche Water Level Modeling

Delft3D is used to investigate any oscillating motions of a seiche in the LSCS cooling lake due to a wind forcing along the longitudinal axis of the lake. The model is run to simulate 9-hours of real time with water level outputs at intervals of 1-minute. The model is forced by a constant 100 mph (45 m/s in the Delft3D model) for 4.5 hours, and the forcing wind is removed for the remaining simulation time in order to model the "free oscillation" (once the storm has passed).

For wind-induced seiches, the height of the initial seiche wave is equivalent to the highest storm surge unless there is resonance. Resonance is the amplification of the seiche water level. Resonance occurs when the dominant frequencies of the external forcing match the fundamental frequencies of the basin.

Because the period of the LSCS cooling lake is less than the available 1-hour time sampling interval for wind data at Midway International Airport, a scenario is created such that the wind forcing is fictitiously turned on and off in the Delft3D model at the same period as the free oscillation period of the cooling lake to induce a "forced oscillation" and to potentially cause an increase in the seiche amplitude.

3.3.2.7 Delft3D Model Set-up

There are three different types of wave computations within the Delft3D module:

1) A WAVE computation that uses user-defined flow properties: for each wave condition, where the modeler specifies a spatially uniform water level and a spatially uniform current velocity, so that the effect of flow on waves is accounted for
2) An offline coupling of WAVE with Delft3D-FLOW: the wave computation uses flow characteristics from a completed Delft3D-FLOW computation, so that the effect of flow on waves is accounted for
3) An online coupling of WAVE with Delft3D-FLOW: the WAVE model has a dynamic interaction with the FLOW module of Delft3D (i.e. two way wave-current interaction). Through this coupling, both the effect of waves on current and the effect of flow on waves are accounted for

For the LSCS Delft3D model, the third option (i.e., online coupling of Delft3D-WAVE with Delft3D-FLOW) is used so that the effect of waves on current and the effect of flow on waves are accounted for. Data is exchanged between the FLOW and WAVE module using a so-called communication file (com-file), which contains the most recent data of the flow and wave computations.

The coupled model is implemented to produce 1-minute water level and wave characteristics information in the lake.

3.3.2.8 Delft3D Computational Grid

Development of a surge model grid or mesh that accurately characterizes the irregular shape and variability in water depth throughout a lake is an important step to properly simulate wind and pressure induced water-level changes and seiche motions. The computational time of a numerical model is directly related to the grid size and the computational time step. Additionally, the grid size must be small enough to provide not only a sufficient description of the lake geometry but also to describe the bottom topography accurately.

Two modes of grid generation are acceptable for Delft3D, curvilinear grids and rectangular grids. Curvilinear grids are applied in finite difference models to provide a high grid resolution in the area of interest and a low resolution elsewhere to decrease computational time by the computer. Curvilinear grids can be generated to take the shape of a coastline, river, structure or other physical features. Rectangular grids provide equal resolution over the computational area in the form of equally sized grid cells. For this calculation, a single layer, rectangular grid is used. The rectangular grid tends to have better model stability because the orthogonality, smoothness and aspect ratio of the grid are automatically set within the recommended limits when a rectangular grid is created in Delft3D. The grid resolution of the cooling lake model is selected to be as fine as possible, subject to computer computational time currently available.

3.3.2.9 Wave Propagation/Transformation

As per ANSI/ANS-2.8-1992, controlling offshore incident waves shall be transformed to the site taking into account shoaling, refraction, diffraction, and reflection. The SWAN, which is a part of the Delft3D modeling package, accounts for (refractive) propagation due to current and depth and represents the processes of wave generation by wind, dissipation due to whitecapping, bottom friction and depth-induced wave breaking and non-linear wave-wave interactions (both quadruplets and triads) explicitly.

3.3.2.10 Vertical Datum

All the elevations from the Delft3D model are referenced to meters-NAVD88 vertical datum and then converted to the plant MSL vertical datum using the benchmark controlling elevations determined during site survey (Aerometric 2013b). The elevation difference between NAVD88 and LSCS MSL vertical datum is equal to 0.22 ft (NAVD88, feet = LSCS MSL, feet + 0.22 feet).

3.3.3 Results

As the result of the probable maximum storm surge and seiche analysis, the maximum water surface elevations in the lake, caused by these phenomena, are determined. These maximum water elevations include the wind setup and wave setup and are called still-water elevations.

Additionally, the wave characteristics, such as wave length and wave period, are determined. The wave characteristics are used as input parameters into the wave runup computations performed in *Calculation L-003861, Beyond Design Basis External Flooding Combined Events* Analysis (Fukushima), (Exelon 2014i).

3.3.3.1 Probable Maximum Storm Surge Results

The Delft3D modeling results shows that a wind blowing along the longest fetch direction (east to west or 90 degrees) causes the largest surge. Storm surge resulting from this PMWS event would produce a maximum surge of 2.71 feet, with a resultant maximum still-water elevation of 702.71 ft MSL at Delft3D observation station in front of the lake screen house.

3.3.3.2 Probable Maximum Seiche Results

A spectral analysis of wind speed data (1-hour recording time interval) for three historical non-convective historical events is performed by applying a FFT in Excel. The spectral analysis shows a dominating fundamental period of 85 hours for two wind storms and 171 hours for the third wind storm. Wind speed data at a time interval of less than 1-hour would have been preferred for spectral analysis to capture potential oscillation periods of less than 1 hour in wind storms. However, data at less than a 1-hour recording time interval is not available from the nearby meteorological stations at this time.

Based on the spectral analysis performed for the lake the fundamental water level mode (fundamental period) of LaSalle cooling lake is 16 minutes, which is significantly smaller than the fundamental period of the forcing mechanism. A conclusion could be made that seiche is not plausible for the LSCS Cooling Lake. However, because only hourly wind speed data is available, the spectral analysis for the forcing mechanism might have missed the oscillation periods less than 1 hour. Therefore, a hypothetical wind storm is created with the fundamental period corresponding to the fundamental period of the lake, i.e. approximately 16 minutes.

As a result of the hypothetical wind storm event with the assumed fundamental period, the probable maximum seiche event (PMS), the maximum seiche height is equal to 4.05 ft with a resultant maximum still-water elevation of 704.05 ft MSL at Delft3D observation station in front of the lake screen house.

3.3.4 Conclusions

The maximum still-water elevations caused by the probable maximum storm surge (702.71 ft MSL) and by the probable maximum seiche (704.05 ft MSL) are significantly lower than the LSCS plant grade elevation of 710.0 ft MSL and floor elevations of 710.5 ft MSL.

The wave runup is determined separately in Calculation L-003861, Beyond Design Basis External Flooding Combined Events Analysis (Fukushima), (Exelon 2014i) and added to the still-water elevations.

The CLB does not consider flooding due to the probable maximum surge and seiche.

