Enclosure 1

Quad Cities Nuclear Power Station
Local Intense Precipitation Evaluation Report
Revision 7

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LOCAL INTENSE PRECIPITATION EVALUATION REPORT, Rev. 7

For the

QUAD CITIES NUCLEAR POWER STATION
22710 206th Avenue, Cordova, IL 61242

Exelon Generation Company, LLC (Exelon)
P.O. Box 805387
Chicago, Illinois 60680-5387

Prepared by:
AMEC Environment & Infrastructure, Inc.
502 West Germantown Pike, Suite 850, Plymouth Meeting, PA 19462

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	Printed Name	Affiliation	Signature	Date
Originator:	Matthew Lehrer	AMEC	[signature]	3/11/13
Verifier:	Petr Masopust	AMEC	[signature]	3/11/13
Approver:	Jeffrey Mann	AMEC	[signature]	3/11/13
Lead Responsible Engineer:	DUSTIN DAMHOFF	Exelon	[signature]	3/11/13
Branch Manager	Douglas F Collins	Exelon	[signature]	03/11/13
Senior Manager Design Engineering:	BRIAN L. STEAMAN	Exelon	[signature]	3/11/13
Corporate Acceptance:	Joseph V. Bellini	Exelon	[signature]	3/11/13

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1. List of Acronyms

ASME	American Society of Mechanical Engineers
CLB	Current Licensing Basis
DEM	Digital Elevation Model
ft	Foot
fps	Feet per second
GIS	Geographic Information System
HMR 52	Hydrometeorological Report 52
lb	Pound-force
LiDAR	Light Detection and Ranging
LIP	Local Intense Precipitation
NAVD-88	North American Vertical Datum of 1988
NRC	Nuclear Regulatory Commission
PMP	Probable Maximum Precipitation
psf	Pounds per Square Foot
SEP	Systematic Evaluation Program
Sq mi	Square Miles
WRF	Width Reduction Factor
WSE	Water Surface Elevation

2. PURPOSE

a. Background

AMEC Environment & Infrastructure, Inc. (AMEC) on behalf of Exelon Corporation (Exelon) performed an evaluation of site runoff generated from a Local Intense Precipitation (LIP) event to supplement the ongoing flooding studies at Quad Cities Nuclear Power Station (Quad Cities Station). AMEC performed this work under a Quality Assurance (QA) Program that conforms to the requirements of ASME NQA-1 and 10 CFR 50 Appendix B. The LIP evaluation was performed in accordance with the Nuclear Regulatory Commission's (NRC's) "Design-Basis Flood Estimation for Site Characterization at Nuclear Power Plants in the United States of America," dated November 2011 (NUREG/CR-7046) (Reference 8).

NUREG/CR-7046 (Reference 8) identifies the LIP under causative mechanisms for design based floods and states that these mechanisms or causes be investigated to estimate the design-basis flood for nuclear power plant sites. Local flooding is associated with inundation caused by localized, short-duration, intense rainfall events. The focus of this study was to evaluate the adequacy of the site's grading, drainage, and runoff carrying capacity. It was conservatively assumed for this analysis that all active and passive drainage system components (e.g., pumps, gravity storm drain systems, small culverts, inlets, etc.) are non-functional during the local intense rainfall event, per Case 3 in NUREG/CR-7046 (Reference 8). As such, only overland flow and open channel systems were modeled and considered in the local flooding analysis.

Per NUREG/CR-7046 (Reference 8), the LIP event is defined as a 1-hour/1-square-mile Probable Maximum Precipitation (PMP). The PMP is the greatest depth of precipitation, for a given duration, that is theoretically possible for a particular area and geographic location (Reference 8). The PMP is not derived from historic rainfall records, although historic atmospheric conditions and patterns are considered. The 1-hour PMP event was developed using Hydrometeorological Report 52 (HMR 52) (Reference 3).

b. Site Description

Quad Cities Station is located approximately three miles north of the Village of Cordova, Illinois. The plant is located on the Mississippi River at its confluence with Wapsipinicon River at Mile Mark 506.8. The contributing drainage area to the Mississippi River, upstream of the cooling water intake, is approximately 88,000 square miles (Reference 10). There are no structural external flood protection systems in place for Quad Cities Station; it relies almost exclusively on flood emergency procedures to mitigate the effects of the probable maximum flood (PMF) along the Mississippi River (Reference 6).

