Exelon Nuclear
200 Exelon Way
KSA3-N
Kennett Square, PA 19348

Telephone 610.765.5610
Fax 610.765.5755
www.exeloncorp.com

Exelon.
Nuclear

52.17

March 24, 2006

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

Early Site Permit (ESP) Application for the Clinton ESP Site
Docket No. 52-007

Subject: Final Safety Evaluation Report (FSER) Proposed Site Characteristic for Probable Maximum Flood

Re: Nuclear Regulatory Commission (NRC) Final Safety Evaluation Report (FSER) for the Exelon Early Site Permit (ESP) Application issued February 17, 2006

In section 2.4.3 of the NRC FSER for the Exelon Generation Company, LLC (EGC), the NRC presented a proposed site characteristic for the probable maximum flood (PMF) level at the EGC ESP site. This value is somewhat higher than conservatively calculated by EGC in its ESP application. As such, EGC is providing the attached additional information in support of its proposed site characteristic PMF level. EGC would appreciate the opportunity to discuss the value of this site characteristic further before it is finalized in the NUREG and a revision to the ESP application. Please contact Christopher Kerr of my staff at 610-765-5814 if you have any questions regarding this submittal.

Sincerely yours,

Thomas P. Mundy

Thomas Mundy
Director, Project Development

D073

AFFIDAVIT OF THOMAS P. MUNDY

State of Georgia

County of Fulton

The foregoing document was acknowledged before me, in and for the County and State aforesaid, by Thomas Mundy, who is Director, Project Development, of Exelon Generation Company, LLC. He has affirmed before me that he is duly authorized to execute and file the foregoing document on behalf of Exelon Generation Company, LLC, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged and affirmed before me this 24 day of March 2006

My commission expires YOLANDA J. CELIK
NOTARY PUBLIC COBB COUNTY GA
MY COMMISSION EXPIRES NOVEMBER 1, 2008.

Yolanda J Celik

Notary Public

CK/erg

cc: U.S. NRC Regional Office (w/ enclosures)
Mr. John P. Segala (w/ enclosures)

Attachment

1.0 Introduction

On February 17, 2006, the NRC staff presented its Final Safety Evaluation Report (FSER). The applicant, EGC, has prepared specific comments on the NRC staff's technical evaluation presented in section 2.4, Hydrology.

The NRC staff designated a COL Action Item (2.4-3), requiring ESP intake structures designed to withstand the combined effects of Probable Maximum Flood (PMF), coincident wind wave activity, and wind setup, as discussed in Section 2.4.3 of the FSER. Additionally, the FSER identifies in Appendix A and in Section 2.4.3, a proposed site characteristic flood elevation of 721.7 ft. This value is identified as including a 714.79 ft MSL still water value, a wind generated wave height value of 6.6 ft, and a storm surge height value of 0.3 ft. This elevation represents a significant deviation from the EGC SSAR still water PMF of 708.9 ft MSL. This deviation may have significant impact on the placement and design of future intake structures at the site. As a result, the requirements of COL Action Item 2.4-3 could be problematic to implement at the COL stage.

In making these calculations, the NRC staff does not appear to have followed the regulatory guidance and industry standards identified in NRC documents as providing acceptably conservative calculation methods. The staff calculations were based on analyses of the effects of probable maximum precipitation (PMP) and wind effects than included many additional conservative assumptions and resulted in unrealistic maximum water surface values. EGC has reviewed these calculations and methods, and offers the following sufficiently conservative assessment of flooding at the ESP site.

2.0 Regulatory Basis

The following documents have been considered in the preparation of this information:

RS-002, Section 2.4.3, "Probable Maximum Flood on Streams and Rivers."

Regulatory Guide 1.59[1], Rev. 2, "Design Basis Floods for Nuclear Power Plants."

Generic Letter 1989-022, "Potential For Increased Roof Loads And Plant Area Flood Runoff Depth At Licensed Nuclear Power Plants Due To Recent Change In Probable Maximum Precipitation Criteria Developed By The National Weather Service."

Hydrometeorological Report (HMR)-51, "Probable Maximum Precipitation Estimates."

Hydrometeorological Report (HMR)-52, "Application of Probable Maximum Precipitation Estimates."

Hydrometeorological Report (HMR)-53, "Seasonal Variation of 10-Square-Mile Probable Maximum Precipitation Estimates."

ANSI/ANS 2.8-1992, "Determining Design Basis Flooding at Power Reactor Sites."

---

[1] RG 1.59, Appendix A, has been updated to require ANSI/ANS 2.8-1992 for calculating PMF.

In the FSER technical evaluations, the NRC staff asserted that it complied with RG 1.59, as well as RS-002, updated HMR standards, and the PMF calculations in ANSI/ANS 2.8-1992. However, as noted below, the NRC has made some unnecessarily conservative assumptions about the hydrology of the watershed, ultimately leading to its overly conservative conclusions.

3.0 Comments on FSER 2.4, Hydrology

3.1 FSER Section 2.4.1.3, Technical Evaluation

3.1.1 Watershed Assumptions

Comment: The NRC staff independently assumed a watershed size of 289.2 mi^2. This represents a differential of approximately 2.4% than that reported and appears to have resulted in a higher probable maximum precipitation (PMP) value. However, the staff's assumption does not account for more than 60 historical and operation documents about the Salt Creek Basin. These documents, including RG 1.59, all conclude that the Clinton Lake catchment basin is 296 mi^2. It is not clear why the NRC chose not to use the value endorsed in NRC Regulatory Guide 1.59.

Discussion: In Section 2.4.1, the NRC staff attempted to independently verify the hydrologic description provided in Exelon Generation Company's (EGC) SSAR, section 2.4.1. The SSAR calculations are based on a watershed of 296 mi^2. The staff manually delineated the watershed using USGS maps, and assumed that the watershed draining into Clinton Lake was 289.2 mi^2. The staff acknowledged a difference in calculation of approximately 2.4 percent (2.4%) less that that reported by EGC's SSAR. The subsequent NRC calculations and assumptions identified in the FSER are based on this smaller watershed.

The SSAR evaluates hydrology at Clinton Lake based on the watershed value of 296 mi^2. This watershed delineation was based on observable data and records at the site and hydrology reports used to build and operate the existing Clinton Power Station (CPS), including the Clinton Lake dam. Additionally, EGC relied on the NRC's RG 1.59, which specifically reports that the Clinton watershed is 296 mi^2. (See RG 1.59, Appendix B, Alternative Methods of Estimating Probable Maximum Floods, Table B-1 at page 8.)

However, in presenting its further comments, EGC has calculated the PMP and PMF for both a watershed of 289.2 mi^2 and a watershed of 296 mi^2.

3.2 FSER Section 2.4.3, Probable Maximum Flood (PMF)

3.2.1 Probable Maximum Precipitation (PMP)

Comment: In FSER section 2.4.3.3, the NRC staff independently assumed that the PMP at the site was approximately 28.7 in., based on a 72-hour storm. Using identical resources (HMR 51-53), EGC has concluded that the PMP is approximately 27.8 in.

Discussion: The calculation of the PMP is an important component of the overall calculations for the PMF. The small deviation between EGC's PMP calculations and the staff assumptions seems to arise from the difference in watershed area discussed above.