3.4 Combined Events Flood

NUREG/CR-7046, Appendix H states that the following combinations of flood causing events provide an adequate design basis for shore and streamside locations:

H.1 Flooding in Rivers and Streams

Alternative 1 – Combination of:

- Mean monthly base flow
- Median soil moisture
- Antecedent or subsequent rain: the lesser of 1) rainfall equal to 40% PMP and 2) a 500-year rainfall
- The PMP
- Waves induced by 2-year wind speed applied along the critical direction.

Alternative 2 – Combination of:

- Mean monthly base flow
- Probable maximum snowpack
- A 100-year, snow-season rainfall
- Waves induced by 2-year wind speed applied along the critical direction.

Alternative 3 – Combination of:

- Mean monthly base flow
- A 100-year snowpack
- Snow-season PMP
- Waves induced by 2-year wind speed applied along the critical direction.

The three PMF alternatives described above are addressed in Section 3.2 except the coincident wind wave activity caused by the 2-year wind speed applied along the critical direction. The Alternative 1, the all-season PMF, is the critical scenario for the LSCS cooling lake. The combination of the flood with the wind waves is addressed in this section of the report.

H 4.1 Shore Location

Combination of:

- Probable maximum surge and seiche with wind-wave activity
- 100-year or maximum controlled level in water body, whichever is less

H.4.2 Streamside location

Alternative 1 – Combination of:

- The lesser of one-half of the Probable Maximum Flood (PMF) or the 500-year flood
- Surge and seiche from the worst regional hurricane or windstorm with wind-wave activity
- The lesser of the 100-year or the maximum controlled water level in the enclosed body of water.

Alternative 2 – Combination of:

- PMF in the stream
- A 25-year surge and seiche with wind-wave activity
- The lesser of the 100-year or the maximum controlled water level in the enclosed body of water

Alternative 3 – Combination of:

- A 25-year flood in the stream
- Probable maximum surge and seiche with wind-wave activity
- The lesser of the 100-year or the maximum controlled water level in the enclosed body of water.

The H.4.1 combination is analyzed in Calculation L-003858, Beyond Design Basis Storm Surge and Seiche Analysis & Tsunami Screening for Lake (Fukushima) (Exelon 2014f).

The H.4.2 combinations are analyzed in Calculation L-003861, Beyond Design Basis External Flooding Combined Events Analysis (Fukushima), (Exelon 2014i). The surge/seiche events with appropriate intensity or frequency as required in the alternatives described above are generated by wind speed with corresponding intensity or frequency. The wind speeds used to generate surge/seiche event on the lake are also used to calculate wind-wave runup.

For assumptions applied to the analysis see Calculation L-003861, Beyond Design Basis External Flooding Combined Events Analysis (Fukushima), (Exelon 2014i).

3.4.1 Inputs

The inputs for the analysis are described below.

3.4.1.1 Probable Maximum Surge and Seiche

The probable maximum surge and seiche are determined in Calculation L-003858, Beyond Design Basis Storm Surge and Seiche Analysis & Tsunami Screening for Lake (Fukushima) (Exelon 2014f). The probable maximum seiche is a hypothetical event applied to the cooling lake and it exceeds the probable maximum surge. Therefore, the resulting still-water elevation and corresponding wave characteristics due to the probable maximum seiche are used to determine the wave runup.

3.4.1.2 2D Hydraulic Model for Lake

The 2-Dimensional hydraulic model (Delft3D) for the lake is developed in Calculation L-003858, Beyond Design Basis Storm Surge and Seiche Analysis & Tsunami Screening for Lake (Fukushima) (Exelon 2014f). This model is used to determine the probable maximum surge and seiche. The same model is used to determine other wind generated events on the lake for the H.4.2 combinations described above.

3.4.1.3 Probable Maximum Precipitation (PMP)

It is assumed that the one-half PMF event required to be considered for combination H.4.2, Alternative 1 is caused by one-half of the all-season PMP. The all-season PMP is determined to be a governing scenario compared to the cool-season precipitation alternatives (Exelon 2014c).

The PMP for LSCS watershed, which is also the watershed of the cooling lake, is determined in Calculation L-003853, Beyond Design Basis Probable Maximum Precipitation Analysis (Fukushima), (Exelon 2014a).

3.4.1.4 PMF on Lake

The PMF on the cooling lake, including the maximum lake water level due to PMF, is determined in Calculation L-003855, Beyond Design Basis Probable Maximum Flood Analysis for Lake (Fukushima), (Exelon 2014c).

3.4.1.5 Hydrologic Model for Lake

The hydrologic model for the cooling lake (HEC-HMS) is developed in Calculation L-003855, Beyond Design Basis Probable Maximum Flood Analysis for Lake (Fukushima), (Exelon 2014c). This model is used to determine maximum water level in the lake due to the PMF. The same hydrologic model is used to determine the water level in the lake due to other precipitation events for the H.4.2 combinations described above.

3.4.1.6 500-Year Rainfall

The 500-year rainfall estimates are determined in Calculation L-003853, Beyond Design Basis Probable Maximum Precipitation Analysis (Fukushima), (Exelon 2014a). The 500-year rainfall estimates are developed based on the point precipitation values obtained from the NOAA Precipitation Frequency Data Server (NOAA 2013b) for the location of LSCS.

3.4.1.7 25-Year Rainfall

The 25-year point precipitation values are obtained from the NOAA Precipitation Frequency Data Server (NOAA 2013b) for the location of LSCS from which the 25-year rainfall estimates are developed.

3.4.1.8 2-Year Wind Speed

The 2-year wind speed applicable to the location of LSCS is obtained from a generalized map presented in ANSI/ANS-2.8-1992.

3.4.1.9 Worst Regional Windstorm

The maximum wind speed observed at close proximity to LSCS is used as the worst regional windstorm. The highest observed wind speeds applicable for the LSCS location are obtained from the NRCS, National Water and Climate Center FTP website (NRCS 2013b).

3.4.1.10 25-Year Wind Speed

The 25-year wind speed is determined based on the annual wind speeds with various probabilities applicable for the LSCS region.

3.4.1.11 Fetch Length

The fetch length is measured using ArcGIS computer software based on the Aerial Topographic Map developed from the LiDAR data (Aerometric 2013a).

3.4.2 Methodology

The analysis of the combined events is performed based on the guidelines outlined in ANSI/ANS-2.8-1992 and NUREG/CR-7046. The wind wave parameters and effects are determined using the guidance and methodology outlined in the USACE Coastal Engineering

Manual EM 1110-2-1100 (USACE 2008). The detailed methodology used in the analysis is presented below.

3.4.2.1 One-Half PMF

The one-half PMF is modeled by applying the one-half PMP over the cooling lake watershed.

The all-season PMF HEC-HMS model developed in Calculation L-003855 (Exelon 2014c) is modified to use the one-half of the PMP as a precipitation input. As the result, the one-half PMF maximum water surface elevation in the lake is determined.

