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Drought Solution for Coffeen Lake:

A Look at the Permitting and Design of a Main-Channel Gate Structure for Water Supply Station

Tony Comerio, P.E., CFM – Hanson Professional Services Inc.
Bill Rice, P.E., CFM, D.WRE – Hanson Professional Services Inc.

Client: **Ameren Energy Resources** Firm: **Hanson Professional Services Inc.**

COFFEEN POWER PLANT
WATER SUPPLY PROJECT

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Ameren

Coffeen, Ill.

Facing new federal air emissions regulations, electricity generating company Ameren Energy Resources chose to install a scrubber system at its 900-megawatt Coffeen Power Plant in southern Illinois to remove sulfur dioxide from its exhaust gases. While this system is designed to improve air emissions, it also requires additional water to operate.

The Coffeen Power Plant is located near East Fork Shoal Creek on Coffeen Lake, a State Fish and Wildlife Area which was constructed with the power plant in the mid-1960s to be its primary source of cooling water. As it proceeded with plans for the scrubbers, Ameren needed to make sure it had enough water to sustain its current operations and the new flue gas desulphurization system. Ameren turned to longtime business partner Hanson Professional Services to assist them in identifying potential water resources, reducing environmental impacts, and developing a workable solution that would meet their needs.

Hanson created a detailed lake water-level model using historical meteorological and plant water-use records that illustrated projected future water levels and water use — providing Ameren with the data it needed to move forward with the next phase of this project, a supplemental water supply study. As the project evolved, Hanson provided a full array of A/E services related to the permitting, design and construction of an innovative new dam gate structure on East Fork Shoal Creek and a new pump station to transfer water from the creek to supplement Coffeen Lake.

Permitting was crucial for this project, and Ameren and Hanson worked together to submit a joint permit application to three government agencies, including the U.S. Army Corps of Engineers, Illinois Environmental Protection Agency and Illinois Department of Natural Resources. This project is the first-of-its-kind in Illinois — the first gate structure to be permitted on a stream in the state.

Hanson's solutions during every phase of this project helped provide Ameren with the water and facilities it needed to comply with new air emissions regulations and permitting requirements, enhance its operations with new systems and equipment, and provide a safe, balanced environment for the area's fish, wildlife and surrounding communities.

ACEC *Illinois*

2012 Engineering Excellence Special Achievement Award

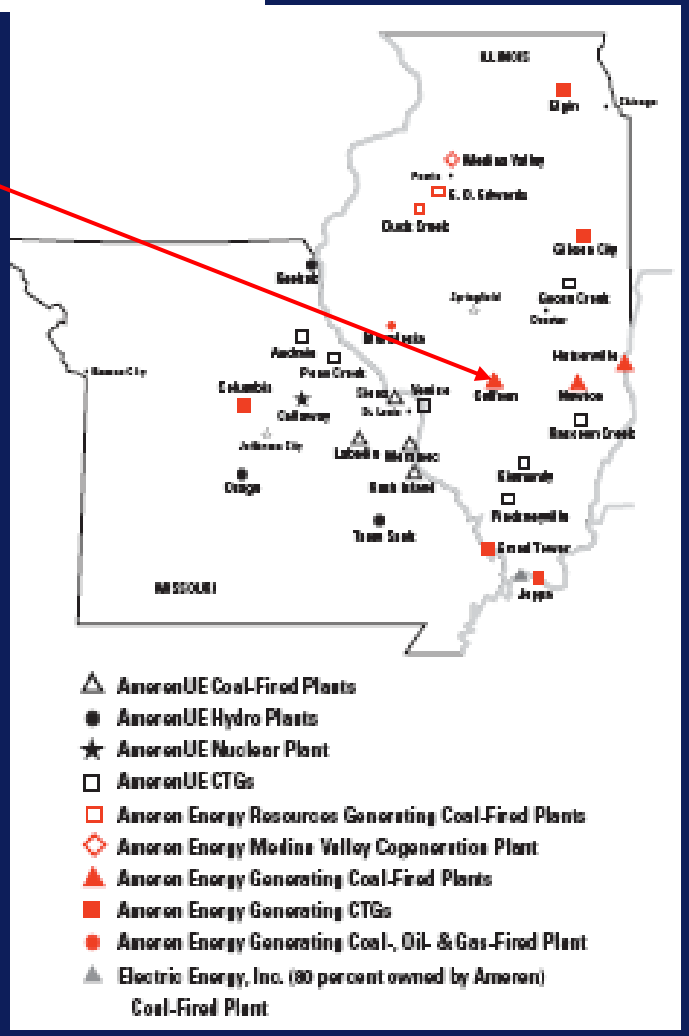
Presentation Summary

- Background
- Drought Modeling
- Hydrologic and Hydraulic Modeling
- Permitting
- Construction

Background

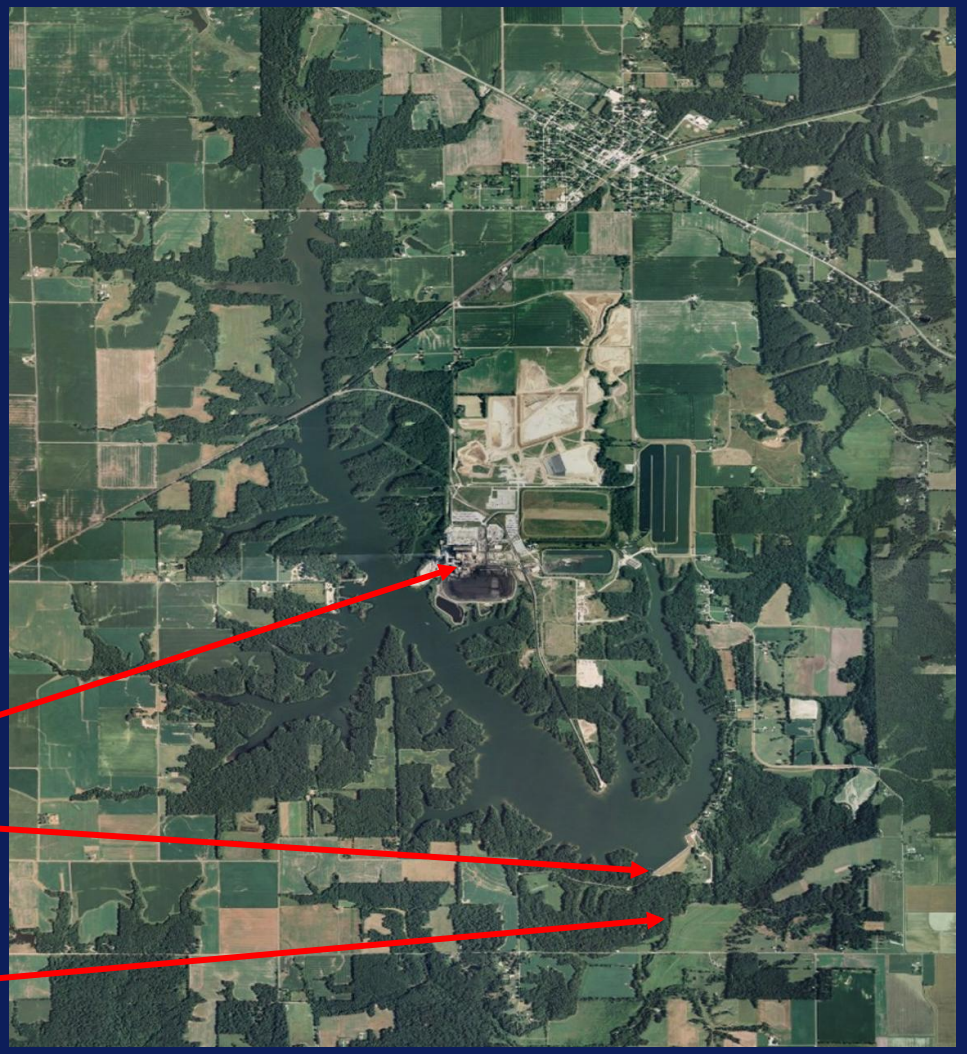
Project Location

- Ameren Coffeen Power Plant
- Montgomery County, Illinois
  - 1000 MW (2 Units)
  - Unit 1 began operation in 1967
  - Unit 2 placed into service in 1972
  - **Wet Flue Gas Desulfurization (**WFGD) scrubbers recently added
    - Both WFGD Units placed into service in 2010
    - Additional Water Demand
      - Design water requirement of 1,470 gallons per minute, in a closed loop system



Coffeen Lake

- 1,100 acre, 22,000 acre-ft lake constructed on the McDavid Branch, a tributary of East Fork Shoal Creek (EFSC). Provides water and cooling for the concurrently constructed Power Station.



Background

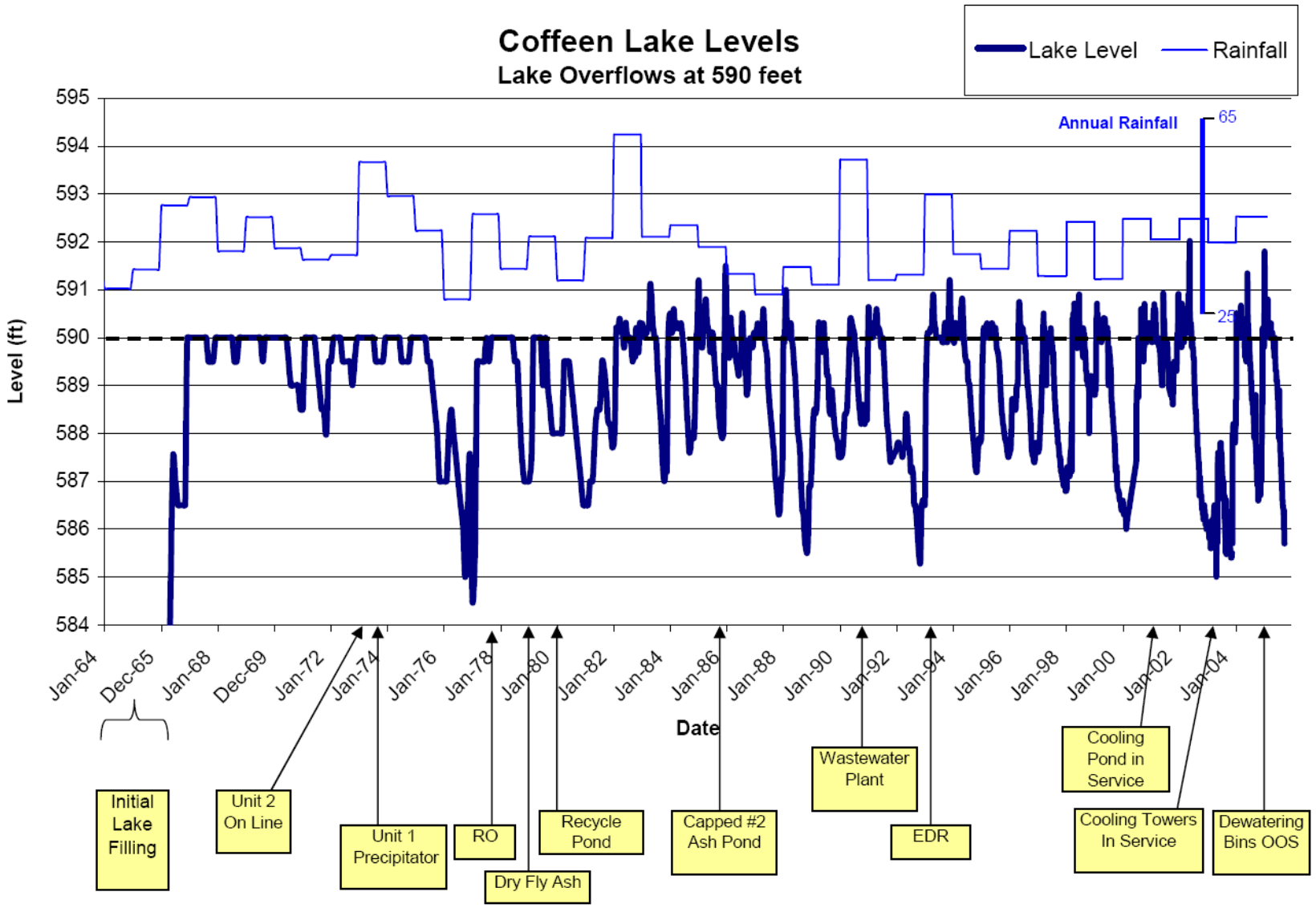
- In 2005, Hanson was contracted by Ameren to complete a Supplemental Water Supply Alternatives.
  - Water balance model of Coffeen Lake with the current and future plant water demands.
  - A computer model of the lake levels utilizing historical meteorological data.
  - Calibration of models using actual lake level readings provided by Ameren.

Drought Modeling

Coffeen Power Station Water Demand

(Acre Feet per Year)

	Historical Plant Water Demand	Water Demand With Current Operating Demands and Scrubber
Forced Evaporation	3630 (3.24 MGD)	8890 (7.9 MGD) includes scrubber use
Natural Evaporation	3270	3270
Seepage at Dam	500	500
Total Demand	7400 (6.6 MGD)	12660 (11.3 MGD)
Additional Demand		5260 (4.7 MGD)

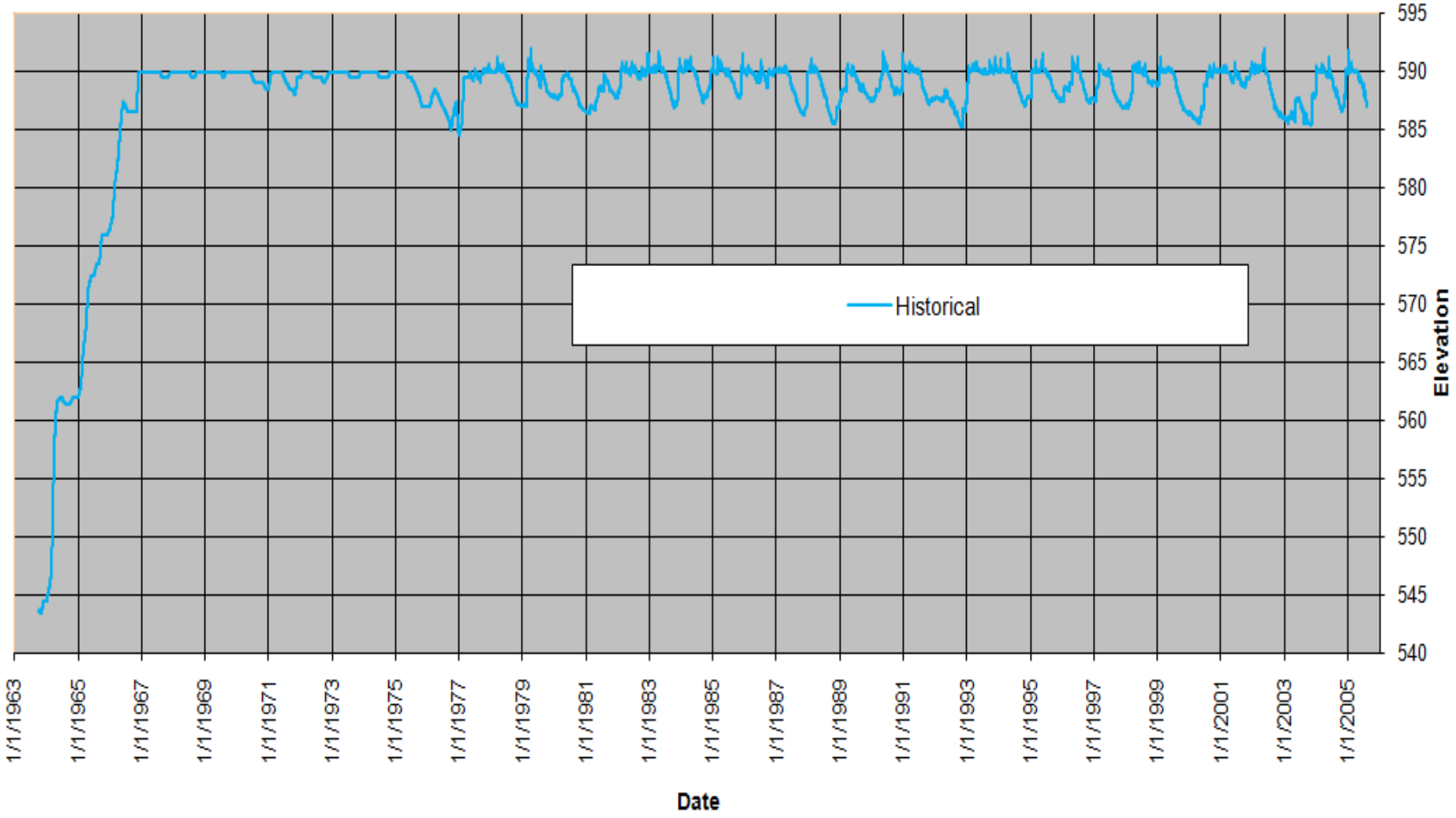

Coffeen Lake Levels
Lake Overflows at 590 feet
Lake Level
Rainfall
Annual Rainfall
65
25
Level (ft)
595
594
593
592
591
590
589
588
587
586
585
584
Jan-64
Dec-65
Jan-68
Dec-69
Jan-72
Jan-74
Jan-76
Jan-78
Jan-80
Jan-82
Jan-84
Jan-86
Jan-88
Jan-90
Jan-92
Jan-94
Jan-96
Jan-98
Jan-00
Jan-02
Jan-04
Date
Initial Lake Filling
Unit 2 On Line
Unit 1 Precipitator
RO
Dry Fly Ash
Recycle Pond
Capped #2 Ash Pond
Wastewater Plant
EDR
Cooling Pond in Service
Cooling Towers In Service
Dewatering Bins OOS