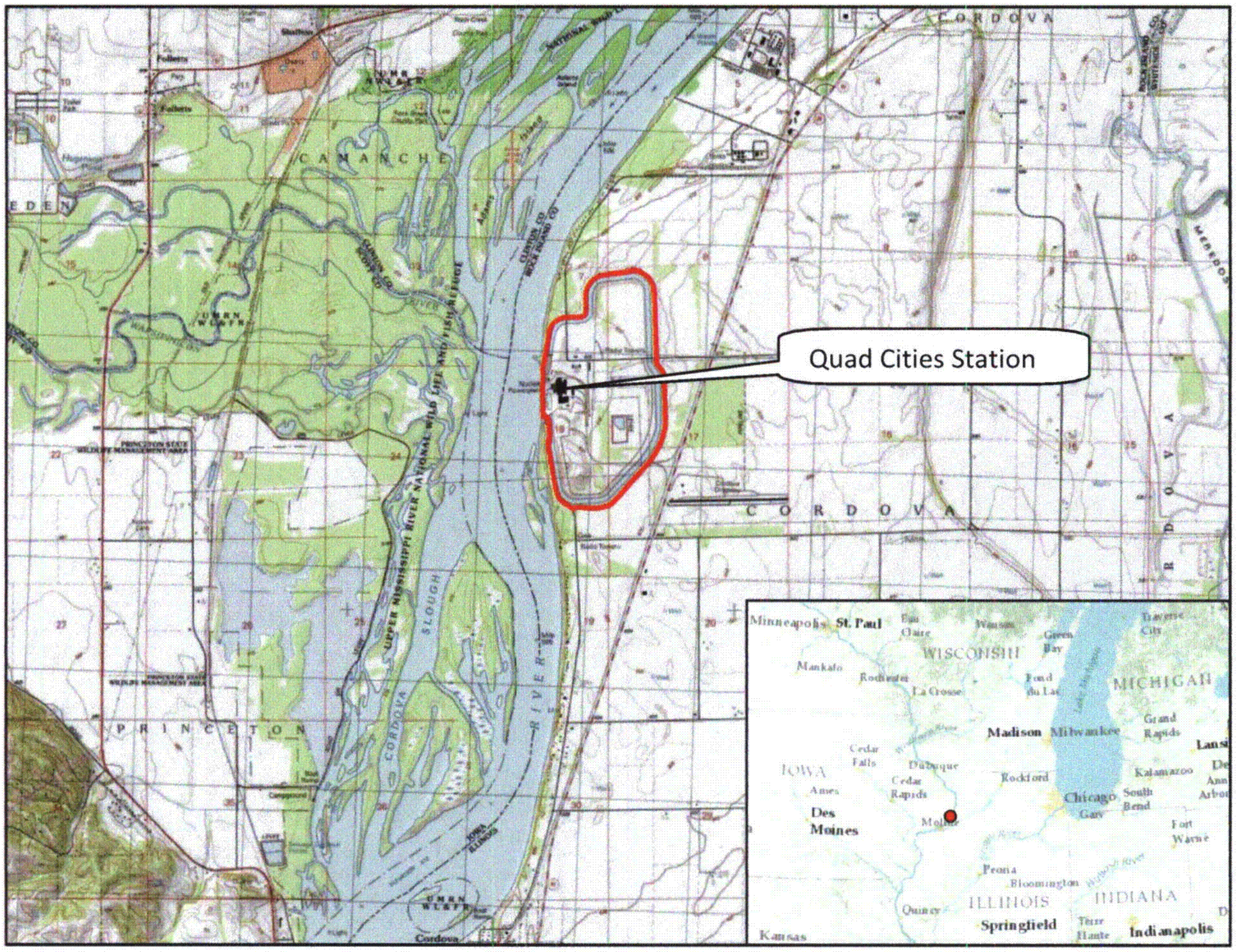

Figure 2-1: Quad Cities Station Location Map (Reference 11)

c. Summary of Current Licensing Basis Flood Hazards

A review of the Quad Cities Station UFSAR (Reference 6), particularly Sections: 2.3, Meteorology; 2.4, Hydrologic Engineering; and 3.4, Water Level (Flood) Design, identified that the LIP flood evaluation is a beyond design basis event, which was not required under the CLB, and therefore LIP has not been previously addressed.

