Table 1: 100-Year Study Existing Conditions Discharges and Elevations vs. FIS Results

Location	Existing FIS Q (cfs)	Existing FIS Elevation	Existing XP-SWMM Q (cfs)	Existing XP-SWMM Elevation
Lake Avenue	50	892.9	45 (240-hr)	890.9
Broadway Avenue	175	891.8	45 (240-hr)	889.3
Country Club Road	175	890.29	91 (2-hr)	888.2
Country Club Parking Lot	175	888.5	160 (2-hr)	888.2
Edgebrook Drive	175	888.39	134(48-hr)	888.2
Lundahl	268	888.15	135(48-hr)	885.4
St. Andrews Lane	268	884.51	172 (48-hr)	885.3
Barlina Road	954	883.78	--	--
McHenry Ave	954	883.1	--	--
Rakow Road	954	877.73	--	--

Table 2: Effect of Alternatives on 100-Year Discharges and Floodplain Elevations

Location	Existing FIS Q (cfs)	Existing FIS Elevation	Existing XP-SWMM Q (cfs)	Existing XP-SWMM Elevation[1]	Alt. 1 Q (cfs)	Alt. 1 Elev[1]	Alt. 2 Q (cfs)	Alt. 2 Elev[1]	Alt. 3 Q (cfs)	Alt. 3 Elev	Alt. 4 Q (cfs)	Alt. 4 Elev	Alt. 5 Q (cfs)	Alt. 5 Elev	Alt. 6 Q (cfs)	Alt. 6 Elev	Alt. 7 Q (cfs)	Alt. 7 Elev
Lake Avenue	50	892.9	45(240-hr)	893.1	131(120-hr)	892	123(120-hr)	891.55	46(240-hr)	890.9	46(72-hr)	890.9	46(240-hr)	891.0	46(240-hr)	891.0	123(120-hr)	892.0
Broadway Avenue	175	891.8	46(240-hr)	889.3	131(120-hr)	890	123(120-hr)	889.9	46(240-hr)	889.3	45(240-hr)	889.3	82(48-hr)	888.2	116(1-hr)	886.8	123(120-hr)	890.0
Country Club Road	175	890.29	91(48-hr)	888.2	165(120-hr)	888.5	150(120-hr)	888.4	90(2-hr)	888.2	91(2-hr)	887.4	171(1-hr)	888.2	163(2-hr)	886.7	145(120-hr)	888.1
Country Club Parking Lot	175	888.5	160(2-hr)	888.2	177(120-hr)	888.5	162(2-hr)	888.3	161(2-hr)	888.2	161(2-hr)	887.3	130(2-hr)	888.2	217(2-hr)	886.7	162(120-hr)	888.0
Edgebrook Drive	175	888.39	126(48-hr)	888.1	201(120-hr)	888.4	185(120-hr)	888.4	137(48-hr)	888.2	139(24-hr)	886.5	170(48-hr)	888.2	214(2-hr)	885.8	192(120-hr)	887.9
Lundahl	268	888.15	163(48-hr)	885.3	238(120-hr)	885.7	223(120-hr)	885.6	178(48-hr)	885.4	197(24-hr)	885.5	165(48-hr)	885.3	259(2-hr)	884.3	244(120-hr)	885.6
St. Andrews Lane	268	884.51**	162(48-hr)	885.2	220(120-hr)	885.6	206(120-hr)	885.5	176(48-hr)	885.3	211(24-hr)	885.4	159(48-hr)	885.2	362(2-hr)	883.6	203(120-hr)	885.5
Barlina Road	954	883.78	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
McHenry Ave	954	883.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Rakow Road	954	877.73	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

[1] Lake Avenue Elevation Represents 100-Year BFE at Crystal Lake

*Critical Duration Elevation 24-hour event

** Represents elevations downstream of St. Andrews Lane, all other reported values for this row represent elevation immediately upstream of St. Andrews Lane

Alternative 1: Increase capacity under Lake Avenue by replacing culvert with larger sized structure to allow increase in discharge from Crystal Lake

Alternative 2: Increase capacity under Lake Avenue by replacing culvert with larger sized structure to allow increase in discharge from Crystal Lake and nothc weir 18-feet

Alternative 3: Increase culvert capacity under Country Club Road to elminate head loss

Alternative 4: Lower road overtop at Edgebrook Drive from 887.7 to 886.0 to reduce upstream BFEs and lower downstream access road crossings to 885.5

Alternative 5: Lower Creek channel between Broadway Avenue and Edgbrook Drive to allow for 10-year gravity storm sewer outlet from Area 4 outlet, lower Edgebrook Drive and downstream overflow elevations (4)

Alternative 6: Lower Creek channel between Broadway Avenue and Edgbrook Drive to allow for 10-year gravity storm sewer from Area 4, create open channel from Edgebrook Drive to St. Andrews Lane

Alternative 7: Modify Lake Street Culvert (Alt. 1) and Crystal Lake Outlet (Alt. 2), Increase capacity of Country Club road crossing (Alt. 3A), lower Edgebrook Drive overflow and build in necessary storage in opens space around schools

Table 3: Summary of Benefits and Costs by Alternative

Alternative	Necessary LOMR Model Support	Approximate Floodplain Properties Removed		Floodway Properties Removed	Benefits	Capital Cost	Non-Monotary Costs
		Around Crystal Lake	Lake Avenue to St. Andrews Lane	Lake Avenue to St. Andrews Lane			
Alternative 1: Culvert under Lake Avenue (Alternatives 3, 4 and Storage)	Enhanced Study Models	200	Increased BFE	0	Better routine drainage around Lake for Areas 1-3	$1,387,000	Increased BFE below Lake Avenue without storage on Country Club Road or School District Property
Alternative 1 and 2 (Alternatives 3, 4 and Storage)	Enhanced Study Models	250	Increased BFE	0	Better routine drainage around Lake for Areas 1-3	$1,463,000	Increased BFE below Lake Avenue without storage on Country Club Road or School District Property
Alternative 3A: Culvert under Country Club Road	Existing FEMA Hydraulic Model Edits	0	40	25	Same result through LOMR submittal	$169,000	Could be accomplished by submitting LOMR on Enhanced Modeling, Increased BFE Downstream without storage on Country Club Road or School District Property
Alternative 3B: LOMR based on enhanced study models	Enhanced Study Models	0	40	25	Support for regulatory flows and approved modeling to support future design and LOMR submittals	$35,000	None
Alternative 4: Improved conveyance downstream of Edgebrook Drive (plus storage on School District)	Enhanced Study Models	0	40	25	Better routine drainage for Area 4	$1,089,000	Increased BFE below St. Andrews Lane without storage on Country Club Road or School District Property
Alternative 5: 10-year storm sewer, lower Crystal Creek 5 feet to Edgebrook Drive, lower overland flow 1.5 feet from Edgebrook Drive to St. Andrews Lane (plus storage on School District)	Enhanced Study Models	0	40	25	Better routine drainage for Area 4 and Crystal Creek	$4,702,000	Increased BFE below Country Club Road without storage on Country Club Road or School District Property
Alternative 6: 10-year storm sewer, lower Crystal Creek 5 feet to St. Andrews Lane (plus storage on School District)	Enhanced Study Models	0	65	25	Better routine drainage for Area 4 and Crystal Creek	$5,002,000	Increased BFE below Country Club Road without storage on Country Club Road or School District Property
Alternative 7: Alternatives 1, 2, 3 and 4 with storage on School District property	Enhanced Study Models	250	65	25	Better routine drainage for Area 4 and Crystal Creek	$1,463,000	Increased BFE below Country Club Road without storage on Country Club Road or School District Property

Table 4 Simulated and Measured Lake Levels

	Annual Mean	June-August Mean
Simulated Existing		
1959-2008	889.52	889.39
2005-2008	890.31	890.29
Measured		
2005-2008	890.25	890.47
Simulated Larger Culvert Under Lake Street		
1959-2008	889.48	889.35
2005-2008	890.32	890.29
Simulated Weir Notch at 890.0 with Larger Culvert		
1959-2008	888.58	888.45
2005-2008	889.42	889.39
Simulated Weir Notch at 890.0 with Larger Culvert and Leak Fixed		
1959-2008	890.12	890.08

Table 5: Project Conceptual Cost Estimates

Alternative			A		B		C		D		E	
			Submit LOMR for Crystal Creek Using New Model		New Hydrologic Model for Crystal Lake		Investigate Leakage to Lakewood Storm Sewer		Increase Culvert Capacity under Lake Avenue		Notch Lake Outlet Weir	
Item	Units	Unit Cost	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
Easements	LS	$5,000.00							0	$0.00	1	$5,000.00
Clearing and Demolition	AC	$5,000.00							0.5	$2,500.00	1	$5,000.00
Earthwork (Assume Haul Off)	CY	$18.00							250	$4,500.00	0	$0.00
Granular Import and Placement	CY	$20.00							500	$10,000.00	0	$0.00
Culvert 6'-8' wide x 3'	LF	$200.00							150	$30,000.00	0	$0.00
Storm Sewer 12" - 36"	LF	$60.00							0	$0.00	0	$0.00
Deep Storm Sewer 24" - 48"	LF	$250.00							0	$0.00	0	$0.00
Utility Replace	LF	$25.00							250	$6,250.00	0	$0.00
Soil Erosion Control	LS	VARIES							1	$12,500.00	1	$1,000.00
Pavement Repair	LS	$25,000.00							1	$25,000.00	0	$0.00
Restoration and Seeding	AC	$10,000.00							0.5	$5,000.00	0	$0.00
Sub-Total										$95,750.00		$11,000.00
Contingency		25%								$23,937.50		$2,750.00
Total Construction										$119,687.50		$13,750.00
Engineering		12%				$25,000.00		$50,000.00		$14,362.50		$1,650.00
Permits (COE, IEPA, IDNR-OWR, CLSO)												
Wetland	LS	VARIES								$5,000.00		$10,000.00
LOMR/CLOMR Submittal	LS	VARIES		$35,000.00								
Stormwater (H&H Modeling)*	LS	VARIES										
Grand Total				**$35,000.00**		**$25,000.00**		**$50,000.00**		**$139,050.00**		**$25,400.00**

Alternative	F		G		H		I		J		K	
	Increase Culvert Capacity under Country Club Road		Lower Crystal Creek 5 Feet from Broadway Avenue to Country Club Road		Add 10-Year Storm Sewer to Area 4 and Lakewood		Lower Overland Flow Channel 1.5 feet between Edgebrook Drive and St. Andrews Lane		Restore Crystal Creek to Open Channel from Edgebrook Drive to St. Andrews Lane		Storage on School District Property	
Item	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total	Quantity	Total
Easements	0	$0.00	1	$5,000.00	9	$45,000.00	1	$5,000.00	2	$10,000.00	0	$0.00
Clearing and Demolition	0.5	$2,500.00	4	$20,000.00	8	$40,000.00	4	$20,000.00	3	$15,000.00	0	$0.00
Earthwork (Assume Haul Off)	250	$4,500.00	15000	$270,000.00	**6500**	$117,000.00	**3000**	$54,000.00	**11000**	$198,000.00	25000	$450,000.00
Granular Import and Placement	500	$10,000.00	0	$0.00	1000	$20,000.00	500	$10,000.00	0	$0.00	0	$0.00
Culvert 6'-8' wide x 3'	150	$30,000.00	150	$30,000.00	0	$0.00	100	$20,000.00	250	$50,000.00	0	$0.00
Storm Sewer 12" - 36"	0	$0.00	0	$0.00	3500	$210,000.00	200	$12,000.00	0	$0.00	0	$0.00
Deep Storm Sewer 24" - 48"	0	$0.00	0	$0.00	4000	$1,000,000.00	0	$0.00	0	$0.00	0	$0.00
Utility Replace	100	$2,500.00	1000	$25,000.00	1000	$25,000.00	500	$12,500.00	1000	$25,000.00	0	$0.00
Soil Erosion Control	1	$15,000.00	1	$30,000.00	1	$50,000.00	1	$30,000.00	1	$30,000.00	0	$0.00
Pavement Repair	1	$25,000.00	1	$25,000.00	20	$500,000.00	3	$75,000.00	5	$125,000.00	0	$0.00
Restoration and Seeding	0.25	$2,500.00	4	$40,000.00	10	$100,000.00	5	$50,000.00	**5**	$50,000.00	0	$0.00
Sub-Total		$92,000.00		$445,000.00		$2,107,000.00		$288,500.00		$503,000.00		$450,000.00
Contingency		$23,000.00		$111,250.00		$526,750.00		$72,125.00		$125,750.00		$110,000.00
Total Construction		$115,000.00		$556,250.00		$2,633,750.00		$360,625.00		$628,750.00		$560,000.00
Engineering		$13,800.00		$66,750.00		$316,050.00		$43,275.00		$75,450.00		
Permits (COE, IEPA, IDNR-OWR, CLSO)												
Wetland		$5,000.00		$25,000.00		$15,000.00		$25,000.00		$25,000.00		$65,000.00
LOMR/CLOMR Submittal												$0.00
Stormwater (H&H Modeling)*												$0.00
Grand Total		**$133,800.00**		**$648,000.00**		**$2,964,800.00**		**$428,900.00**		**$729,200.00**		**$625,000.00**