3.4.2.2 500-Year Flood

A 500-year flood is modeled by applying a 500-year rainfall over the cooling lake watershed.

The all-season PMF HEC-HMS model developed in Calculation L-003855 (Exelon 2014c) is modified to use a 500-year rainfall as a precipitation input. As the result, the maximum water surface elevation in the lake due to a 500-year flood is determined.

The combination H.4.2, Alternative 1 requires to use the lesser of one-half of the PMF or the 500-year flood. The 500-year flood is determined to be a smaller event for the LSCS cooling lake as it results in a lower maximum water surface elevation in the lake. Therefore, the maximum water surface elevation in the lake due to a 500-year flood is used as the starting water level for the H.4.2, Alternative 1 combination.

3.4.2.3 25-Year Flood

A 25-year flood is modeled by applying a 25-year rainfall over the cooling lake watershed.

The all-season PMF HEC-HMS model developed in Calculation L-003855 (Exelon 2014c) is modified to use a 25-year rainfall as a precipitation input. As the result, the maximum water surface elevation in the lake due to a 25-year flood is determined.

3.4.2.4 Wind Speed Adjustments

The wind speeds (2-year, 25-year, and the maximum wind speed) are adjusted following the guidance outlined in USACE Coastal Engineering Manual (USACE 2008) for level (measurement height), duration, and wind speed over water vs. wind speed over land.

3.4.2.5 Surge and Seiche from Worst Regional Windstorm

The surge and seiche from the worst regional windstorm is modeled by applying the wind with the maximum velocity observed at close proximity to LSCS. There are no historical records for the surge and seiche activities on the LSCS cooling lake as the lake is small. Therefore, a hypothetical surge and seiche has to be generated by applying an appropriate forcing mechanism, in this case wind.

The forcing mechanism, the wind with the maximum velocity (velocity is constant), is applied to the Delft3D model along the critical direction.

3.4.2.6 25-Year Surge and Seiche

The 25-year surge and seiche is modeled by applying the wind speed with a 25-year reoccurrence interval (4% exceedance probability) determined for the LSCS region. There are no historical records for the surge and seiche activities on the LSCS cooling lake as the lake is small. Therefore, a hypothetical surge and seiche has to be generated by applying an appropriate forcing mechanism, in this case wind.

The wind velocities for the exceedance probability of 1%, 5% and 10% are available from NOAA Climatic Maps (NOAA 2013f). The 25-year, or 4% exceedance probability, wind speed is determined by applying a second order polynomial regression equation to the known values using Microsoft Excel.

The forcing mechanism, the wind with a 25-year velocity (velocity is constant), is applied to the Delft3D model along the critical direction.

3.4.2.7 2-Year Wind Speed

The wind velocities for the exceedance probability of 1%, 5% and 10% are available from NOAA Climate Maps (NOAA 2013f). The 2-year, or 50% exceedance probability, wind speed is not readily available from the NOAA Climate Maps. In lieu of the site-specific wind analysis the 10-year, or 10% exceedance probability, extreme wind speed is used instead of the 2-year wind speed. The approach is conservative as the 10-year wind speed is a more conservative, higher, value than a 2-year wind speed.

3.4.2.8 Combined Event Modeling

The combined events are modeled using the Delft3D computer software. The Delft3D model for the LSCS cooling lake is developed for the probable maximum surge and seiche analysis (Exelon 2014f).

The Delft3D model is modified to use the lake water level due to the flooding event as a starting water level (pre-storm) and the appropriate wind velocity as a forcing mechanism. As an example, for the H.4.2 Alternative 1 the lake maximum water level due to a 500-year flood is used as a starting water level in the Delft3D model. The wind with the maximum velocity (worst regional windstorm) is used as the forcing mechanism for this combination.

The wind is applied in two directions. Wind applied from east to west (the critical direction) causes the maximum water levels at the location of the lake screen house. Wind applied from west to east results in significantly lower water surface elevations in the lake. However, the scenario is examined to assess the maximum water levels at the location of the discharge structure at the west side of the plant.

3.4.2.9 Wave Runup and Maximum Wave Height

The wave runup is determined following the guidelines outlined in the USACE Coastal Engineering Manual (USACE 2008).

The maximum wave runup is calculated based on the significant wave height using irregular waves approach as these are more descriptive of waves seen in nature. A surf similarity parameter is used to determine the wave runup, which is dependent on the deep water wave length and wave period. The wave parameters (wave length and wave period) are determined from the Delft3D modeling results. The deep water wave condition is verified in accordance to USACE Coastal Engineering Manual guidance.

For the wave runup on smooth vertical surfaces (wall of the lake screen house) the maximum wave runup is limited to 2.5 times significant wave height based on the methodology described in the USACE CERC-90-4 (USACE 1990).

The maximum wave height is equal to the significant wave height multiplied by 1.67 (ANSI/ANS-2.8-1992).

The maximum water surface elevation is determined by summing the maximum still water elevation (starting water level + setup) and the maximum wave runup or maximum wave height, whichever is higher.

3.4.2.10 Wave Load

The wave load is determined following the guidance outlined in the American Society of Civil Engineers (ASCE) Standard 7-10 (ASCE 7-10). The wave load is the force that results from a breaking wave acting on a vertical surface of a structure. The maximum wave height is used as a breaking wave height in order to determine the wave load on the safety-related structures. The safety-related structures subject to the wave loads are the lake screen house and the CSCS inlet structure.

3.4.3 Results

The critical combination of events is the Combination H.4.2, Alternative 3, the 25-year flood on the lake combined with the probable maximum seiche.

3.4.3.1 Maximum Water Levels

The maximum water surface elevations in the lake due to the H.4.2, Alternative 3 scenario are presented in Table 3.4.3.1.

Table 3.4.3.1 – Lake Maximum Water Surface Elevations due to Combined Events

Location	**Max Water Level** (still-water level + runup or max. wave height) (ft MSL)
Lake Screen House	710.55
CSCS Inlet Structure	712.04

The combined events flooding could potentially result in the lake impounding dike failure. However, this will not affect any safety related structures or the UHS. As discussed in Section 2.2.9 in the event of a breach of the peripheral dikes, emergency shutdown water supply would be obtained from the UHS, which is an excavated pond within the cooling lake.

3.4.3.2 Flood Duration

The duration of the flooding due to the combined events is not directly applicable to LSCS because the site is not flooded. The only structures that are affected by the combined events flood are the lake screen house and the CSCS inlet structure. There are no actions warranted due to the combined events flood.

3.4.3.3 Wave Loads

The wave loads are determined as force per unit length of structure (lb/ft). To determine the force for the entire structure the loads need to be multiplied by the structure length. The loads on the lake screen house and the CSCS inlet structure are presented in Table 3.4.3.3.