It should be noted that, per Section 3.4 of the UFSAR, there would be adequate time for a safe shutdown of the plant prior to the flood reaching the plant grade. If a flood ever exceeded plant grade, independently powered portable pumping equipment would be deployed, above the projected flood elevation, to supply the make-up water required in the storage pools and reactor vessels due to the evaporative cooling losses.

Topographic relief at the site is low compared to the land surrounding the plant and relatively flat. The site generally slopes to the west toward the Mississippi River. Areas just upslope of the station to the east partially drain through the site to the west and drain toward the manmade channel to the east (Reference 6). The manmade channel (Spray Canal) runs along the north, east, and south sides of the station. The channel intake and outfall are located along the Mississippi River. Berms run along both sides of the manmade channel.

3. METHODOLOGY

a. Modeling Approach

A two-dimensional (2D) hydrodynamic model, FLO-2D, was used to evaluate the flow characteristics of the runoff caused by a LIP event. The FLO-2D model boundaries are along the east bank of the Mississippi River and the top of berm along the eastern bank of the man made channel. Figure 3-1 shows the exterior boundary of the FLO-2D model and landmarks referenced in this document.

The FLO-2D model consists of 48,608 20-ft by 20-ft grid elements. The 20-ft by 20-ft grid size was chosen to provide an adequate level of detail to reflect the hydrodynamic effects at the site, while requiring a reasonable amount of computational resources. Based on Table 1.1 of the FLO-2D Input Manual, any model that contains over 60,000 grid elements would be considered to have a "slow" model simulation speed (Reference 5).

The FLO-2D model required the following inputs to evaluate LIP:

- Topography to characterize grading, slopes, drainage divides, and low areas of the site;
- Manning's Roughness Coefficients (n-values) to characterize the land cover of the site and its effects on flow depths and velocities; and
- 1-hour PMP event to characterize the LIP event (volume, distribution, and duration).

The model was run with the above inputs to evaluate the adequacy of the site grading and runoff carrying capacity during the LIP event. The model provides the following outputs:

- Predicted duration of flooding conditions;
- Predicted maximum velocities;

- Predicted maximum resultant static loads; and
- Predicted maximum resultant impact loads.

All active and passive drainage system components (e.g., pumps, gravity storm drain systems, small culverts, inlets, etc.) were considered non-functional or blocked during the LIP event, per Case 3 in NUREG/CR-7046 (Reference 8). NUREG/CR-7046 discusses that it is extremely rare that the passive site drainage network would remain completely unblocked during the LIP event. This is a reasonable, yet conservative assumption to consider potential conditions of a storm sewer system during a LIP event, such as buildup of debris, reduced conveyance capacity due to deformation in pipes, or the system being surcharged due to the limited capacity. Additionally, NUREG/CR-7046 requires the utility to provide justification for crediting partial or full conveyance from drainage structures (Reference 8).

The LIP evaluation was conducted independently of external high-water events. That is, the LIP event was assumed to have occurred non-coincidental to a river flood. Therefore, backwater or tailwater was not considered.

As shown in Table 1, the Quad Cities Station's land cover is predominantly grass and shrubs, which could potentially allow for runoff infiltration losses in these areas. However, NUREG/CR-7046 requires that runoff infiltration losses be ignored to maximize the runoff from the event. While this assumption could possibly produce conservative estimates of calculated water surface elevations, NUREG/CR-7046 does not provide any LIP discussion or scenario where infiltration losses are considered. If infiltration losses are to be considered in a LIP evaluation, NUREG/CR-7046 requires justification (Reference 8). Only overland flow and open channel systems were modeled and considered in the LIP flooding analysis.