*Assumed to be modeling necessary for permit submittal to establish revised regulatory floodplain elevations and flows including finalization of existing modeling done for this report

Table 6 Crystal Creek Drainage Analysis Permitting Matrix

Alternative	ACOE	USFWS	IDNR	MCSWCD	IEPA	IDNR-OWR	MCSO/CLSO	FEMA
1	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of LOMR Review of New BFE	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
2	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of LOMR Review of New BFE	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
3	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
4	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
5	Regional Permits 7-Temporary Construction Activities 9-Maintenance 5-Wetland and Stream Restoration and Enhancement	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
6	Section 404 Individual Permit	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	Section 401 Individual Water Quality Certification	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
7	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR

APPENDIX A

FEMA FIS MODELS

(See Digital Copy)

09021

APPENDIX B

CRYSTAL CREEK HABITAT AND MACROINVERTEBRATE ASSESSMENT AND WETLAND DELINEATION

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Introduction

Many of the alternatives to reduce flooding for Crystal Lake and Crystal Creek involve potential impacts to Crystal Creek for new culverts or additional conveyance. These impacts are regulated both by the Chicago District Corps of Engineers and the Crystal Lake Stormwater Ordinance. Crystal Creek is under the jurisdiction of the Corps. Impacts to High Quality Aquatic Resources (HQAR) involve greater permit documentation and justification. The purpose of this assessment was twofold. The first was to provide a preliminary wetland delineation to document the boundaries of jurisdictional wetlands. The second was to provide a preliminary assessment of the quality of Crystal Creek and any associated wetlands.

Sampling Locations

On April 23, 2009 instream habitat assessments and macroinvertebrate surveys were conducted on three approximately 330-foot stream reaches on Crystal Creek (Figure B-1). Crystal Creek is a small stream resulting from the outflow of Crystal Lake. It flows south and then east to Edgebrook Drive and then Crystal Creek flows underground in a storm sewer on the grounds of South elementary and Lundahl J middle school. The Creek emerges just south of St. Andrews Lane and flows into the Fox River at Algonquin.

Site 1 is located just downstream from the spillway on Crystal Lake. Site 2 is located just downstream from the Crystal Lake Country Club. Site 3 is located just downstream from the emergence of Crystal Creek below St. Andrews Lane from its underground sewered section.

The water was very clear at all three sites on the sample date and there is a mixture of gravel, sand, and silt substrates on the stream bottom. The only fish observed during the site investigation were a small number of large common carp.

Methods

Crystal Creek is classified as a river/stream wetland in the McHenry County Advanced Identification Study (ADID). It was listed in that study as having no particularly high resource value. Crystal Lake is classified as L68, a High Quality Lake by the ADID study.

Studies of Crystal Creek's habitat and macroinvertebrate population were conducted to independently establish the Creek's resource value. The habitat assessment used a method known as the Qualitative Habitat Evaluation Index (QHEI; Rankin 1989 and Ohio Environmental Protection Agency 2006). The QHEI is a visual-based method and gives an estimate of the suitability of a stream segment to meet warmwater habitat for aquatic organisms based on metrics related to substrate, instream cover, channel morphology, riparian zone and bank erosion, pool-glide and riffle-run quality, and stream gradient. Metrics from each category are assigned a score. When summed generally total scores for each site range from 20-100. The following is how Ohio EPA interprets QHEI scores:

- QHEI > 75: Exceptional Warmwater Habitat (EWH); Exceptional Warmwater Habitat is used for waters with unique and unusual assemblages of aquatic life (e.g., waters with the potential for significant populations of endangered species, unusually good chemical quality, above-average abundance of sensitive species, above-average populations of top carnivores).

- QHEI between 60 and 74: Stream segment suitable for Warmwater Habitat (WWH) without use impairment. Warmwater Habitat is applicable to most of the state's rivers and streams. These waters are capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization.

- QHEI between 45 and 60: Stream segment may meet Warmwater Habitat in some circumstances, but it may show a level of impairment that requires classification as Modified Warmwater Habitat (MWH).

- QHEI between 32 and 45: Stream segment meets MWH. Modified Warmwater Habitat applies to extensively modified habitats that are capable of supporting the semblance of a warmwater biological community, but fall short of attaining WWH because of functional and structural deficiencies due primarily to altered macrohabitat.

- QHEI < 32: Stream segment may be suitable for Modified Warmwater Habitat only if the watershed is greater than 3 square miles. Even then, this may not be possible. Where Modified Warmwater Habitat is not possible, the stream segment is classified as a Limited Resource Water (LRW). The LRW designation applies to streams and channels that lack the potential for any semblance of any other aquatic life habitat. The potential for recovery of the fauna to the level characteristic of any other aquatic life habitat is realistically precluded due to natural background conditions or irretrievable human-induced conditions.

The macroinvertebrate survey used the 20-jab Qualitative Multi-Habitat (QMH) method for field collection (Illinois Environmental Protection Agency 2005) and the Illinois RiverWatch program's guidelines for laboratory identification of specimens (Illinois Department of Natural Resources 2000).

The QMH method emphasizes proportionately sampling habitat types as they occur in the stream channel into 20 kick net collections called dips. The first division of effort between dips is associated with the stream bottom and the submerged portions of the banks. At all sites 12 dips were allocated to the stream bottom and 8 dips to the submerged bank zones because their average widths were 10-29 feet. At each site, the number of dips was further allocated according to bottom-zone and bank-zone habitats present. The QHEI habitat evaluation was used to approximate the proportion of habitats and determine the average stream width prior to sampling. The 20 dips were combined into a single sample bottle after net contents were examined for live organisms. Bottles were appropriately labeled and filled with 95% ethanol as a preservative. Samples were sorted and picked upon return to the lab. All organisms present in the sample were identified as per the RiverWatch identification key. Three metrics to evaluate the quality of the macroinvertebrate community were calculated. The Macroinvertebrate Biotic Index (MBI) value, the number of total taxa or taxa richness, and the number of combined Mayfly, Caddisfly, and Stonefly (EPT) taxa. Each of the macroinvertebrate metrics are used to classify the stream quality as excellent, good, fair, poor, or very poor relative to reference streams in Illinois (Table B-1).

Table B-1 Quality Ratings for Macroinvertebrate Data

	Taxa Richness	EPT Taxa Richness	MBI
Excellent	≥ 14	≥ 5	≤ 4.35
Good	12-13	4	≥ 4.36 - ≤ 5.00
Fair	9-11	3	≥ 5.01 - ≤ 5.70
Poor	7-8	2	≥ 5.71 - ≤ 6.25
Very Poor	≤6	0-1	≥ 6.25

Source: Illinois RiverWatch Program 2004

Results

The following sections summarize the habitat and macroinvertebrate survey results for Crystal Creek.

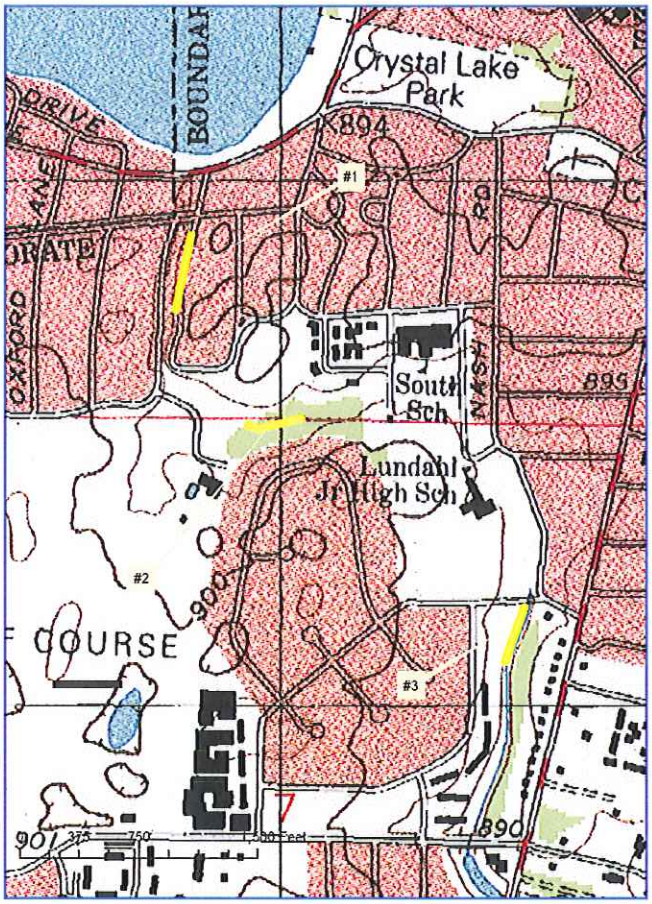
Physical Habitat

The QHEI score was 40.5 for Site 1 resulting in classification as Modified Warmwater Habitat. Modified Warmwater Habitat applies to extensively modified habitats that are capable of supporting the semblance of a warmwater biological community, but fall short of attaining Warmwater Habitat because of functional and structural deficiencies due primarily to altered macrohabitat. Site 1 is lacking in suitable substrate (sand and silt dominated), contains sparse instream cover, displays poor channel morphology, contains a virtually nonexistent riparian zone, exhibits poor riffle-run and pool-glide quality, and supports generally shallow water levels. Additional issues at Site 1 include isolation from potential downstream fish communities due to the significant underground portion of the channel downstream from Site 2, culverts that may be impassable to smaller fish species, and intermittent flows.

The QHEI score for Site 2 was 50.5 resulting in an indeterminate classification as either MWH or WWH. In this case, professional judgment must be used to determine whether MWH or WWH is an appropriate classification for the sampling reach. Site 2 is dominated by silt and sand substrates although gravel, cobble, and boulders are present in small quantities. Instream cover is present in moderate amounts including shallows in slow water, rootwads, boulders, aquatic macrophytes, and woody debris. The overall channel morphology is poor with low sinuosity, poor development, and moderate channel stability. The riparian zone is narrow to moderate in width along the reach. The flood plain is a mixture of wooded areas and residential development. The banks exhibit a moderate amount of erosion likely due to flashy inputs from upstream stormwater sources. The pool-glide and riffle-run quality is fair with moderate depths, pool widths, and riffle-run stability. Because of its isolation from downstream reaches this section of stream will not likely support a high quality warmwater fish community and should be classified as MWH.

The QHEI for 61 for Site 3 resulting in a classification of WWH. Site 3 is suitable for Warmwater WWH without use impairment. In terms of habitat this section of stream is capable of supporting and maintaining a balanced, integrated, adaptive community of warmwater aquatic organisms having a species composition, diversity, and functional organization. The substrate at Site 3 is dominated by sand and gravel with small amounts of silt along the stream margin. The instream cover is moderate and includes shallows in slow moving waters, rootwads, and boulders. The channel morphology is poor characterized by low sinuosity, fair development, and moderate stability. The riparian zone is narrow to moderate with wider areas of woods on the left downstream bank. Bank erosion is moderate along most portions of the reach. Pool-glide and riffle-run quality is fair with a diverse current velocity regime.