Lake Level Modeling

- Model Input = Water In and Water Out of Coffeen Lake
  - Water In
    - Rainfall on Lake Area
    - Lake Inflow From Watershed Area
    - Water pumped from East Fork Shoal Creek
  - Water Out
    - Natural Evaporation from Lake and Plant Operation Ponds
    - Forced Evaporation and Plant Use (varies with Plant Net Capacity Factor)
    - Scrubber Water Usage
    - Lake Seepage at Dam

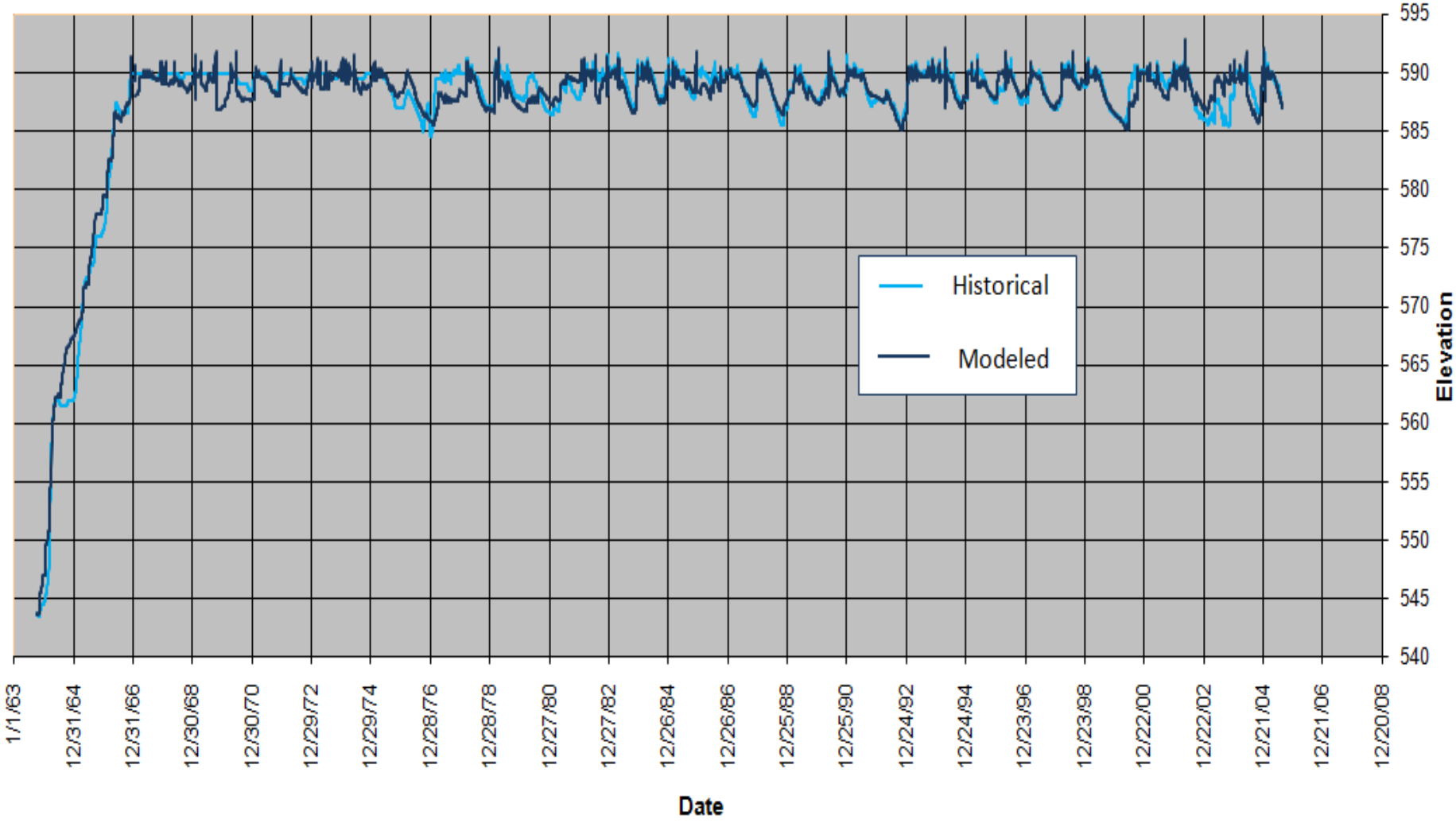
1963 Thru 2005 Lake Levels

Spillway at Elevation 590

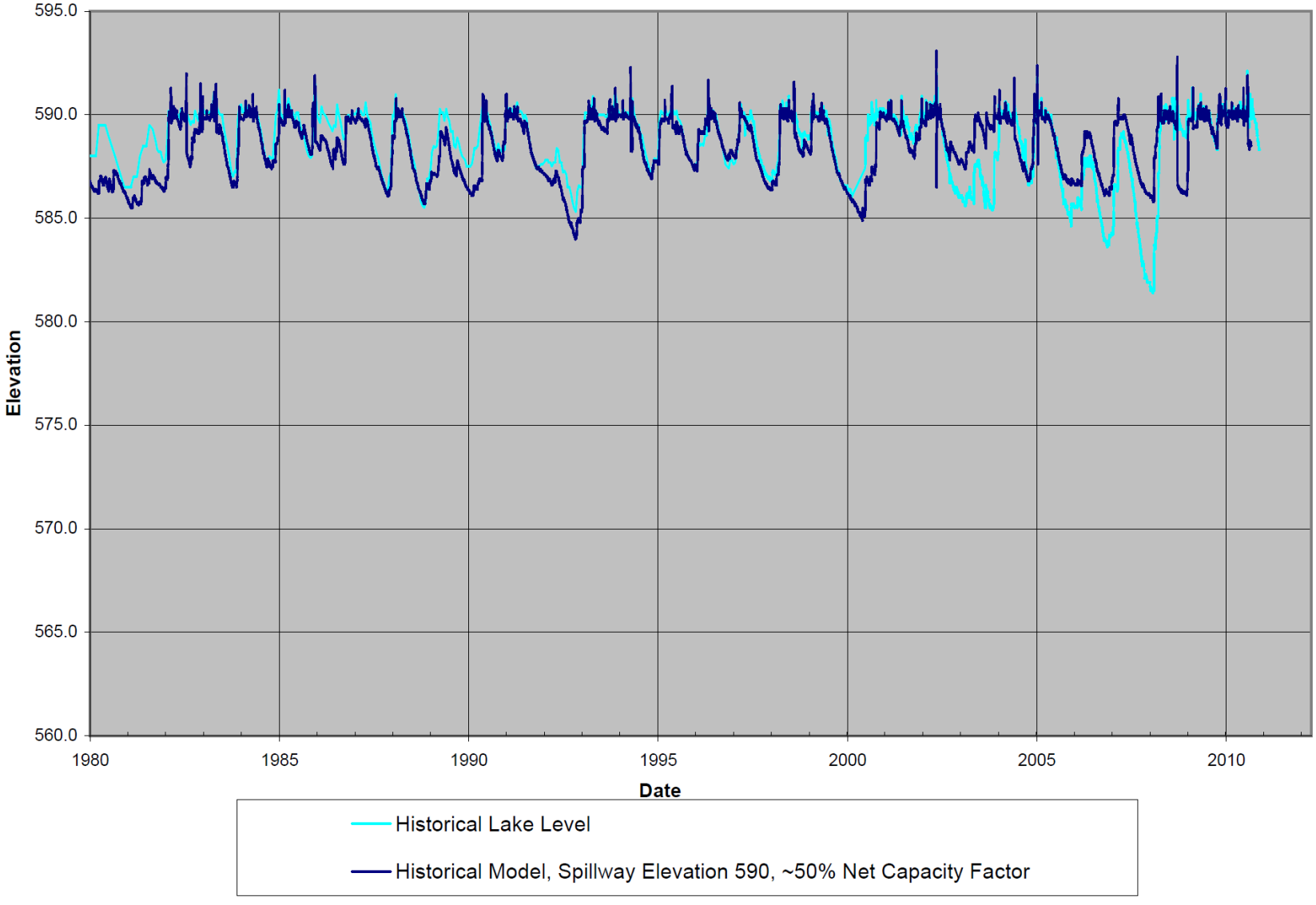


1963 Thru 2005 Lake Levels

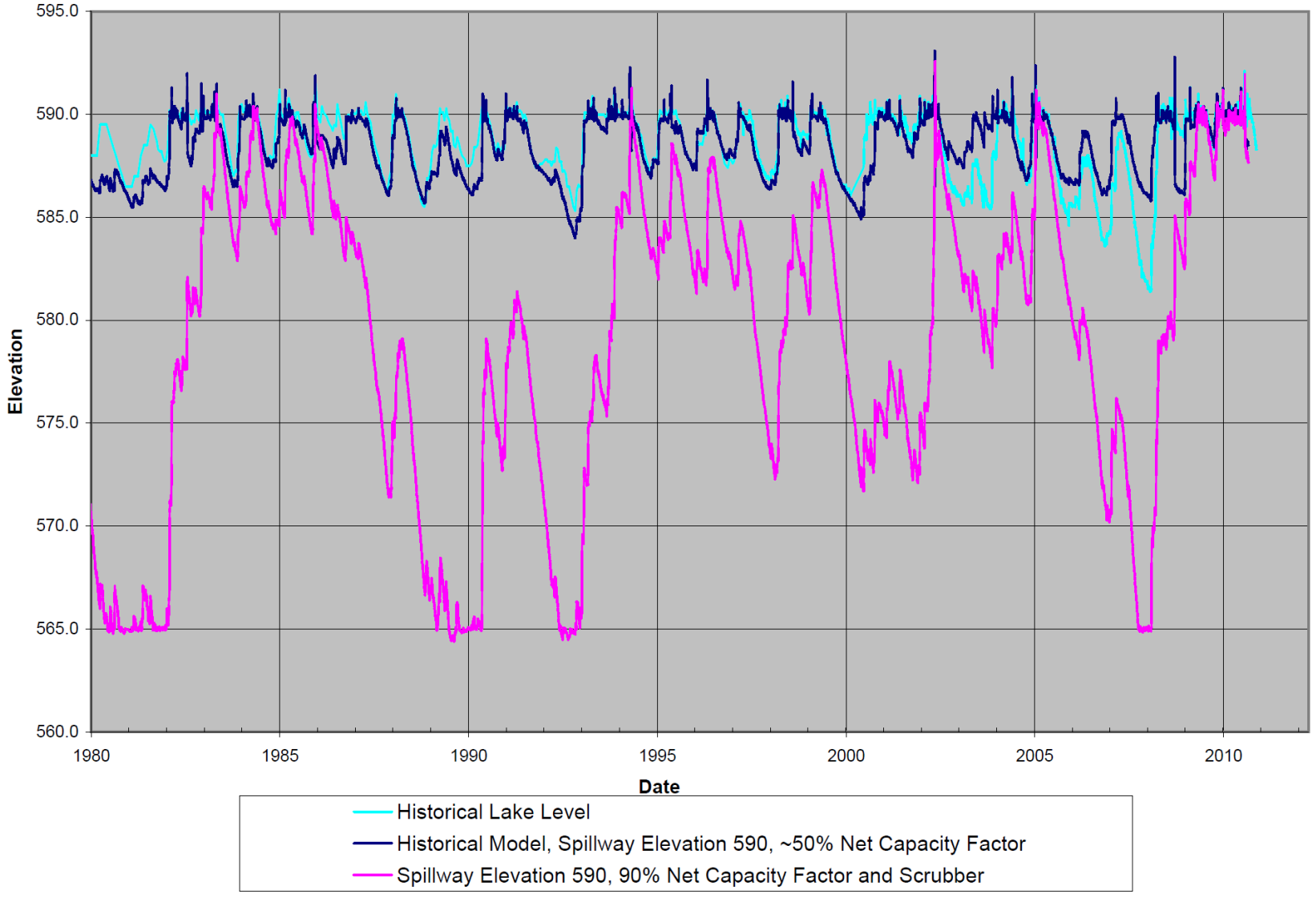
Spillway at Elevation 590



Historical Lake Levels - 1980 Thru 2010



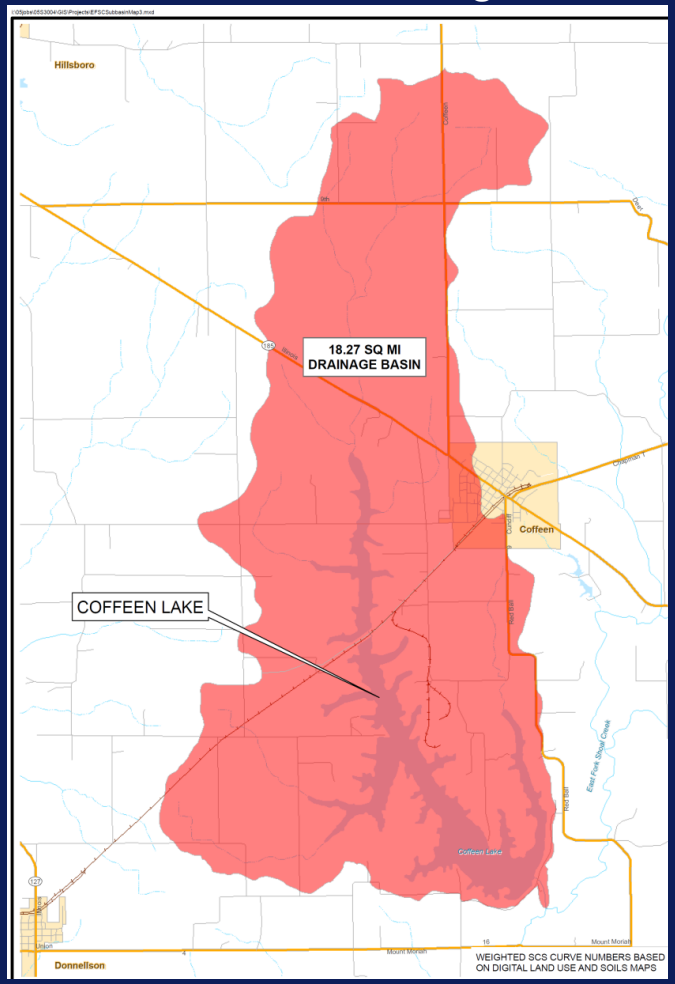
Historical Lake Levels - 1980 Thru 2010



Obvious Water Supply Shortfall

- Existing Coffeen Lake water sources are inadequate for anticipated demand
  - Watershed Area : Lake Surface Area Ratio
    - Coffeen Lake = 10.6 (Low)
  - Temporary Dam on EFSC and pump station constructed and used for initial lake filling
    - Over 50% of initial lake volume pumped from EFSC
    - State required dam removal after lake was filled.
    - Pump station left in place and used sporadically.