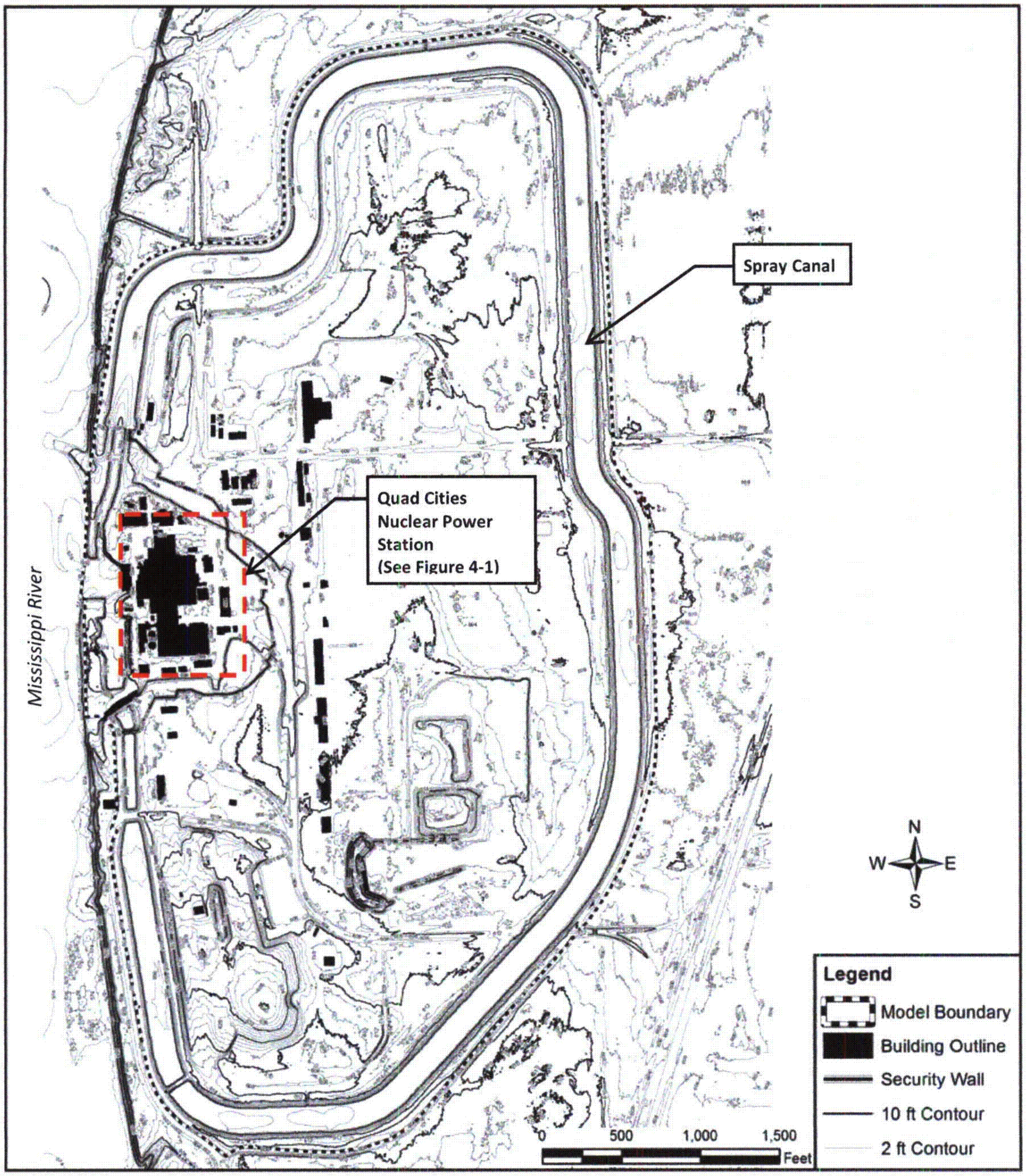

Figure 3-1: FLO-2D Model Boundary

b. Topography

The FLO-2D model was developed using a Digital Elevation Model (DEM) produced from available LiDAR data and supplemental field survey to characterize grading, slopes, drainage divides, and low areas of the site.

Publically available LiDAR data was collected in 2009. According to the January 5, 2010 Aero-Metric Vertical Accuracy Assessment Report for Rock Island County, Illinois (Reference 1), the data has a vertical accuracy of ± 6 inches, and was accompanied with digital orthoimagery. AMEC validated the LiDAR data through a commercial grade dedication process under AMEC's 10 CFR 50 Appendix B Quality Assurance Program.