Figure B-1: Sampling Locations on Crystal Creek (stream reaches are indicated in yellow)



Macroinvertebrates

The macroinvertebrate community at Site 1 is classified as poor to very poor. While a large number of organisms (n=468) were collected, only 7 taxa were represented, no EPT taxa (stoneflies, mayflies, caddisflies) were collected, and the MBI score was 6.05. These values correspond to poor, very poor, and poor classifications for Site 1. The macroinvertebrate community was dominated by back fly and midge larvae and included other pollution tolerant organisms. Because the water quality at Site 1 appears suitable for macroinvertebrates, it is likely that the stream's intermittent status or poor substrate is the cause of the poor rating.

The macroinvertebrate community at Site 2 is classified as poor to very poor. A large number of organisms (n=392) were collected representing 7 taxa. The EPT taxa richness was zero and the MBI score was 6.16. Black fly and midge larvae dominate the macroinvertebrate community. Because the water quality at Site 2 appears suitable for macroinvertebrates, it is likely that the stream's intermittent status or poor habitat is the cause of the poor rating.

The macroinvertebrate community at Site 3 is classified as very poor. A total of 162 organisms were collected representing 3 taxa. No EPT taxa were collected. The MBI score was 6.01. Midge and black fly larvae dominate the community. Because the habitat at Site 3 is suitable to support healthy macroinvertebrate communities, other factors are likely contributing to the low quality such as intermittent flows.

Summary

The habitats found in Crystal Creek at Sites 1 and 2 are classified as Modified Warmwater Habitats. They should not be expected to support a fish community comparable to the diversity of natural communities found in Illinois. Instream habitat and substrates are generally lacking, the stream is intermittent, and it is effectively isolated from potential downstream populations of desirable species. The habitat at Site 3 is sufficient to support warmwater aquatic communities, but may exhibit intermittence thus limiting its potential.

The macroinvertebrate communities found at all three sites were similar and were assessed as poor to very poor quality. Very low taxa counts including EPT taxa and poor MBI scores are likely caused by the intermittent status of the stream limiting the potential for colonization by more sensitive taxa.

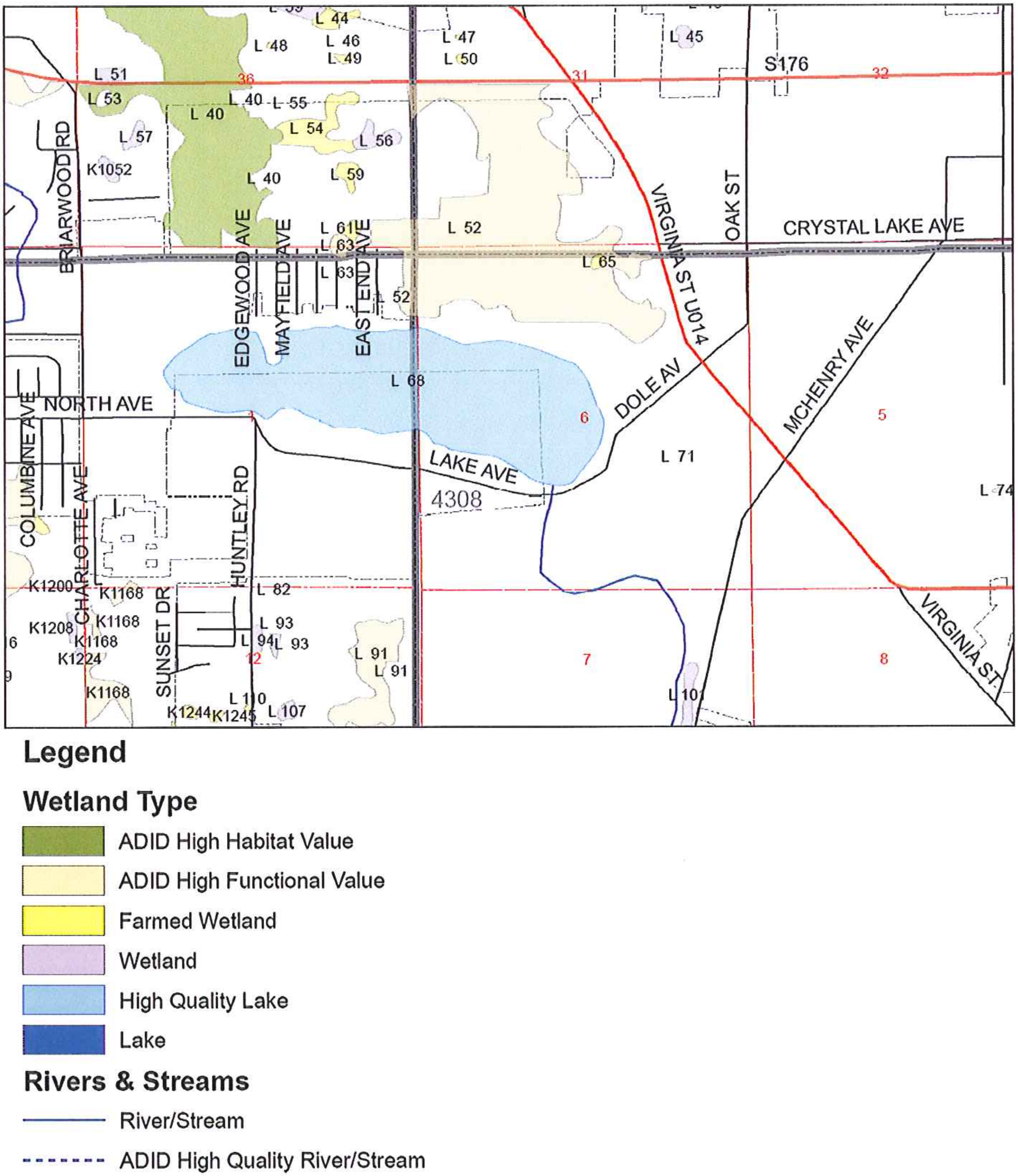
The McHenry County ADID classification of Crystal Creek does not indicate a High Quality status.

WETLAND DELINEATION

A preliminary wetland delineation was performed for Crystal Creek and its riparian zones. As shown on Exhibit B-2 Crystal Lake is identified as being high quality resource in the McHenry County ADID study. Crystal Creek is not listed as a high quality resource in the project area.

The preliminary wetland delineation for Crystal Creek is shown on Exhibit B-3. The jurisdictional boundaries of the Creek are limited very closely to the channel. Little off-channel wetland exists within the project corridor.

Exhibit B-2 McHenry County ADID Map



PERMITTING ASSESSMENT

In terms of U.S. Army Corps of Engineers' permitting, the project should be eligible for Regional Permit 5 for restoration and enhancement. The design alternatives do not require any actual fill of Waters of the United States, other than minor work associated with culvert replacements. The actual acreage of wetland and Waters habitat should actually increase with all of the alternatives. Staff of the U.S. Fish and Wildlife Service and Illinois Department of Natural Resources have been informed about the about the project and possible design options. No major concerns about habitat disruption or intolerant species occurrences were noted.

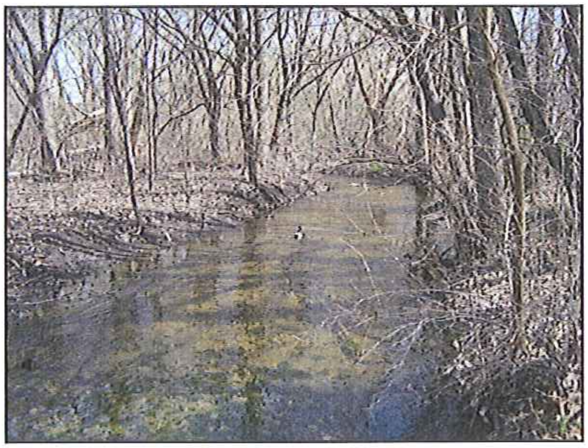
Table 2 Crystal Creek Drainage Analysis Permitting Matrix

Alternative	ACOE	USFWS	IDNR	MCSWCD	IEPA	IDNR-OWR	MCSO/CLSO	FEMA
1	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of LOMR Review of New BFE	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
2	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of LOMR Review of New BFE	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
3	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
4	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
5	Regional Permits 7-Temporary Construction Activities 9-Maintenance 5-Wetland and Stream Restoration and Enhancement	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
6	Section 404 Individual Permit	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	Section 401 Individual Water Quality Certification	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR
7	Regional Permits 7-Temporary Construction Activities 9-Maintenance	Consultation under Federal Endangered Species Act	Consultation under the Illinois Endangered Species Protection Act	Soil Erosion and Sediment Control Plan Review	N/A	Review of New BFE Review of LOMR	Review of BFE for 100-640 ac watersheds	Confirmation of LOMR

APPENDIX B – SITE PHOTOS

Site 1

Site 2



Site 3

References

Illinois Department of Natural Resources. 2000. Illinois River Watch Stream Monitoring Manual. 4th Edition. Springfield, Illinois.

Illinois Environmental Protection Agency. 2005. Methods of Collecting Macroinvertebrates in Streams. Illinois EPA Bureau of Water.

Rankin, E.T. 1989. The Qualitative Habitat Evaluation Index (QHEI): Rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). OHIO EPA Technical Bulletin EAS/2006-06-1. State of Ohio Environmental Protection Agency Division of Surface Water.

0 200 400
Scale In Feet

N

LEGEND

Existing Contours

Wetland/Waters Boundary

No.	Revision/Issue	Date

Hey and Associates, Inc.
Water Resources, Wetlands and Ecology
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Volo, Illinois 60073
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Fax (847) 740-2888
Volo@Heyassoc.com

Crystal Creek Flooding Analysis

Preliminary Wetland/Waters Boundaries on 2005 Aerial Photograph

PROJECT NO:	09021	SHEET NO:
DESIGNED BY	GCS/DAK	B-3
DRAWN BY	CFR	
CHECKED BY	GCS	
APPROVED BY	GCS	
ISSUE DATE	08/28/2009	

I:\09000+\09021 Crystal Creek Analysis\Working\Engineering\09021_Crystal Creek.dwg, Wetland Delineation (A-3), 9/3/2009 10:10:50 AM

APPENDIX C

HYDROLOGIC AND HYDRAULIC MODELING SUPPORT

Study Models

Attempts to recover the official regulatory hydrology modeling for Crystal Lake were unsuccessful. It appears that FEMA does not have this model. The regulatory hydraulic model was recovered but was run with the unsupported flow values, and thus also provides unsupported results. To replace the missing hydrology model, two separate models, representing the storage in Crystal Lake and the detailed drainage of Area 4 and the downstream areas of Crystal Creek, were constructed for this project. It should be noted that this modeling was not performed with the intent to submit for review and acceptance of new regulatory flood elevations. This modeling was performed to provide a basis of comparison to weigh the potential design alternatives detailed in this report. Should the City pursue revised regulatory floodplain elevations for both Crystal Lake and Crystal Creek downstream of the lake outlet, the modeling described below will need to be supplemented with additional detailed as-built survey and calibrated further to available data.

A PondPack hydrologic model was constructed for the Lake. An XP-SWMM model was constructed for Crystal Creek from Lake Avenue to St. Andrews Lane. Tributary areas for these models were delineated using available 1968 1-footCity topography, 2005 McHenry County 2-foot topography and detailed survey performed by Hey (included in this Appendix C). Stage storage information, culvert, storm sewer and channel data were taken from the data listed above as well as numerous available engineering studies, field reconnaissance and the City of Crystal Lake storm sewer atlas.

Crystal Lake Model

Hydrologic parameters for this model were estimated using soils information, review of aerial photography and topography as noted above. The stage storage information for Crystal Lake was taken from the 2005 McHenry County 2-foot topography. Table 1 outlines hydrologic parameters for the PondPack model representing the Lake. A copy of the model schematic is included with this Appendix. The area draining from Lippold Park through the Honeysuckle drain tile was included in the model as a 15 cfs input based upon gauged data and previous calculations performed by Hey. The digital modeling and digital results files are included on the attached CD.

