Required Action: None / Monitor / Maintenance / Engineer

☐ **EROSION** [no problem, could not inspect thoroughly]

☐ Runoff Erosion (Gullies): Quantity: ____ Depth:____ Width:____ Length:____ ☐ ☐ ☐ ☐

Location: ____________________

Notes/Causes: ____________________

____

☐ **INSTABILITIES** [no problem, could not inspect thoroughly]

☐ Slides: Transverse Length:________ Longitudinal Length:__________ ☐ ☐ ☐ ☐

Scarp: Width:__________ Length:_________

Location: ____________________

Crack: Width: ________ Length:_________

Notes/Causes: ____________________

____

☐ Cracks: ☐ Transverse ☐ Longitudinal ☐ Other

Quantity:________ Length:_______ Width:________ Depth:________ ☐ ☐ ☐ ☐

Location: ____________________

Notes/Causes: ____________________

____

☐ Cracks: ☐ Transverse ☐ Longitudinal ☐ Other

Quantity:________ Length:_______ Width:________ Depth:________ ☐ ☐ ☐ ☐

Location: ____________________

Notes/Causes: ____________________

____

☐ Bulges: ☐ Depressions ☐ Hummocky

Size: ______ Height:_______ Depth:________ ☐ ☐ ☐ ☐

Location: ____________________

Notes/Causes: ____________________

____

☐ **OTHER** [no problem, could not inspect thoroughly]

☐ Rodent Burrows: (few, numerous)____________________ ☐ ☐ ☐ ☐

Location: ____________________

Notes: ____________________

____

☐ Other: ____________________ ☐ ☐ ☐ ☐

Notes: ____________________

____

☐ **SEEPAGE** [no problem, could not inspect thoroughly]

☐ Wet Area ☐ Flow ☐ Boil ☐ Sinkhole ☐ ☐ ☐ ☐

Flow Rate____________________ Size: ____________________

Location: ____________________

☐ Aquatic Vegetation ☐ None

☐ Rust Colored Deposits ☐ None

☐ Sediment in Flow ☐ None

☐ Other: ____________________

Notes/Causes: ____________________

____

{Inside Slope, Crest, **Outside Slope**, Outlet/Inlet Structures, Pond Drain}

None / Monitor / Maintenance / Engineer
Required Action

Required Action

None | Monitor | Maintenance | Engineer

□ Wet Area □ Flow □ Boil □ Sinkhole □ □ □ □

Flow Rate__________ Size:__________

Location:__________

□ Aquatic Vegetation □ None

□ Rust Colored Deposits □ None

□ Sediment in Flow □ None

□ Other:__________

Notes/Causes:__________

____

8) OUTLET/INLET STRUCTURES

□ **GENERAL INLET** [no problem, could not inspect thoroughly] □ □ □ □

□ Inlet Pipe Dimensions:______ (adequate, too small)

Type: (steel, concrete, aluminum, stainless steel, corrugated metal wood, other):______

Location:__________

Deterioration: (missing sections, rusted, collapsed)__________

In Use: (Yes, No)__________

□ Pond Erosion at Inlet: (Describe)__________ □ □ □ □

____

____

____

□ Other__________ □ □ □ □

____

____

□ **OUTLET STRUCTURES** [no problem, could not inspect thoroughly] □ □ □ □

□ Number of Outlet Structures:__________

□ Description/Location of Outlet Structures:__________

____

____

□ Outlet Structure 1: □ □ □ □

Type: (steel, concrete, aluminum, stainless steel, corrugated metal wood, other):______

____

Deterioration:(missing section, collapsed, rusted):__________

____

Erosion at Outlet Structure: (soil piping, seep collar, etc.)__________

____

Debris: (leaves, trash, logs, ice, etc.)__________

____

Notes:__________

____

None | Monitor | Maintenance | Engineer

Required Action

Required
Required
Action

None Monitor Maintenance Engineer

☐ Outlet Structure 2 ☐ ☐ ☐ ☐

Type: (steel, concrete, aluminum, stainless steel, corrugated metal wood, other):____________

Deterioration:(missing section, collapsed, rusted):____________

Erosion at Outlet Structure: (soil piping, seep collar, etc.)____________

Debris: (leaves, trash, logs, ice, etc.)____________

Notes:____________

☐ Outlet Structure 3 Dimensions:____________ ☐ ☐ ☐ ☐

Type: (steel, concrete, aluminum, stainless steel, corrugated metal wood, other):____________

Deterioration:(missing section, collapsed, rusted):____________

Erosion at Outlet Structure: (soil piping, seep collar, etc.)____________

Debris: (leaves, trash, logs, ice, etc.)____________

Notes:____________

9) POND DRAIN

☐ **GENERAL** ☐ ☐ ☐ ☐

☐ None Found ☐ Does not have one ☐ ☐ ☐ ☐

☐ Type of Pond Drain

(isolated control/intake tower, valve vault w/outlet conduit, valve in riser/drop inlet, siphon)

Notes:____________

☐ Operated During Inspection (yes, no) ☐ ☐ ☐ ☐

Notes:____________

☐ **ACCESS TO VALVE/SLUICE GATE** [no problem, could not inspect thoroughly] ☐ ☐ ☐ ☐

☐ Type (not accessible, from shore, boat, walkway, other)____________

Notes:____________

☐ Walkway/Platform:____________ ☐ ☐ ☐ ☐

☐ Concrete Deterioration ☐ Cracks (platform, piers, end supports, railing)

Location:____________

Notes:____________

Required Action: None / Monitor / Maintenance / Engineer

☐ Wood Deterioration ☐ ☐ ☐ ☐
Notes:______________________________________
____

☐ Metal Deterioration (minor, moderate, extensive, other) ☐ ☐ ☐ ☐
Notes:______________________________________
____

☐ **POND DRAIN COMPONENTS** [no problem, could not inspect thoroughly]

☐ Concrete Structure ☐ ☐ ☐ ☐
Locations:______________________________________
Description: (deterioration, misalignment, cracks):______________________
Notes/Causes:______________________________________
____

☐ Valve Control (Operating Device) ☐ ☐ ☐ ☐
☐ No Operating Device ☐ No Stem ☐ Bent/Broken Stem ☐ Other
Notes/Operability:______________________________________
____

☐ Metal Deterioration: (surface rust, minor, moderate, extensive, other) ☐ ☐ ☐ ☐
Location:______________________________________
Flow Rate:______________________________________
Notes/Causes:______________________________________

☐ Mis-alignment ☐ ☐ ☐ ☐
Notes/Causes:______________________________________
____

☐ Leakage – Flow Rate: ☐ ☐ ☐ ☐
Notes/Causes:______________________________________
____

☐ Outlet Conduit ☐ ☐ ☐ ☐
☐ Metal: (loss of coating/paint, surface rust, corrosion (pitting, scaling), rusted out)
Location:______________________________________
Notes/Causes:______________________________________
____