AMEC considered the available LiDAR data sufficient as a baseline for the LIP evaluation. However, supplemental field survey of the site allowed for the incorporation of site features that were not identified by the LiDAR survey. The features included depressions/low points, isolated concrete barriers/blocks, concrete pads, and sill elevations. The field survey was performed in July of 2012 by a Professional Land Surveyor licensed in the State of Illinois.

The supplemental field survey data was incorporated into the LiDAR data using AutoCAD Civil 3D software to produce the DEM. The DEM was clipped to match the FLO-2D model limits shown in Figure 3-1 above.

All LiDAR and survey inputs were provided in North American Vertical Datum of 1988 (NAVD-88) and, therefore, all model result elevations in the LIP evaluation are reported in NAVD-88.

c. Land Cover

The FLO-2D model uses Manning's Roughness Coefficients (n-values) to characterize the site's surface roughness and calculate affects on flow depths and velocities. Land cover for the site was evaluated using interpretation of orthoimagery that was verified in the field by AMEC during subsequent visits to the site to support the surveying and LiDAR validation efforts. Manning's n-values were assigned to each land cover type and were based on ranges described on page 22 of the FLO-2D Reference Manual (Reference 4). The assigned n-values are provided in Table 1 below.

Table 1: Assigned Manning's Roughness Coefficients (n-values)

Land Cover Surfaces of Quad Cities Station	Recommended Range of n-values	Assigned n-value	% Coverage
Bermuda and dense grass, dense vegetation	0.17 - 0.48	0.32	39
Shrubs and forest litter, pasture	0.30 - 0.40	0.40	26
Asphalt, concrete, buildings	0.02 - 0.05	0.035	14
Gravel	-	0.05	9
Water surface (Primarily due to spray canal)	-	0.02	12

The Manning's n-values for gravel and water land cover surfaces were assigned values from the recommended range for asphalt/concrete to reflect their surface roughness. Gravel was assigned the upper end of the range to consider typical irregularities in the gravel surface. The Manning's n-value for water was assigned the lower end of this range as it was considered a near smooth surface. Shrubs and forest litter were assigned a Manning's n-value at the upper end of the recommended range to reflect the dense brush surface observed on site. The remaining land cover surface categories were assigned the middle of their respective recommended ranges.

A sensitivity analysis was performed on the Manning's n-values to evaluate the effect this parameter has on the maximum water surface elevation. As part of the analysis, the upper and lower ranges of the Manning's n-values presented in Table 1 were evaluated. The results indicate that the difference in water surface elevations between the upper and lower range of the Manning's n-values presented in Table 1 are within ± 0.10 ft.

d. Probable Maximum Precipitation

The 1-hour PMP event distribution was developed using Hydrometeorological Report 52 (HMR 52) (Reference 3). Per NUREG/CR-7046 (Reference 8), the LIP event is defined as a 1-hour/1-square-mile PMP event. Per the procedures outlined in HMR-52, the total PMP depth per square mile for the 1-hr event was interpolated from the PMP depth contour map provided in Figure 24 of HMR 52 (Reference 3). Next, the distribution of the 1-hr PMP was developed for the 5-, 15-, and 30-minute time intervals, with the 60-minute interval being the 1-hr PMP depth. The depth for each time interval was calculated using the ratios obtained from Figures 36, 37, and 38 of HMR 52. The 1-hr PMP distribution is provided in Table 2 and Figure 3-2 below. The 1-hour PMP event was run in the FLO-2D model to calculate the subsequent site flooding.