Table 1 PondPack Hydrologic Parameters

Subbasin	Area (ac)	CN	Tc (hr)
Crystal Lake	175.0	77	6
Woodland Wetland	55.0	77	1
Cove Pond	640.0	77	12
East	245.6	77	6

This modeling was then supplemented with revised outlet conditions to represent Alternatives 1 and 2. Digital models of these two alternatives are also included on the attached CD.

Crystal Creek Model

The focus of this project was to define detailed drainage conditions in the area south of the Lake, termed Area 4, and to assess design alternatives to decrease drainage problems in this area as well as along Crystal Creek between the Lake outlet and St. Andrews Lane. A detailed model of this was constructed to create a basis for evaluating the selected alternatives. Initially Hey reviewed the available effective HEC-RAS hydraulic model for

Crystal Creek. However, due to limitations in modeling storm sewers, supplementing this model with additional information would not allow for an adequate representation of the area. XP-SWMM was selected instead for its ability to model storm sewer, storage, hydrology and open channel flows in detail. An XP-SWMM model for the area draining to Crystal Creek, the Creek itself and area downstream of Edgebrook Avenue where the creek enters storm sewer was constructed. The modeling was carried to the open channel downstream of St. Andrews Lane, where the storm sewer daylights to the Crystal Creek channel. Table 2 identifies hydrologic parameters used in the modeling as well as identifying the SWMM node that each subbasin is added to the model (shown on Exhibit 8). Flow from Crystal Lake was put into the model as tabular hydrograph data taken from the PondPack model described earlier. A spreadsheet containing this hydrograph data is included in the digital portion of this appendix.

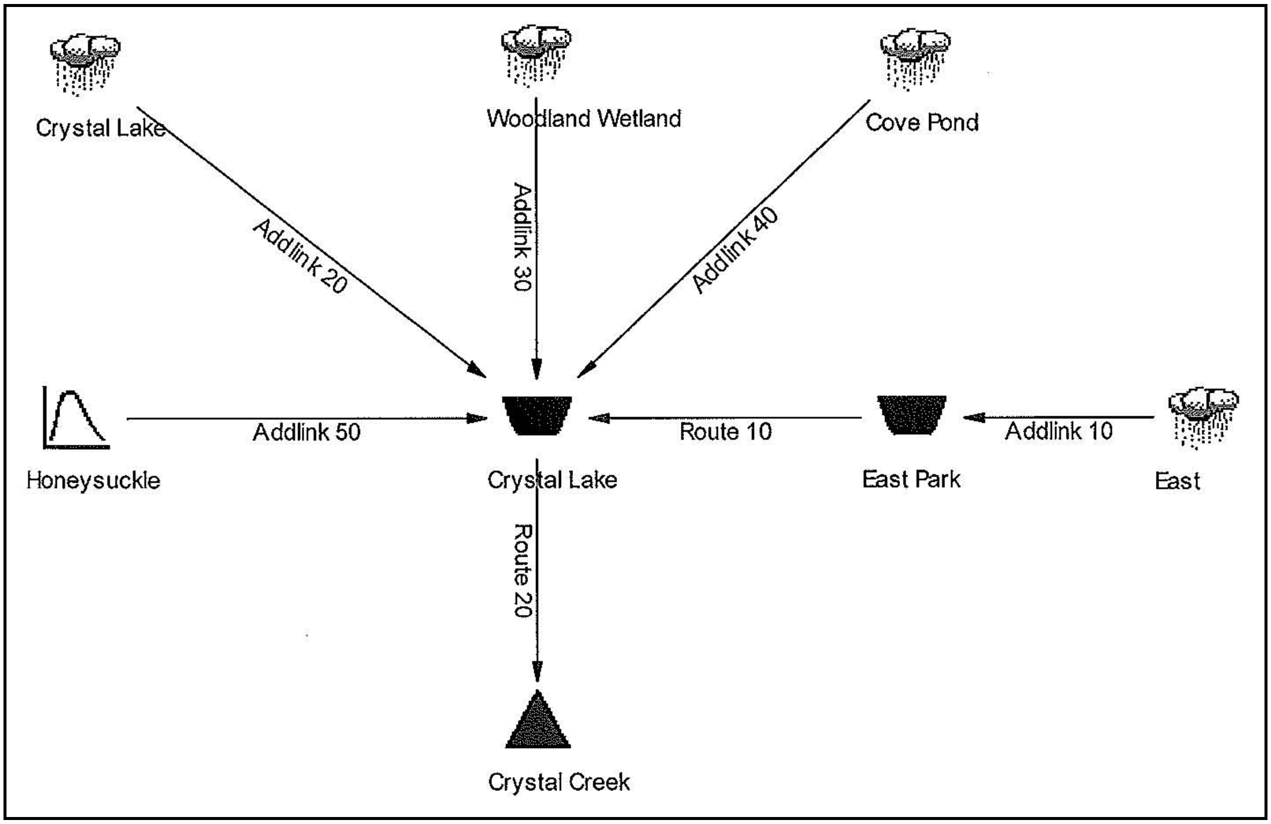
A curve number of 61 was selected for open space areas representing open space with good vegetated cover and Hydrologic Soil Group B soils. The percentage of impervious area in each subbasin was estimated from available aerial photography and specified in the model. Time of concentration values were determined based upon measured flow path lengths and an assumed velocity of 1.5 fps, as much of the flow length for each basin takes place within storm sewer. Stage Storage information was developed from the 1968 1-foot City topographic information. Controlling hydraulic parameters, including invert and rim elevations, overflow weirs and pipe geometries, were taken from a variety of sources as described earlier in this appendix. Table 2 identifies hydrologic parameters for each subbasin shown on Exhibit 8.

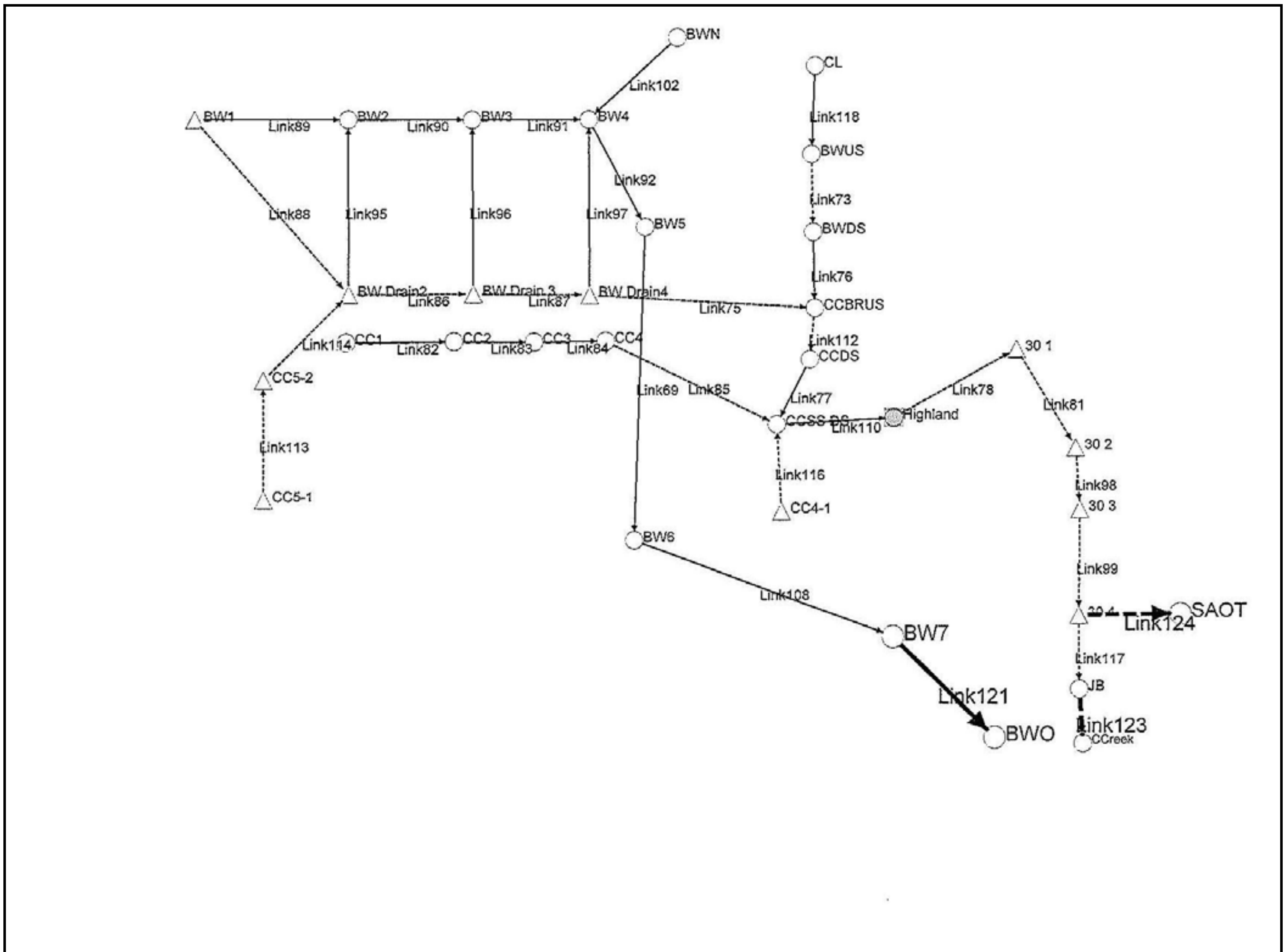
Table 2: XP-SWMM Hydrologic Parameters

Subbasin	Area (ac)	Tc FP L (ft)	Tc (min)	XP-SWMM Node
BW1	108.46	4733	53	BW1
BW2	37.31	2345	26	BW2
BW4	22.28	2384	26	BW4
BW Drain 2	12.28	1401	16	BW Drain 2
BW Drain 3	13.54	1396	16	BW Drain 3
BW Drain 4	13.65	1226	14	BW Drain 4
BWN	14.08	1193	13	BWN
CL	14.22	1146	13	CL
CC1	21.54	1599	18	CC1
CC5-2-1	15.54	1722	19	CC5-2
CC5-2-2	10.59	1287	14	CC5-2
CC5-1	24.38	1382	15	CC5-1
CC4-1	40.06	1993	22	CC4-1
CC4-2	19.65	1486	17	CCSS DS
CCSS DS	13.75	1356	15	CCSS DS
CC DS	45.55	2412	27	CCDS
30 1	16.58	1010	11	30 1
30 2	2.58	936	10	30 2
30 3	27.41	1956	22	30 3
30 4	42.59	1558	17	30 4
BW7	33.43	2008	22	BW7

A copy of the model schematic for the XP-SWMM model is included with this appendix and the attached CD contains digital model inputs and results files.

The existing conditions XP-SWMM model was edited to assess the various alternatives for storage and conveyance described in this report. Appropriate changes were made to the XP-SWMM model for each alternative to assess variance conveyance and storage solutions. The attached CD also contains digital modeling for Alternatives 1 through 7 along with digital copies of the results from these models.





Scale 1 : 1180.09

APPENDIX C

DIGITAL H+H MODELS

(See Digital Copy)

09021

APPENDIX D

LAKE LEVEL MODEL

26575 W. COMMERCE DRIVE, SUITE 601, VOLO, ILLINOIS 60073
OFFICE (847) 740-0888 FAX (847) 740-2888

Description

The Crystal Lake Water Level Model is a spreadsheet simulation of historic water levels. It was built using the water budget simulation for Crystal Lake prepared for the Crystal Lake Park District as part of the Phase I Diagnostic Report Clean Lakes Study in 2006. It too is a water budget model and computes change in water level based on the difference between water input and output. Crystal Lake inflow and outflow are presented below.

Inputs	Outputs
Precipitation	Evaporation
CLDD (Honeysuckle Storm Sewer)	Flow over the weir
Cove Pond Storm Sewer	Leakage to sewers
Groundwater	Groundwater
Direct Surface Runoff	

The model uses only precipitation and evaporation to simulate Crystal Lake levels. All other inputs and outputs are calculated based on hydrologic or hydraulic formulae or by empirical relationships observed from CLPD monitoring data over the last four years. A discussion of how each of the elements was calculated in the water level model follows.