☐ Concrete (bug holes, hairline crack, efflorescence) ☐ ☐ ☐ ☐
(spalling, popouts, honeycombing, scaling, craze/map cracks)
(isolated crack, exposed rebar, disintegration, other)
Dimensions/Location:______________________________________
Notes/Causes:______________________________________
____

☐ Plastic: (deterioration, cracking)______________________ ☐ ☐ ☐ ☐
Location:______________________________________
Notes/Causes:______________________________________
____

Required Action: None | Monitor | Maintenance | Engineer

☐ Conduit Deformation ☐ Mis-Alignment: ☐ ☐ ☐ ☐
Location:______________________________
Notes/Causes:______________________________
____

☐ Separated Joint ☐ Loss of Joint Material ☐ ☐ ☐ ☐
Location/Description:______________________________
Notes/Causes:______________________________
____

☐ Undermining ☐ ☐ ☐ ☐
Location/Description:______________________________
Notes/Causes:______________________________
____

☐ Vegetation (trees, brush) ☐ ☐ ☐ ☐
Notes:______________________________
____

☐ Other ☐ ☐ ☐ ☐
Notes:______________________________
____

☐ Discharge Outlet
☐ Type (pipe outlet, concrete channel, rock-lined channel, none) ☐ ☐ ☐ ☐
Notes:______________________________
____

☐ Riprap: Average Diameter:
(adequate, sparse, displaced, weathered, vegetation) bedding/fabric noted – yes, no)) ☐ ☐ ☐ ☐
Notes:______________________________
____

☐ Concrete (bug holes, hairline crack, efflorescence)
(spalling, popouts, honeycombing, scaling, craze/map cracks) ☐ ☐ ☐ ☐
(isolated crack, exposed rebar, disintegration, other)
Dimensions/Location:______________________________
Notes/Causes:______________________________
____

☐ Mis-alignment
Location/Description:______________________________ ☐ ☐ ☐ ☐
Notes/Causes:______________________________
____

☐ Separated Joint ☐ Loss of Joint Material ☐ ☐ ☐ ☐
Location/Description:______________________________
Notes/Causes:______________________________
____

☐ Undermining
Location/Description:______________________________
Notes/Causes:______________________________ ☐ ☐ ☐ ☐
____

☐ Other
Notes:______________________________
____

APPENDIX C

Example Maintenance Forms

Ash Pond Maintenance Form
Petersburg Generating Station
Indianapolis Power & Light Company
Petersburg, Indiana

Date: ______________________________

Personnel: ______________________________

Maintenance Performed: ____

____

____

____

____

Reason for Maintenance: ____

____

____

____

____

Follow-up Inspection Required? ____

____

____

____

____

I:/4295/4295A/Reports/EV Maintenance Form.xls

APPENDIX D

Completed Forms

ATTACHMENT F

PONDS A & A' EMERGENCY SPILLWAY DESIGN

Sargent & Lundy LLC

ISSUE SUMMARY
Form SOP-0402-07, Revision 11

DESIGN CONTROL SUMMARY			
CLIENT:	Indianapolis Power & Light Company	UNIT NO.: N/A	PAGE NO.: 1
PROJECT NAME:	EVHSP CCR – Petersburg Station	S&L NUCLEAR QA PROGRAM	
PROJECT NO.:	10572-096	APPLICABLE ☐ YES ☒ NO	
CALC. NO.:	10572-096-PGS-ESW		
TITLE:	Ponds A and A' Emergency Spillway Design		
EQUIPMENT NO.:	N/A		

IDENTIFICATION OF PAGES ADDED/REVISED/SUPERSEDED/VOIDED & REVIEW METHOD

Main Document: 10 pages.
Total pages are 23 pages including 13 pages of the attachments.

INPUTS/ ASSUMPTIONS
☒ VERIFIED
☐ UNVERIFIED

REVIEW METHOD:	Detailed	REV.:	0
STATUS:	☒ APPROVED ☐ SUPERSEDED BY CALCULATION NO. ☐ VOID	DATE FOR REV.:	5/16/2016
PREPARER:	Cheegwan Lee (signed)	DATE:	5/16/2016
REVIEWER:	Nikhil M. Patel (signed)	DATE:	5/16/2016
APPROVER:	Darrel J. Packard (signed)	DATE:	5/16/2016

IDENTIFICATION OF PAGES ADDED/REVISED/SUPERSEDED/VOIDED & REVIEW METHOD

INPUTS/ ASSUMPTIONS
☐ VERIFIED
☐ UNVERIFIED

REVIEW METHOD:		REV.:	
STATUS:	☐ APPROVED ☐ SUPERSEDED BY CALCULATION NO. ☐ VOID	DATE FOR REV.:	
PREPARER:		DATE:	
REVIEWER:		DATE:	
APPROVER:		DATE:	

IDENTIFICATION OF PAGES ADDED/REVISED/SUPERSEDED/VOIDED & REVIEW METHOD

INPUTS/ ASSUMPTIONS
☐ VERIFIED
☐ UNVERIFIED

REVIEW METHOD:		REV.:	
STATUS:	☐ APPROVED ☐ SUPERSEDED BY CALCULATION NO. ☐ VOID	DATE FOR REV.:	
PREPARER:		DATE:	
REVIEWER:		DATE:	
APPROVER:		DATE:	

NOTE: PRINT AND SIGN IN THE SIGNATURE AREAS

TABLE OF CONTENTS

1. PURPOSE & SCOPE 3
2. DESIGN INPUTS 3
3. ASSUMPTIONS 3
4. METHODOLOGY & ACCEPTANCE CRITERIA 4
5. CALCULATIONS 6
6. RESULTS 8
7. REFERENCES 9
8. ATTACHMENTS 10

1. PURPOSE & SCOPE

1.1. The purpose of this calculation is to determine the dimension of two emergency spillways for Pond A and Pond A' respectively (i.e. width and crest elevation) to meet the allowable maximum water elevation of 438 feet. The maximum allowable water elevation was determined in the inundation calculation for the Petersburg emergency action plan to reduce the inundation depth in the plant area due to Pond A breach scenario (Ref. 7.9).

1.2. The purpose of this calculation is also to determine the level of erosion protection that is necessary for passing the peak discharge flow for each spillway.

1.3. The scope of this calculation is limited to preparing a spillway calculation for the detailed design.

2. DESIGN INPUTS

2.1. Vertical Datum is NAVD 88, feet (Ref. 7.7)

2.2. Design rainfall event is a 1000-year recurrence for a surface impoundment with significant hazard potential (Section 257.82 in Ref. 7.1). The design rainfall depth is 10.1 inches for the 1000-yrs/24-hr event (Ref. 7.2).

2.3. The elevation-storage curves of Ponds A and A' are shown in Attachment A (per Ref. 7.8).

2.4. The surface area of Pond A is 57.7 acres. The surface area of Pond A' is 7.1 acres (per Ref. 7.9).

2.5. Conservatively, initial water elevations are set to the crest elevations for the emergency spillways, 437 feet for Pond A' and 437.5 feet for Pond A, respectively.