EGC believes its calculations of the PMP to be appropriately conservative. However, in performing the calculations to support these comments, EGC used both the staff assumption of 28.7 and its own calculation of 27.8 in.

3.2.2 Probable Maximum Flood into Clinton Lake (FSER Table 2.4-6)

Comment: The NRC staff's calculation of runoff into Clinton Lake is unreasonably conservative. Table 2.4-6, for example, shows a maximum runoff event of 571,314 cfs. No observable data supports this calculation.

Discussion: The EGC team developed its flood frequency analysis to show the probabilities of the flood magnitude anticipated by the NRC staff. We looked at these probabilities for the following reasons:

- The anticipated flow developed by the NRC staff makes unrealistic assumptions for response times, errors, and uncertainties, and is therefore significantly more conservative than required or necessary.
- Further, as explained below, the anticipated peak flow is not based on hydrologic engineering principles.

In response, the EGC team conducted a flood frequency analysis (FFA) to calculate the probabilities of various flood flows. As noted in ANSI/ANS-2.8-1992:

> In this standard, guidelines to determine design basis floods are primarily associated with "probable maximum" events of deterministic origins. The standard does not include guidelines for using a probabilistic approach, including stochastic techniques. ... At the time this standard was prepared, there were no recognized procedures to accurately and objectively define the exceedance probabilities of significant rare events included in probable maximum analysis. As data and procedures improve, probabilistic approaches are encouraged. The exclusion of probabilistic approaches from this standard should not be construed in a manner to inhibit innovation because preferred methodology for a particular case could likely be beneficial and acceptable for a specific site. (Section 1.1.2)

Since 1992, probabilistic modeling for hydrologic events has been developed at a rapid pace. The accepted scholarship now considers such probabilistic analysis as an essential part of modeling and decision-making in water resource systems (Haan, 2002).

Using the well-established methods of FFA prescribed in Haan (2002), the EGC team developed a model of probable peak flows that can be used to estimate a conservative magnitude for the PMF at the Rowell USGS gage. Disregarding the contribution from the watershed falling between the dam site and the Rowell gage, EGC conservatively assumed the PMF at the dam site equal to the PMF at the Rowell gage. Then, the EGC team tried to locate the NRC calculated PMF on the flood frequency curve (Figure 3.2-1). We noticed that the NRC calculated PMF falls way far on the y-axis of Figure 3.2-1 indicating that this magnitude is overly conservative. We further determined the 95% confidence intervals (CIs) for the predicted peak flows as depicted in Figure 3.2-1.

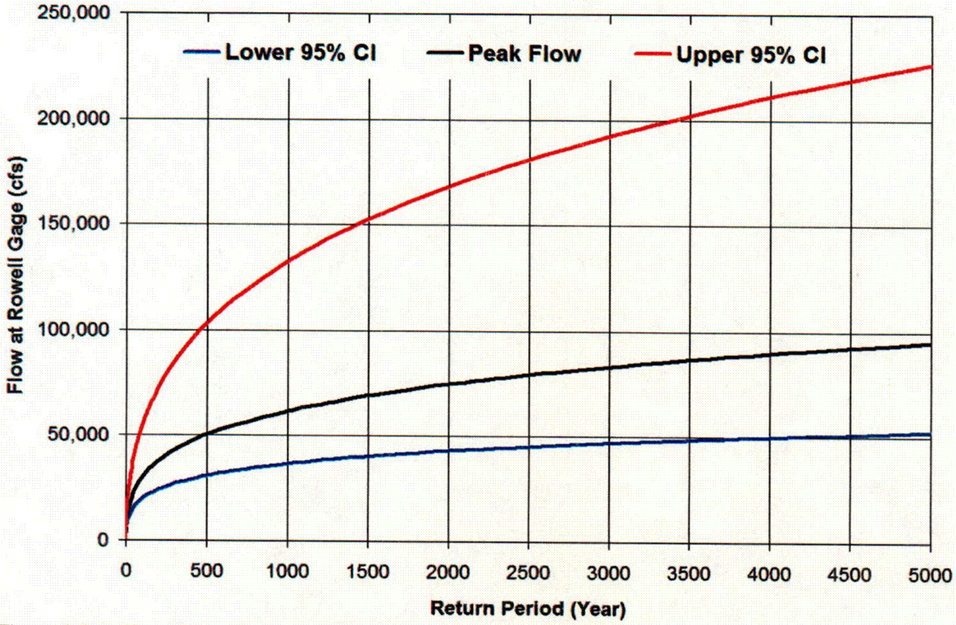


Figure 3.2-1: Flood Flow Analysis at Rowell Gauge

Based on the NRC calculations, the maximum inflow to the lake is as follows:

- During the 1st peak = 275,000 cfs (FSER, Fig. 2.4-8)
- During the 2nd peak = 575,000 cfs (FSER, Fig. 2.4-8)

With this information, the EGC team developed the FFA analysis using pre-dam observed data at the USGS gage near Rowell. The results of this comparison are tabulated in Table 3.2-1:

Table 3.2-1: FFA calculations showing 95% upper and lower confidence limits at Rowell gauge

Recurrence Interval (Year)	Lower 95% CI of Peak Flow (cfs)	Peak Flow (cfs)	Upper 95% CI of Peak Flow (cfs)
100	19,730	29,930	54,247
500	30,787	50,377	102,975
1000	36,566	61,687	132,270
5000	52,798	95,219	226,518

Based on this analysis, even the NRC calculated 1st-peak of 275,000 cfs does not seem to occur, indicating the occurrence of a second peak of 575,000 cfs is highly unlikely. In fact, expected flow flattens out. One can appropriately assume, then, that the flood flow predicted by the NRC is not probable. By application of probability principles, we see that the flow predicted by the NRC is significantly more conservative than required or necessary.

C01

3.2.3 Hydrostatic, or Still Water, PMF levels

Comment: The FSER imposes a site characteristic PMF at 721.7 ft. MSL, based on the staff's "independent review." The site characteristic is based on a hydrostatic, or still water, flood elevation of 714.79 ft. MSL. This characteristic is too conservative, and imposes unreasonable conditions on the new plant and all existing infrastructures.

Discussion: The NRC staff review "independently assessed" PMF levels without regard to infiltration or response time. Even with the assumption of a smaller watershed, it is unreasonable to assume that a PMP event delivered to the watershed would be "instantaneous[ly] transfer[red]" to Clinton Lake. Rather, the calculations should include appropriate lag times, infiltration, and accurate responses of the watershed during a PMF event as identified in ANSI/ANS 2.8, section 5.2.8. The EGC team has performed a thorough review of the NRC staff calculations, and disagrees that the staff has reached an appropriately conservative design characteristic based on a PMF event.