Precipitation

Daily precipitation data was obtained from the following gages.

Crystal Lake North	1989 - 2008
Marengo	1959 - 1988
McHenry	1945 - 1957

Data were downloaded directly from the ISWS WARM Illinois Climate Network site and the Midwest Regional Climate Center (MRCC) site. Missing data or trace amounts were converted to "0" values.

Evaporation

Daily evaporation data were taken from the following gages.

DeKalb	1990 - 2008
Rockford	1952 - 1954, 1959 - 1989
Minneapolis	1945 - 1951
Chicago Midway	1955 - 1957

Data were downloaded directly from the ISWS WARM Illinois Climate Network site and the Midwest Regional Climate Center (MRCC) site. Missing data or trace amounts were converted to "0" values.

Honeysuckle Storm Sewer

The Honeysuckle storm sewer is the final outlet for all flow from the 2305 acre Crystal Lake Drainage District field tile system. It is the single most important inflow to the Lake accounting for 45 percent of total annual inflow.

Honeysuckle flows have been monitored continuously since 2005 by the CLPD. These flow data were combined with groundwater data at Lippold Park to develop an empirical relationship between groundwater elevation and Honeysuckle flow. A simple water budget model was built for the aquifer that is drained by the tile system. The model is presented below.

Inputs

Groundwater infiltration = precipitation*(winter or summer yield factors)

Outputs

Honeysuckle Flow = an empirical relationship developed from measured Honeysuckle flows versus groundwater levels at Lippold Park. Groundwater elevation minus the Lippold Wetland Restoration sewer invert is used along with direct precipitation on the Lippold wetlands.

Groundwater Flow to Lake = (Groundwater elevation -890)*hydraulic conductivity*area/Distance from Lippold well to the Lake.

Change in Groundwater Elevation

Inputs-Outputs over a groundwater pool based on aquifer surface area and porosity

The Honeysuckle model was calibrated against measured Honeysuckle flow and Lippold groundwater measurements for 2005-2008. The Honeysuckle flow calibration chart is shown in Exhibit C-1. The Lippold groundwater calibration chart is shown in Exhibit C-2.

Cove Pond Storm Sewer

Flow enters the Lake from Cove Pond through a 58-inch by 36-inch elliptical pipe. Cove Pond receives flow from a 640 acre watershed to its north and east. The pipe is often over half submerged since its invert at the Lake (887.5) is actually about 1.5 feet below the shore elevation. As a result it is difficult to obtain accurate discharge measurements for its flow. The CLPD has monitored this inflow since 2005. It is the second most important inflow to the Lake at about 17 percent of annual inflow.

The Cove Pond inflow was calculated based on a surface water budget that was calibrated to observed Cove Pond water levels. The City of Crystal Lake has monitored water levels in the pond since at least 1998. These observations are typically weekly and have produced an extensive data base for calibration.

The Cove Pond water budget that was used in the model is shown below.

Inputs

Precipitation*Cove Pond Area

Runoff = Precipitation*Contributing Watershed*Yield Factor (winter, non-winter and wet period)

Outputs

Evaporation*Cove Pond Area

Outflow = Cove Pond Discharge to Lake based on an empirical relationship based on the difference between the simulated elevation of the pond and the nominal outlet culvert invert.

Cove Pond Elevation = Inputs – Outputs over Cove Pond Area

The water budget calibration for Cove Pond is shown in Exhibit C-3.

Groundwater Inflow and Outflow

Groundwater inflow and outflow was calculated using Darcy's Law.

Flow = Gradient*Hydraulic Conductivity*Flow Area

The hydraulic conductivity was taken from studies by Scott Meyer of the ISWS in 1998 as 0.00174 fps.

Inflow area and outflow area were based on detailed resistivity testing by the ISGS in 2006 as part of the Clean Lakes study. This work mapped the geologic distribution of sand and gravel and silt and clay around the Lake to a depth of 50 feet.

The gradient was calculated for inflow using the difference between simulated Lippold groundwater levels from the Honeysuckle water budget model and simulated Lake levels divided by the distance between the Lippold groundwater well and the Lake.

The outflow gradient was calculated using simulated Lake level minus a constant downstream groundwater level of 887 divided by the flow distance from the Lake outlet to ISGS monitoring well 2 from the Clean Lakes study.

Direct Surface Runoff

Direct surface runoff to the Lake was calculated using precipitation*direct contributing area (175 acres from the Clean Lakes Study)* a yield factor.

Flow Over the Weir

Surface outflow leaves the Lake over a –foot weir that flows into a 3-foot by 2.5 foot box culvert under Lake Avenue. Discharge was calculated based on the difference between Lake elevation and the weir invert of 890.9 and the hydraulic formula for discharge from either a weir or the box culvert depending on which controlled discharge. Further discussion of the Lake outlet hydraulics is in the main report.

Leakage to Sewers

Leakage to sewers occurs around the eastern and southern shore of the Lake. Known leakage points are the Crystal Lake and Lakewood sanitary sewer systems. Leakage also occurs into storm sewers in Crystal Lake and Lakewood. However, based on four years of measurement the primary leakage is to the 24-inch tile that also serves as Area 4 and Lakewood's storm sewer down Broadway Avenue.

Leakage from the Lake was simulated in two ways. The first was a simple leakage input constant that was intended to represent sanitary and minor storm sewer infiltration. The second was the leakage that reaches the Broadway tile.

Leakage down the Broadway 24-inch tile was based on an empirical relationship that was demonstrated in the monitoring data from the Clean Lakes Study. The four years of monitoring data indicated that the measured flow in the Broadway tile was directly proportional to Lake elevation – 885. This relationship is shown in Exhibit C-4.

Lake Elevation

Lake elevation was simulated by subtracting daily outflows from daily inflows and dividing the result by Lake area. This number was then added to the previous days Lake elevation resulting in an increase when inflows exceeded outflows or a decrease when they did not.

Calibration

The Lake level model was calibrated against observed daily Lake elevations from 2005 through 2008 taken from the Clean Lakes Study and CLPD continuing monitoring. The result of the calibration is shown in Exhibit C-5.

Verification

Once model parameters had been calibrated using measured Honeysuckle flows, groundwater levels, Cove Pond levels and Lake elevations it was verified using data from 1946-1957. There is a limited amount of Lake elevation data from this period. It was used to confirm that the calibrated model did a reasonable job of predicting the measured Lake elevations from that period. The results of the verification model are shown in Exhibit C-6.

Simulations

The calibrated and verified model was used to simulate long-term Lake levels. The first simulation was for the period 1959 through 2008. Statistics from this simulation were used as baseline conditions for comparison of alternatives. Exhibit C-7 presents this simulation. Table 3 presents simple water level statistics from this simulation for different periods along with the same statistics for measured Lake elevations from 2005 through 2008.

Table 3 Simulated and Measured Lake Levels

	Annual Mean	June-August Mean
Simulated Existing		
1959-2008	889.52	889.39
2005-2008	890.31	890.29
Measured		
2005-2008	890.25	890.47
Simulated Larger Culvert Under Lake Street		
1959-2008	889.48	889.35
2005-2008	890.32	890.29
Simulated Weir Notch at 890.0 with Larger Culvert		
1959-2008	888.58	888.45
2005-2008	889.42	889.39
Simulated Weir Notch at 890.0 with Larger Culvert and Leak Fixed		
1959-2008	890.12	890.08

Three alternatives were then simulated using the model.

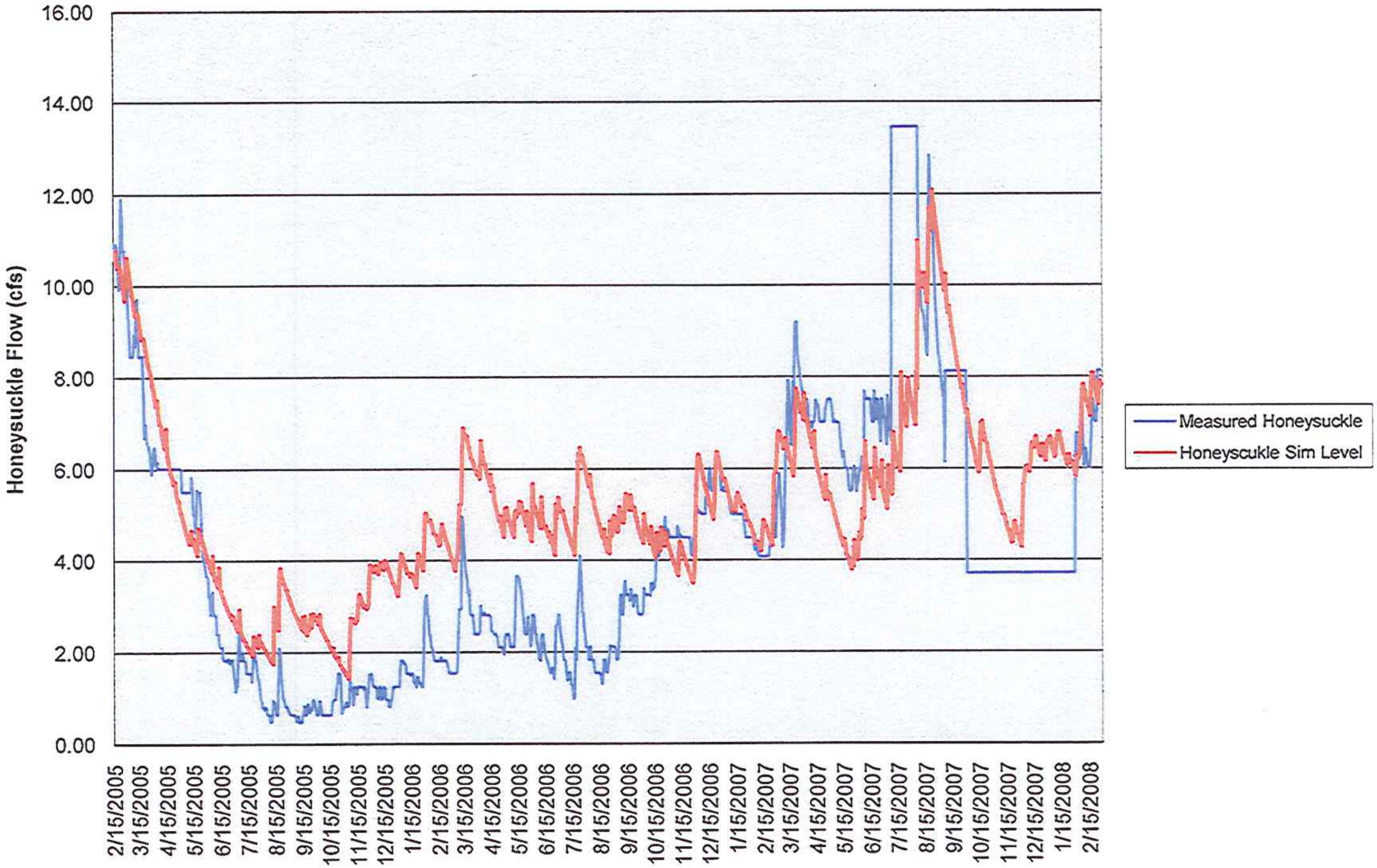
- Alternative 1 - Adding culvert capacity under Lake Avenue to reduce peak Lake elevations and the 100-year floodplain elevation.
- Alternative 2 - Lowering a portion of the weir to 890.0 and adding culvert capacity under Lake Avenue to further reduce peak Lake elevations and the 100-year floodplain elevation.
- Eliminating 90 percent of the leakage down the Broadway tile with and without the second alternative above.

Exhibit C-8 presents the results of the first alternative plotted against the historic conditions model. Both this exhibit and the statistics for this alternative presented in Table 3 show that it has only a very minor effect on average Lake elevations.

Exhibit C-9 presents the results of the second alternative plotted against the historic conditions model. This exhibit and the statistics for this alternative presented in Table 3 show that it would lower average Lake elevations by about one foot.