Table 3.4.3.3 – Wave Loads due to Combined Events

Location	Wave Force (lb/ft)
Lake Screen House	1,134
CSCS Inlet Structure	4,759

3.4.3.4 Warning Time

A probable maximum storm seiche event at LSCS cooling lake has no appreciable warning time except those provided by a weather (extreme wind) forecast.

3.4.3.5 Debris Loads

The watershed of the cooling lake and LSCS is small, 5.066 square miles. The surrounding area land cover is cultivated crops and grass. There are no areas with dense forest or other heavy debris around the lake that could cause significant debris loads. Therefore, the debris load is not a plausible hazard for LSCS.

3.4.3.6 Groundwater Ingress

Section 2.4.13.5 of the UFSAR states that the groundwater level assumed for calculation of hydrostatic loading on the power plant foundations is elevation 700.00 ft MSL, which is equivalent to the normal pool of the cooling lake. The design groundwater level is based on the assumption that granular fill around the plant foundations will be hydraulically connected with the cooling lake through the granular fill around the intake pipelines. The groundwater level in the granular fill around the plant foundations would reflect the cooling lake level.

The UFSAR states that the granular fill around the plant foundations is covered with 20 feet of essentially impermeable, compacted clay. In addition, the surrounding clayey till is also essentially impermeable. Due to the compacted clay cover and clayey till, it is expected that infiltration of precipitation during the H.1 combination would likely be minimal.

Due to the fact that the granular fill around the plant foundation is hydraulically connected with the cooling lake, the groundwater level might be expected to be equivalent to the still-water level in the lake. The maximum still-water level in the lake is equal to 705.68 ft MSL due to H.1 combination, the all-season PMF, and to 701.02 ft MSL due to H.4 combination.

3.4.3.7 Erosion and Sediment Deposition

Because the lake is an enclosed body of water, unlike an open river, an appreciable sediment transport is not expected.

3.4.3.8 Scour

Scour is not a plausible mechanism for LSCS due to absence of major streams with high flow velocities in close proximity to the site. The Unnamed Creek is the largest stream where scour is possible and it would not cause any hazard to the site as the runoff from the stream is discharged directly to the cooling lake and does not affect any plant structures.

3.4.3.9 Errors and Uncertainties

The errors and uncertainties potentially affecting the results determined from the combined events flooding are analyzed in Calculation L-003862, Beyond Design Basis External Flooding Error/Uncertainty Analysis (Exelon 2014j).

It is determined that the calculated water surface elevations resulting from the combined events flooding at LSCS can be potentially affected by the errors and/or uncertainties associated with the following:

- 25-year rainfall estimates
- Depth-induced wave breaking parameter
- Wave bottom friction coefficient (Delft3D model)
- Surface roughness coefficient for the bottom of the lake (Delft3D model)
- Wave computational method (Delft3D model)

The results of determined errors/uncertainties are presented in Table 3.4.3.4.

Table 3.4.3.4 – Errors/Uncertainties for Combined Events Flooding Results

Parameter	Associated Error
25-Year rainfall estimates	0.07 ft
Depth-induced wave breaking parameter	0.004 ft
Wave bottom friction coefficient	0.003 ft
Surface roughness coefficient	0.283 ft
Wave computational method	0.014 ft

3.4.4 Conclusions

The maximum still-water level in the lake is equal to 705.68 ft MSL due to H.1 combination, the all-season PMF, and to 701.02 ft MSL due to H.4 combination.

The maximum water surface elevation at the lake screen house, including wave runup, is equal to 710.55 ft MSL. The maximum water surface elevation at the CSCS inlet structure, including wave runup, is equal to 712.04 ft MSL.

The maximum still-water elevation occurs due to the H.1 combination and maximum elevation with wind-wave runup occurs due to H.4.2 combination.

Even though the maximum water elevation, including runup, at the lake screen house is above the plant grade elevation (710.0 ft MSL), this does not result in a flooding hazard for the site because the lake water level is below the top of the intake flume. The elevation of the ground surface around the screen lake house and intake flume is at approximately 714 ft NAVD88, or 713.78 ft MSL (Aerometric 2013a). Therefore, the water at its maximum level is contained in the intake flume.

The maximum water elevation in the lake, including wave runup, at the west side of the plant is equal to 707.25 ft MSL. This elevation is below the plant grade elevation of 710.0 ft MSL and plant floor elevation of 710.5 ft. The available margin between the maximum water level and plant floor elevation is equal to 3.25 ft (710.5 ft MSL – 707.25 ft MSL = 3.25 ft).

The CLB does not consider flooding due to the H.4 combination of events.

The combined-effect floods bound individual flood-causing mechanisms, including still-water levels and associated effects (i.e. flooding in rivers and streams, surge, seiche, etc.).

3.5 Ice-Induced Flooding

The ice-induced flooding is analyzed in Calculation L-003860, Beyond Design Basis Ice-Induced Flood and Channel Migration Analysis (Fukushima), (Exelon 2014h). There are no historical records available for the ice jams at the streams in the LSCS watershed. However, the ice jams have occurred in the streams in the same region. Therefore, this phenomenon is plausible for the LSCS watershed. It is determined that in the unlikely event of an ice jam in the Unnamed Creek the resulting water surface elevation will be lower than the all-season PMF water surface elevation. Therefore, the ice-induced flooding in the Unnamed Creek is bounded by the PMF. All the other streams in close proximity to LSCS are not a part of the LSCS watershed and are not a flooding hazard.

The ice jam on the Illinois River is possible. However, due to the significant distance between the Illinois River and LSCS site (about 5 miles horizontally and about 220 ft vertically) the ice-induced flooding on the Illinois River will not cause flooding hazard for LSCS.

For assumptions applied to the analysis see Calculation L-003860, Beyond Design Basis Ice-Induced Flood and Channel Migration Analysis (Fukushima), (Exelon 2014h).

3.6 Channel Migration

As described in the UFSAR, channel diversion of the Illinois River is unlikely because the river is wide, well-maintained for navigational purposes and has a well-developed floodplain. Currently, the conditions of the Illinois River are still the same, so channel migration of the Illinois River towards the site is still not likely.

The channel migration possibility for the small streams in the vicinity of LSCS is analyzed in Calculation L-003860, Beyond Design Basis Ice-Induced Flood and Channel Migration Analysis (Fukushima), (Exelon 2014h). Based on comparison of historical topographic maps and present-day topographic map the streams have been at the same approximate location for the past 55 years. Additionally, based on the USGS data, the LSCS and surrounding area has low landslide incidents. Therefore, diversion of the small channels located in close proximity to LSCS is not likely.

For assumptions applied to the analysis see Calculation L-003860, Beyond Design Basis Ice-Induced Flood and Channel Migration Analysis (Fukushima), (Exelon 2014h).