3.2.3.1 Background

In its application, the EGC team relied upon the discussion in the Clinton Power Station USAR:

> 2.4.3.3 Runoff and Stream Course Models
>
> The unit hydrograph for Salt Creek at the gauging station near Rowell was derived from storm data recorded in 1943 and 1944. It is presented in the publication, "Unit Hydrographs in Illinois," by W. D. Mitchell. [2] In the same publication, a synthetic method of deriving a unit hydrograph was developed. This method is applied in constructing the unit hydrographs. Figure 2.4-6 shows the synthetically developed unit hydrograph for Salt Creek at the dam site under natural river conditions compared with the Rowell Station unit hydrograph adjusted by direct ratio of drainage areas at the dam site and the gauging station. Figure 2.4-7 shows the unit hydrographs derived from the subbasin drainage areas above the dam site. The total drainage area at the dam site is relatively small. There are no existing or proposed reservoirs upstream of Lake Clinton. Flood hydrographs were developed for headwater areas and other subareas in the drainage basin that drain directly into the lake.

This information from the CPS USAR served as a baseline for EGC to determine a reasonable PMF at the proposed EGC ESP site. In its ESP Application, EGC noted that hydrologic characteristics at the lake had not changed. As a result EGC assumed that information from the USAR could be repeated in its application. The calculations in EGC's application included required calculations and assumptions about infiltration and response time, relying on the unit hydrographs identified in the Clinton USAR.

The figures used in the Clinton USAR (and subsequently in the EGC SSAR) show a basin-wide response time of approximately 24 hours (see SSAR Figure 2.4-10). Sub-basin responses show varying response times, ranging from 10.5 to 0 hours (see SSAR Figure 2.4-

[2] "W. D. Mitchell, "Unit Hydrographs in Illinois," Illinois Division of Waterways and U.S. Geological Survey, 1948" as referenced in EGC ESP SSAR and Clinton Power Station (CPS) USAR; CPS USAR Figure 2.4-6 is reproduced in the EGC ESP SSAR as Figure 2.4-10. CPS USAR Figure 2.4-7 is reproduced in the EGC ESP SSAR as Figure 2.4-11.

11). The impact of the differences between the lag times associated with the PMF evaluation is addressed in the following section.

3.2.3.2 PMP calculations and relationship to developing runoff calculations

In response to various RAIs and DSER Open Items, EGC reviewed and revised its own conclusions about the PMF and its relationship to site characteristics. Based on the large difference in the still water PMF between the NRC FSER and the ESP SSAR, EGC performed a re-review of the SSAR PMF evaluation. In addition, an independent evaluation for the PMF was performed.

For the first step of the evaluation, EGC determined the relationship of a PMP event to response times in the watershed.

EGC used the stepwise procedure of National Weather Service Hydrometeorological Report (HMR) No. 53 and additional information from HMR 51 and HMR 52 to estimate the 72-hour PMP (both precipitation volume and temporal distribution). Figures 3.2-2 and 3.2-3 show the Depth-Area and Depth-Area-Duration relationships for Clinton Lake watershed, respectively.

[GRAPHICS ON FOLLOWING PAGE TO ASSURE CLARITY]

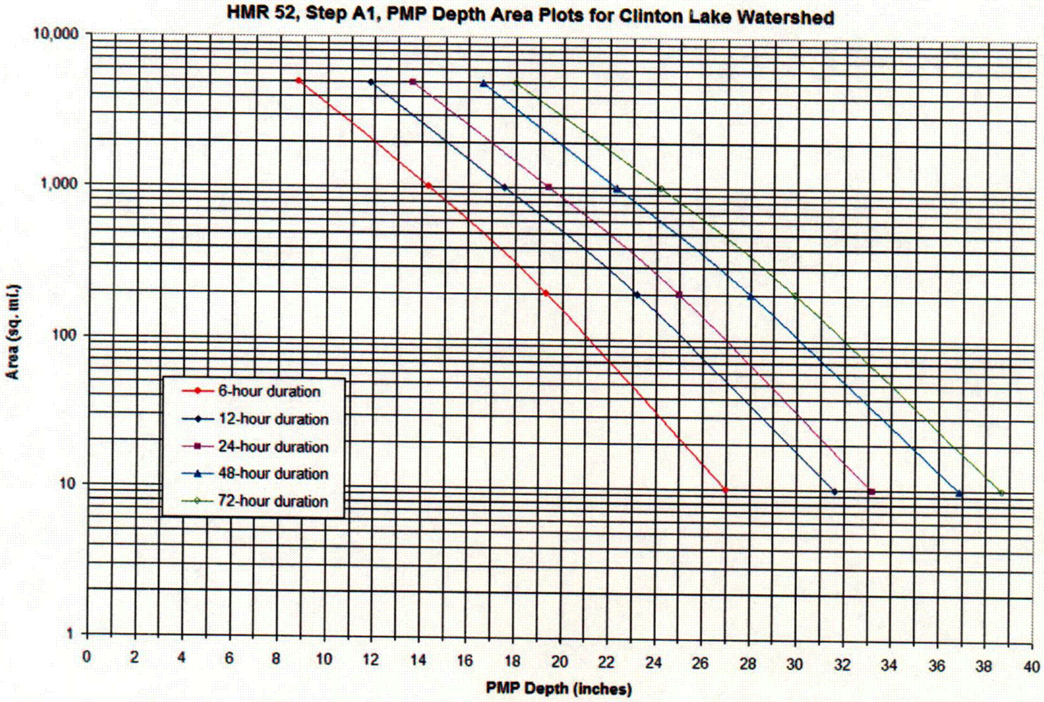


Figure 3.2-2: PMP Depth-Area Plot For Clinton Lake Watershed

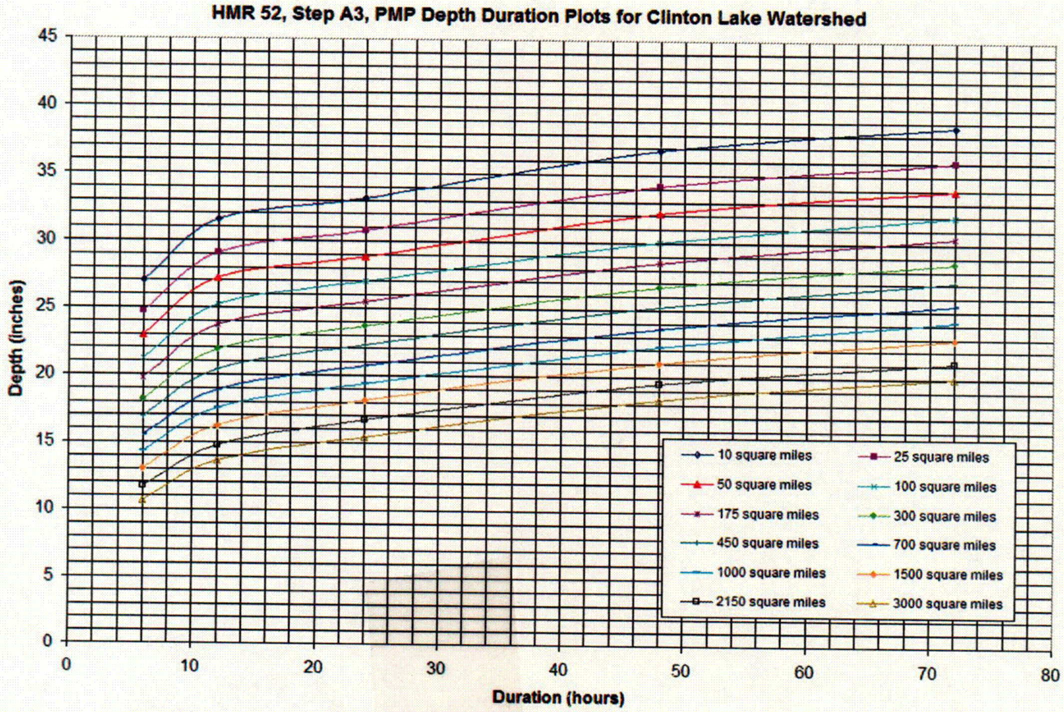


Figure 3.2-3: PMP Depth-Area-Duration Plot For Clinton Lake Watershed

C02

Based on this analysis, the PMP storm corresponding to Clinton Lake watershed (Area = 296 mi²) was determined. Further, the PMP storm was distributed according to ANSI/ANS-2.8-1992 as given in Table 3.2-2 below. It can be noted that the total rainfall for the 72-hr duration was found to be 27.8 inches.