Coffeen Lake Drainage Basin



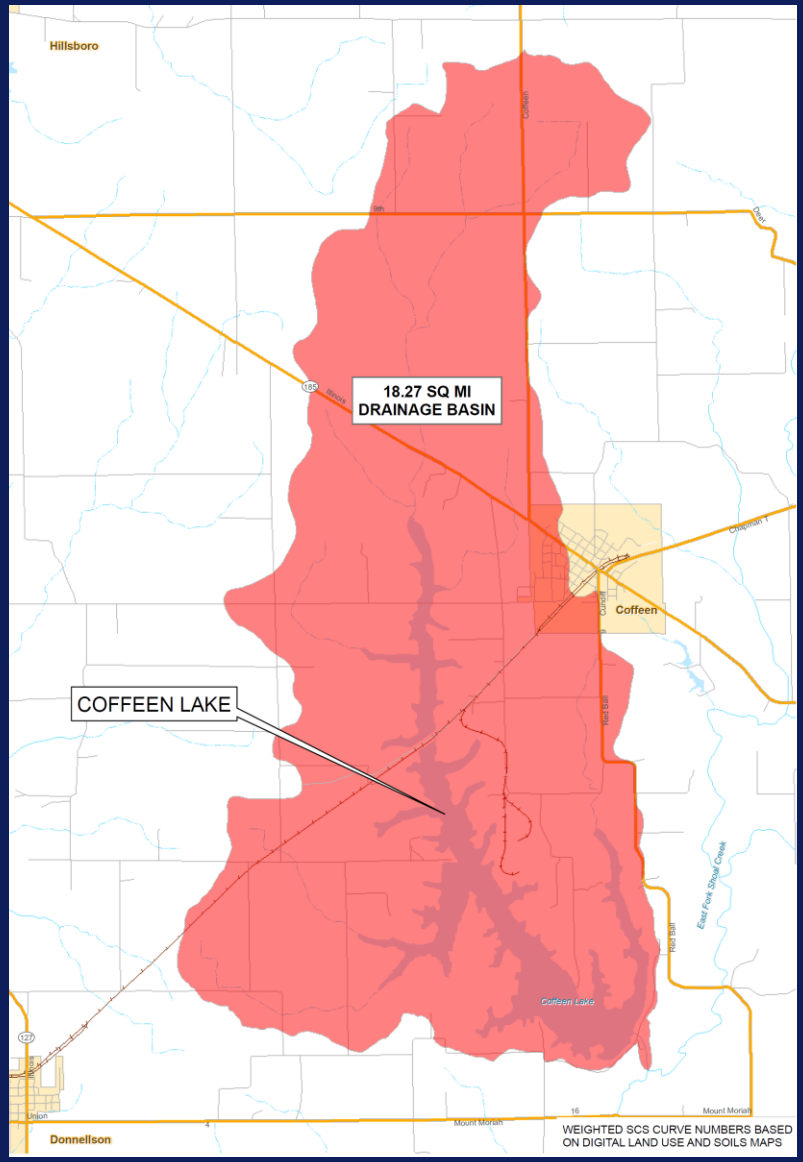
Water Supply Alternatives – Report

SUPPLEMENTAL WATER SUPPLY ALTERNATIVES
AMEREN ENERGY GENERATING
COFFEEN POWER STATION
COFFEEN, ILLINOIS

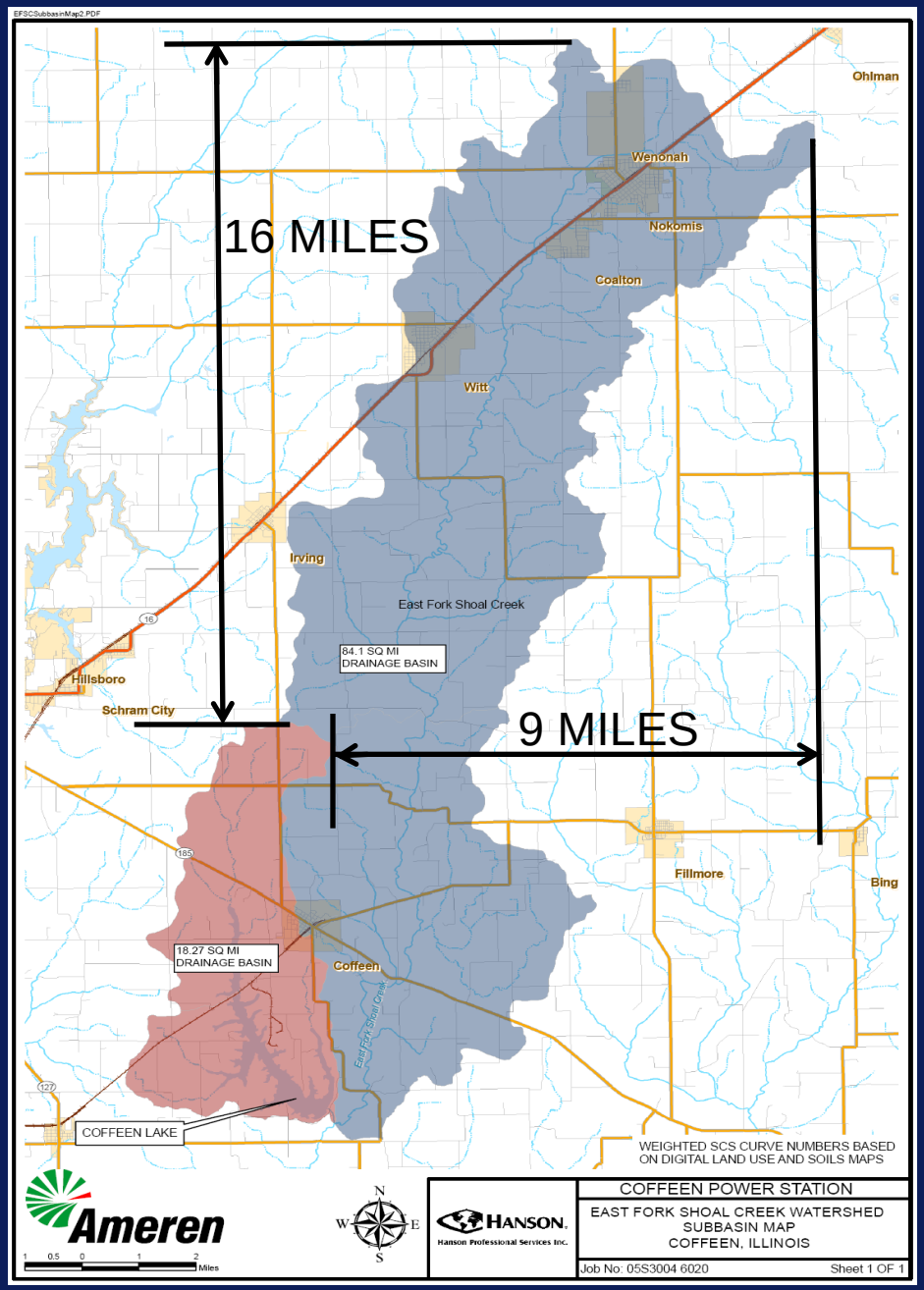
TABLE OF CONTENTS

- A study of supplemental water supply alternatives was completed by Hanson in 2005 to examine possible ways to meet this anticipated demand
- The EFSC pump station and gate structure was identified as feasible, cost-effective way of providing additional water.

Coffeen Lake Drainage Basin

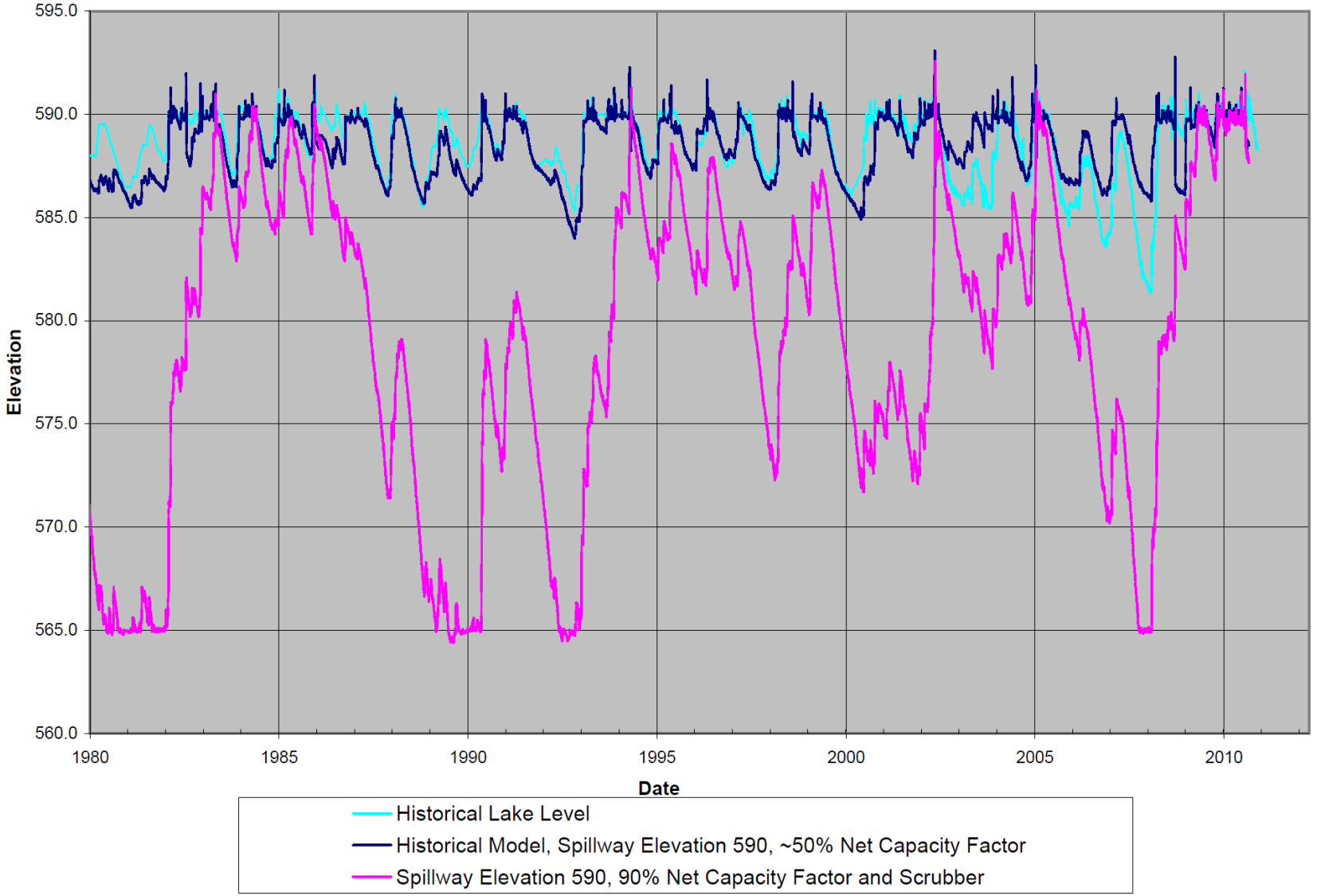


East Fork Shoal Creek Drainage Basin

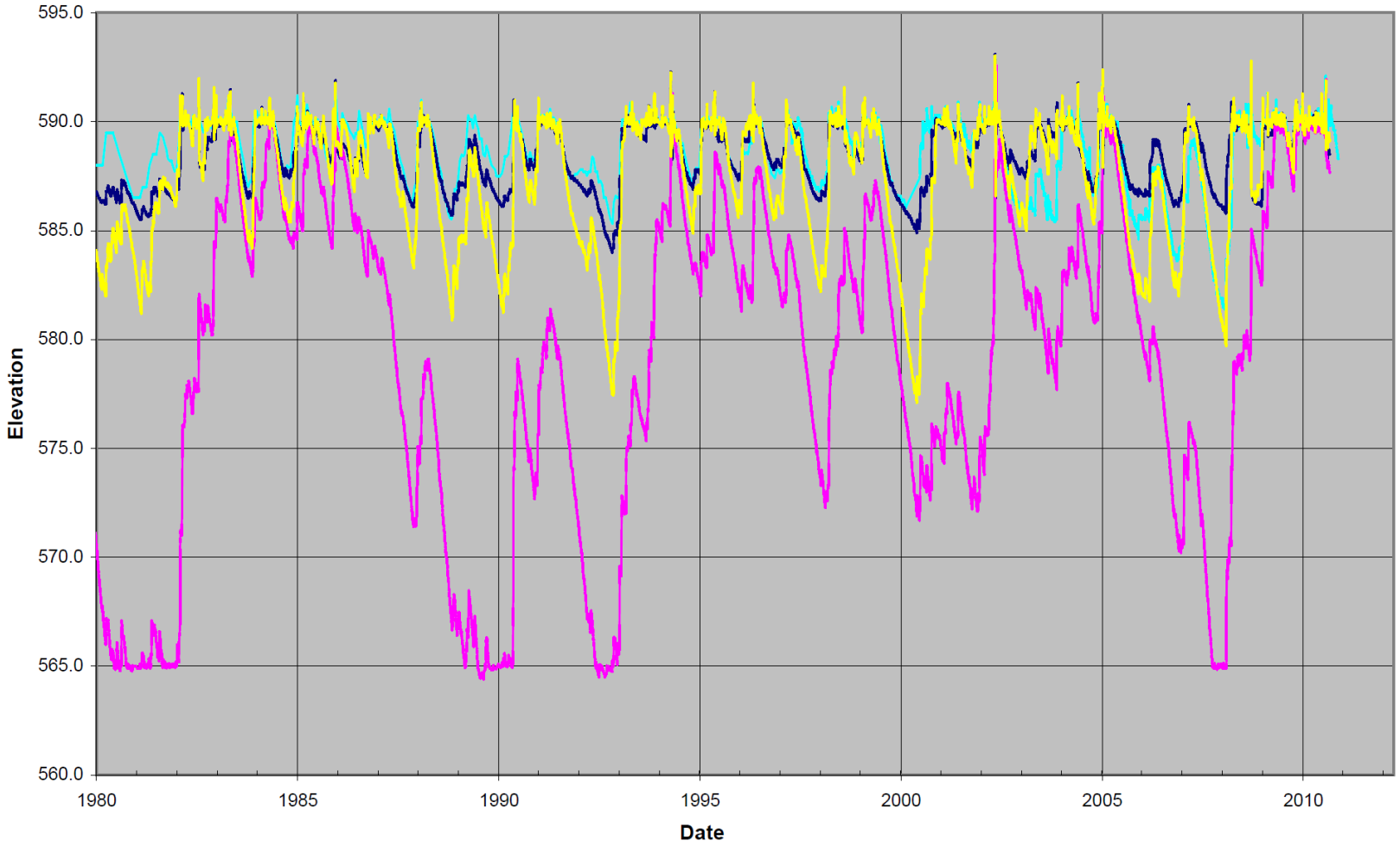


The East Fork Shoal Creek Watershed Area upstream of the proposed gate structure is 4.6 times larger than the Watershed Area of Coffeen Lake

Historical Lake Levels - 1980 Thru 2010



Historical Lake Levels - 1980 Thru 2010



Coffeen Lake Water Sources

(based on AVERAGE year rainfall amounts)

	Anticipated Total Water Demand*	Coffeen Lake Watershed (Net yield)	East Fork Shoal Creek Gate/Pump Station Upgrade	Total Sources
Ac – ft/yr	**12,660**	9,270	13,100	22,370
MGD	**11.3**	8.3	11.7	20.0
GPM	**7,848**	5,745	8,124	13,869