3. ASSUMPTIONS

There are no unverified assumptions.

3.1. The discharge coefficient for Pond A' is considered to be 2.97, considering the sloping embankment with lower tailwater condition per Page 410 of Ref. 7.4. For Pond A, a standard discharge coefficient is considered to be 2.6 because the sloped embankment condition is not met due to the higher tailwater condition in Pond A' (i.e. tailwater level at the crest elevation of Pond A).

3.2 The existing embankment side slope protection for Pond A' spillway is sufficient for handling the discharge flow for a 1000-year storm event. Thus, the top of weir crest erosion protection is only evaluated in this calculation.

4. METHODOLOGY & ACCEPTANCE CRITERIA

4.1. Methodology

Emergency spillways are intended to be used for the routing of Inflow Design Flood (IDF) in the event of a malfunction of the flow control structures that safely pass the normal operational flow (Page 24 of Ref. 7.6).

The HEC-HMS hydrologic modeling system (Ref. 7.5), developed by the US Army Corps of Engineers, was used to determine the spillway dimensions required to meet the maximum allowable water elevation in Pond A and Pond A'.

Erosion protection requirement is evaluated per the flow depth in the guideline on Page 347 in Ref. 7.10.

The steps followed in performing the calculation are shown below:

4.1.1. Estimate and/or obtain the model input parameter values including the pond surface area, weir crest, elevation-storage curve, rainfall depth, spillway dimension, and weir discharge coefficients.

4.1.2. Set up the HEC-HMS model using the input data.

4.1.3. Find the optimal spillway dimension to meet the acceptance criteria through a model sensitivity analysis.

4.1.4. Determine the type of erosion protection based on the spillway water depth.

4.2. Acceptance Criteria

The following acceptance criteria were used to determine if the results satisfy the purpose and scope of the calculation:

4.2.1. The computed maximum water elevation in Pond A does not exceed the maximum allowable water level of 438 feet (Refs. 7.8 and 7.9).

4.2.2. The computed maximum water elevation in Pond A' does not exceed the crest elevation (i.e. 437.5feet) of Pond A emergency spillway to maintain a free flow broad-crested weir condition over the emergency spillway of Pond A. Note that this free flow broad-crested weir condition will ensure that the maximum allowable water level in Pond A is not exceeded.

4.2.3. The significant decimal digit of accuracy for the elevation computation is one (1).

4.2.4. The type of erosion protection meets the spillway water depth criteria on Page 347 in Ref. 7.10.

4.3. Computer Programs Used

4.3.1. HEC-HMS Version 3.5, S&L program No. 03.7.852.3.5, run on PC ZD8684. This program is verified and validated per S&L requirements.

5. CALCULATIONS

The HEC-HMS model setup and calculation procedures are summarized as follows:

5.1. Primary input parameter values for HEC-HMS model are as follows:

Table 5-1 Summary of Primary Input Parameters for HEC-HMS Model

	Design Spillway Crest EL. (ft)	Weir Discharge Coefficient ($ft^{0.5}$/sec)	Initial Water EL. (ft)	Subbasin Area (acre)	Pond Storage (acre-ft)	Rainfall (inch)	Runoff Transformation
Pond A'	437.0	2.97	437.0	7.1	Elevation-Storage Curve (p.A3)	SCS Type II Distribution	SCS Unit Hydrograph
Pond A	437.5	2.60	437.5	57.7	Elevation-Storage Curve (p.A2)	SCS Type II Distribution	SCS Unit Hydrograph

Note: No rainfall loss is considered.

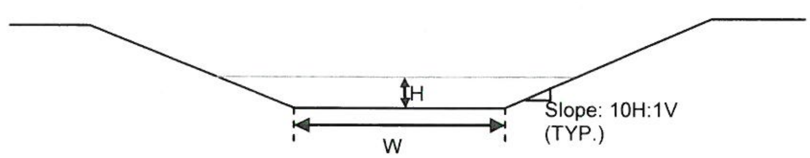

Figure 5-1 Schematics of Emergency Spillway

5.1.1. The design spillway crest elevation of Pond A is 437.5 feet NAVD 88. The design spillway crest elevation of Pond A' is 437.0 feet NAVD 88 per engineering judgment. Note that the dike elevation at the spillway location is 439 feet NAVD88 for both Ponds A and A' based on the topographic data available (Ref. 7.7).

5.1.2. The spillway is considered as a broad-crested weir with free flow condition. The discharge coefficient for Pond A is conservatively considered to be 2.6 (i.e. lower bound of standard broad-crested weir coefficient), considering that the design maximum pool elevation (i.e. 437.5 feet) of Pond A' (or A-discharge) is close to the design spillway crest elevation of Pond A (i.e. the upper limit of a submerged weir condition). The discharge coefficient for Pond A' is considered to be 2.97 per Page 401 of Ref. 7.4. The tailwater condition for the normal river flow is far below the spillway crest elevation, which meets the sloping embankment criteria with free flow (i.e. higher discharge coefficient).

5.1.3. The initial water elevations are conservatively considered to be the same as the design crest elevations of the spillway for each pond. This is a consistent approach with the inundation map calculation for Petersburg Emergency Action Plan (Ref. 7.9).

5.1.4. The subbasin area is the pond surface area.

5.1.5. The NRCS (SCS) Type II rainfall distribution (per Ref. 7.3) is considered to generate the time-varying rainfall hyetograph in the HEC-HMS model.

5.1.6. The SCS Unit Hydrograph method was used to transform the rainfall to discharge into the ponds. No loss is considered. No time lag is considered. Thus, the discharge rate is likely to be a direct precipitation runoff.

5.2. The model setup schematic and results are shown in Attachment B.

5.3 The optimal effective crest widths (i.e. considering rectangular shape) of spillway were determined to be 50 feet for both Pond A and Pond A'. The design crest width considering the side slope of 10H:1V of spillway is computed as follows:

Maximum flow area (A) = effective crest width (W_e=50 feet) x maximum allowable water depth above crest (H=6 inch) = 25 feet^2.

Considering the trapezoidal weir with 10H:1V side slope and 6-inch water depth,

Maximum flow area (A) = W x H + (10 x H x H)
W = (A – 10 x H x H)/H = (25 – 10 x 0.5 x 0.5)/0.5 =45 feet.

5.4 Per Pages 345 and 347 of Ref. 7.10, 6-inch coarse gravel (i.e. d_{50}=6 inch) protection is required on the crest of spillway. The peak water depth is significantly less than 2 feet and the peak velocity at the crest of Pond A' is 2.3 feet/s. Type 1 protection (i.e. next higher type) is selected from the table on Page 347 of Ref. 7.10 (Pages C2 and C3) because critical depth may occur beyond the road crossing.

6. RESULTS

6.1. The minimum crest width (W) of spillway is determined to be **45 feet** for both Pond A and Pond A' considering the 10H:1V side slopes on each side of each spillway crest.