Table 2: 1-hr PMP Distribution for Quad Cities Station

Time (minutes)	Percent Total PMP (%)	Cumulative Depth (inches)	Reference
0	0%	0.00	N/A
5	33.77%	6.00	HMR 52, Page 94, Figure 36
15	53.24%	9.47	HMR 52, Page 95, Figure 37
30	76.48%	13.60	HMR 52, Page 96, Figure 38
60	100%	17.78	HMR 52, Page 79, Figure 24

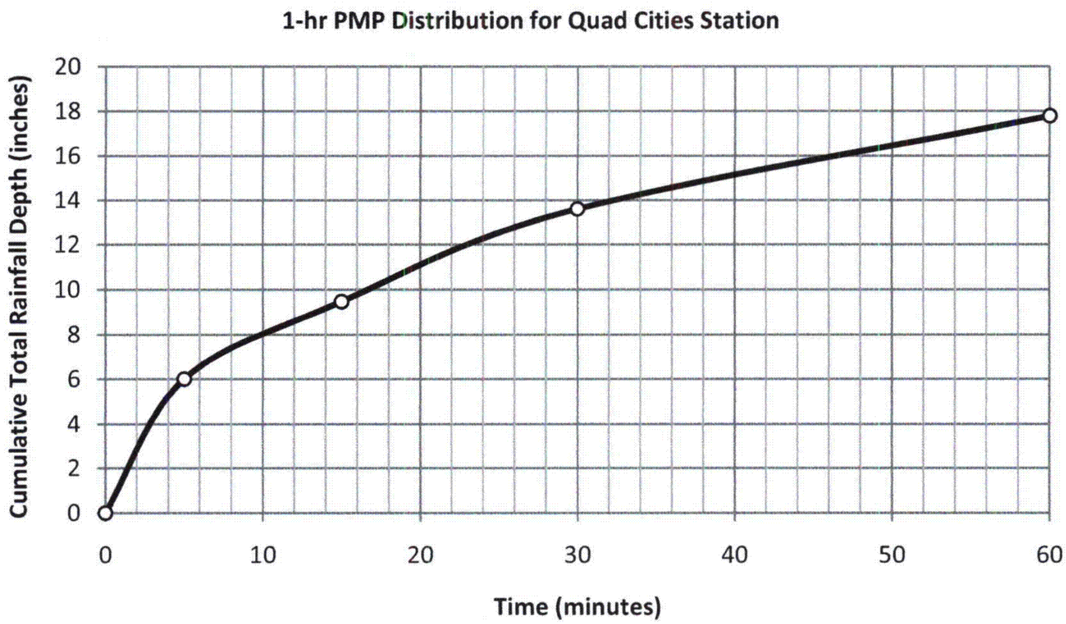

Figure 3-2: 1-hr PMP Distribution for Quad Cities Station

4. RESULTS

The LIP flooding evaluation, as per the Case 3 assumptions of NUREG/CR-7046, Section 3.2 (Reference 8) predicted the maximum flooding depths, water surface elevation, velocities, predicted resultant static loads, and resultant impact loads that could be expected for an LIP event at the site. The maximum resultant impact load and maximum resultant static load are expressed as pounds per unit width. Multiplying these loads by the horizontal width of the structure within the grid element will provide the magnitude of the resultant force. Detailed calculations, results, and figures are presented in the Quad Cities LIP Evaluation Calculation Package LIP-QDC-001 (Reference 2).

The maximum results of the LIP evaluation are presented in Table 3. Results provided in this report are direct outputs from the FLO-2D model. The FLO-2D model reports results to the hundredth of a foot. However, based on the sensitivity analysis of grid size and Manning's n-values, an accuracy of ± 0.1 foot should be taken into consideration when evaluating the reported results.