*Based on increased Plant demands

Coffeen Lake Water Sources

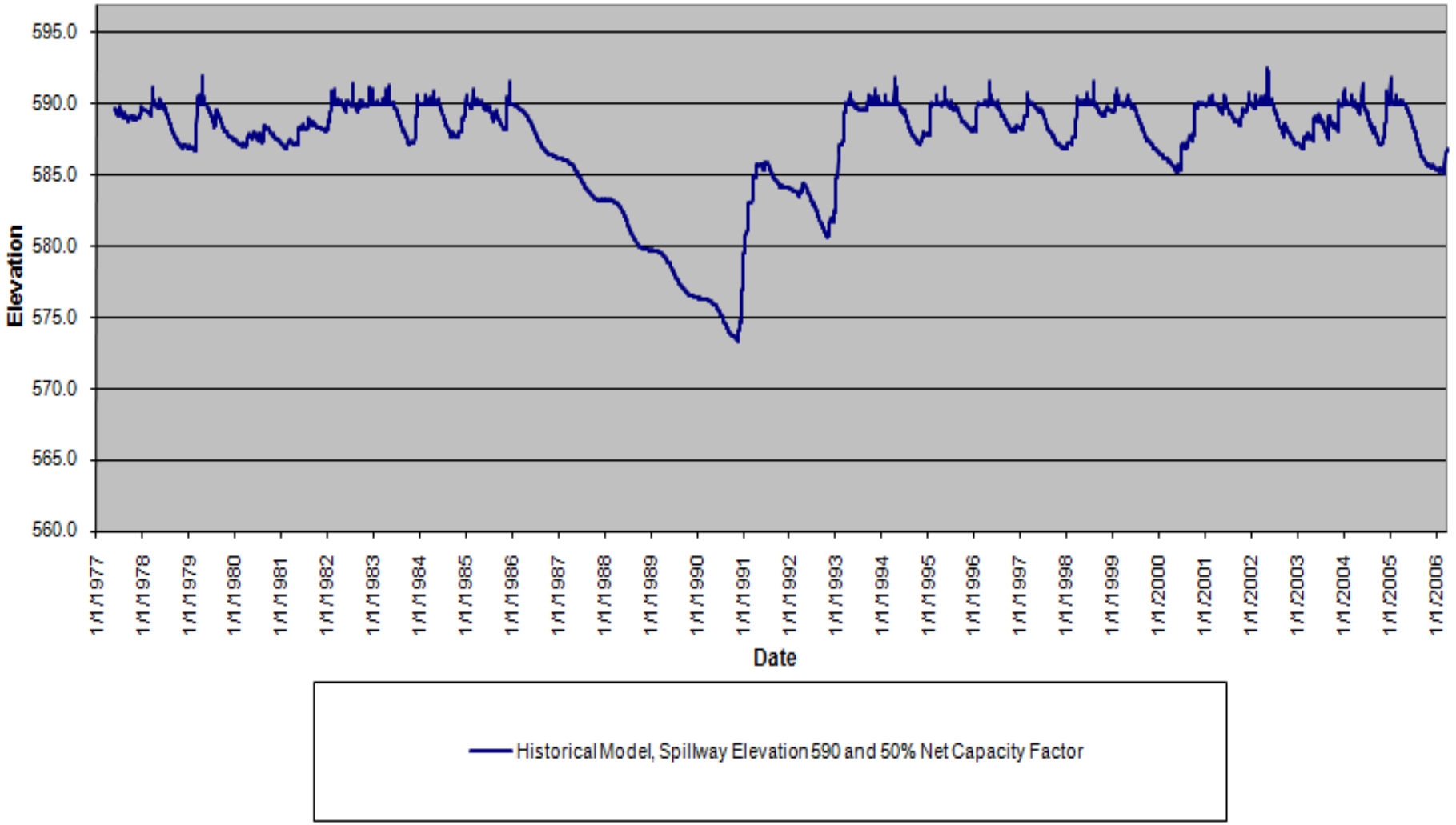
(based on 10-year drought rainfall amounts)

	Anticipated Total Water Demand*	Coffeen Lake Watershed (Net yield)	East Fork Shoal Creek Gate/Pump Station Upgrade	Total Sources
Ac – ft/yr	**12,660**	6,520	6,986	13,506
MGD	**11.3**	5.8	6.2	12.0
GPM	**7,848**	4,042	4,331	8,373

*Based on current water demands, with proposed uprate and scrubber

25 Year Drought

58 Month Duration



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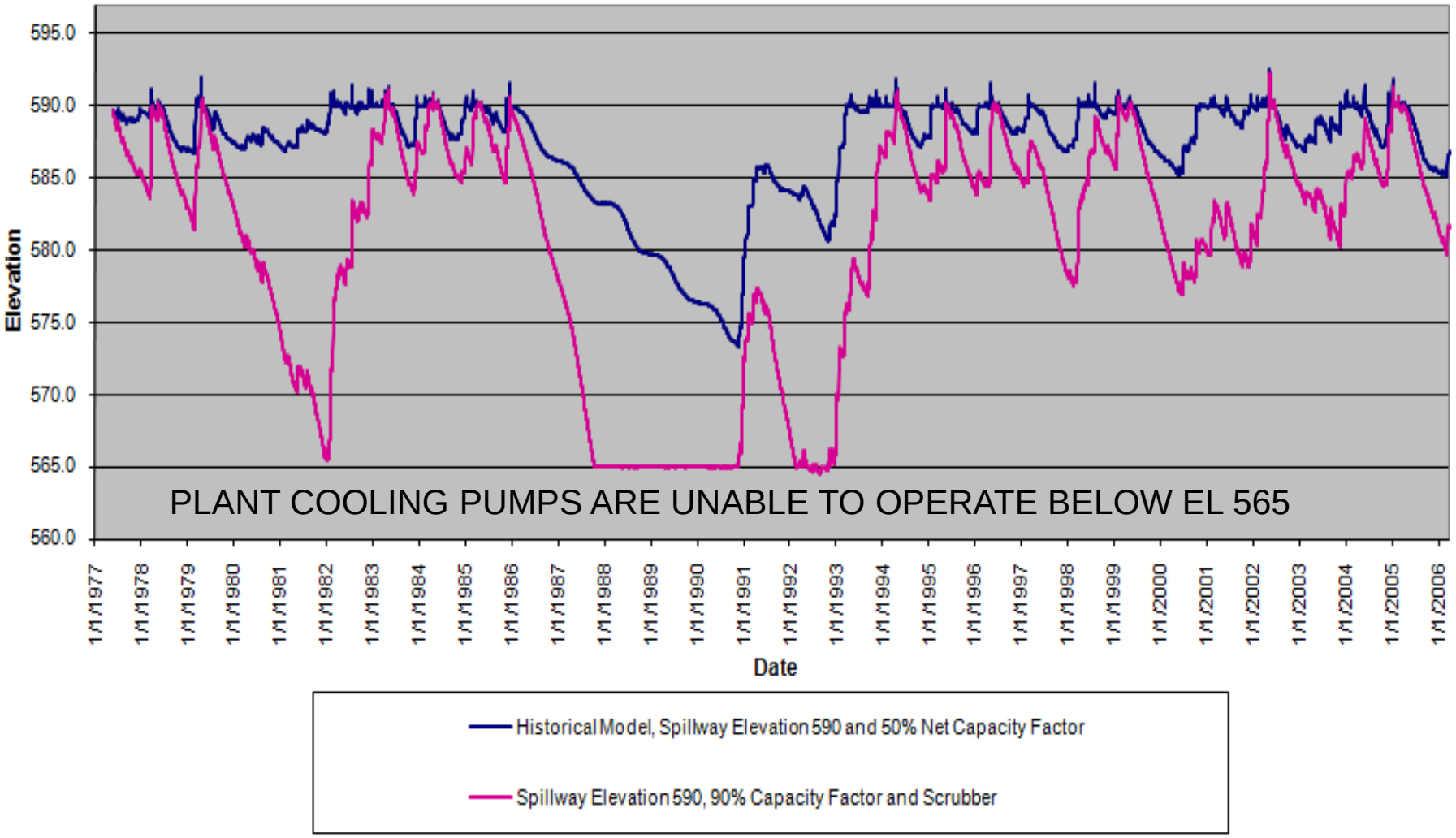

25 Year Drought

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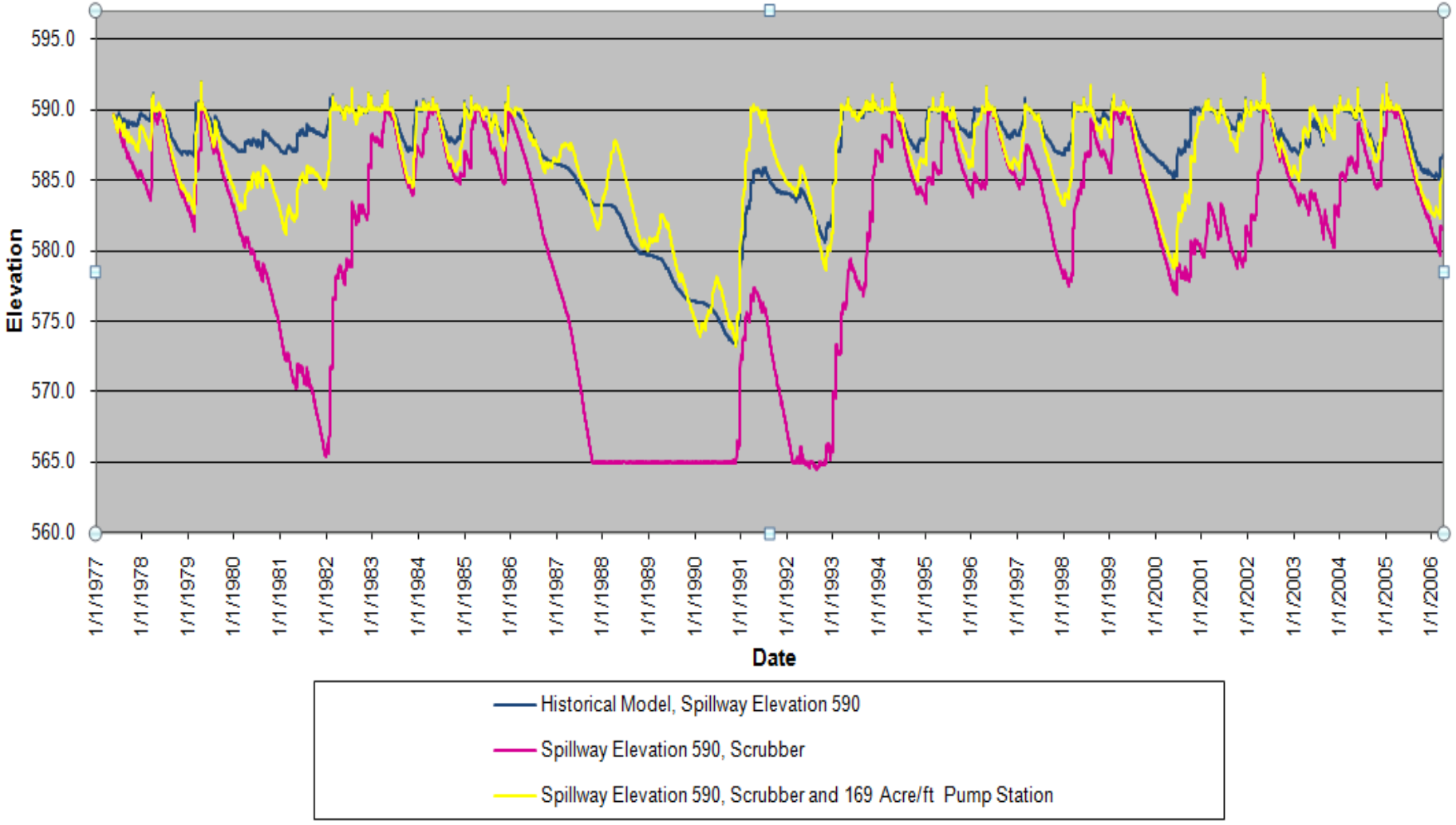


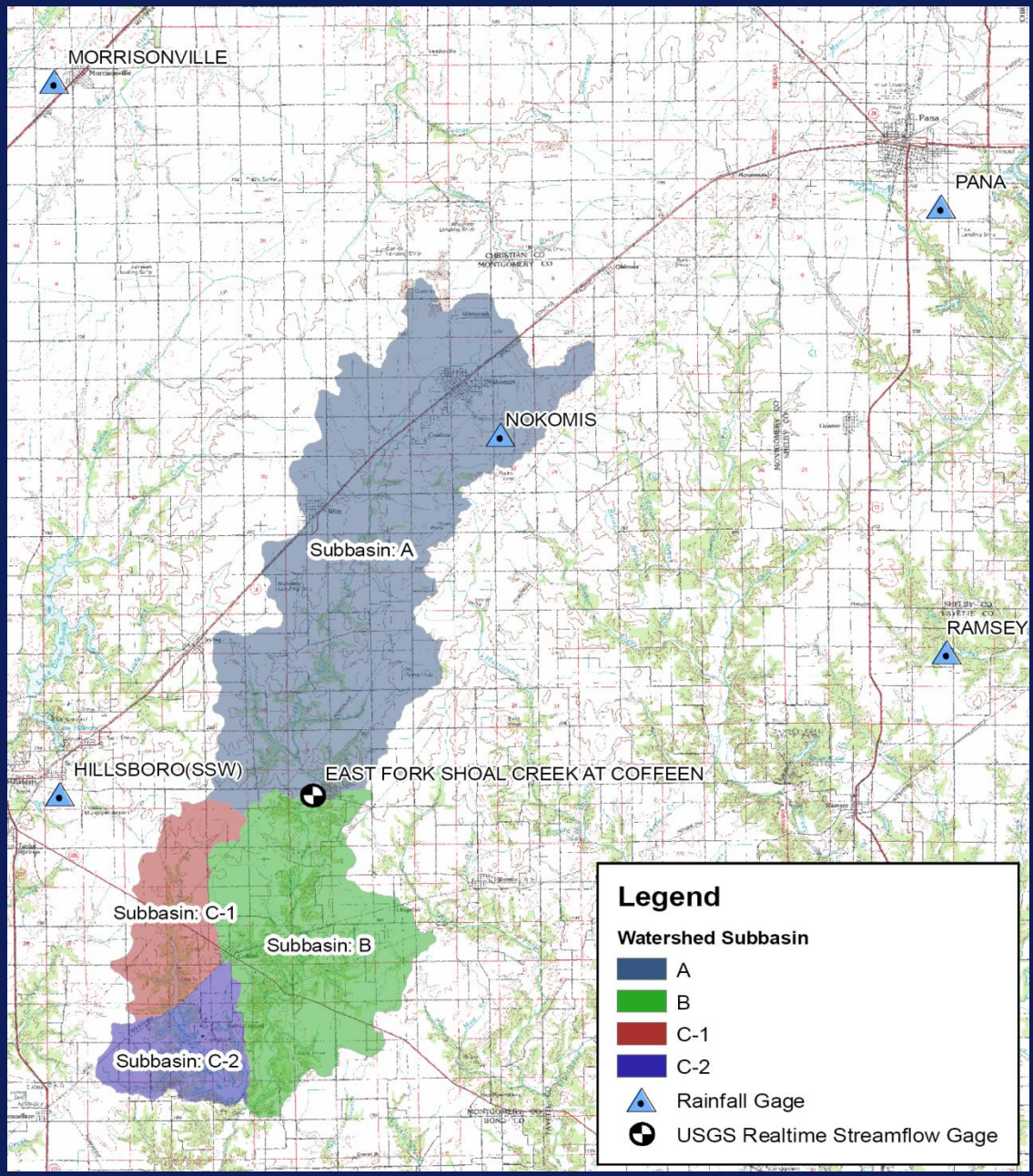
EFSC Pump Station and Gate Structure Design Process

- The East Fork Shoal Creek (EFSC) basin hydrology was modeled utilizing HEC-HMS to model flows to the proposed pump station and gate structure.
- The model was calibrated based on actual storm events.
- HEC-RAS unsteady flow model was developed to evaluate various gate geometry and pump station capacity combinations.
- **Goal:** Gate would not result in increased flood levels on property not owned by Ameren.