3.7 Flooding on Streams and Rivers (Illinois River)

The nearest point of the Illinois River to LSCS is in between Marseilles Lock and Dam and Dresden Lock and Dam. The drainage area of the Illinois River near the LSCS site is 7640 sq.mi. A reevaluation study for the PMF on Illinois River at Dresden Nuclear Generation Station (Dresden NGS), located right upstream from Dresden Lock and Dam, was performed in 2013 (Exelon 2013b) as a response to the NRC March 2012 letter. The drainage area of the Illinois River at Dresden is equal to approximately 7300 sq.mi. The drainage areas of the Illinois River at LSCS and Dresden locations are close, so the reevaluated PMF levels for Dresden can be applied directly to the LSCS location.

The peak discharge due to PMF on the Illinois River including upstream dam failures is approximately 418,000 cfs at Dresden NGS location (Exelon 2013b). The CLB PMF on the Illinois River at LSCS is 350,000 cfs. The CLB PMF and the reevaluated PMF are comparable. The CLB PMF of 350,000 cfs results in the PMF water surface elevation of 521.8 ft MSL, which is 39 ft above the normal pool elevation (521.8 – 482.8 ft = 39 ft). Conservatively assuming the reevaluated PMF on the Illinois River results is the doubling of the water surface elevation increase, 39 ft x 2 = 78 ft. Then the conservative reevaluated water surface elevation would be 482.8 ft + 78 ft = 560.8 ft MSL. The conservative reevaluated PMF water surface elevation on the Illinois River is 149 ft below the LSCS grade elevation (710.0 ft – 560.8 ft = 149.2 ft).

Additionally, the plant grade elevation of LSCS (710.0 ft) is well above the normal elevation of Lake Michigan (579 ft) (USACE 2014) by approximately 130 ft. Since the Illinois River is connected to Lake Michigan, Lake Michigan would have to flood at least 130 ft before LSCS would be affected, which is not postulated. The PMF flows on the Illinois River would discharge to Lake Michigan before they reach the LSCS site grade. Therefore, it is concluded that flooding from the Illinois River is screened out.

3.8 Tsunami

Tsunami phenomenon in relationship to LSCS is analyzed in Calculation L-003858, Beyond Design Basis Storm Surge and Seiche & Tsunami Screening for Lake (Fukushima) (Exelon 2014f). A tsunami is a series of water waves generated by a rapid, large-scale disturbance of a water body due to seismic, landslide, or volcanic tsunamigenic sources. Therefore, only geophysical events that release a large amount of energy in a very short time into a water body generate tsunamis. The most frequent cause of tsunamis is an earthquake. Less frequently, tsunamis are generated by submarine and sub-aerial landslides.

The National Oceanic and Atmospheric Administration (NOAA) natural hazards tsunami database (NOAA 2013a) identifies no known tsunami causing earthquake events at LSCS. The U.S. Geological Survey Earthquake Hazards Program hazard fault database (USGS 2013a) contains no known earthquake greater than magnitude 6.5 in the Eastern or Central United States. Moreover, earthquake hazard level in the region of LSCS shows very small probability of ground shaking. As a result, the required level of seismic activity for development of a tsunami, i.e., an earthquake with a magnitude greater than 6.5, is absent from the region. Therefore, a tsunami wave is not an applicable flooding scenario at LSCS. Moreover, as an inland site, LSCS is not susceptible to oceanic tsunamis. Furthermore, the bottom profile and shoreline slopes of the LaSalle Cooling Lake are not steep enough to initiate a tsunami by submarine landslide.

For assumptions applied to the analysis see Calculation L-003858, Beyond Design Basis Storm *Surge and Seiche & Tsunami Screening for Lake (Fukushima)* (Exelon 2014f).

4. FLOOD PARAMETERS AND COMPARISON WITH CURRENT DESIGN BASIS

Per the March 12, 2012, 50.54(f) letter (NRC March 2012), Enclosure 2, the following flood-causing mechanisms were considered in the flood hazard reevaluation for LSCS.

1. Local Intense Precipitation;
2. Flooding in Streams and Rivers;
3. Dam Breaches and Failures;
4. Storm Surge;
5. Seiche;
6. Tsunami;
7. Ice Induced Flooding; and
8. Channel Migration or Diversion.

Some of these individual mechanisms are incorporated into alternative 'Combined Effect Flood' scenarios per Appendix H of NUREG/CR-7046 (NUREG/CR-7046).

The March 12, 2012, 50.54(f) letter, Enclosure 2, requests the licensee to perform an integrated assessment of the plant's response to the reevaluated hazard if the reevaluated flood hazard is not bounded by the current design basis. This section provides comparisons with the current design basis flood hazard and applicable flood scenario parameters per Section 5.2 of JLD-ISG-2012-05 (NRC ISG-2012-05), including:

1. Flood height and associated effects
    a. Stillwater elevation;
    b. Wind waves and run-up effects;
    c. Hydrodynamic loading, including debris;
    d. Effects caused by sediment deposition and erosion (e.g., flow velocities, scour);
    e. Concurrent site conditions, including adverse weather conditions; and
    f. Groundwater ingress.

2. Flood event duration parameters (per Figure 6, below, of JLD-ISG-2012-05)
    a. Warning time (may include information from relevant forecasting methods (e.g., products from local, regional, or national weather forecasting centers) and ascension time of the flood hydrograph to a point (e.g. intermediate water surface elevations) triggering entry into flood procedures and actions by plant personnel);
    b. Period of site preparation (after entry into flood procedures and before flood waters reach site grade);
    c. Period of inundation; and
    d. Period of recession (when flood waters completely recede from site and plant is in safe and stable state that can be maintained).

3. Plant mode(s) of operation during the flood event duration

4. Other relevant plant-specific factors (e.g. waterborne projectiles)

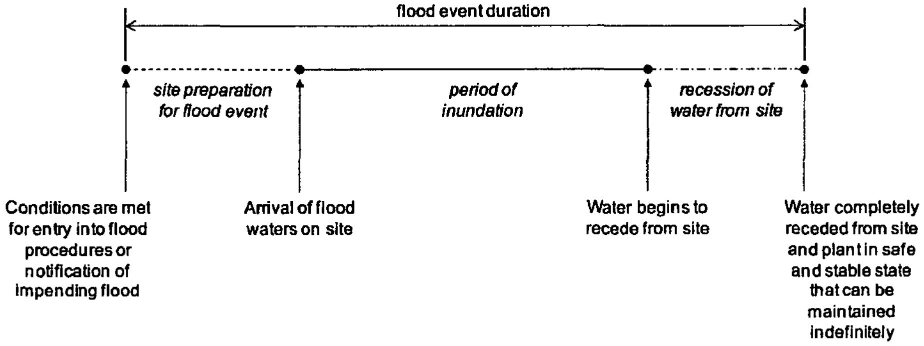


Figure 4.0.1 – Illustration of Flood Event Duration (NRC ISG-2012-05, Figure 6)