6.2. The primary output values of this calculation are reported as follows (see Attachment B).

Table 6-1 Summary of Emergency Spillway Dimension (for 1000-yr Storm)						
	Top of Dike Elevation (ft)	Spillway Crest Elevation (ft)	Peak Water Elevation (ft)	Min. Spillway Crest Width (ft)	Min. Spillway Top Width (ft)	Peak Outflow (cfs)
Pond A'	439	437	437.5	45	85	57.4
Pond A	439	437.5	438.0	45	75	51.7

Notes:

1) The top of dike elevation is at the spillway location. The actual elevation along the dike varies generally 439 to 440 feet.
2) Spillway Top Width = Spillway Crest Width + 2 x [10 x (Dike Elevation – Spillway Crest Elevation)]. Freeboard is available 1.5ft for Pond A' and 1.0ft for Pond A.

6.3 The recommended erosion protection needed to pass the peak discharge flow over the spillway crest is 6-inch median size gravel and 1 foot thick.

7. REFERENCES

7.1. Federal Register, Vol. 80, No. 74, April 17, 2015, Part II Environmental Protection Agency, 40 CFR Part 257.

7.2. NOAA Atlas 14, Volume 2, Version 3, Location Name: Petersburg, Indiana, US, Latitude: 38.5357°, Longitude: -87.2464°.

7.3. United States Department of Agriculture, Natural Resources Conservation Service, 1986, Urban Hydrology for Small Watersheds, TR 55.

7.4. Haun, Stefan, Reidar, N., and Feurich R., 2011, Numerical Modeling of Flow over Trapezoidal Broad-Crested Weir, Engineering Application of Computational Fluid Mechanics, Vol. 5, No. 3, pp. 397-405.

7.5. US Army Corps of Engineers, Hydrologic Engineering Center, 2010, Hydrologic Modeling System HEC-HMS, User's Manual, Version 3.5, S&L Program No. 03.7.852-3.5.

7.6 FEMA, 2013, Selecting and Accommodating Inflow Design Floods for Dams, FEMA P-94.

7.7 DLZ Industrial, LLC, 2015, Petersburg Generating Station, Overall Ash Pond Survey.

7.8 S&L, 2016, Ash Pond System Emergency Action Plan, Petersburg Generating Station, Indianapolis Power & Light Company.

7.9 S&L, 2016, Investigation and Analyses of Surface Impoundment Breach Floods for Emergency Action Plan, Petersburg Generating Station, Indianapolis Power & Light Company.

7.10 United States Department of the Interior, Bureau of Reclamation, Design of Small Canal Structures.

8. ATTACHMENTS

		Total No. of Pages
A.	Elevation-Storage Curves	3
B.	HEC-HMS Model Setup and Results	7
C.	Erosion Protection Guideline	3

ATTACHMENT A: ELVATION-STORAGE CURVES

Elevation	Cum. Storage
ft	acre-ft
415	0
416	48.4
417	97.1
418	146.3
419	195.9
420	245.8
421	296.2
422	347.0
423	398.1
424	449.7
425	501.7
426	554.1
427	607.0
428	660.2
429	713.8
430	767.9
431	822.4
432	877.3
433	932.6
434	988.4
435	1044.6
436	1101.2
437	1158.3
438	1215.7
439	1251.0
440	1303.8

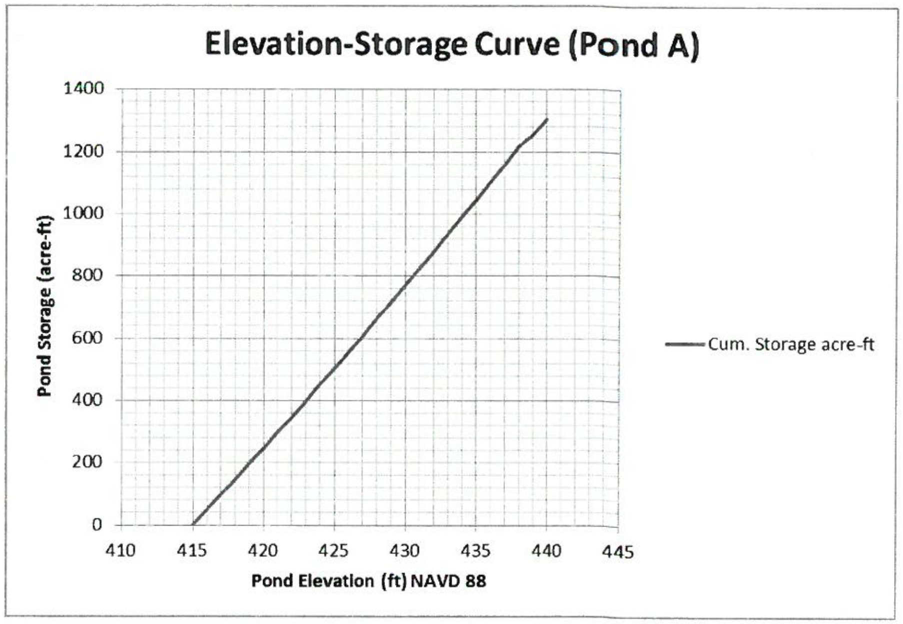

Table A1- Pond A Elevation-Storage Curve

Sargent & Lundy LLC	Calcs. For	Ponds A and A' Emergency Spillway Design		Calc. No.	10572-096-PGS-ESW
				Rev. 0	Date: 5/16/2016
		Safety-Related	X Non-Safety Related	Page	A3 of A3

Client	Indianapolis Power & Light Company	Prepared by	Cheegwan Lee	Date	5/16/2016
Project	EVHSP CCR - Petersburg	Reviewed by	Nikhil M Patel	Date	5/16/2016
Project No.	10572-096	Approved by	Darrel J. Packard	Date	5/16/2016

Elevation	Cum. Storage
ft	acre-ft
415	0
416	3.6
417	7.4
418	11.3
419	15.4
420	19.6
421	23.9
422	28.3
423	32.9
424	37.7
425	42.6
426	47.6
427	52.8
428	58.1
429	63.6
430	69.3
431	75.1
432	81.0
433	87.1
434	93.4
435	99.9
436	106.5
437	113.3
438	120.2
439	127.3
440	134.3