Hydrologic and Hydraulic Modeling

BASIN HYDROLOGY

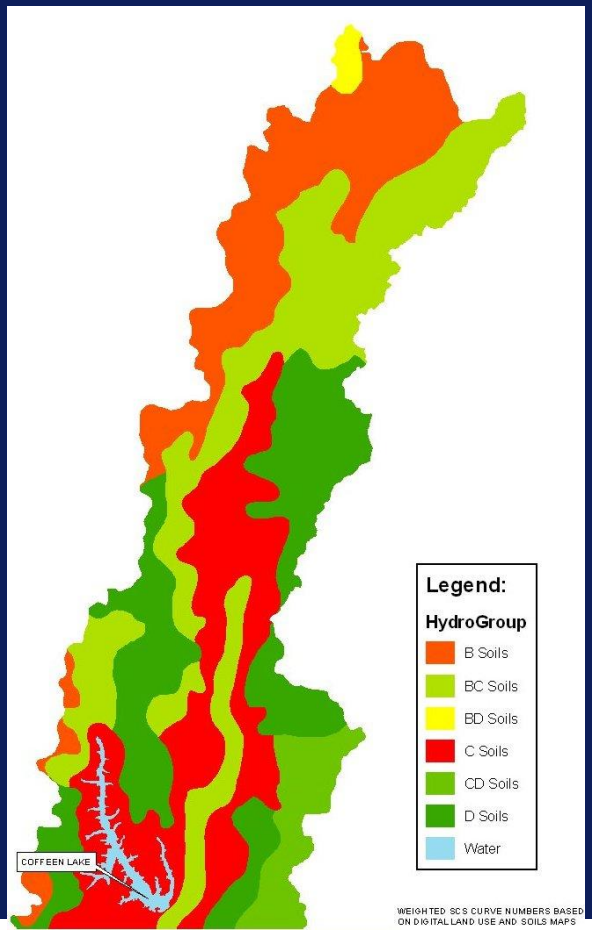
- 5 Rainfall Gages
- 1 Realtime Streamflow & Stage Gage

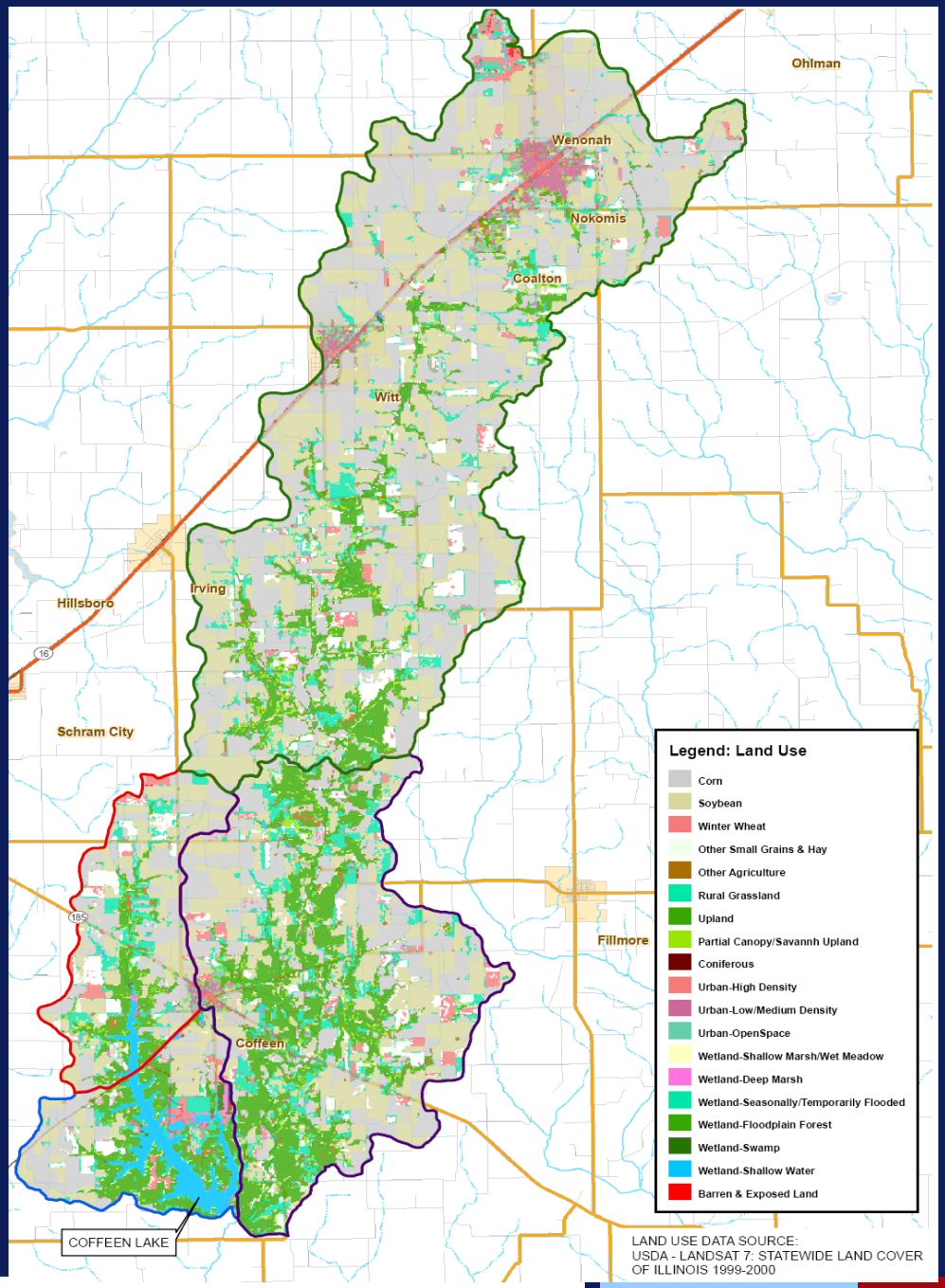


BASIN HYDROLOGY

SATELLITE-BASED LAND USAGE / COVER DATA

DIGITAL SOILS MAPS

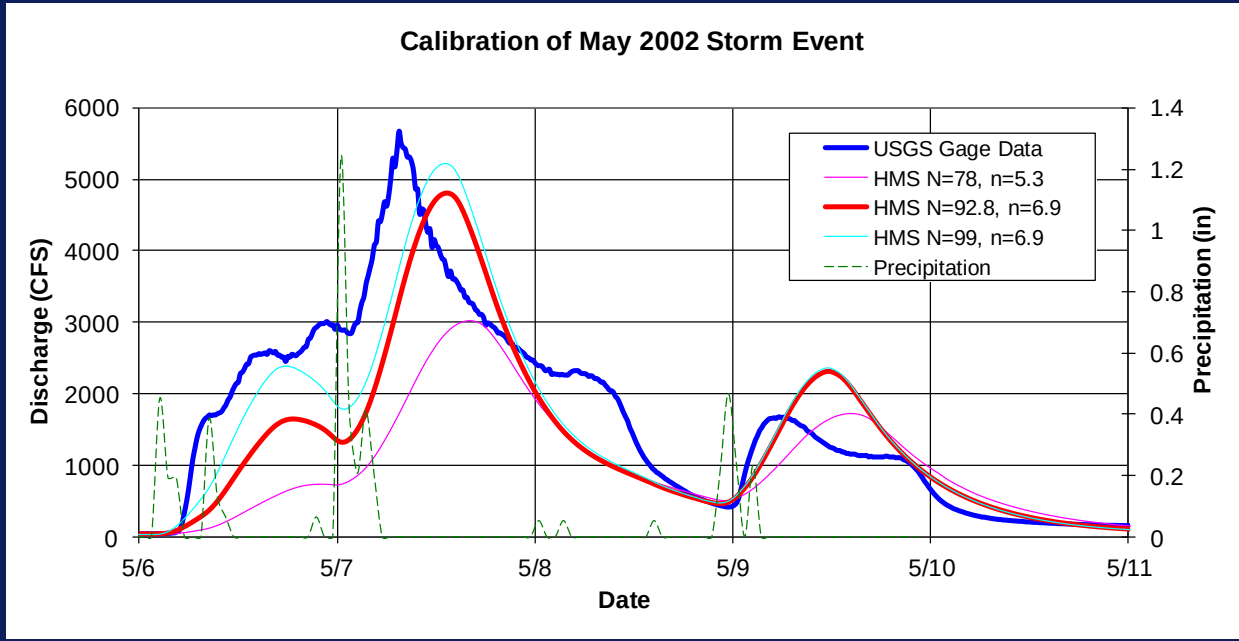


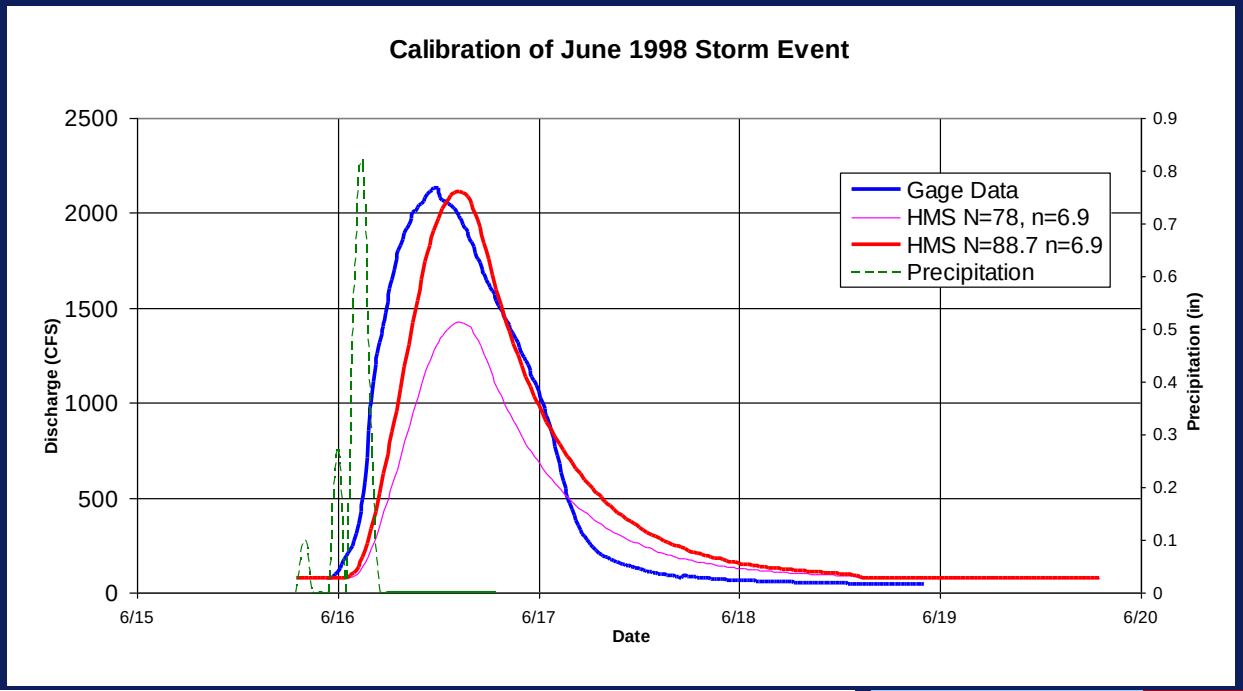


MODEL CALIBRATION

May 2002
(5680 cfs)

June 1998
(2130 cfs)





DESIGN FREQUENCY EVENTS

Frequency (years)	Peak Flows (cfs)							USGS Regression Peak Flow
	Duration							
	6	12	18	24	48	72	120	
100	11771	14009	13198	14497	**14929**	13820	11808	**14865**
50	9227	11413	10806	11915	**12482**	11621	9680	**12832**
25	7522	8971	8690	9361	**10514**	9674	8294	**10821**
10	5643	6892	6603	7333	**8180**	7699	6548	**8204**
5	4291	5218	5080	5687	**6496**	6199	5350	**6237**
2	2835	3582	3442	3887	**4531**	4367	3829	**3531**
1	2021	2552	2482	2853	**3322**	3242	2890	**N/A**

CHECK OF MODEL PEAK DISCHARGES

HYDRAULICS

DATA COLLECTION

- Detailed LiDAR Surface Mapping
- Topographic Survey Including:
  - 17 Stream Sections (1000 ft spacing)
  - 2 Bridges
  - Spillway Outlet Channel

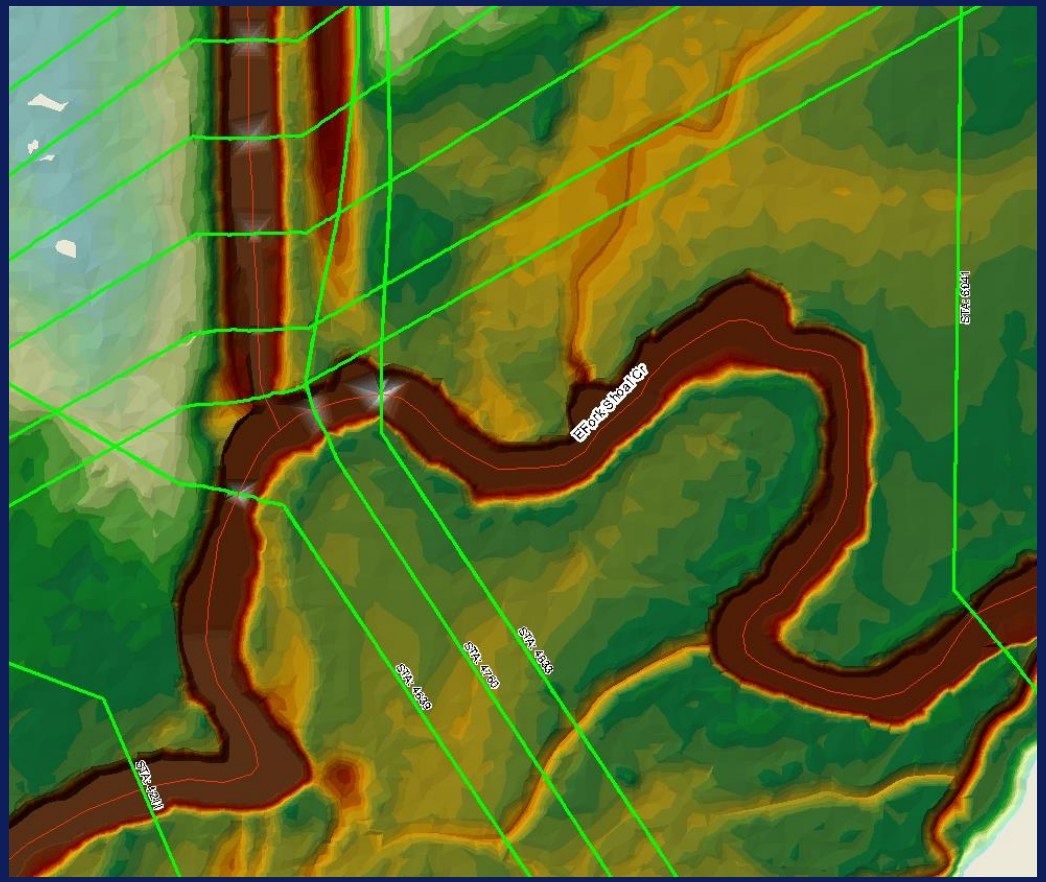
MODELING

- HEC-RAS Model combining all the collected data.