Table 3.2-2: Time Distribution of PMP According to ANSI/ANS-2.8-1992

6-hour Period	Time (hours)	Accumulated Average PMP (inches)	Incremental Average PMP (inches)	6-Hour Sequence No.	ANSI Storm Distribution	Storm Pattern
1	6	17.46	17.46	1	0.80	0.70
2	12	20.98	3.52		3.52	0.70
3	18	22.08	1.10		17.46	0.70
4	24	22.88	0.80		1.10	0.80
5	30	23.67	0.80	2	0.80	0.80
6	36	24.37	0.70		0.70	3.52
7	42	25.07	0.70		0.70	17.46
8	48	25.76	0.70		0.70	1.10
9	54	26.26	0.50	3	0.50	0.50
10	60	26.76	0.50		0.50	0.50
11	66	27.26	0.50		0.50	0.50
12	72	27.76	0.50		0.50	0.50

We also applied 6-hour rainfall smoothing according to Figure 3.2-4.

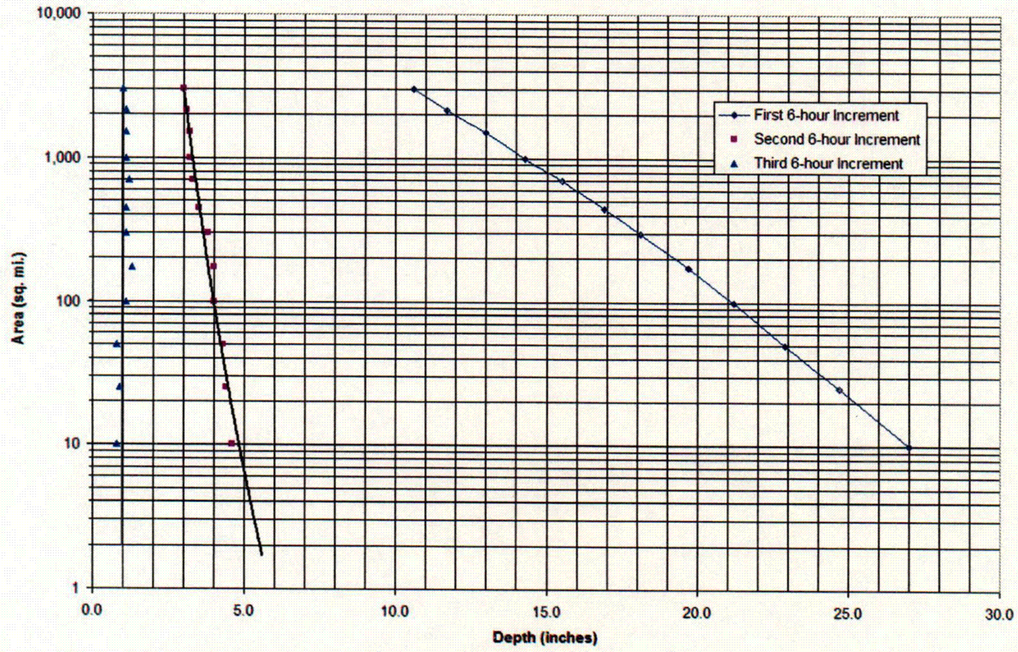


Figure 3.2-4: Six-Hour Incremental Rainfall Depth Smoothing

C03

The resulting PMP rainfall distribution is shown in Figure 3.2-5. For this review, it has been compared with the rainfall distribution used by the NRC. It is worth mentioning that the 72-hr total rainfall used by NRC is 28.7 inches whereas EGC has calculated 27.8 inches. This difference may be due to the different values of the watershed area used by EGC and NRC. The watershed areas for Clinton Lake used were 289.2 and 296.0 mi² by NRC and ECG, respectively, as discussed in previous sections.

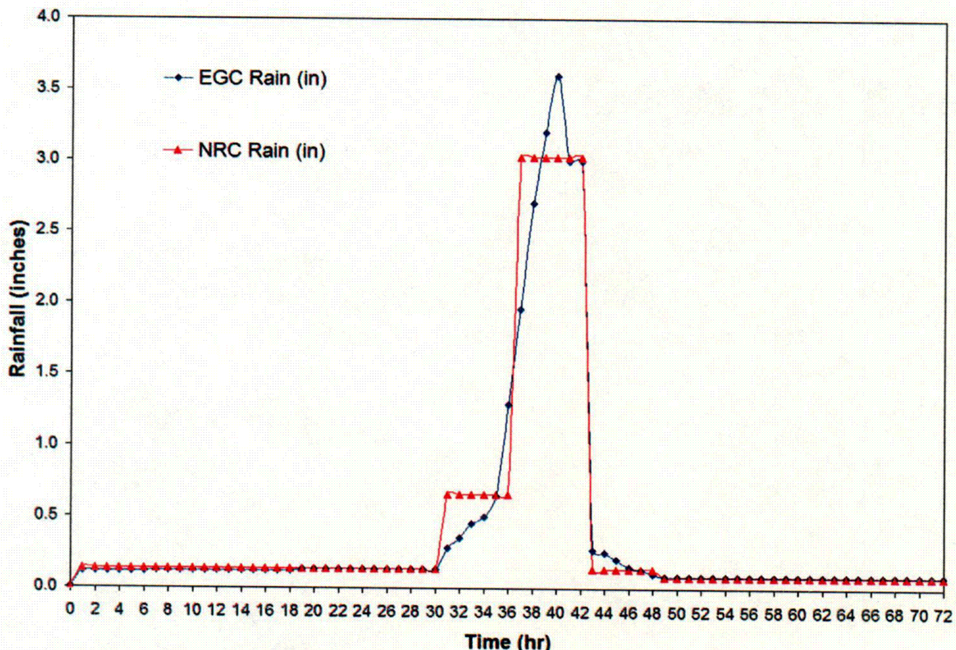


Figure 3.2-5: PMP Rainfall Distribution

3.2.3.3 Runoff calculations based on PMP

Using the methodology described above, we developed an antecedent 72-hour storm having a volume that was 40% of the PMP followed by 72-hours of no rain, followed by the full 72-hour PMP rainfall as the storm rainfall input in the HEC-HMS model (Army Corps of Engineers, Version 3.0.0; Dec. 2005). The 40% PMP is based on the requirements of ANSI/ANS 2.8-1992, section 9.2.1.1, "Combined Events." The original CPS USAR and ESP Application used 50% PMP for the antecedent storm which was slightly more conservative.