Exhibit C-10 however, shows that if the leakage down the Broadway tile were fixed, Alternative 2 would not lower Lake levels below their historic average elevations. Table 3 presents the statistics for this condition. Exhibit C-10 also shows the effect that just fixing the leakage to the Broadway tile would have on historic Lake elevations.

Exhibit C-1: Simulated v. Measured Honeysuckle Flow



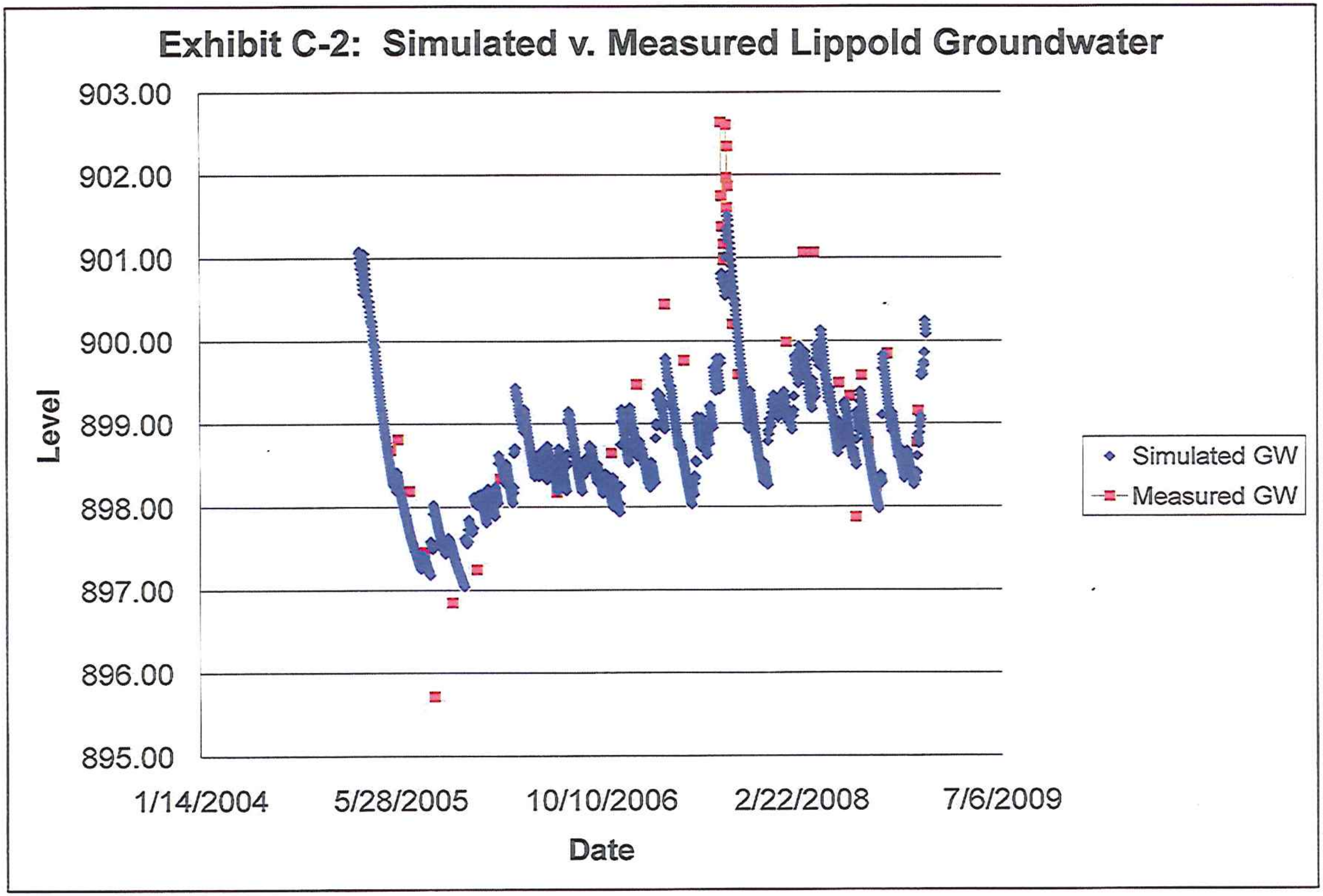


Exhibit C-2: Simulated v. Measured Lippold Groundwater
903.00
902.00
901.00
900.00
899.00
898.00
897.00
896.00
895.00
Level
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
Date
Simulated GW
Measured GW

Exhibit C-3: Cove Pond Water Level Calibration

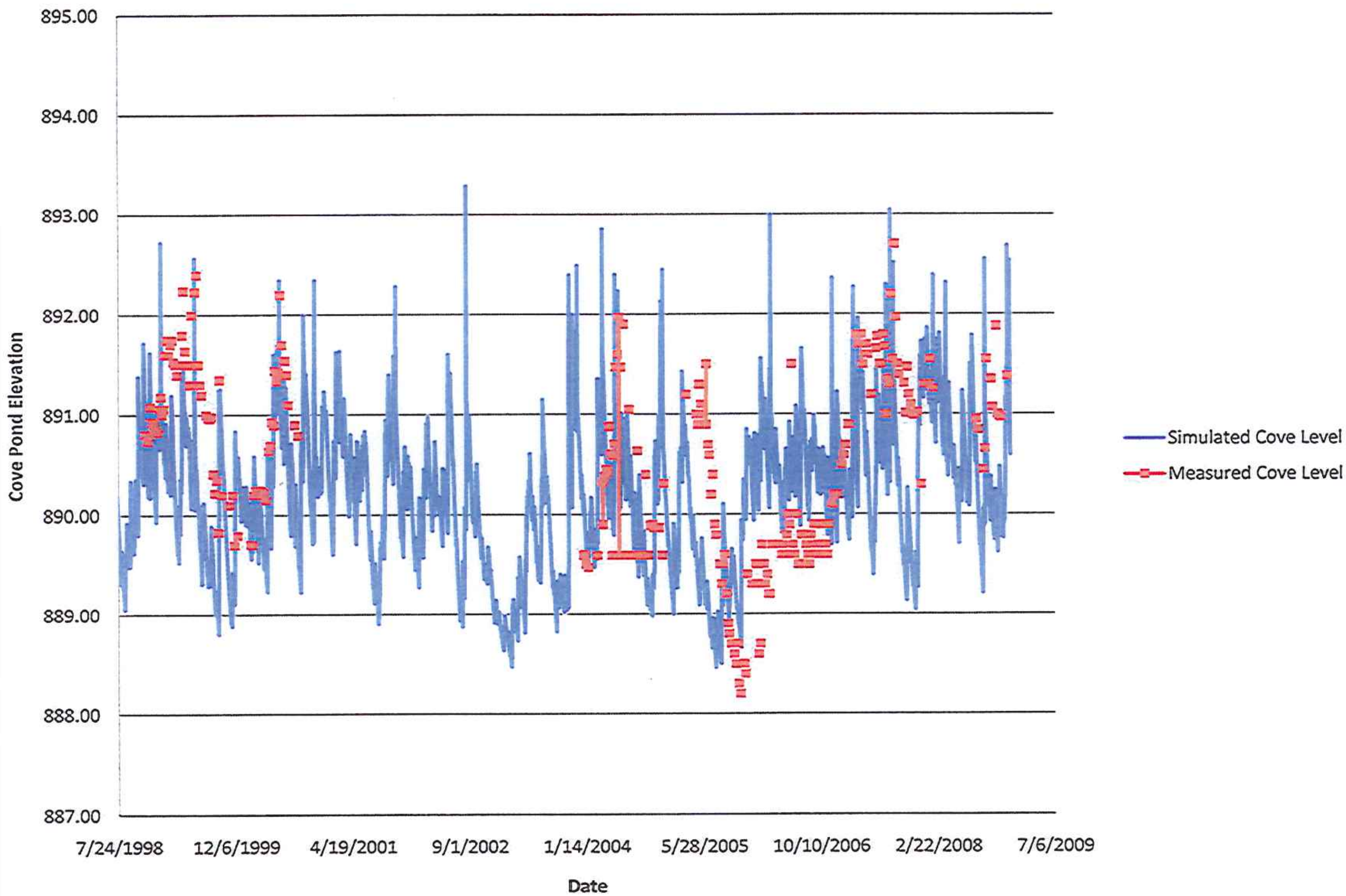


Exhibit C-4: Broadway Flow v. Lake Level

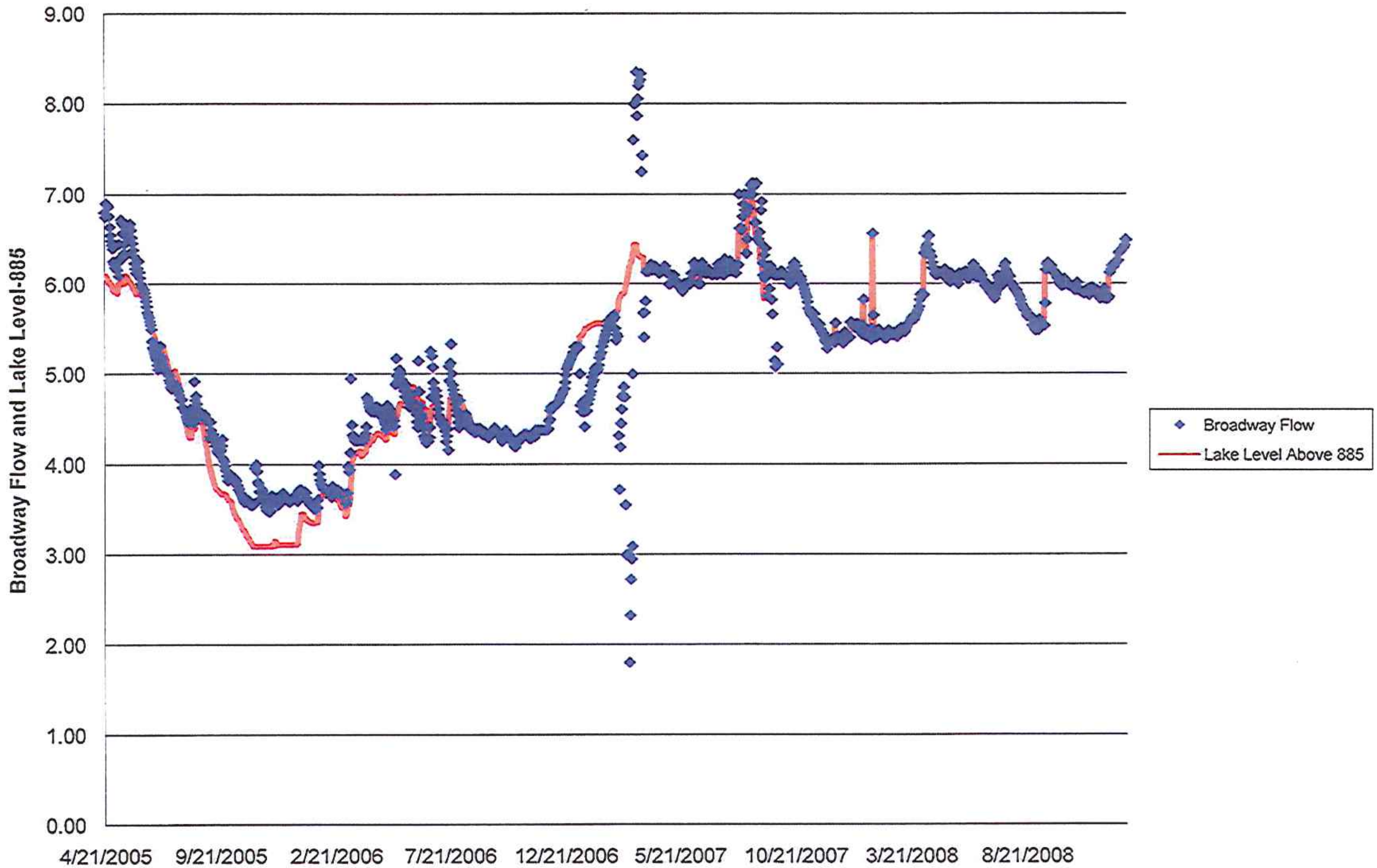
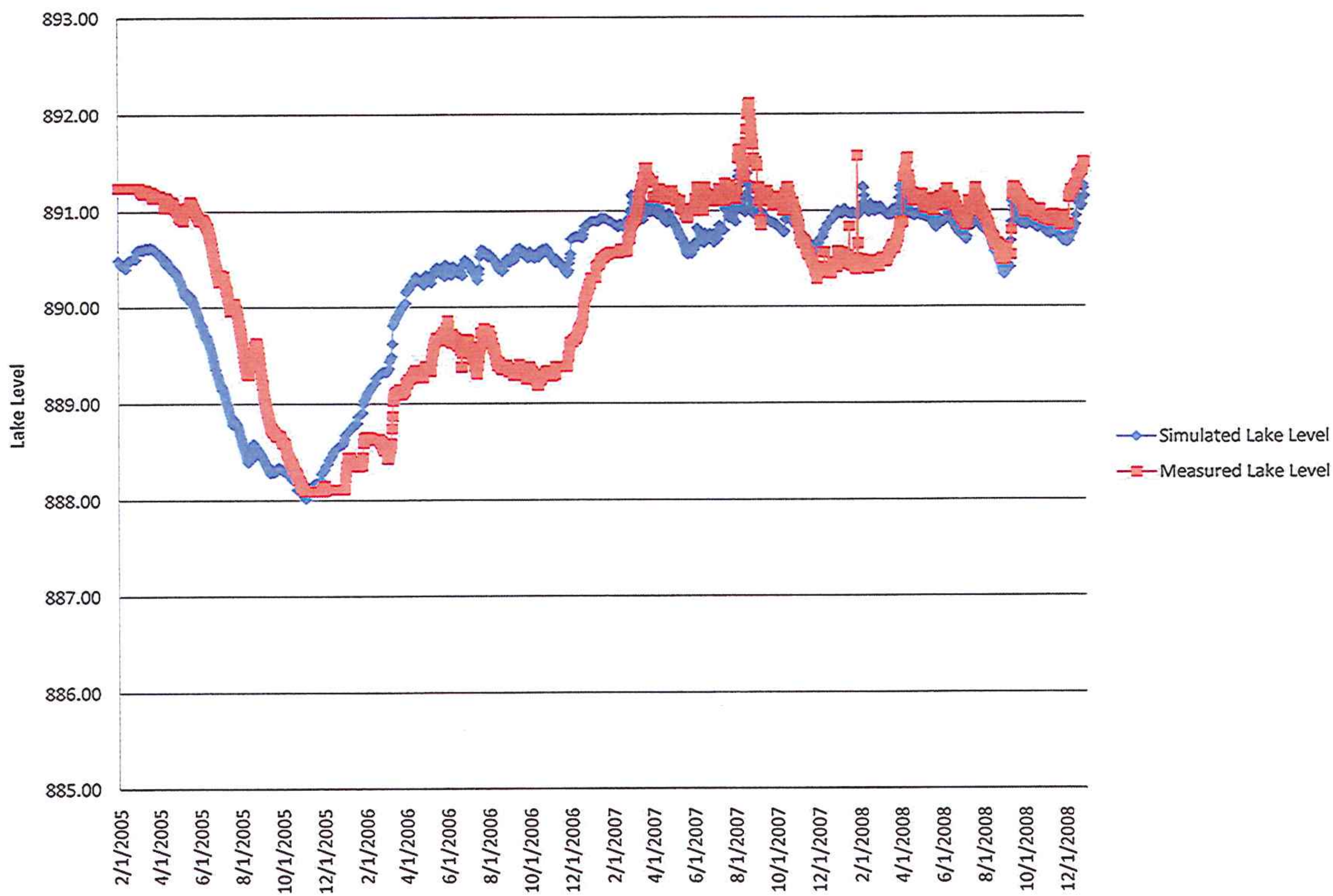