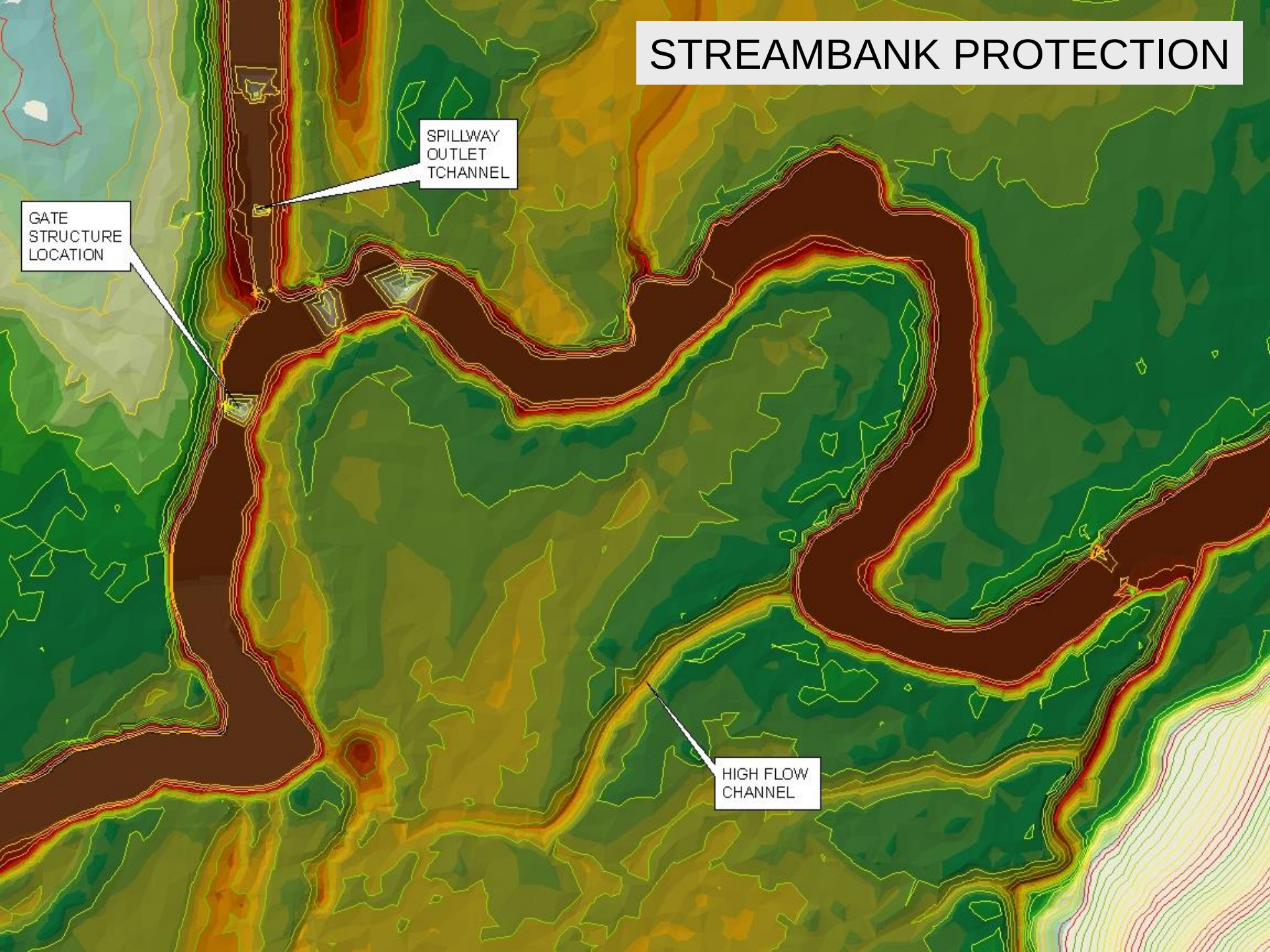
HYDRAULICS

MODELING

- HEC-RAS Model combining all the collected data.



STREAMBANK PROTECTION



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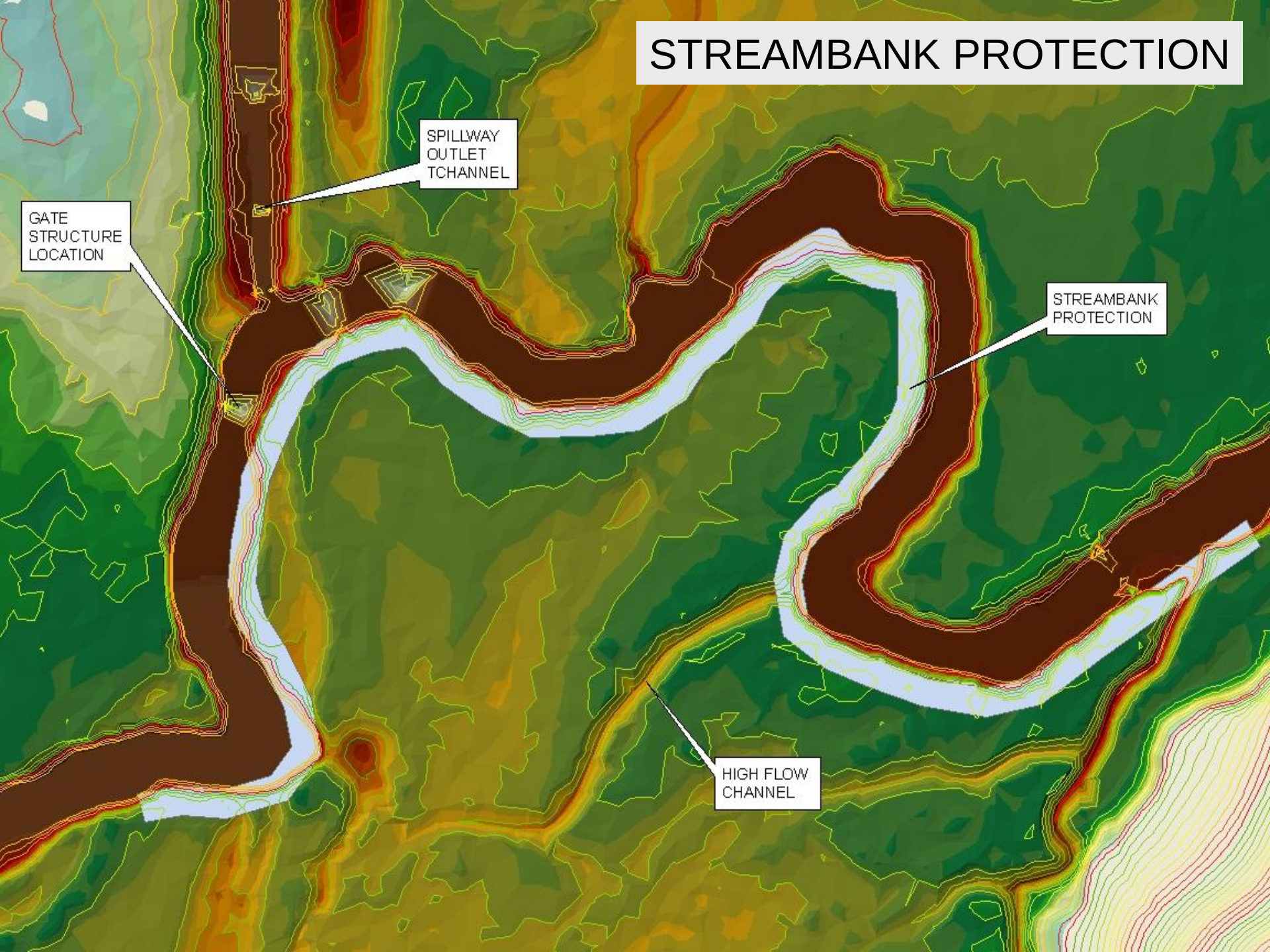
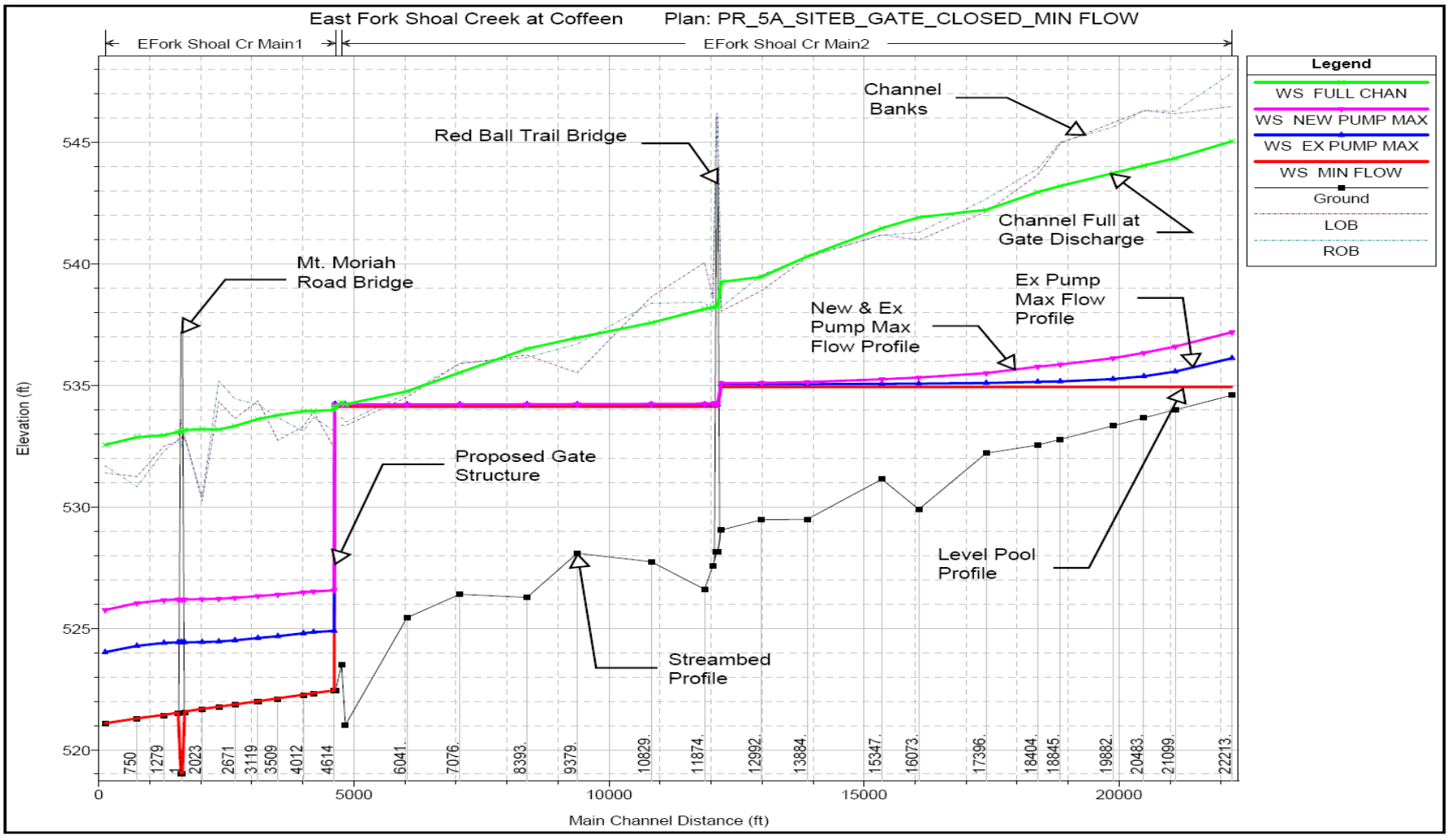
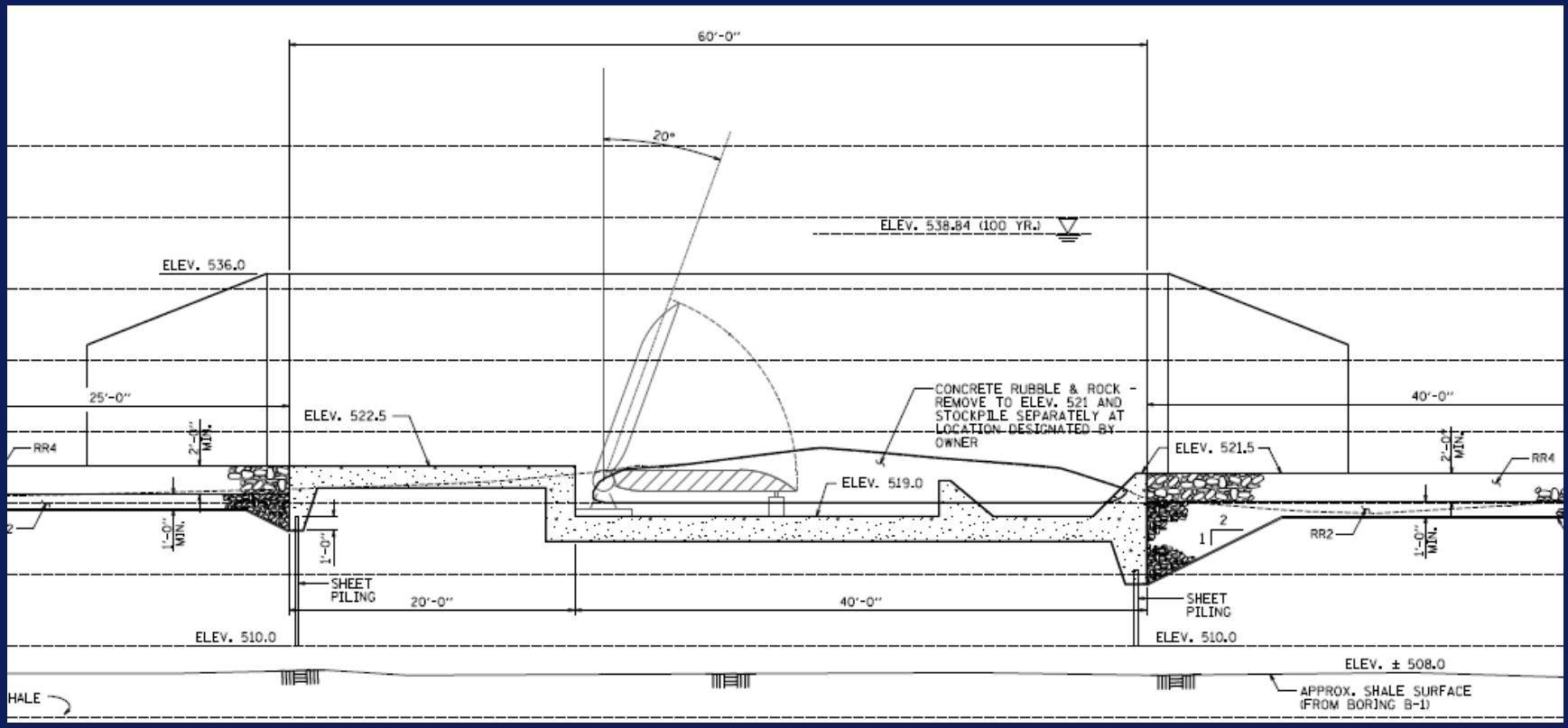