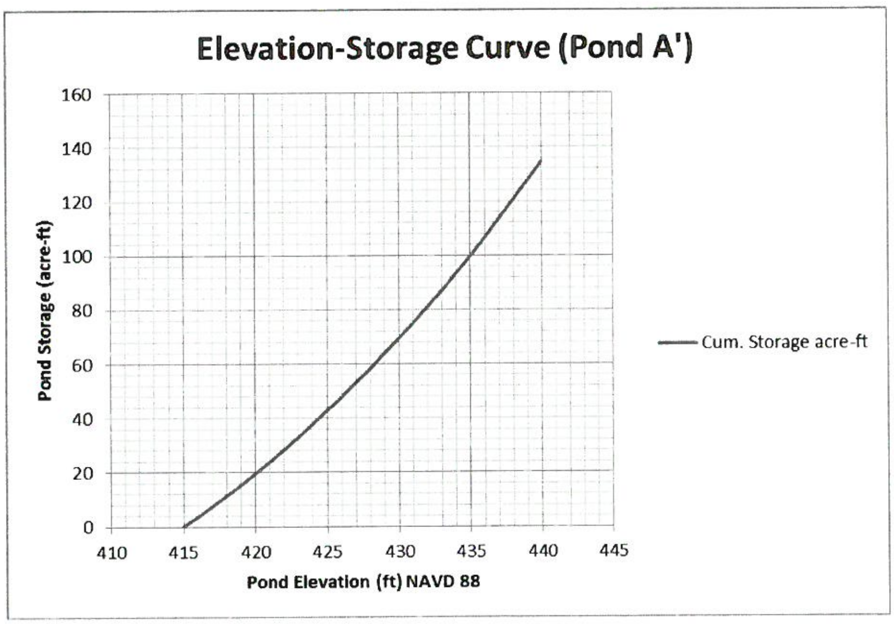

Table A2- Pond A' Elevation-Storage Curve

ATTACHMENT B: HEC-HMS MODEL SETUP AND RESULTS

Sargent & Lundy LLC	Calcs. For	Ponds A and A' Emergency Spillway Design	
		Safety-Related	X Non-Safety Related

Calc. No.	10572-096-PGS-ESW		
Rev. 0	Date:	5/16/2016	
Page	B2	of	B7

Client	Indianapolis Power & Light Company
Project	EVHSP CCR - Petersburg
Project No.	10572-096

Prepared by	Cheegwan Lee	Date	5/16/2016
Reviewed by	Nikhil M Patel	Date	5/16/2016
Approved by	Darrel J. Packard	Date	5/16/2016

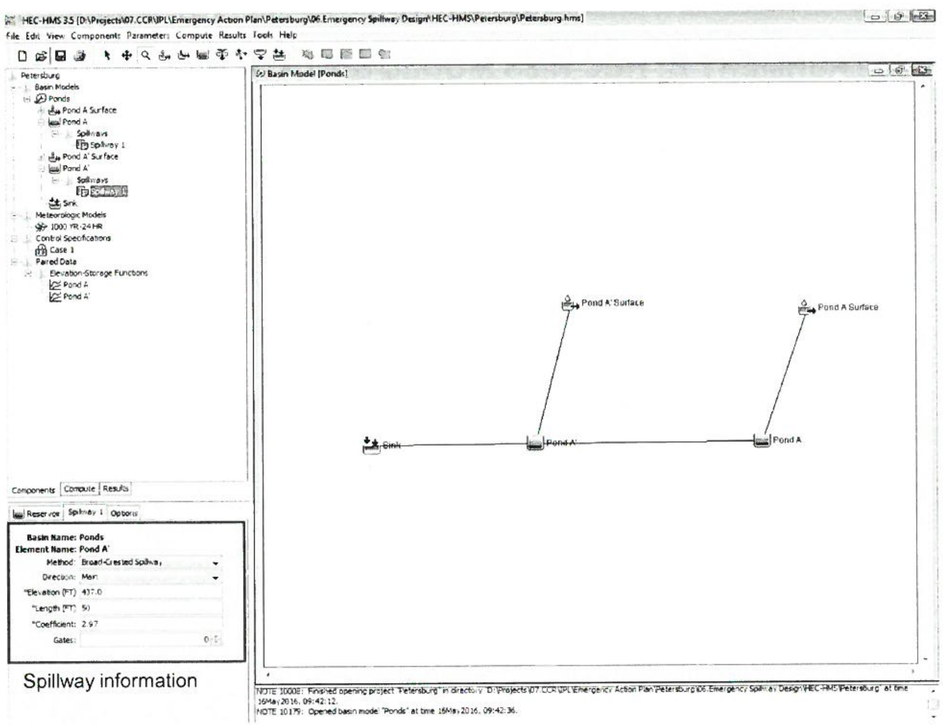

Figure B1- Schematic of HEC HMS Model Setup (including Pond A' Spillway)

Sargent & Lundy LLC	Calcs. For	Ponds A and A' Emergency Spillway Design		Calc. No.	10572-096-PGS-ESW
				Rev. 0	Date: 5/16/2016
		Safety-Related	X	Non-Safety Related	Page B3 of B7

Client	Indianapolis Power & Light Company
Project	EVHSP CCR - Petersburg
Project No.	10572-096

Prepared by	Cheegwan Lee	Date	5/16/2016
Reviewed by	Nikhil M Patel	Date	5/16/2016
Approved by	Darrel J. Packard	Date	5/16/2016

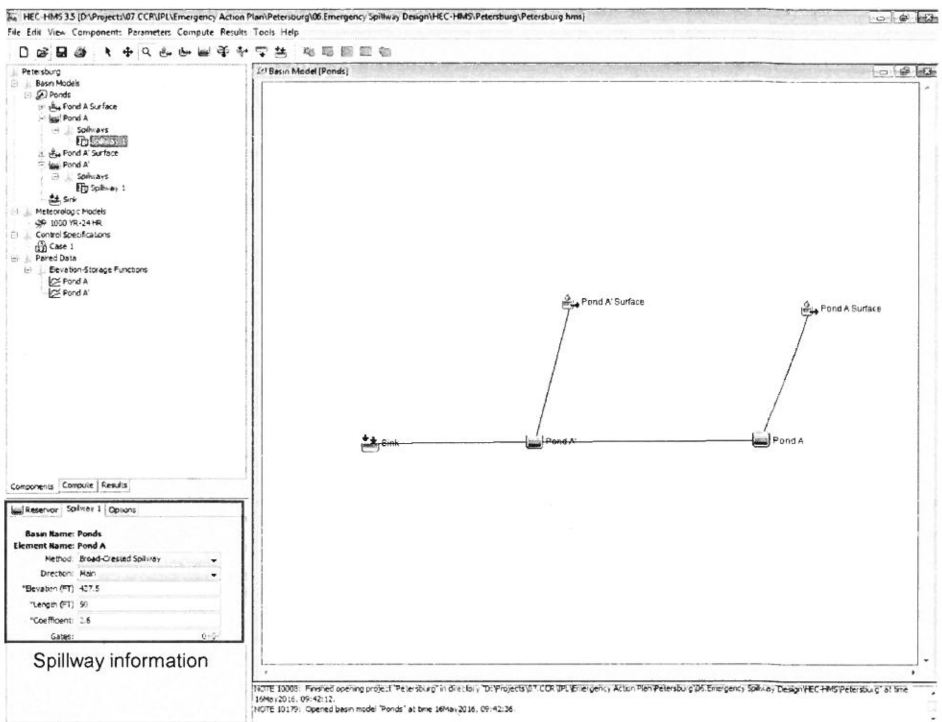

Figure B2- Schematic of HEC HMS Model Setup (including Pond A Spillway)