Exhibit C-5: Lake Level Calibration



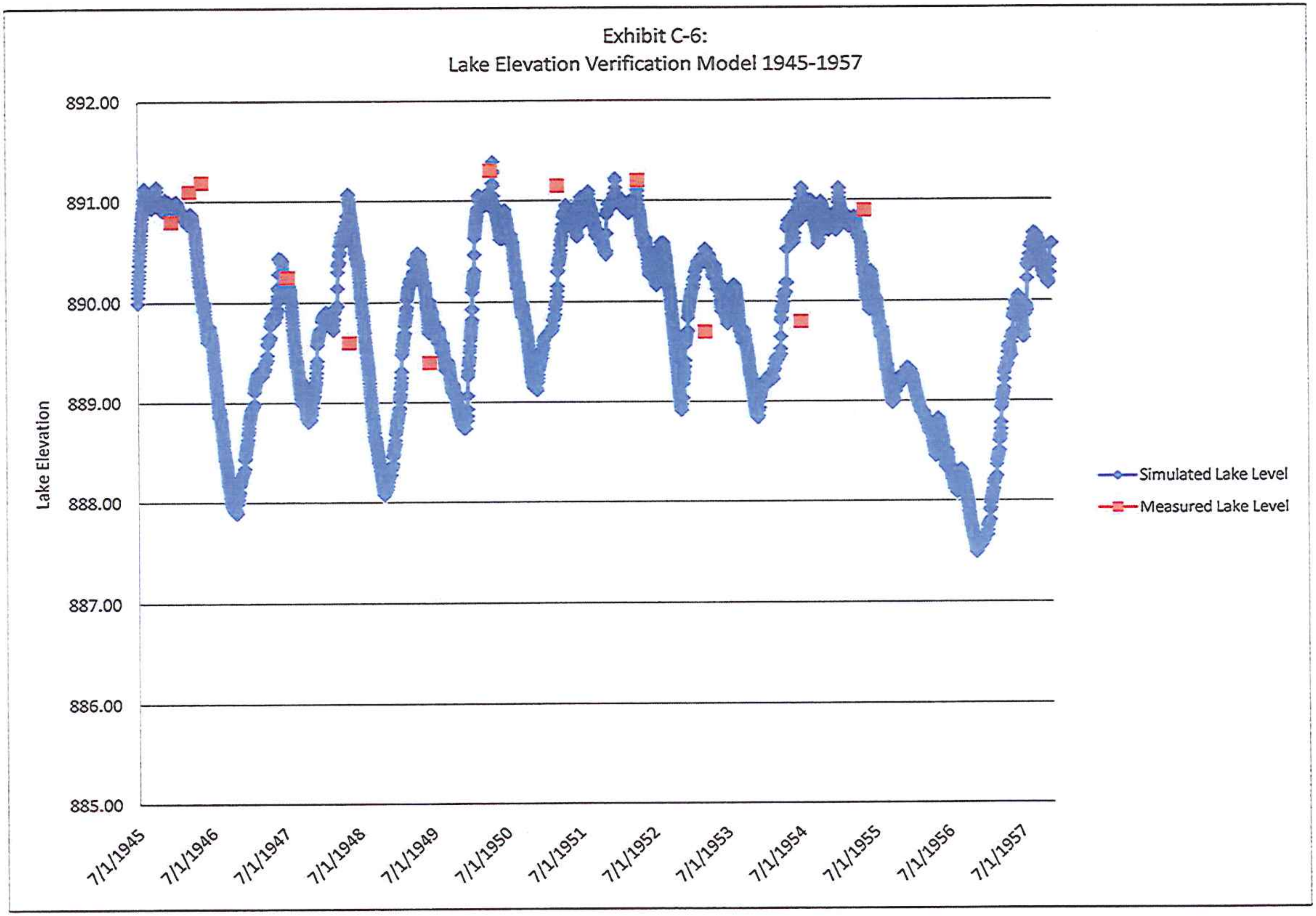


Exhibit C-6:
Lake Elevation Verification Model 1945-1957
Lake Elevation
892.00
891.00
890.00
889.00
888.00
887.00
886.00
885.00
7/1/1945
7/1/1946
7/1/1947
7/1/1948
7/1/1949
7/1/1950
7/1/1951
7/1/1952
7/1/1953
7/1/1954
7/1/1955
7/1/1956
7/1/1957
Simulated Lake Level
Measured Lake Level

Exhibit C-7: Simulated Lake Levels 1959-2008

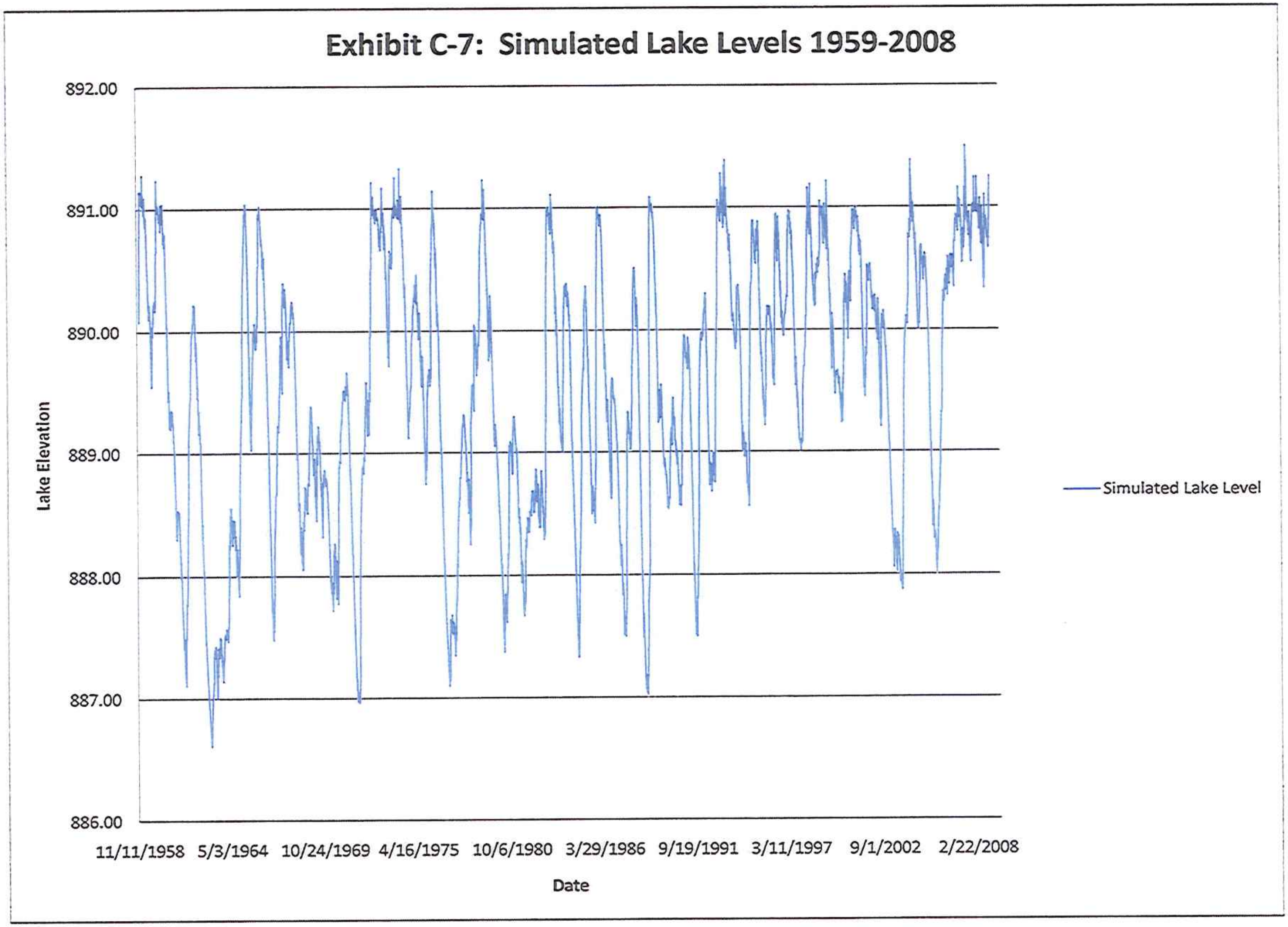


Exhibit C-8: Alt 1 Larger Culver Under Lake Ave.