Per Section 5.2 of JLD-ISG-2012-05 (NRC ISG-2012-05), flood hazards do not need to be considered individually as part of the integrated assessment. Instead, the integrated assessment should be performed for a set(s) of flood scenario parameters defined based on the results of the flood hazard reevaluations. In some cases, only one controlling flood hazard may exist for a site. In this case, licensees should define the flood scenario parameters based on this controlling flood hazard. However, sites that have a diversity of flood hazards to which the site may be exposed should define multiple sets of flood scenario parameters to capture the different plant effects from the diverse flood parameters associated with applicable hazards. In addition, sites may use different flood protection systems to protect against or mitigate different flood hazards. In such instances, the integrated assessment should define multiple sets of flood scenario parameters. If appropriate, it is acceptable to develop an enveloping scenario (e.g., the maximum water surface elevation and inundation duration with the minimum warning time generated from different hazard scenarios) instead of considering multiple sets of flood scenario parameters as part of the integrated assessment. For simplicity, the licensee may combine these flood parameters to generate a single bounding set of flood scenario parameters for use in the integrated assessment.

For LSCS, the following flood-causing mechanisms were either determined to be implausible or completely bounded by other mechanisms:

1. Illinois River (and associated upstream dam failure) flooding;
2. Tsunami;
3. Ice Induced Flooding;
4. Channel Migration or Diversion; and
5. Combined-Effect Flood H.4.1 (from Appendix H of NUREG/CR-7046)

LSCS was considered potentially exposed to the flood hazards (individual flood-causing mechanisms and/or combined-effects flood scenarios per Appendix H of NUREG/CR-7046) listed below. In some instances, an individual flood-causing mechanism (e.g. 'Flooding in Streams and Rivers') is addressed in one or more of the combined-effect flood scenarios.

1. Local Intense Precipitation
2. Combinations in Section H.1 of NUREG/CR-7046 (Floods Caused by Precipitation Events) for the Cooling Lake.
3. Combinations in Section H.4.2 of NUREG/CR-7046 (Floods along the Shores of Enclosed Bodies of Water, Streamside Location) for the Cooling Lake.

The tables below summarize the parameters for each flood hazard and provide comparisons with the current design basis flood.

Table 4.0.1 – Summary of Licensing Basis and External Flooding Study Parameters

Parameter	Current Licensing Basis Value/Methodology	Reevaluation Study Value/Methodology
Probable Maximum Precipitation		
Methodology	HMR 33, USACE, U.S. Bureau of Reclamation	HMR 51 and HMR 52
Storm Duration	48 hours	72 hours
Cumulative PMP	33.35 in	37.40 in
Probable Maximum Flood on Lake		
Nonlinear Basin Response	No	Yes
Hydrologic Model	None (Rational Method)	HEC-HMS
Total area	3,258 ac (5.091 sq.mi.)	5.066 sq. mi.
Subbasins	2	4
Lake Modeling Methodology	Stage-Storage	Stage-Storage
Discharge	Service and auxiliary spillways	Auxiliary spillway only
Wind Wave Activity coincident with PMF on Lake		
Methodology	USACE "Waves in Inland Reservoirs", "Computation of Freeboard Allowances for Waves in Reservoirs"	USACE Coastal Engineering Manual ANSI/ANS-2.8-1992
Wind speed	40 mph	20 mph
Wave parameters determination	Hand calculation	2D Hydrodynamic Model (Delft3D)
Local Intense Precipitation		
Methodology	HMR 33, U.S. Bureau of Reclamation	Site-Specific Hydrometeorological Study
1-Hour LIP (inches)	14.8	13.8
5-min Peak Intensity (inches)	4.3	4.7
Effects Local Intense Precipitation		
Methodology	Rational Method, Weir Flow, HEC-RAS Backwater Step Calculation	Hydrodynamic Modeling using FLO-2D Computer Software
Probable Maximum Surge and Seiche		
Model	Not Evaluated	2-Dimensional Hydrodynamic modeling (Delft3D computer software)
Combined Events (precipitation events on the lake combined with surge and seiche events)		
Methodology	Not Evaluated	Lake elevation – HEC-HMS Surge/Seiche – Delft3D

Table 4.0.2 – Local Intense Precipitation

Flood Scenario Parameter		CDB	Reevaluated	Bounded (B) or Not Bounded (NB)
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL)	710.1 and 710.3	710.81	NB
	2. Max Wave Run-up Elevation (ft. MSL)	N/A	N/A	N/A
	3. Max Hydrodynamic / Hydrostatic Loading (lb/ft)	Not Determined	3.94 / 27.72	B
	4. Effects of Sediment Deposition/Erosion	N/A	N/A	B
	5. Concurrent Site Conditions	N/A	See Notes	NB
	6. Effects on Groundwater	N/A	N/A	N/A
Flood Event Duration	7. Warning Time (hours)	N/A	See Notes	NB
	8. Period of Site Preparation (hours)	N/A	N/A	N/A
	9. Period of Inundation (hours)	N/A	1.1	NB
	10. Period of Recession (hours)	N/A	N/A	N/A
Other	11. Plant Mode of Operations	Modes 1-5 or defueled	Modes 1-5 or defueled	Modes 1-5 or defueled
	12. Other Factors	N/A	N/A	N/A

Notes:

1. None
2. Consideration of wind-wave action for the LIP event is not explicitly required by NUREG/CR-7046 and is judged to be a negligible associated effect because of limited fetch lengths and flow depths.
3. 2-dimensional modeling indicates that the maximum hydrodynamic force per linear foot of structure is 3.94 lbs/ft. The maximum hydrostatic force is 27.72 lbs/ft. This force is bounded by other design basis criteria for protection from external forces (e.g. tornado missiles), (UFSAR Figure 3.3-3).The debris load for the LIP event is negligible due to the absence of heavy objects at the plant site and due to low flow velocity, the factors combination of which could lead to a hazard due to debris load.
4. Because of generally low velocities, ranging between 0.03 and 3.0 fps around the power block area, sediment transport is not expected to be an effect of LIP flooding. The maximum velocity in the power block area (3.0 fps) is well below permissible velocities for paved surfaces (USACE 1984) so erosion and localized scour is also not expected to be an effect of LIP flooding.
5. High winds could be generated concurrent to a LIP event.
6. Due to the compacted clay cover and clayey till and the impervious cover immediately around the power block buildings, the infiltration of precipitation and groundwater seepage would likely be minimal. Additionally, the event is a short-duration (1-hour precipitation) which limits the amount of soil infiltration. Therefore, groundwater level changes are not expected to occur.
7. A local intense precipitation event has no appreciable warning time except those provided by a weather (precipitation) forecast. Site has a current procedure place addressing beyond design basis PMP (Exelon 2012b). The procedure will be updated to address the new LIP flood levels.
8. N/A, see note 7.
9. Period of inundation is determined as time for which the maximum water surface elevation exceeds the CLB maximum water surface elevation.
10. Period of inundation (Item 9) includes the period of recession.
11. Any plant mode of operation can be expected to be in place when the LIP event occurs. See Technical Specification (TS) 1.1 for Mode Definition.
12. There are no plant-specific factors, including waterborne projectiles, applicable to the LIP flood.