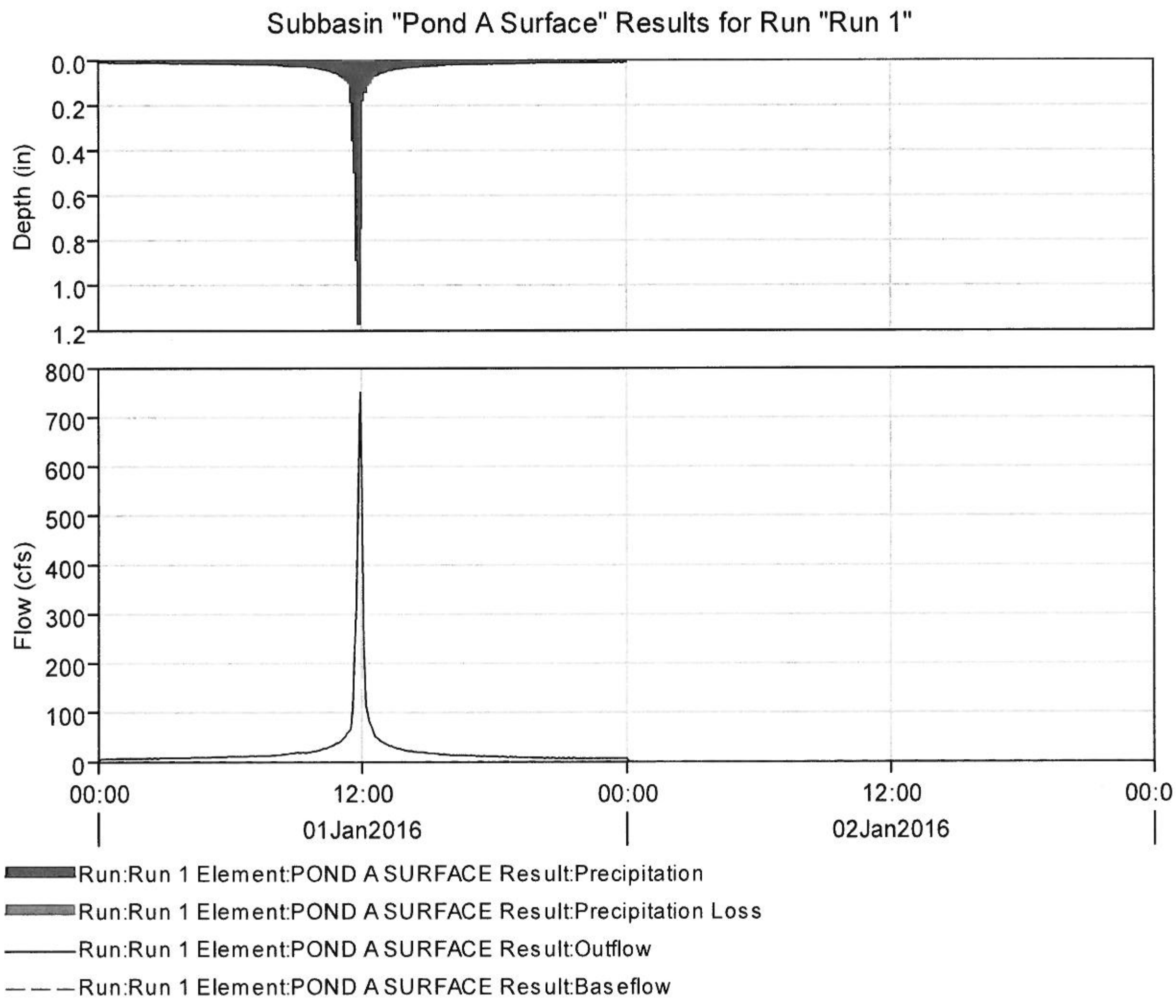

Figure B3- Pond A Precipitation and Outflow from Subbasin from HEC-HMS Model Results

Sargent & Lundy LLC	Calcs. For	Ponds A and A' Emergency Spillway Design	Calc. No.	10572-096-PGS-ESW
			Rev. 0	Date: 5/16/2016
	Safety-Related	X Non-Safety Related	Page	B5 of B7

Client	Indianapolis Power & Light Company	Prepared by	Cheegwan Lee	Date	5/16/2016
Project	EVHSP CCR - Petersburg	Reviewed by	Nikhil M Patel	Date	5/16/2016
Project No.	10572-096	Approved by	Darrel J. Packard	Date	5/16/2016