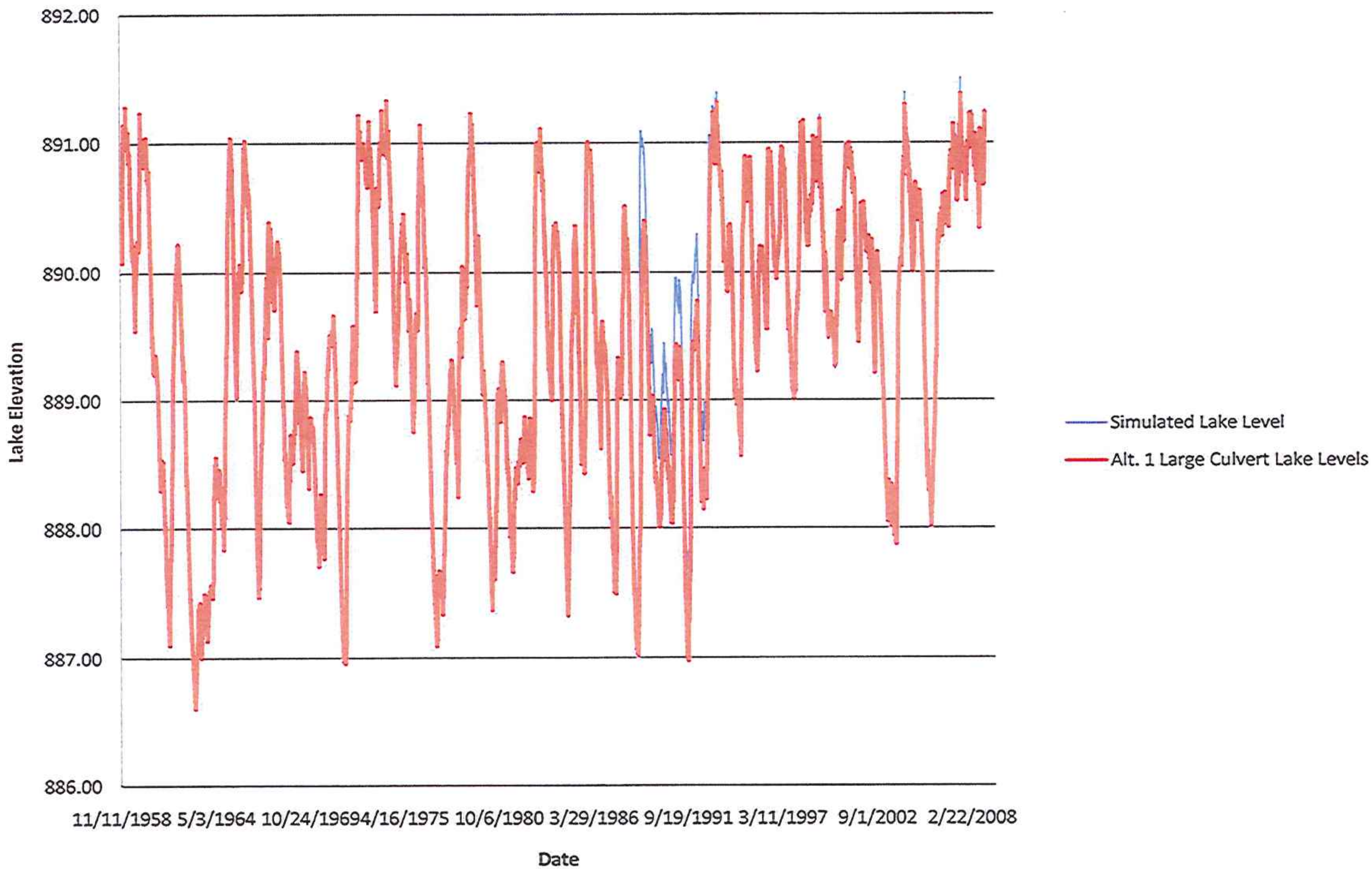
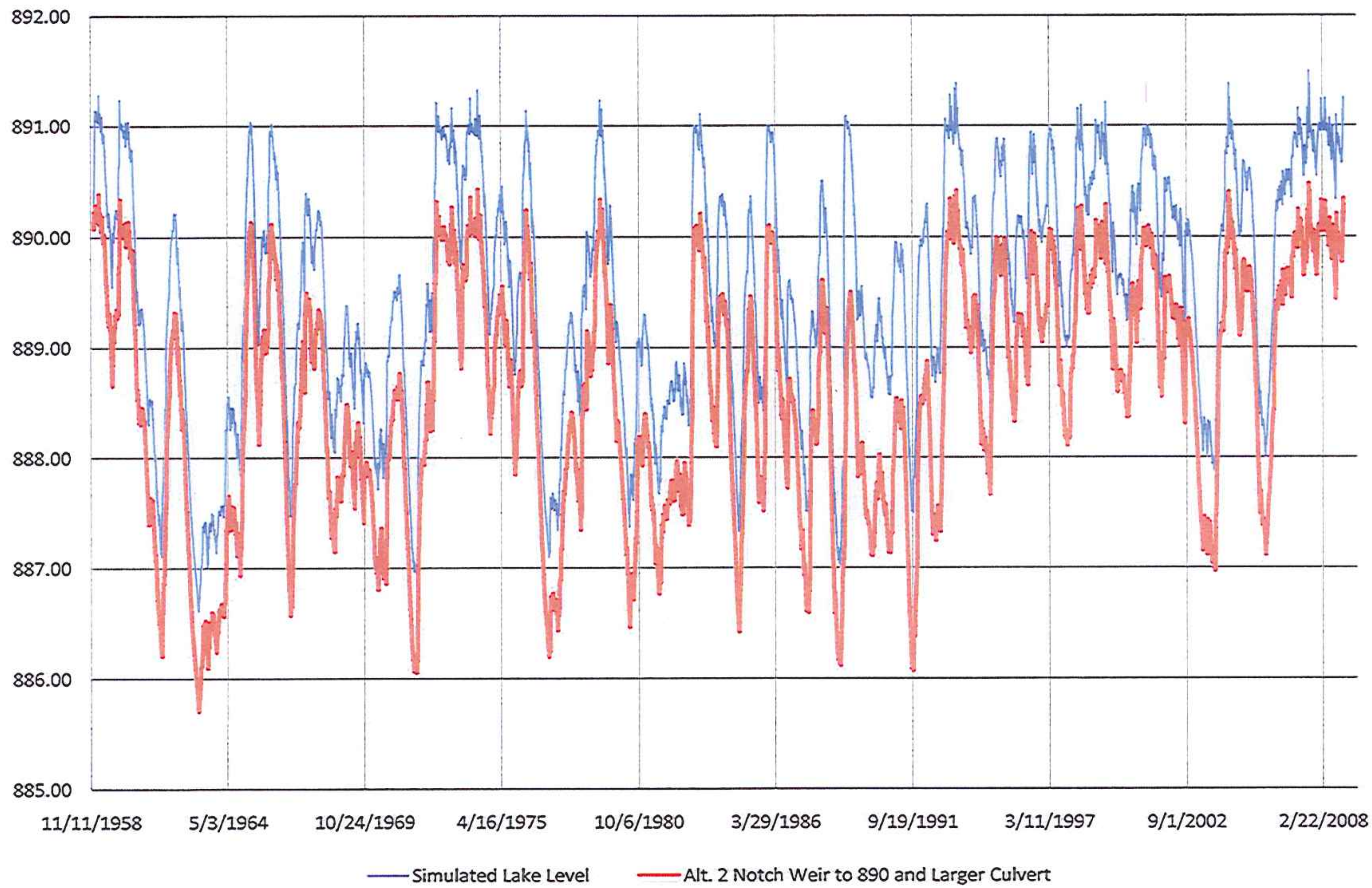


Exhibit C-9: Alt 2 Notch Weir to 890.0 and Larger Culvert Under Lake Ave.



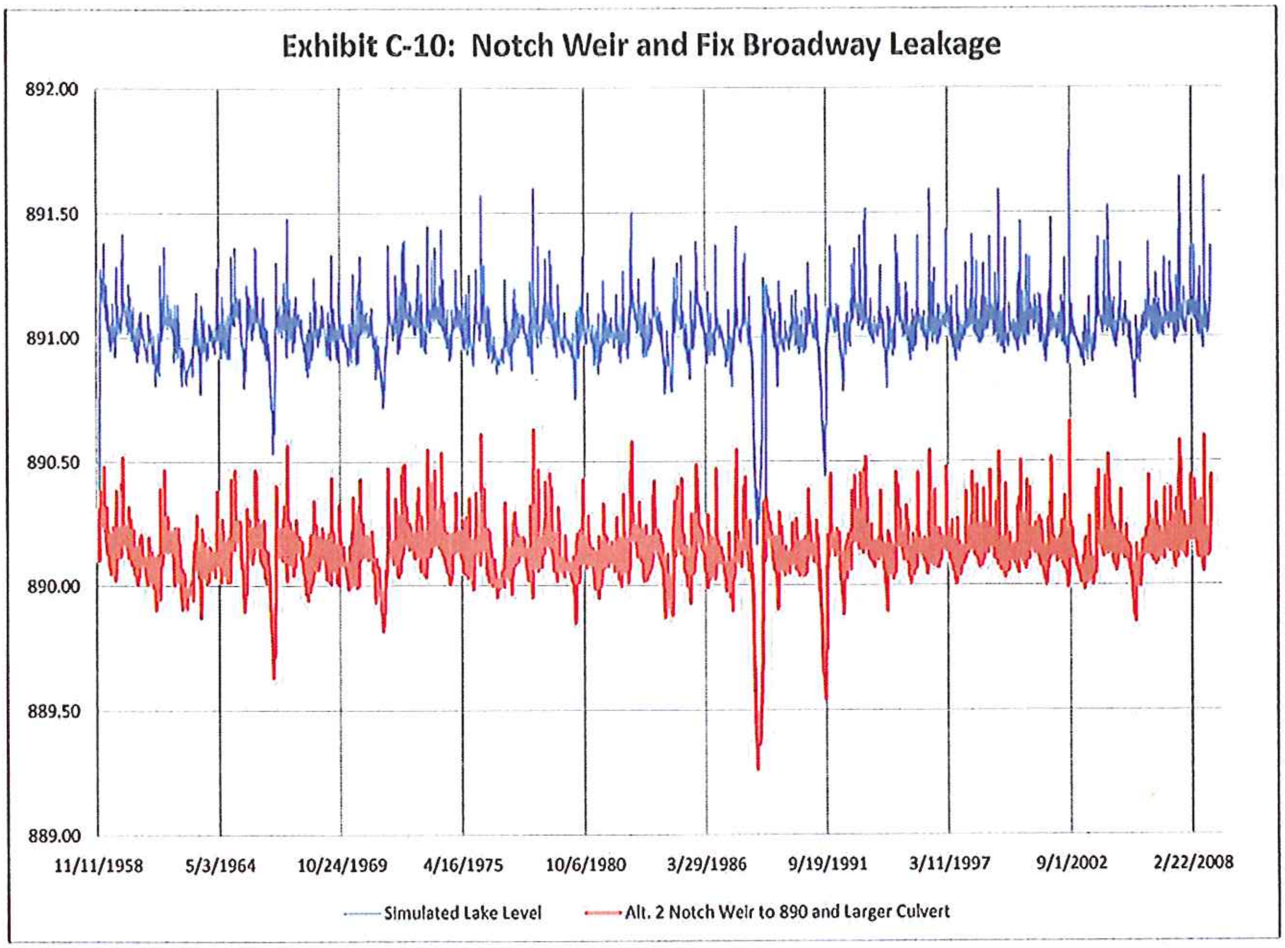


Exhibit C-10: Notch Weir and Fix Broadway Leakage
892.00
891.50
891.00
890.50
890.00
889.50
889.00
11/11/1958
5/3/1964
10/24/1969
4/16/1975
10/6/1980
3/29/1986
9/19/1991
3/11/1997
9/1/2002
2/22/2008
Simulated Lake Level
Alt. 2 Notch Weir to 890 and Larger Culvert