Table 4.0.3 – Combinations in Section H.1 of NUREG/CR-7046 for the Cooling Lake

Flood Scenario Parameter		CDB	Reevaluated	Bounded (B) or Not Bounded (NB)
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft. MSL)	704.3	705.68	NB
	2. Max Wave Run-up Elevation (ft. MSL)	705.6	707.33	NB
	3. Max Hydrodynamic/Debris Loading	Not Determined	See Notes	N/A
	4. Effects of Sediment Deposition/Erosion	Not Determined	See Notes	NB
	5. Concurrent Site Conditions	N/A	N/A	N/A
	6. Effects on Groundwater	Not Determined	See Notes	NB
Flood Event Duration	7. Warning Time (hours)	N/A	N/A	N/A
	8. Period of Site Preparation (hours)	N/A	N/A	N/A
	9. Period of Inundation (hours)	N/A	N/A	N/A
	10. Period of Recession (hours)	N/A	N/A	N/A
Other	11. Plant Mode of Operations	Modes 1-5 or defueled	Modes 1-5 or defueled	Modes 1-5 or defueled
	12. Other Factors	N/A	N/A	N/A

Notes:

1. The reevaluated still-water elevation is not bounded by the current design basis flood.
2. The reevaluated wind-wave runup elevation is not bounded by the current design basis flood
3. Hydrodynamic loads, specifically due to wind-wave impacts, are governed by the H.4.2 combination (see Table 4.0.4). Due to low velocities in the cooling lake, loads from large debris are not expected.
4. The reevaluated wind-waves may produce erosion along the cooling lake dike. The watershed draining to the cooling lake is relatively small with no upstream dams. Therefore, sediment deposition in the cooling lake and associated effects on flooding is negligible.
5. High-velocity wind speeds (up to 20 mph) could be expected during the flood event. However, manual actions are not required to protect the plant from a cooling lake PMF so this concurrent condition is not applicable.
6. Extended periods of elevated still-water levels in the cooling lake may cause elevated groundwater levels at SSCs important to safety, particularly through granulated fill material along intake pipes.
7. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake PMF.
8. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake PMF.
9. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake PMF.
10. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake PMF.
11. Any plant mode of operation can be expected to be in place when the PMF event occurs. See Technical Specification (TS) 1.1 for Mode Definition.
12. Dam break is determined to be not-plausible for LSCS as no upstream dams exist in the watershed. Waterborne projectiles are not expected during the PMF event as no heavy debris exists in the watershed and the expected wind velocities are not high enough to initiate this phenomenon (see Note 5).

Table 4.0.4 – Combinations in Section H.4.2 of NUREG/CR-7046 for the Cooling Lake

	Flood Scenario Parameter	CDB	Reevaluated	Bounded (B) or Not Bounded (NB)
Flood Level and Associated Effects	1. Max Stillwater Elevation (ft MSL)	704.3	701.02	B
	2. Max Wave Run-up (Including Setup) Elevation (ft. MSL)	705.6	710.55 and 712.04	NB
	3. Max Hydrodynamic and Debris Loading (lb/ft)	Not Determined	1,134 and 4,459	NB
	4. Effects of Sediment Deposition/Erosion	Not Determined	See Notes	NB
	5. Concurrent Site Conditions	Not Determined	See Notes	NA
	6. Effects on Groundwater	Not Determined	See Notes	NB
Flood Event Duration	7. Warning Time (hours)	N/A	N/A	N/A
	8. Period of Site Preparation (hours)	N/A	N/A	N/A
	9. Period of Inundation (hours)	N/A	N/A	N/A
	10. Period of Recession (hours)	N/A	N/A	N/A
Other	11. Plant Mode of Operations	Modes 1-5 or defueled	Modes 1-5 or defueled	Modes 1-5 or defueled
	12. Other Factors	N/A	N/A	N/A

Notes:

1. The reevaluated still-water elevation is bounded by the current design basis flood with the maximum still-water level in the lake due to the PMF equal to 704.3 ft MSL. The maximum still-water elevation in the lake is equal to 701.24 ft NAVD88, or 701.02 ft MSL. The vertical datum difference is equal to NAVD88 – MSL = 0.22 ft (Aerometric 2013b).
2. The reevaluated wind-wave runup elevation is not bounded by the current design basis. The reevaluated elevations shown are at the Lake Screen House and CSCS inlet structure, respectively.
3. The wave loading is determined for the Lake Screen House (1,134 lb/ft) and for CSCS Inlet Structure (4,759 lb/ft). The wave loads are specified as force per unit length of structure (lb/ft). To determine the force for the entire structure the loads need to be multiplied by the structure length. The debris load is not an applicable hazard for LSCS as no heavy debris exists in the watershed. Additionally the design basis tornado missiles bound any possible debris loading due to the probable maximum storm seiche as the tornado velocities are significantly higher (360 mph) that the water or wind velocities during the flooding event.
4. The reevaluated wind-waves may produce erosion along the cooling lake dike. The watershed draining to the cooling lake is relatively small with no upstream dams. Therefore, sediment deposition in the cooling lake and associated effects on flooding is negligible.
5. Extremely high-velocity wind speeds (up to 100 mph) could be expected during the flood event. However, manual actions are not required to protect the plant from a cooling lake PMF so this concurrent condition is not applicable
6. Extended periods of elevated still-water levels in the cooling lake may cause elevated groundwater levels at SSCs important to safety, particularly through granulated fill material along intake pipes.
7. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake flooding event.
8. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake flooding event.
9. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake flooding event.
10. SSC's important to safety are currently protected by means of permanent/passive measure. Therefore, flood event duration parameters are not applicable to the cooling lake flooding event.

Table 4.0.4 – Combinations in Section H.4 of NUREG/CR-7046 (Continued)

11. Any plant mode of operation can be expected to be in place when the Combined Events flood occurs. See Technical Specification (TS) 1.1 for Mode Definition.
12. Dam break is determined to be not-plausible for LSCS as no upstream dams exist in the watershed. Waterborne projectiles due to the probable maximum seiche event and associated high-velocity wind speeds of 100 mph are bounded by the projectiles from tornado with the CLB wind speed of 360 mph (UFSAR Section 1.2.2.1.6.2).