STORAGE VOLUME

FLOW (CFS)	VOLUME (AC-FT)
0	107.5
25	116.8*
85	127.2*
1500	455.6*

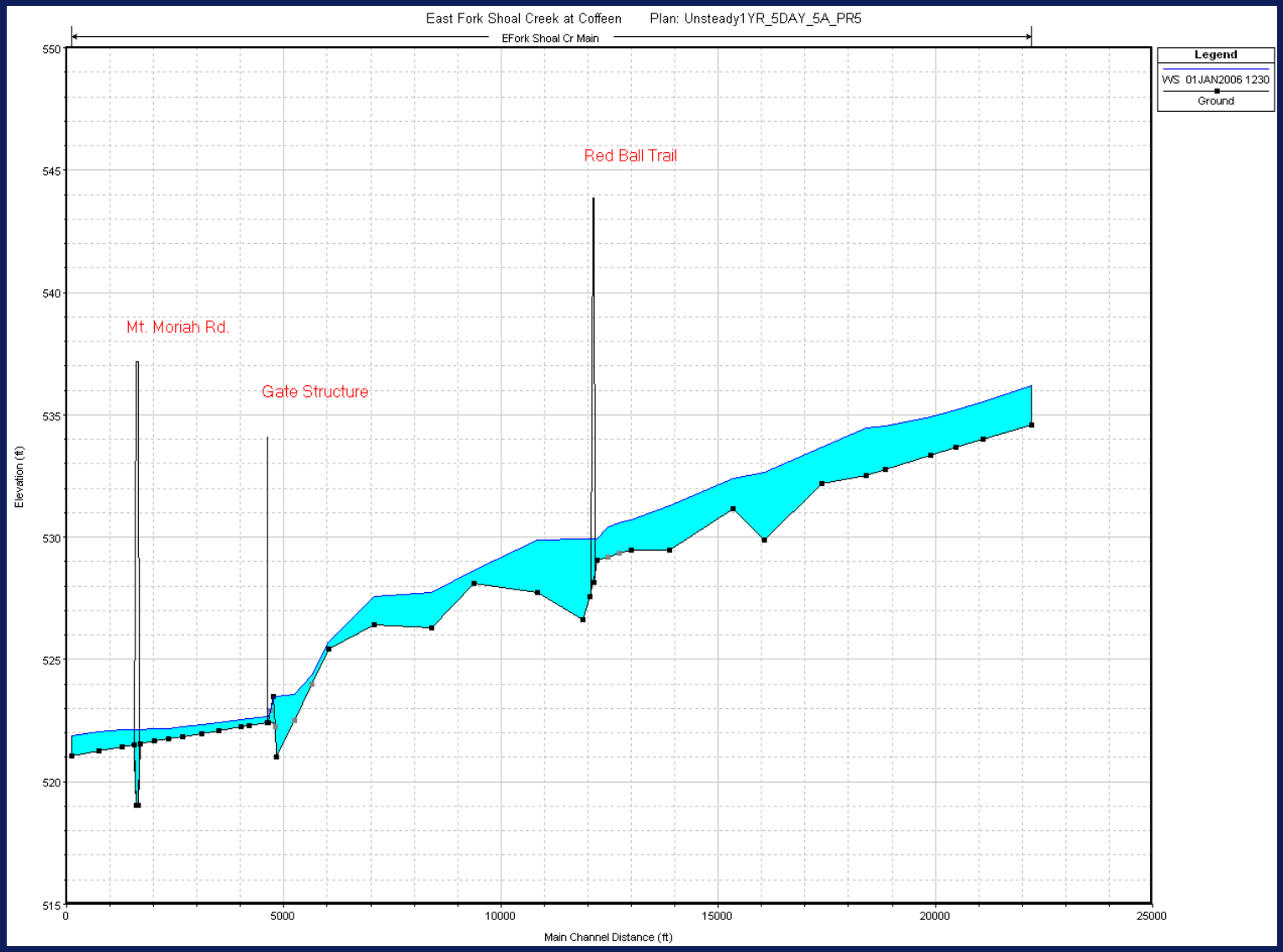


EFSC Pump Station and Gate Structure

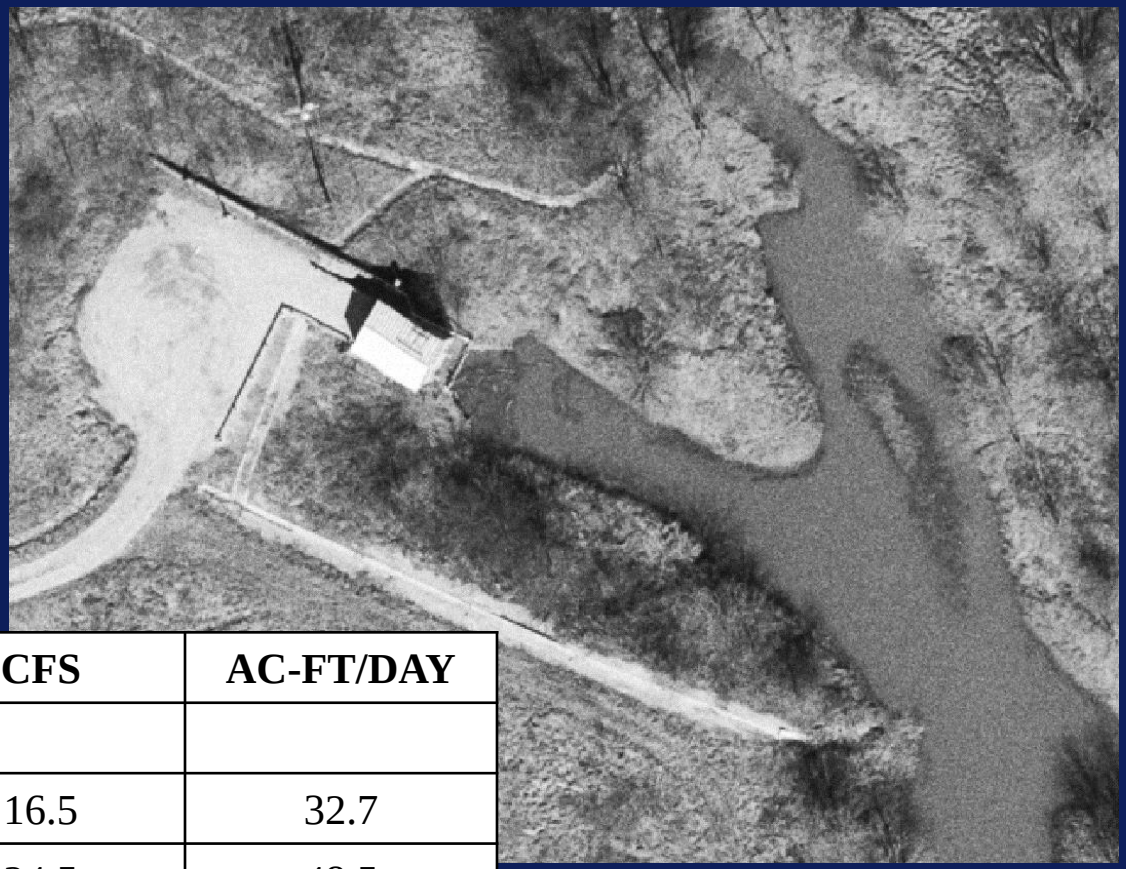


Section view of the training structure. The gate lies flush with the stream bed when not in use. Energy dissipation blocks prevent the hydraulic jump from leaving the training structure

UNSTEADY FLOW SIMULATION OF 1YR-5DAY STORM EVENT THROUGH PROPOSED GATE



EXISTING & PROPOSED PUMP STATIONS



EXISTING PUMP STATION CAPACITY

	GPM	CFS	AC-FT/DAY
Station 1			
Existing Pump 1	7,410	16.5	32.7
Existing Pump 2	10,983	24.5	48.5

PROPOSED PUMP STATION CAPACITY

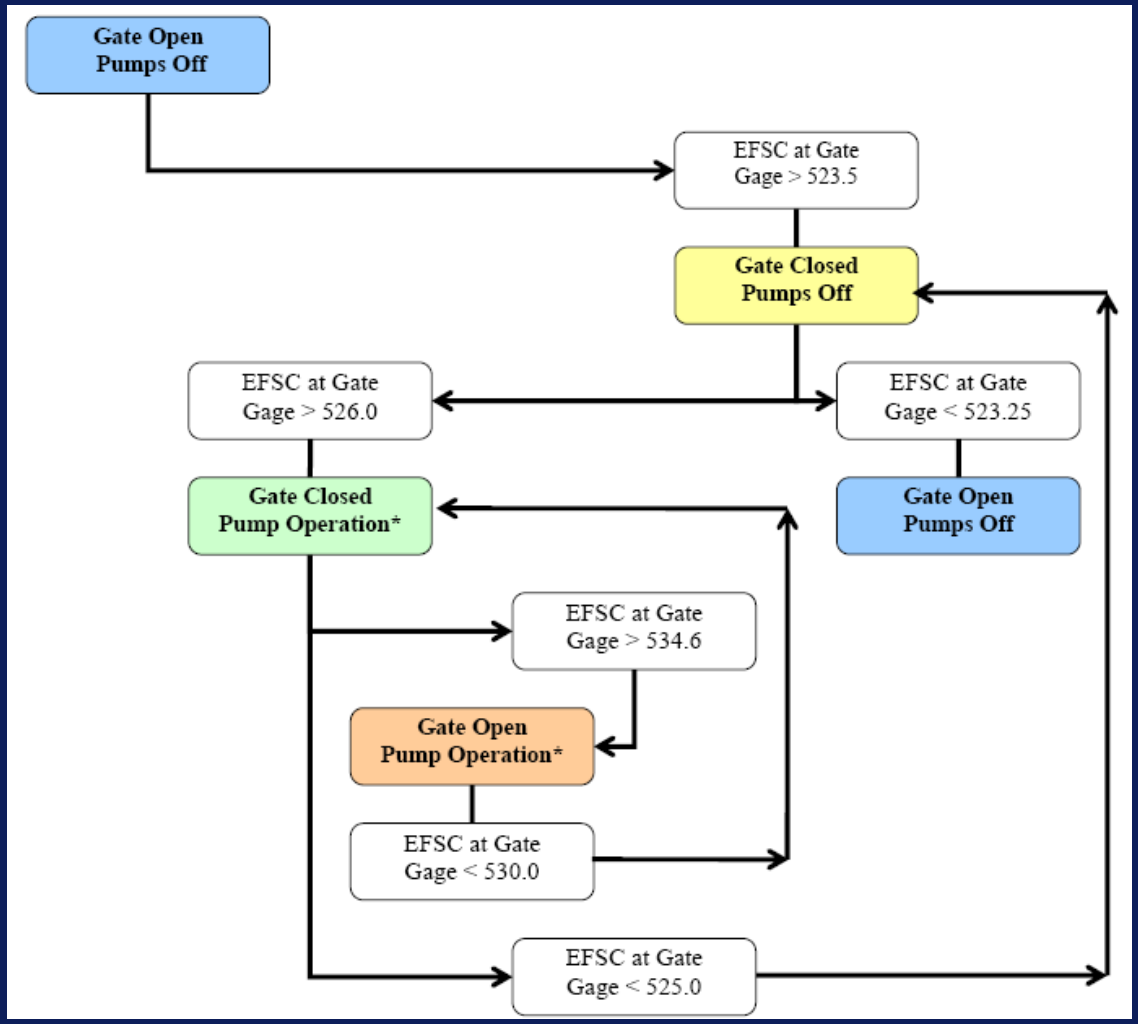
	GPM	CFS	AC-FT/DAY
Station 2			
Proposed Pump 1	10,750	24.0	47.5
Proposed Pump 2	20,000	44.6	88.4
Proposed Pump 3	27,250	60.7	120.4

EFSC Pump Station and Gate Structure – Operation Plan

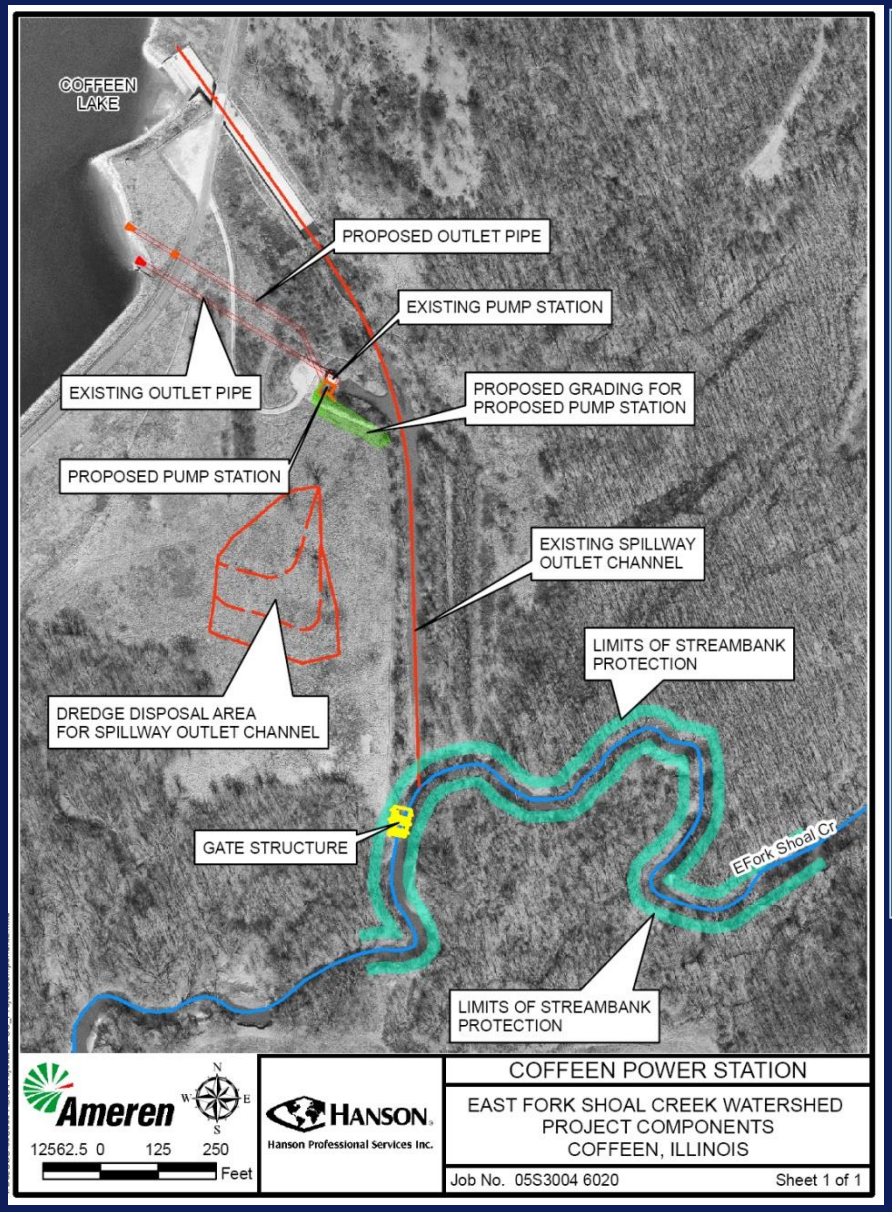
*Pump Operation Elevations

	Pump On	Pump Off
Ex Pump 1	526.0	525.0
Ex Pump 2	527.0	526.0
Pr Pump 1	528.5	527.5
Pr Pump 2	529.5	528.5
Pr Pump 3	530.5	529.5

Using the models, Hanson developed a gate and pump station operational plan. The hydraulics model was used to adjust the plan to ensure no impacts to adjacent property owners, as well as to meet regulatory stream by-pass flow requirements.



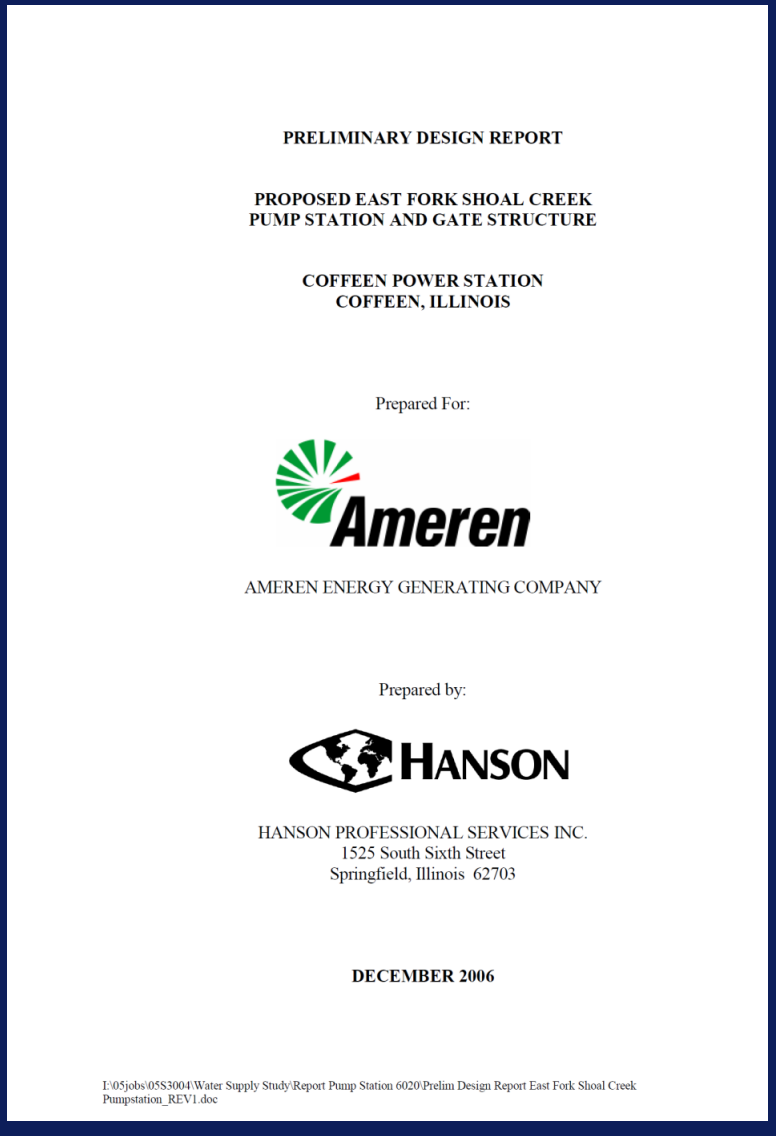
EFSC Gate Structure and Pump Station



Selected project included:

- 85.2-cfs pump station;
- 42-in ductile iron pipe;
- Spillway channel dredging;
- Expansion of the pump station forebay;
- 25-ft wide hinge crest bascule gate and training structure;
- Streambank stabilization.