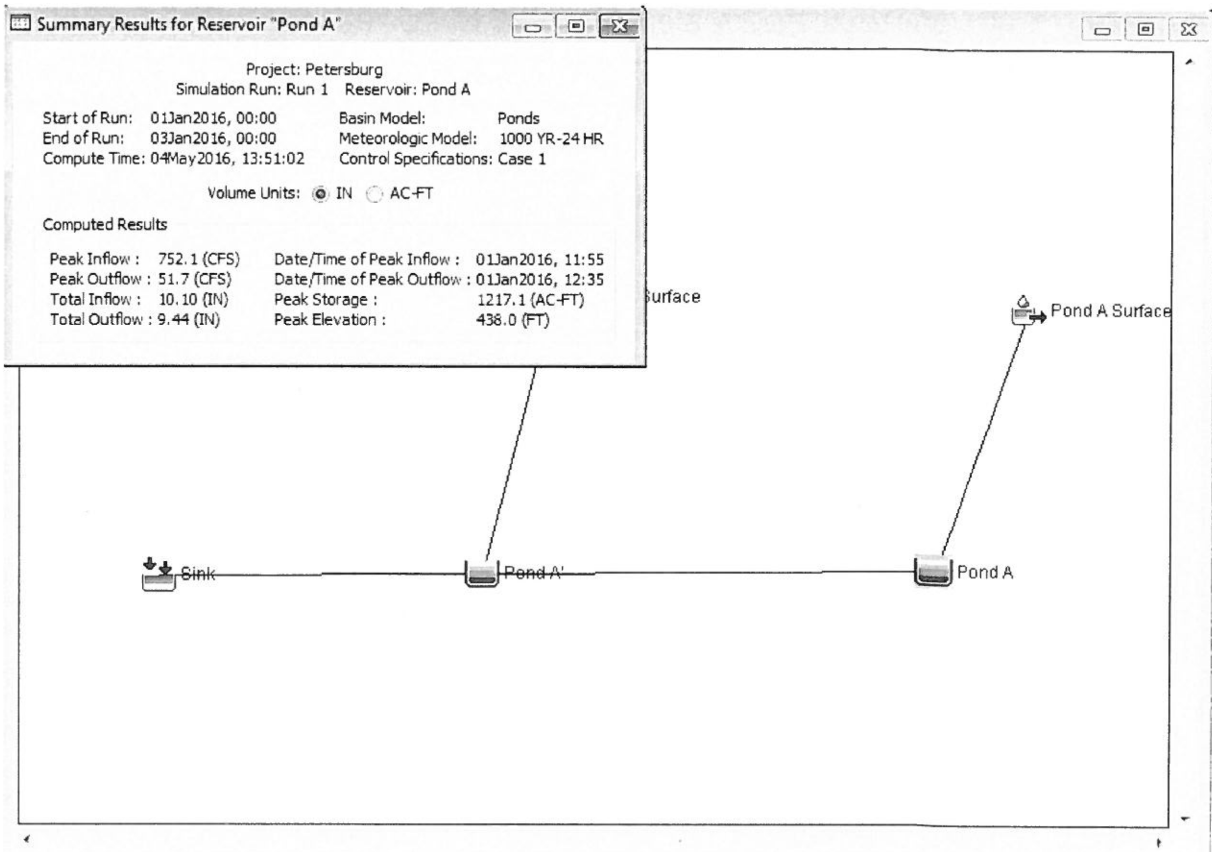

Figure B4- Summary Results for Pond A

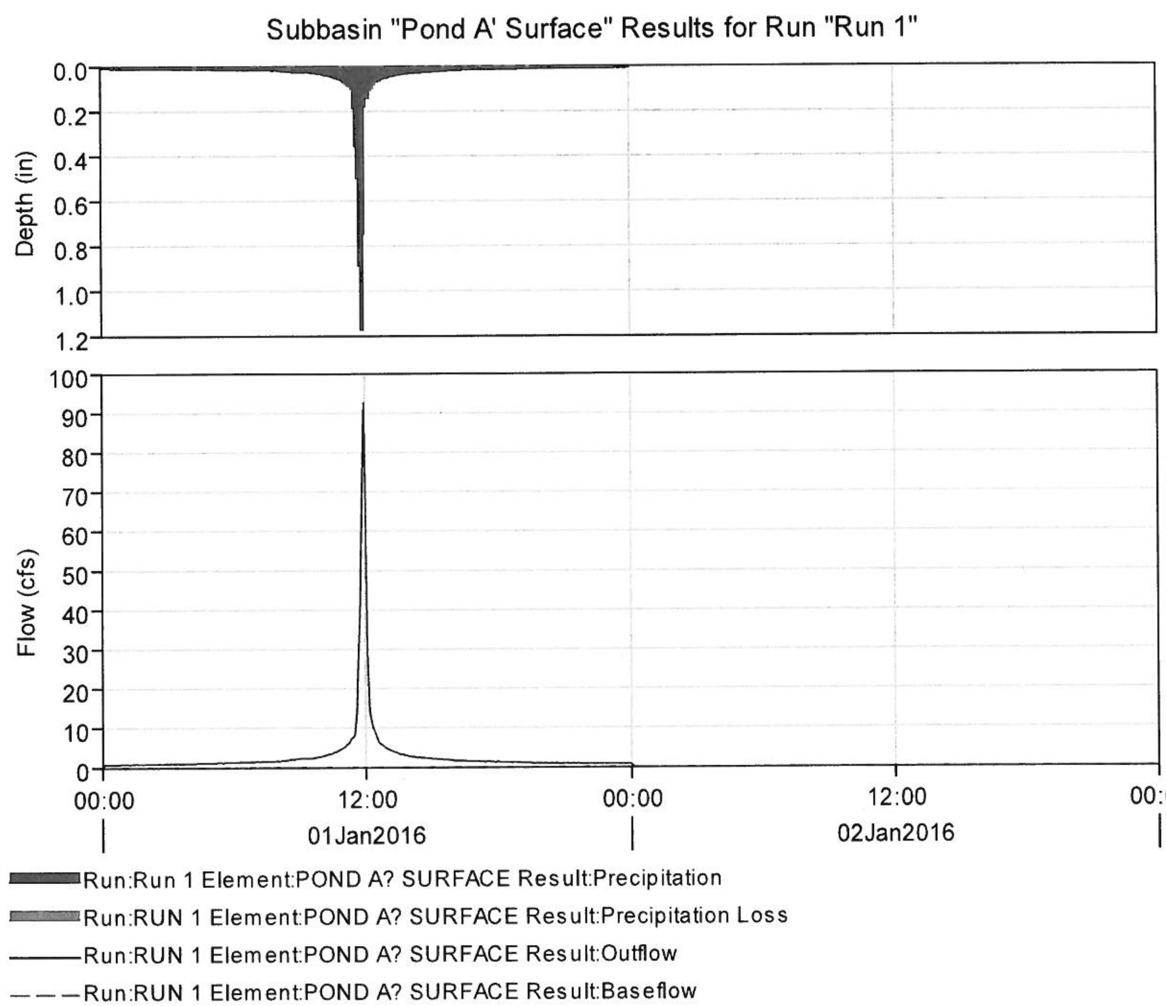

Figure B5- Pond A' Precipitation and Outflow from Subbasin from HEC-HMS Model Results