The HEC-HMS model includes the reservoir stage volume relationship and the spillway stage discharge relationship. The resulting model assumed an initial condition where inflow to the reservoir was equal to outflow, and this initial flow was equal to 580 cfs, a conservative value (i.e., we assumed a full reservoir) that was assumed to be equal to the mean monthly flow (see ANSI/ANS-2.8-1992 section 9.2.1.1 and SSAR Table 2.4-3). The initial water surface elevation in the reservoir was therefore about 1 foot above the elevation of the spillway crest, or 691 feet.

Since the NRC assumed that runoff from a PMP is instantly delivered to Clinton Lake, the EGC team developed assumptions about runoff and lag time in order to develop its HEC-HMS model. Such calculations can be highly variable, considering the uncertainties

C04

involved in lag time, and EGC found a wide variation in the estimates (Table 3.2-5). The EGC team's independent evaluation, based on preliminary calculations, calculated a lag time of 41 hours, and further reduced it to 19.6 hours (a safe assumption). The team estimated the runoff generated from a single watershed of 296 mi² in area using two different unit hydrograph methods of runoff calculation: Snyder and Soil Conservation Service (SCS). Table 3.2-3 presents the parameters used in these methods.

Table 3.2-3: Soil Conservation Service And Snyder Runoff Calculations

Description	Value	Unit
	SCS Method	
Length along stream to basin divide	25	mi
Curve Number	75	None
Slope	0.2	%
Basin lag time (SCS, 1975) $\frac{L^{0.8}[(1000/CN)-9]^{0.7}}{1900S^{0.5}}$	41 Calculated 19.6 Used	Hours
Base Flow	580	cfs
% Imperviousness	5 - 100	%
Initial Loss	0 – 1.5	in
	Snyder Method	
Length along stream to basin divide, L	25	mi
Length along stream to center of watershed, L_c	12	mi
Basin Lag coefficient, C_t	2	None
Snyder peaking coefficient, C_p	0.6	None
Snyder lag time $CC_t(LL_c)^{0.3}$	11.1	h
Base Flow	580	cfs
% Imperviousness	5 - 100	%
Initial Loss	0 – 1.5	in
Constant Loss Rate	0.1	in/h

Based on these methods, the hydrographs shown in Figures 3.2-6 and 3.2-7 were obtained. Both methods result in a maximum water level of 708.9 feet that agrees with the value submitted as part of the ESPA SSAR.

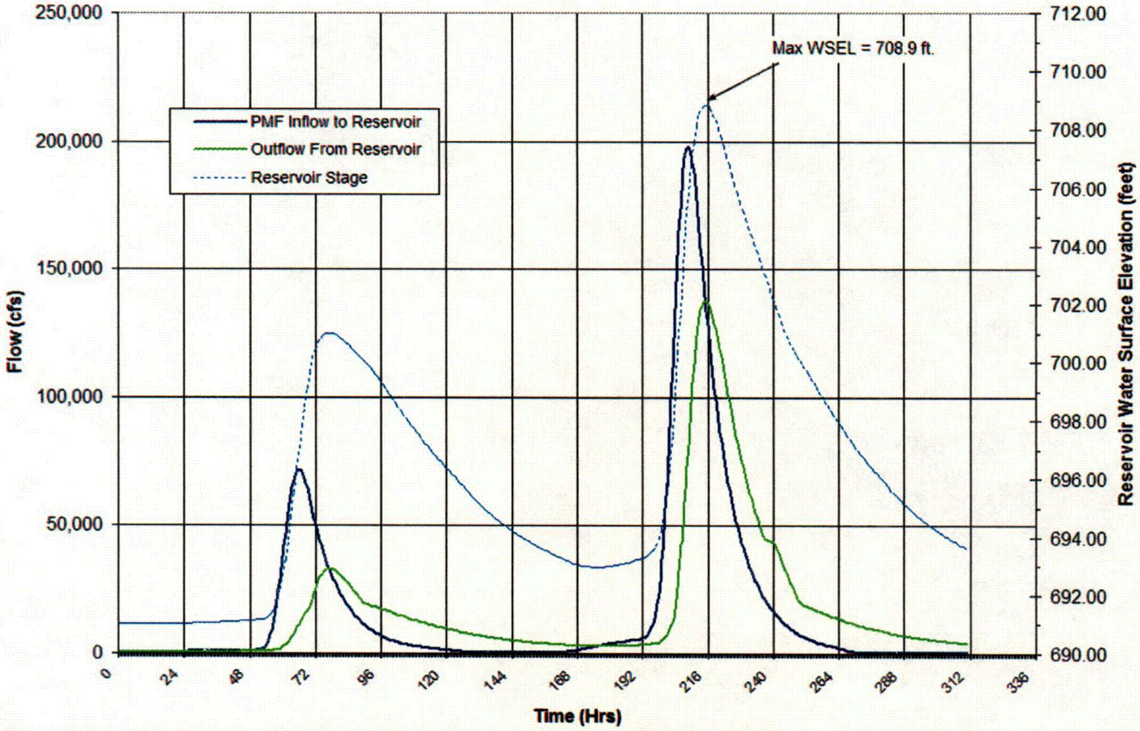


Figure 3.2-6: HEC-HMS Model Results Using Snyder's Method and Routing of PMF through Clinton Lake