2006 Preliminary Design Report



PRELIMINARY DESIGN REPORT

PROPOSED EAST FORK SHOAL CREEK
PUMP STATION AND GATE STRUCTURE

COFFEEN POWER STATION
COFFEEN, ILLINOIS

Prepared For:

Ameren

AMEREN ENERGY GENERATING COMPANY

Prepared by:

HANSON

HANSON PROFESSIONAL SERVICES INC.
1525 South Sixth Street
Springfield, Illinois 62703

DECEMBER 2006

I:\05jobs\05S3004\Water Supply Study\Report Pump Station 6020\Prelim Design Report East Fork Shoal Creek Pumpstation_REV1.doc

- Hanson completed a preliminary design report for the proposed East Fork Shoal Creek Pump Station and Gate Structure.
- The report was later included as part of a joint state and federal (404) permit application package.

Permitting

Permitting Challenges

- Illinois Department of Natural Resources
  - Office of Water Resources (OWR) - Waterway and Dam Construction Permitting
    - Jurisdiction over any upstream or downstream water level impacts.
  - Office of Real Estate and Planning (OREP) – Project Concurrence
    - Jurisdiction over overall stream biologic health, including Threatened and Endangered Species.
    - Stream Biota Sampling, Stream Sediment and Water Quality Sampling Report completed by Hanson.
    - Required minimum bypass flows set by OREP.
- Illinois Historical Preservation Agency
  - Cultural Resource Survey
- U.S. Army Corps of Engineers
  - Permitting required by Section 404 of the Clean Water Act, and all that that entails, including:
- Illinois Environmental Protection Agency Bureau of Water
  - Anti-degradation Certification required by Section 401 of the Clean Water Act.

EFSC Project Permitting Timeline

- Late 2005: Supplemental water supply alternatives report completed by Hanson
- Mid-2006: Initial meeting with IEPA and DNR Office of Water Resources RE: transfer of water from EFSC to Lake
- Feb. 28, 2007: Joint Permit Application submitted to IDNR, IEPA and USACE.
- July, 2007: USACE Public Notice
- July, 2007: Hanson response to Public Notice Comments provided to USACE
- Oct. 2007: Meeting with IEPA Re: anti-degradation analysis
- Oct. 2007: Additional modeling of gate operations provided to IEPA due to Dissolved Oxygen concerns
- Nov. 2007: IEPA Public Notice and (Favorable) Anti-Degradation Analysis published
- Dec. 2007: IEPA extends Public Notice period due to concerns expressed by City of Greenville
- Feb. 27, 2008: Presentation to Ameren Senior Level Management Project Review Board; approval to proceed with project final design and contractor selection based on IEPA Public Notice/Anti-Degradation Analysis
- April 30, 2008: Public Meeting held in Coffeen
- May 16, 2008: Meeting with City of Greenville held in State Sen. Frank Watson's office
- May 16, 2008: Project design documents sent to potential bidders
- June, 2008: Hanson provides WORD documents to IEPA with responses to Public Comments, including those provided at April Public Meeting, and later by Town of Breese
- July 15, 2008: IDNR-OWR permit for project issued
- July, 2008: Project awarded to Plocher Construction ($5M+)
- Aug. – Sept., 2008: Correspondence with and submittals to City of Greenville on water supply concerns
- Sept. 9, 2008: Responses to Questions Submitted to IEPA
- Oct. 2008: Letter from City of Greenville's consultant agreeing with little/no impact on proposed future EFSC Reservoir
- Feb., March, 2009: Phosphorous TMDL concerns raised by IEPA
- September 8, 2009: EPA Issues 401 Water Quality Certification
- September 22, 2009: Permit Issued by USACE

Feb 28, 2007: Joint Permit Application submittal to IEPA, IDNR, and USACE

Nov. 2007: IEPA Public Notice (including a favorable Anti-Degradation Analysis) published

April 30, 2008: Public Meeting held in Coffeen

July 15, 2008: IDNR-Office of Water Resources permit for project issued

March, 2009: Phosphorous TMDL concerns raised by IEPA

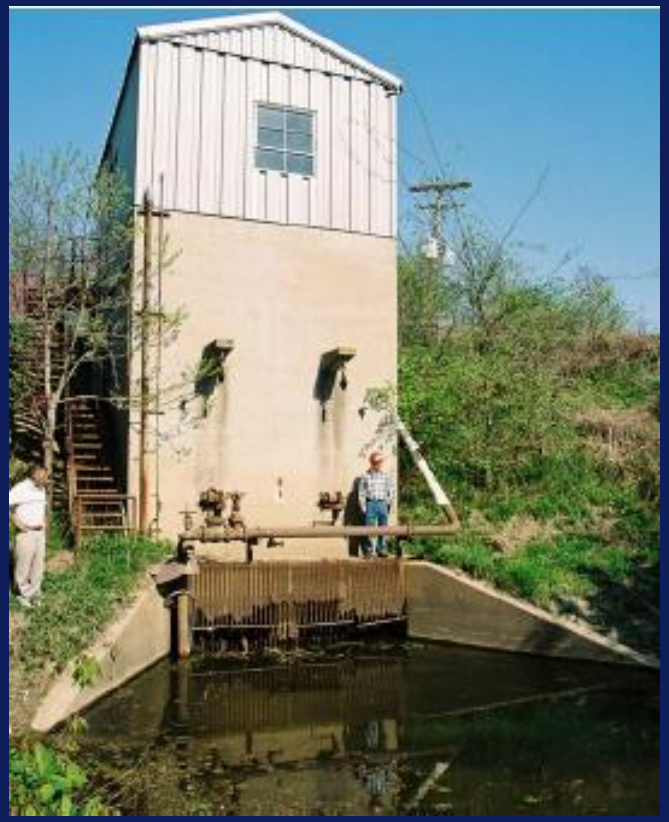
September 22, 2009: Permit Issued by USACE


Congratulations Team
E.F.S.C.
404 Permit !

Construction

EFSC Pump Station

Original Pump Station



Existing pump and motor actuated valve

EFSC Pump Station and Gate Structure

- Pump station intakes with the new galvanized trash racks installed.

EFSC Pump Station and Gate Structure

A break in the weather in March allowed the contractor to work on the building envelope.

EFSC Pump Station and Gate Structure.

The pump station was completed and commissioned in July of 2010.

EFSC Pump Station and Gate Structure.

Forming up the base slab on the downstream side of the training structure.

EFSC Pump Station and Gate Structure.

- Plocher Construction selected a Rodney Hunt gate system to meet the specified project requirements.
- The gate was installed on March 24, 2010.

EFSC Pump Station and Gate Structure

The gate is being lowered to meet the torque tube assembly. The two were bolted together and welded. The gate pivots on two spherical bearings. The walls around the sweep plate were later ground and parged to blend in with the training structure walls.

EFSC Pump Station and Gate Structure

View looking upstream at the gate.

The low flow bypass has been installed at the left hand side.

The gate and side seals have been adjusted and the control building is nearing completion.

EFSC Pump Station and Gate Structure.

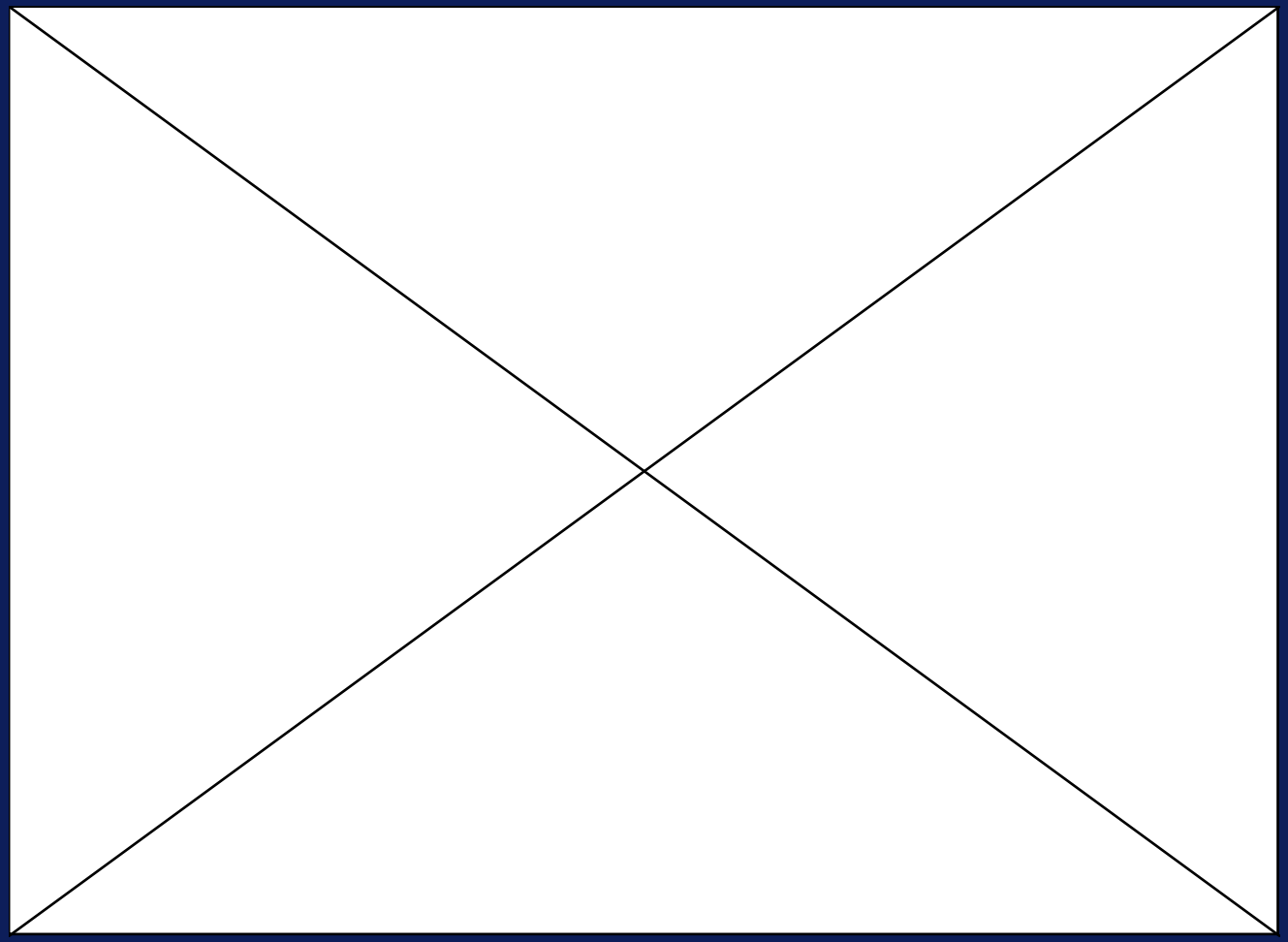
Gate with EFSC back in its original channel.

Note the low flow bypass inlet upstream of the gate. With the gate upright, the bypass maintains a minimum Q75 stream flow, as required by permit.

EFSC Pump Station and Gate Structure

Ameren and Hanson personnel testing the gate during high flow conditions. Stream flow during testing was between 1000 and 1200 CFS (high flow).

Video of EFSC Gate in Operation.



EFSC Pump Station and Gate Structure.

Downstream of the gate with the gate fully lowered. Stream flows were high, approximately 1200 CFS.

Before

After

After

Before

After

Before

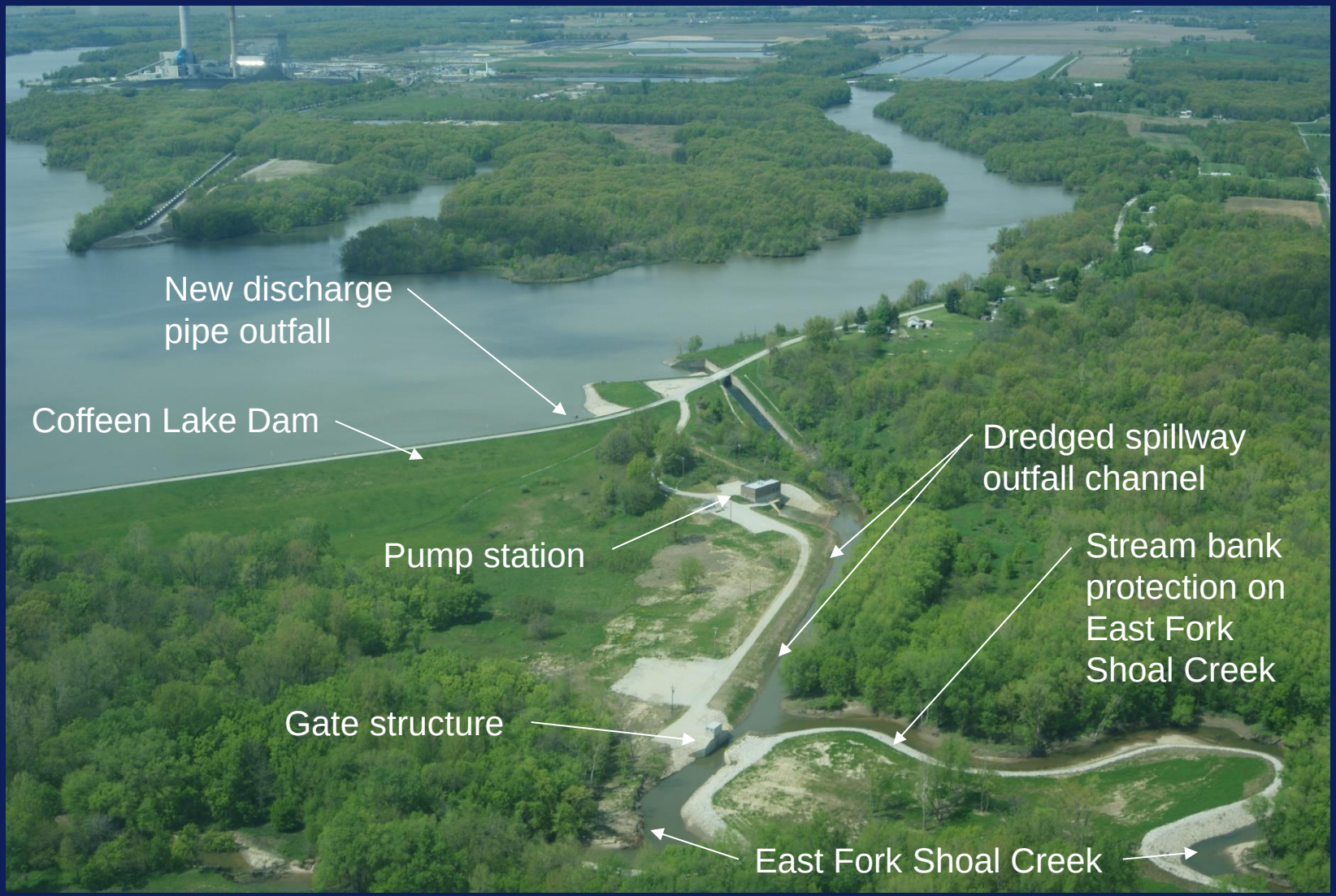
After

Before

After

Before

After - Completed Project



HANSON

Engineering | Architecture | Planning | Allied Services

QUESTIONS

For more information, please contact

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