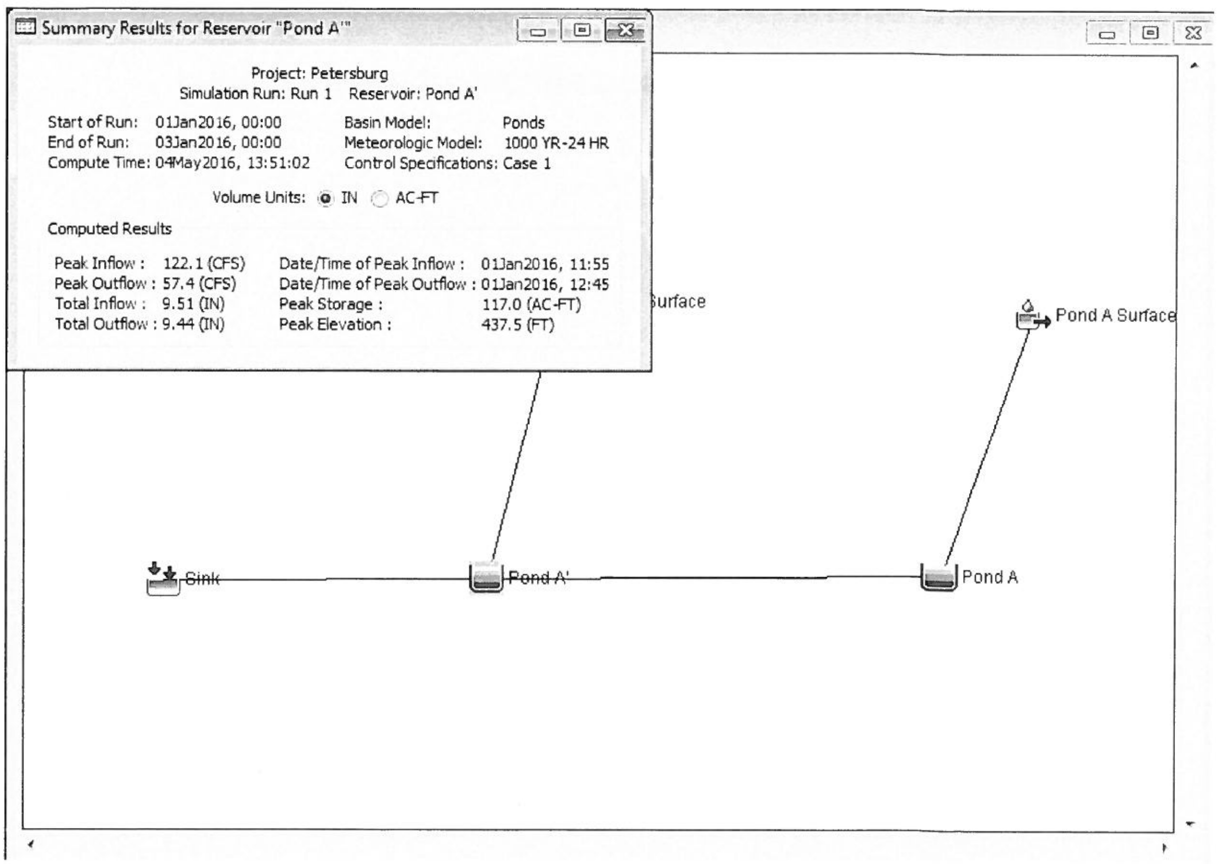

Figure B6- Summary Results for Pond A'

ATTACHMENT C: EROSION PROTECTION GUIDELINE

by reducing the depth and velocity for flows less than design flow.

To provide adequate canal bank freeboard, the inlet water surface for design flow should be at least 2 feet below the top of the canal bank. The orifice equation [1], $Q = CA\sqrt{2gh}$, may be used to calculate the inlet water surface required to discharge the design flow. For a type 4 inlet transition, a discharge coefficient, $C = 0.6$ may be used. The head, h, measured from the centerline of the opening to the water surface for free flow may be conveniently determined by rearranging the orifice equation and making appropriate substitutions:

$$h = 0.0433V^2$$

where V is the design velocity of the pipe.

7-10. *Type 5 Transitions.*—Figure 7-3 shows a typical type 5 transition. These transitions are simply an extension of the concrete canal lining which matches the normal concrete-lined section at one end and has a headwall on the pipe end. These transitions may be used where minimum head loss is not a factor. Figure 7-3 has a table of dimensions for pipes up to 36 inches in diameter. Because of headwall stability considerations, the maximum pipe diameter used with type 5 transitions is 36 inches.

The table of dimensions provide for the following:

1. Full-pipe velocity of 5 feet per second.
2. Transition length equal to 3 pipe diameters or 5 feet minimum.
3. Maximum invert slope of 4 to 1.
4. Inlet pipe submergence of at least 1.5 pipe velocity heads when full-pipe velocity equals 5 feet per second.
5. Pipe submergence at outlet sufficient to cause pipe to flow full.
6. Inlet and outlet freeboard varying from the lining freeboard to about 1.5 feet at the headwall.

7-11. *Earth Transitions.*—Earth transitions may be used for transitioning from a canal section to a canal structure where structure velocities do not exceed 3.5 feet per second. Lengths of earth transitions are usually related to the size of the structure. For pipe structures, inlet and outlet earth transition lengths are both usually equal to 3 pipe diameters or a minimum of 5 feet. For other structures, earth transition lengths are usually 5 feet for relatively small capacity structures and 10 feet for other structures. Invert slopes should not be steeper than 4 to 1 for both inlet and outlet transitions.

Lengths used for earth transitions in conjunction with concrete transitions should be 10 feet long or as otherwise required so that invert slopes are not steeper than the maximum allowable for the type 1 concrete transitions, 4 to 1 for inlets and 6 to 1 for outlets.

B. EROSION PROTECTION

7-12. *Purpose and Description.*—Riprap and gravel protection (fig. 7-8) is often used adjacent to structures and at other locations in earth-surfaced canals where erosion may occur. Local conditions must be considered in determining the type and the amount of protection to be provided. These conditions include the cost of riprap; cost of gravel; danger to structures and crops or to human life should scour occur; rodent damage; type of soil; and velocity of water. The following protection requirements should be used as a guide only. The types shown represent minimum thicknesses and sizes of material to be used, and adjustments should be made to meet the local conditions mentioned above.

Type 1—6-inch coarse gravel
Type 2—12-inch coarse gravel
Type 3—12-inch riprap on 6-inch sand and gravel bedding
Type 4—18-inch riprap on 6-inch sand and gravel bedding

Except for cross-drainage structures, type 3 minimum protection should be used where velocities exceed 5 feet per second, regardless of water depth.

7-13. *Inverted Siphons.*—The following protection is considered minimum for inverted siphons.

Water depth, feet	Type of protection		Length of inlet protection	Length of outlet protection
	Inlet	Outlet		
0 to 2.00	None	None	--	--
2.01 to 3.50	None	Type 1	--	2.5 depths (5 ft. min.)
3.51 to 7.00	Type 1	Type 2	1 depth (3 ft. min.)	2.5 depths (5 ft. min.)

7-14. ***Cross-drainage Structures.***—The following protection is considered minimum for cross-drainage structures with concrete transitions.

Q, cfs	Type of protection		Outlet length, feet
	Inlet	Outlet	
0 to 30	None	Type 2	8
31 to 90	None	Type 2	12
91 to 240	Type 1	Type 3	16

Where the velocity in the conduit is greater than 15 feet per second at the outlet, use the protection type for the next higher discharge (type 3 minimum). Where baffled outlets are provided at the outlet of a structure the protection should be a thickness of $\frac{W}{6}$ with the minimum diameter of rock equal to $\frac{W}{20}$ and extending a distance W (5 feet minimum) beyond the baffled outlet. W is the inside width of the baffled outlet box.

7-15. ***Other structures.***—The following protection is considered minimum for Parshall flumes, checks, check-drops, inclined drops, chutes, turnouts, road crossings and pipe drops with the hydraulic control section on concrete, that is, where critical depth does not occur beyond the concrete structure. Where critical depth may occur beyond the concrete, the next higher type of protection should be used at the inlet.

Water depth, feet	Type of protection	
	Inlet	Outlet
0 to 2.00	None	Type 2
2.01 to 3.50	None	Type 2
3.51 to 7.00	Type 1	Type 3

Length of protection for outlets should normally be 2.5 depths (5.0 feet minimum), but where turbulent water may occur at the outlet, the length of protection should be increased to 4 depths. Gates or stoplogs near the outlet increase turbulence.

The rock for riprap and gravel protection should be hard, dense, durable, and should be reasonably well graded. The size range of rock used for 18-inch riprap should have a maximum size of 1/8 cubic yard and a minimum size of 1/10 cubic foot. The size range used for 12-inch riprap should have a maximum size of 1 cubic foot and a minimum size of 1-1/2 inches. The size range used in coarse gravel protection should have a maximum size of 1/8 cubic foot and a minimum size of 3/16 inches.

The 6-inch sand and gravel bedding for riprap should be a continuous layer of sand and gravel or sand and crushed rock, reasonably well graded to a maximum of 1-1/2 inches in size.