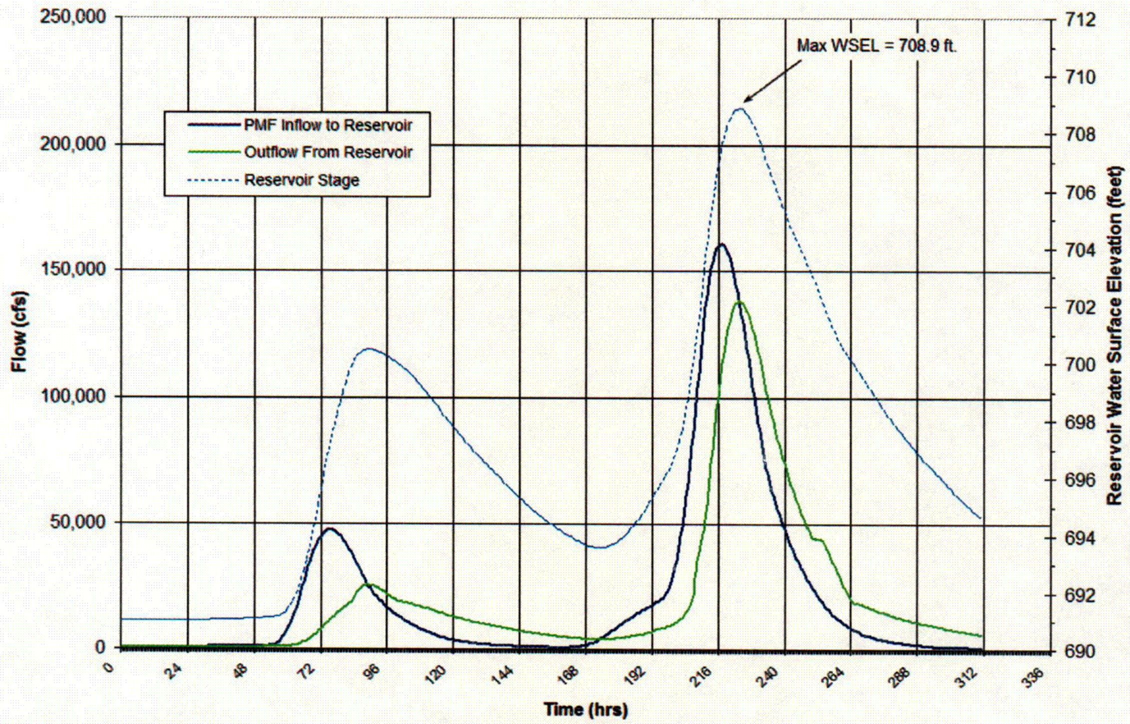


Figure 3.2-7: HEC-HMS Model Results Using SCS's Method and Routing of PMF through Clinton Lake

C05

3.2.3.4 Justification for EGC Lag Time Assumptions

EGC assumed the following definitions in calculating lag times for this watershed. These definitions are consistent with the HEC-HMS (Army Corps of Engineers, Version 3.0.0; Dec. 2005).

Lag time (T_L): time interval from the center of mass of rainfall excess to the peak of the resulting hydrograph

Time to peak (T_P): time interval from the start of rainfall excess to the peak of the resulting hydrograph

The relationship between the TL and TP is given as:
$T_P = T_L + D/2$

Where, D is the duration of the rainfall excess. There are several methods for determining the time parameters for a unit hydrograph (Haan et al., 1994). EGC used the lag equation developed by SCS (Haan et al., 1994; Viessman and Lewis, 1996):

$$T_L = \frac{L^{0.8}[(1000/CN)-9]^{0.7}}{1900S^{0.5}} \quad (1)$$

EGC approximately estimated L = 25 miles from the Clinton Lake watershed map given in Figure 2.4-4 of SSAR. Based on an assumed curve number (CN) = 75 (whereas CPS USAR estimated CN=74) and assumed average watershed slope of 0.2%, this equation gives a lag time of 41 hours. For additional conservatism, we assumed a lag time of 19.6 h in our analysis while using the SCS method. Table 3.2.4, taken from ESPA SSAR Table 2.4-13, shows the lag times for the synthetic hydrographs for the overall Clinton Lake watershed and its various component sub-basins.

Table 3.2-4: Lag Times In The Salt Creek Watershed (Including Clinton Lake)

Name	Area (mi^2)	Duration, D of UH (h)	Lag Time, T_L (h)	D/T_L	Time to Peak T_p (h)	Peak Flow Q_p (cfs)
			Salt Creek Components			
Headwaters	126.8	2	19.1	0.10	10.5	4490
Total Local Areas	*35.7*	*2*			*4*	*4260*
Local 1 (SE side)	6.2	0.5	3.1	0.16	2.1	1275
Local 2 (NE Side)	5	0.5	2.8	0.18	2	1155
Local 3 (NW Side)	16.3	1	5.6	0.18	3.9	1880
Local 4 (SW Side)	8.2	0.5	3.7	0.14	2.5	1410
			North Fork Components			
Head waters	111	2	17.85	0.11	10	4250
Local Area	15	0.5	5.3	0.09	2.92	1890
Reservoir Surface	8	2				*2500*

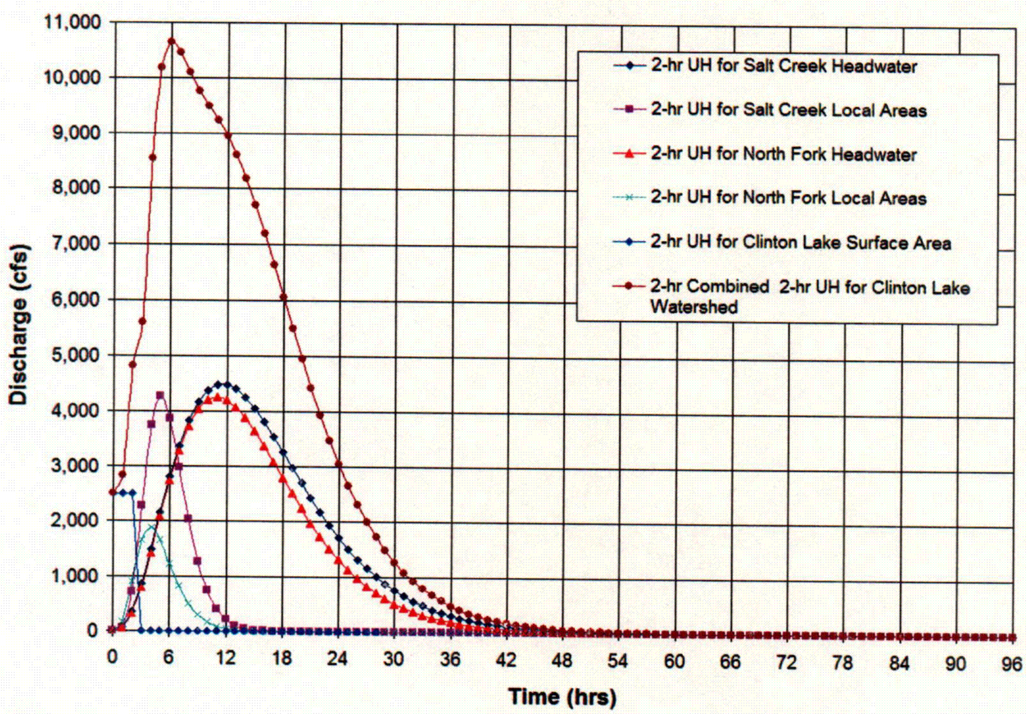
Table 3.2-4: Lag Times In The Salt Creek Watershed (Including Clinton Lake)

Name	Area (mi^2)	Duration, D of UH (h)	Lag Time, T_L (h)	D/T_L	Time to Peak T_p (h)	Peak Flow Q_p (cfs)
Area						
Overall Lake Watershed	296.5	2	32	0.1	24	5690

Reference: CPS-USAR (2002), SSAR
Note: In the above Table the definitions of the time parameters are found in Mitchell (1948). In developing its hydrographs, EGC used the following definitions:
Lag Time: time interval in hours from the center of mass of excess rainfall to the peak of the resulting hydrograph
Time to Peak: time interval in hours from the start of excess rainfall to the peak of the resulting hydrograph
Thus, Mitchell's T_P becomes EGC's lag time.

It can be noted from the last row of this table (Table 3.2-4) that, according to our definition, the lag time of the synthetic hydrograph is 24 hours. In the earlier calculations, EGC used a lag time of 19.6 hours, which is a more conservative and thus indicates that our assumption of using a lag time of 19.6 hours was safe.

It can be further noticed that the lag times given in Table 3.2-4 have discrepancies. The overall lag time for the synthetic UH hydrograph is 24 h whereas the lag times of various component sub-basins of Clinton Lake watershed are less than 10.5 h indicating the inconsistencies between the overall lag time and lag times of various components of Clinton watershed. This issue is further illustrated in Figures 3.2-8 (a) and (b).