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(USACE 2014) U.S. Army Corps of Engineers, Detroit District, Great Lakes Water Levels website, available at http://www.lre.usace.army.mil/Missions/GreatLakesInformation/GreatLakesWaterLevels.aspx, Accessed January 2014

(USGS 2013a), U.S. Geological Survey (USGS) Hazards website, Earthquake Hazards Program, Available at: http://earthquake.usgs.gov/earthquakes/search/, Accessed November 2013

Enclosure 2

CD-R labeled:

LaSalle County Station Flood Hazard Reevaluation Submittal
Pertinent Site Data

Enclosure 3

SUMMARY OF REGULATORY COMMITMENTS

The following table identifies commitments made in this document. (Any other actions discussed in the submittal represent intended or planned actions. They are described to the NRC for the NRC's information and are not regulatory commitments.)

COMMITMENT	COMMITTED DATE OR "OUTAGE"	COMMITMENT TYPE	
		ONE-TIME ACTION (Yes/No)	PROGRAMMATIC (Yes/No)
The LaSalle County Station design basis flood does not bound the reevaluated hazard for all flood-causing mechanisms and combined-effect floods. Specifically, local intense precipitation and combined-effect flood combinations H.1 and H.4 were not bounded by the design basis flood hazard. Therefore, LaSalle County Station plans to prepare a full Integrated Assessment (Scenario 4).	March 12, 2016	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
1.	Evaluation of the effects of higher waves and associated loads on the lake screen house concrete structure and CSCS inlet concrete structure from PMF/surge/seiche/waves. This evaluation will consider the total load on the structure including wave impact and hydrostatic. Debris and drag loads are considered negligible for structures within the lake.	Report Cover Letter, Section d.ii	This evaluation is currently in progress.	June 12, 2014	Yes	No
2.	Identify any unsealed penetrations up to the reevaluated stillwater elevation to address potential surcharge of groundwater levels due to increase stillwater levels in the lake.	Report Cover Letter, Section d.ii	Flooding walkdowns were conducted per Recommendation 2.3, but will be reviewed for the reevaluated stillwater elevation.	June 12, 2014	Yes	No
3.	Evaluation of the hydrostatic loading on the power plant foundations using groundwater level at the reevaluated stillwater elevation in the lake.	Report Cover Letter, Section d.ii	CLB does not address an increase in groundwater.	June 12, 2014	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
4.	Inspection of existing sealant on Plant Doors 479, 554, and 508 and fix as required.	Report Cover Letter, Section d.ii	These existing doors have permanent seals installed as they are not used for plant access, although seals are not required by the CLB requirements. They will be reinspected for the reevaluated LIP.	June 12, 2014	Yes	No
5.	Determine which doors/openings are not used and should have barrier/sealant applied to them as a permanent passive flood protection feature. Determine type of sealant and elevation at which the sealant should be applied.	Report Cover Letter, Section d.ii	Some plant grade level floor doors do not have seals, as seals are not required by the CLB requirements.	June 12, 2014	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (*Committed** Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
6.	Identify temporary or permanent flood protection features (e.g. berm/barriers), including installation and staging requirements, at doors/openings that are frequently used and where water ingress cannot be mitigated by other means. Consideration shall be for barriers that can be driven or walked over. Barriers shall not impede or negatively impact safety or security functions.	Report Cover Letter, Section d.ii	The plant grade level floor elevation is above the CLB LIP event and therefore not subject to external flooding.	September 12, 2014	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
7.	Evaluate the effects of ingress of water from the LIP event on the plant, with respect to the following subareas: a. Evaluate the building structures and doors for the amount of inleakage over the duration of the event, how the buildings handle the volume of water, and how it can be routed to the turbine building (TB) and Offgas basements/old service Bldg/technical support center/tube pull area, including the effect of impact pressure of the moving water on the plant buildings. b. Determine the capacity of the existing multiple local floor drains that would intercept water prior to reaching any plant safety-related equipment areas and determine which floor drains to inspect/clean. c. Determine if/how the leakage through the doors affects equipment important to safety, including differences between winter and summer requirements. If necessary to support plant work during winter months (outage), berms/barriers may not be required if it can be shown that winter LIP is much less than all-season LIP and will not exceed door thresholds. d. Evaluate procedure LOA-FLD-001 for possible enhancements to improve mitigation of the reevaluated LIP flood. e. Prioritize actions for high risk areas.	Report Cover Letter, Section d.ii	The plant grade level floor elevation is above the CLB LIP event and therefore not subject to external flooding.	September 12, 2014	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
8.	Determine if additional doors need to be surveyed and perform survey if necessary.	Report Cover Letter, Section d.ii	The results of this action are being evaluated under Interim Action Item Number 7.	June 12, 2014	Yes	No
9.	Evaluate the need for signs on the doors with barriers (e.g. caulk, berm, sandbag, sheet metal, etc.) to identify them as a flood protection feature.	Report Cover Letter, Section d.ii	Flood protection signs at doors are not required by the CLB requirements.	June 12, 2014	Yes	No

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
10.	Revise procedure LOA-FLD-001 to incorporate Beyond Design Basis Flooding changes based on input from Design Engineering evaluations and determinations.	Report Cover Letter, Section d.ii	The existing procedure LOA-FLD-001 will be revised as required based on the results of the completed Interim Actions. The plant grade level floor elevation is above the CLB LIP event and therefore not subject to external flooding.	December 12, 2014	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
11.	Determine training needs for site personnel to perform associated Beyond Design Basis Flooding actions required by procedure LOA-FLD-001 and conduct training as applicable using the Systematic Approach to Training (SAT).	Report Cover Letter, Section d.ii	The plant grade level floor elevation is above the CLB LIP event and therefore not subject to external flooding.	December 12, 2015	Yes	No
12.	Demonstrate/simulate site personnel Beyond Design Basis Flooding actions required by procedure LOA-FLD-001 can be performed within the timeframe per NEI 12-07.	Report Cover Letter, Section d.ii	The plant grade level floor elevation is above the CLB LIP event and therefore not subject to external flooding.	December 12, 2015	Yes	No

Enclosure 3: LaSalle County Station, Units 1 and 2 – Flood Hazard Reevaluation Report Interim Action Commitments* ("Commitments" are bolded header columns)

Item Number	**Interim Actions Taken or Planned to Take as Included in the Reevaluation Report (Commitment*)**	Report Reference	Additional Information	**Implementation Date (Committed* Date or Outage)**	**Commitment Type One-Time Action* (Yes/No)**	**Commitment Type Programmatic* (Yes/No)**
13.	Install barrier/sealant for doors that do not currently have it installed as required.	Report Cover Letter, Section d.ii	Seals are not required by the CLB requirements. The results of this action will be based on the results of the completed Interim Actions.	December 12, 2014	Yes	No
14.	Stage flood protection equipment (e.g. berm material) and/or post signs as required.	Report Cover Letter, Section d.ii	The results of this action will be based on the results of the completed Interim Actions.	December 12, 2014	Yes	No
15.	Inspect/clean floor drains as required.	Report Cover Letter, Section d.ii	The results of this action will be based on the results of the completed Interim Actions.	December 12, 2014	Yes	No