Table 3: LIP Predicted Flooding Results

Building Name[1]	Max. Water Surface	Max. Flooding Depth[2]	Max. Velocity	Max. Resultant Impact Load	Max. Resultant Static Load
	ft (NAVD-88)	ft	ft/sec.	lb/ft	lb/ft
OGFB	595.19 - 595.38	1.01 - 1.51	0.64 - 2.15	1.43 - 17.22	31.73 - 71.26
Fab Shop	595.38 - 595.89	1.10 - 1.59	0.39 - 3.66	0.21 - 46.5	37.92 - 78.58
Outage Support Building	594.82 - 595.85	0.28 - 1.82	0.39 - 3.13	0.10 - 44.16	2.48 - 103.71
IRSF	595.82 - 597.00	1.61 - 3.60	0.82 - 6.29	0.84 - 271.83	78.74 - 404.31
IDNS	594.95 - 595.27	0.91 - 1.13	1.06 - 2.51	3.04 - 16.73	25.68 - 40.13
Cribhouse	576.26 - 595.18	0.10 - 2.63	0.37 - 5.10	0.03 - 70.34	0.33 - 216.48
Chimney House	595.15 - 595.29	0.99 - 1.59	1.23 - 1.82	6.55 - 12.45	57.54 - 75.20
Radwaste	594.18 - 595.15	0.15 - 2.03	0.24 - 2.64	0.02 - 25.14	0.69 - 128.33
Boiler House	594.34 - 594.88	0.15 - 0.88	0.24 - 2.22	0.02 - 10.76	0.69 - 24.23
Turbine Building	594.82 - 597.52	0.22 - 3.43	0.21 - 4.00	0.02 - 125.66	1.51 - 367.05
U-2 HRSS	597.23 - 597.37	3.05 - 3.47	0.79 - 2.59	4.60 - 56.51	289.64 - 374.88
Design Engineering Building	597.42 - 597.64	2.59 - 3.21	0.70 - 2.71	2.75 - 49.11	208.54 - 321.79
Reactor Building	597.21 - 597.77	2.47 - 3.93	0.32 - 2.16	0.08 - 32.64	189.67 - 482.69
SBO	597.54 - 597.63	3.00 - 3.93	0.34 - 1.19	0.04 - 12.58	279.98 - 482.69
Admin.	597.55 - 597.81	2.13 - 5.97	0.37 - 2.43	0.24 - 57.17	141.5 - 1111.15
U-1 HRSS	597.52 - 597.53	2.79 - 3.67	0.32 - 0.97	0.03 - 3.55	242.07 - 420.04
FL Drain Surge Tank	593.74 - 594.73	0.10 - 1.07	0.19 - 6.10	0.01 - 46.33	0.34 - 35.77
LTD BLDG.	595.07 - 595.78	0.20 - 4.64	0.32 - 3.51	0.05 - 61.19	1.25 - 672.35
Service Building	595.63 - 597.52	1.08 - 3.44	0.28 - 3.91	0.04 - 79.02	39.33 - 342.89
Security Building	597.41 - 597.66	2.18 - 2.84	0.77 - 2.83	3.05 - 51.85	147.82 - 251.82
Weld Shop	594.53 - 595.95	0.14 - 1.92	0.56 – 3.75	0.08 – 34.31	0.57 - 114.98
Mauseleum	596.02 - 596.60	1.03 - 1.86	0.95 - 3.20	1.41 - 44.04	33.39 - 108.4
TSC	596.74 - 597.16	2.39 - 3.19	1.15 - 3.98	2.57 - 111.63	178.8 - 318.45

[1] Figure 4-1
[2] Max Flooding Depth is based on the ground surface, which varies in elevation depending on location.

The maximum predicted LIP flooding results are also provided at the critical entrances to the site buildings. Table 4 provides detailed LIP flooding results at main building doors.

Table 4: LIP Predicted Flooding Results at the Main Doors and Bays of the Site Buildings

Door/Building	Reference Grid Element No.	Max. Water Surface	Max. Flooding Depth[1]	Max. Velocity	Max. Resultant Impact Load	Max. Resultant Static Load
		ft (NAVD-88)	ft	ft/sec	lb/ft	lb/ft
Door 1 Reactor Building	8129	597.60	3.18	0.77	4.46	314.70
Door 2 Reactor Building	5649	597.22	3.22	0.44	0.12	324.34
Door 3 Turbine Building	5384	597.11	2.83	2.96	58.92	250.19
Door 4 Turbine Building	3527	595.52	1.67	1.97	15.89	87.08
Door 5 Reactor Building	7017	597.54	3.00	1.44	2.39	280.20
Door 6 Turbine Building	5627	597.52	2.84	0.41	0.10	251.23
Door 7 Reactor Building	5633	597.52	3.38	0.40	0.15	356.62

[1] Max Flooding Depth is based on the ground surface, which varies in elevation depending on location.