C06

Figure 3.2-8(A): Comparison Of Unit Hydrographs For Various Sub-Basins Of Clinton Lake Watershed And Their Combined Unit Hydrograph For The Whole Watershed

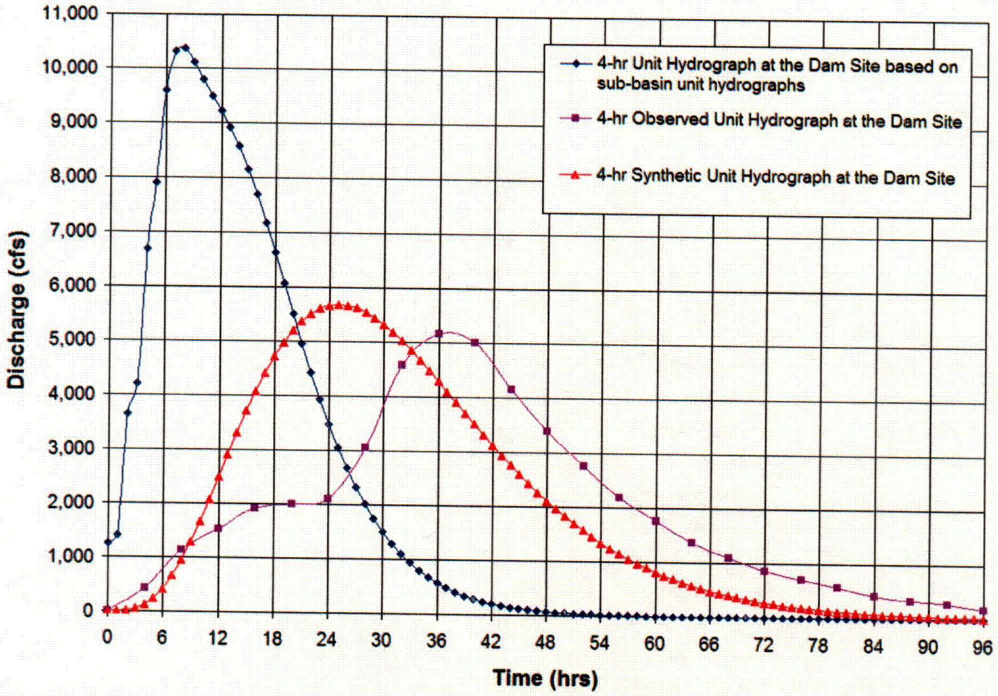


Figure 3.2-8(B): Comparison Of Unit Hydrographs And Their Lag Times For Observed, Synthetic, And Sub-Basin Based Hydrographs For Clinton Lake Watershed

Figure 3.2-8(a) represents EGC ESP SSAR Figure 2.4-11, and additionally, combine them together to get an overall unit hydrograph for the Clinton Lake subwatershed based on its component sub-basins. Figure 3.2-8(b) compares this combined unit hydrograph based on various sub-basins of Clinton Watershed (after converting it into a 4-h unit hydrograph), with synthetic and observed hydrographs taken from the EGC ESP SSAR 2.4-10. The EGC team combined these materials to compare all of the figures relied on during the ESP application preparation. It is clear from Figure 3.2-8(b) that the combined hydrograph based on component sub-basins shows an overall lag time of 6 hours (T_P is 8 hrs). Whereas observed and synthetic hydrographs (both taken from 2.4-10 of the SSAR and replicated for this response) give an observed lag time of 36 hours and a synthetic lag time of 24h. The lag times based on a sub-basin components is not consistent with the observed or synthetic unit hydrograph. While reviewing Mitchell (1948) and SSAR Figure 2.4-1, the EGC team noted that the sub-basin component UH lag times (SSAR Figure 2.4-11) were obtained using the empirical relationship represented by Equation 5, and are not based on observed data as mentioned by the NCR team during the March 9, 2006 conference call. As a result, the lag time (12 h mentioned by NRC) based on the combined unit hydrograph is not reliable. While the observed hydrograph can be relied on, the synthetic curve is more conservative. It is suggested that use of the synthetic hydrograph representing the overall watershed hydrograph, which has a 24-hour lag time is more appropriate.

C07

3.2.3.5 Further Investigation of Lag Time

As mentioned above, according to Mitchell (1948), the observed lag time is 36 hrs whereas the lag time suggested for the development of the synthetic 2-hr unit hydrograph is 24 hours. Mitchell (1948) provided a detailed discussion on this issue and provided various equations based on watershed characteristics such as drainage area (A), length (L), mean length (L_{ca}), and slope specific to this particular area. He further mentioned that *in all these areas there is vast capacity for storage of flood water, with consequent reduction in magnitude and increase in length of time to peak discharge.* Table 23 of Mitchell (1948) suggests the following equations for determining the lag times, *t* according to Mitchell's definition, for synthetic hydrographs.

$$t = 3.85A^{0.35}L^{0.43}L_{ca}^{0.04}S^{-0.29} \quad (2)$$

$$t = 0.849A^{0.53}L^{0.26}L_{ca}^{-0.1} \quad (3)$$

$$t = 1.01A^{0.43}L^{0.12}L_{ca}^{0.20} \quad (4)$$

$$t = 1.05A^{0.6} \quad (5)$$

$$t = 1.17A^{0.59} \quad (6)$$

$$t = 0.537A^{0.70} \quad (7)$$

$$t = 6.64L_{ca}^{1.09}S^{-0.32} \quad (8)$$

$$t = 4.64A^{0.58}S^{-0.25} \quad (9)$$

$$t = 2.8T_P^{0.81} \quad (10)$$

We independently calculated the values of lag times using Equations (2) to (9) and then converted them into T_P values using Equation (10). Table 3.2-5 presents the results of the calculation.

Table 3.2-5:
Lag Time Calculations,
Flood Analysis Inconsistency

Equation	A	L	L_{ca}	S	t	T_L	T_P
2	296	26.1	13	0.0189	401.50	459.6	460.6
3	296	26.1	13		31.3	19.7	20.7
4	296	26.1	13		28.8	17.8	18.8
5	296				31.9	20.2	21.2
6	296				33.6	21.5	22.5
7	296				28.8	17.8	18.8

Table 3.2-5:
Lag Time Calculations,
Flood Analysis Inconsistency

Equation	A	L	L_{ca}	S	t	T_L	T_P
2	296	26.1	13	0.0189	401.50	459.6	460.6
3	**296**	**26.1**	**13**		**31.3**	19.7	**20.7**
4	**296**	**26.1**	**13**		**28.8**	17.8	**18.8**
8			13	0.0189	386.9	439.1	440.1
9	296			0.0189	339.3	373.3	374.3

Note:
A = Watershed area (sq. miles)
L = Watershed Length (miles)
Lca = Mean watershed length (miles)
S = Watershed Slope (ft/ft)

It can be noted from Table 3.2-5 that the lag time varies from 17.8 hrs to 400 hrs based on the regression equations developed by Mitchell (1948). The lag time used by the EGC team in its PMF calculations was 19.6 h, which is very close to the lowest value of various lag times obtained in Table 3.2-5. To evaluate the impact of this marginal difference in the lag time (17.8 h versus 19.6 h); EGC further used the minimum value for lag time, that is 17.8 hours corresponding to Equations 4 and 7 and performed the PMF calculation a water elevation of 709.2 ft in the reservoir. If the watershed area were 289.2 sq. miles as used by the NRC the lag time based on Equations 4 and 7 will be 17.4 and the corresponding water elevation in the reservoir will be 709.1 ft.

3.2.3.6 Support for proper lag time of 19.6 hours

A previous analysis by EGC determined that an assumed lag time of 19.6 hours would produce a PMF elevation in Clinton Lake of approximately 708.9 feet. During a conference call on March 9, 2006, EGC asked NRC to consider a lag time of 19.6 as appropriately conservative. NRC requested support for the lag time of 19.6 hrs, compared with the lag time based on the observed data for Salt Creek at the USGS Gage near Rowell reported by Mitchell (1948). The NRC review team observed that a lag time based on Mitchell (1948) appeared to be 12 hours and asked for the rationale to support any other values.

The EGC team reviewed the Mitchell (1948) report but could not replicate or find 12 hours as the lag time for Clinton Lake watershed. Table 3.2-4 indicates that the lag time (using the EGC definition) for a 2-hr unit hydrograph is 24 hours. Based on this 2-hr unit hydrograph, a 4-hr unit hydrograph is developed and compared with the 4-hr unit hydrograph based on observed data (Figure 3.2-9).

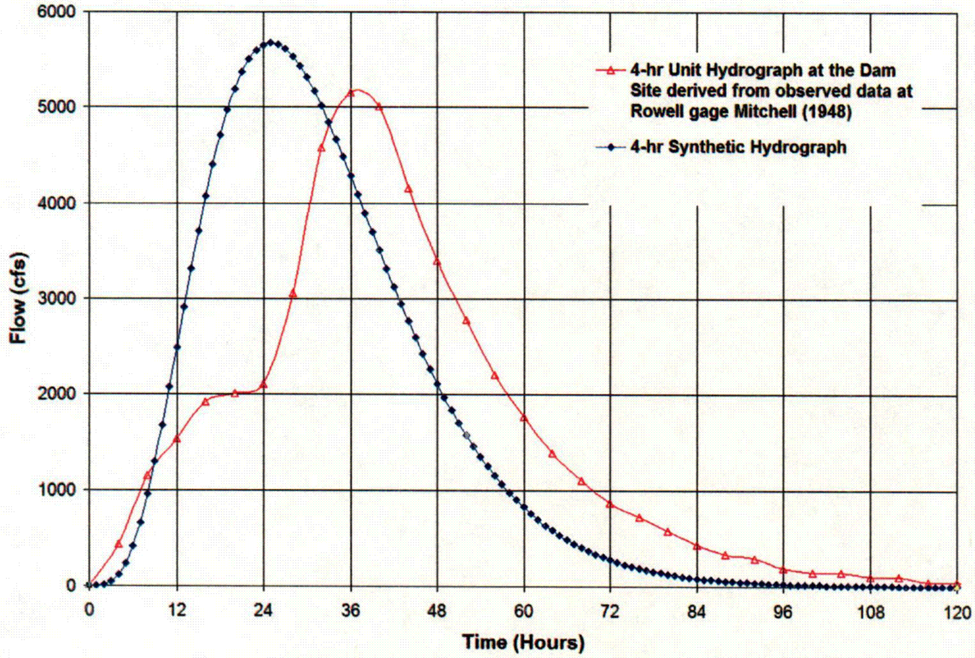


Figure 3.2-9: Comparison Between Observed And Synthetic Hydrograph At The Dam Site

It can be noted that the lag times for the observed and synthetic hydrographs are 36 and 24 hours, respectively.[3]

3.2.4 Wind Run Up Calculations

Comment: The NRC based its PMF site characteristic on a potential wind wave of 6.6 ft. The NRC staff relied on ANSI/ANS 2.8-1992, section 7, to calculate a wind storm appropriate for the Great Lakes. The wind runup should reflect the geography surrounding Clinton Lake. Further, the staff's reliance on section 7 of the ANSI report ignores instructions in sections 5 and 9 of the same standard that require analysis of a combined 2-year event. EGC used the combined event as directed by the endorsed standard, which is appropriately conservative.

Discussion: During its original SSAR review, EGC calculated potential wind wave action using ANSI/ANS-2.8-1992. Based on that standard, EGC calculated wind run up using the maximum 2-year wind provided in section 9 of the ANSI Standard. The NRC staff calculated its potential wind wave assuming a probable maximum wind storm (PMWS) under section 7 of the ANSI standard. The staff assumed a 100 mph wind developed for the Great Lakes. These bodies of water are approximately 150 miles north and east of the ESP site, and the EGC team assumed that the PMWS requirements did not apply. Thus, the EGC team assumed wind wave action of approximately 6.4 ft, while the NRC staff determined a wind run up of 6.6 ft.

---

[3] The NRC staff may have assumed a 12-h lag time based on unit hydrographs found in the Clinton USAR, and repeated in the SSAR. This problem is discussed in section 3.2.3.4.

C08

3.2.5. Probable Maximum Surge and Seiche Flooding

Comment: In its PMF, the NRC included a wind setup seiche of 0.3 ft (FSER 2.4.5). This seiche is conservative, given the configuration of the lake, and the likelihood of a PMWS of the magnitude assumed by the NRC.

Discussion: EGC did not calculate a seiche effect.

4.0 Conclusion

The FSER contains unreasonably conservative assumptions in its calculation of PMF. As a result, EGC respectfully requests the NRC staff to review its calculations and assumptions so that the safety features of the new plant and existing infrastructure are appropriately accounted for. Specifically, EGC requests NRC to do the following:

- Adopt the watershed area value of 296 mi^2 so that the appropriate watershed size corresponds with existing NRC license documentation and regulations.
- Adopt a hydrostatic PMF level of 708.9 ft. MSL based on the development of hydrographs as shown in this report. The revised PMF event is supported by the latest (i.e. alternate) hydrologic data and modeling. Additionally, the still water level of 708.9 ft reflects appropriate review of the response times for the watershed. Finally, this PMF level accounts for safety features at the ESP site as well as safety features of the existing plant and infrastructure.
- Adopt a site characteristic PMF of 715.8 ft.

Appropriate EGC ESP SSAR revisions will be made once agreement is reached on the appropriate PMF site characteristic.

References

Haan 2002. Haan, C. T. Statistical Methods in Hydrology, Second Edition. (2002). Iowa State Press, Ames, Iowa.

Haan et al. 1994. Haan, C. T., Barfield, B.J., and Hayes, J.C. *Design of Hydrology and Sedimentology for Small Catchments.* 1994. Academic Press, San Diego, California.

Mitchell 1948. W. D. Mitchell, *Unit Hydrographs in Illinois,* Illinois Division of Waterways and U.S. Geological Survey, 1948

Veissman and Lewis 1996. Viessman, W. and Lewis, G. L. Introduction to Hydrology. (1996). Harper Collins College Publishers, New York, NY.