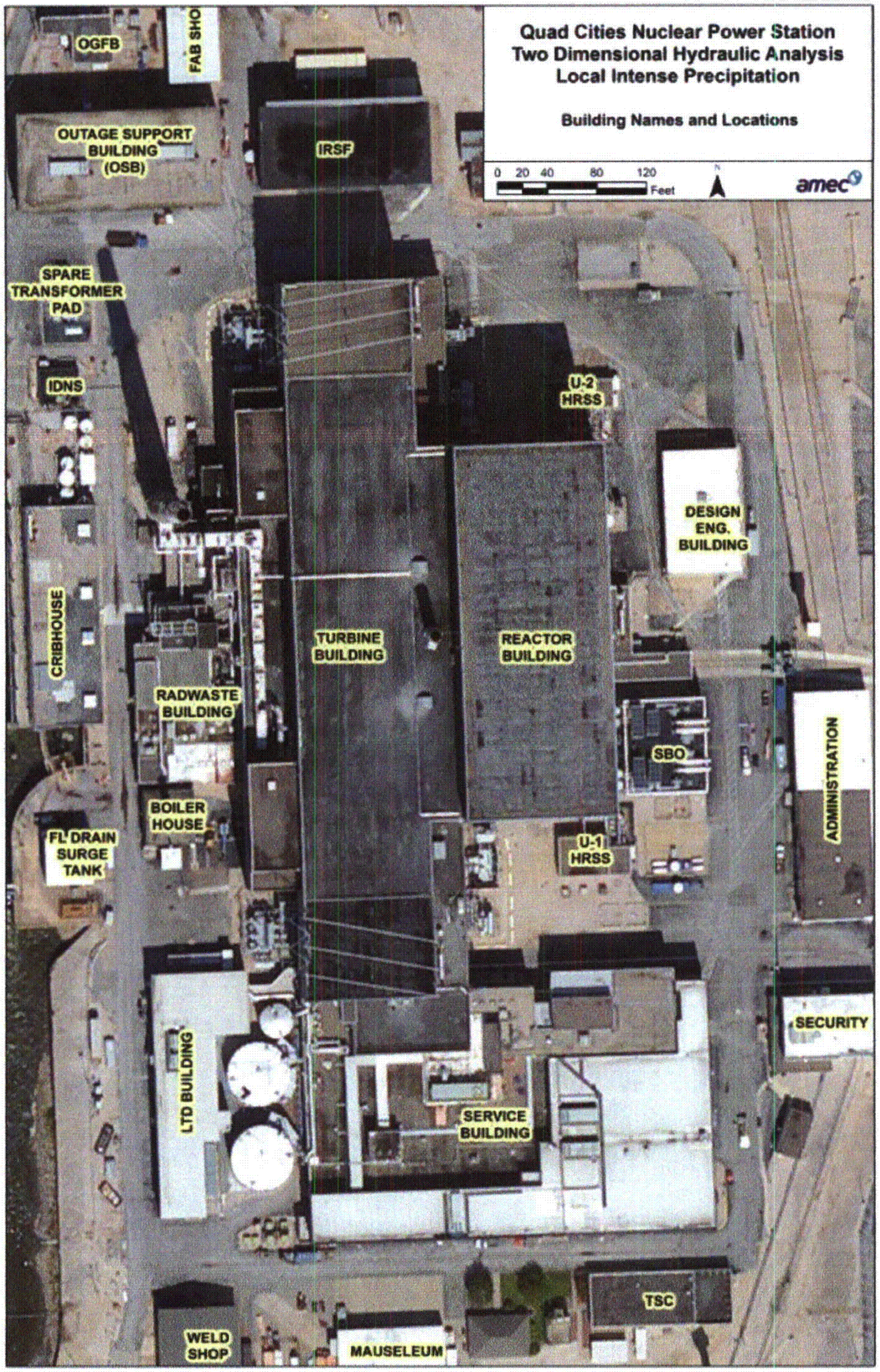

Figure 4-1: Building Names and Locations

5. CONCLUSIONS

The Quad Cities Station CLB does not address a LIP flood evaluation, and although it is a beyond design basis event, additional evaluations to disposition the LIP flood effects are warranted.

The results of the analysis show that the predicted maximum LIP flooding water surface elevations at the main doors and bays of the site buildings range between 595.52 feet NAVD-88 to 597.60 feet NAVD-88. However, based on the performed sensitivity analysis of grid size and Manning's n-values, an accuracy of ± 0.1 foot should be taken into consideration when evaluating the reported results.

6. REFERENCES

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