CORALVILLE LAKE
WATER CONTROL UPDATE REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

CORALVILLE LAKE
IOWA CITY, IOWA

APPENDIX B

HYDROLOGY AND HYDRAULICS

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HYDROLOGY AND HYDRAULICS

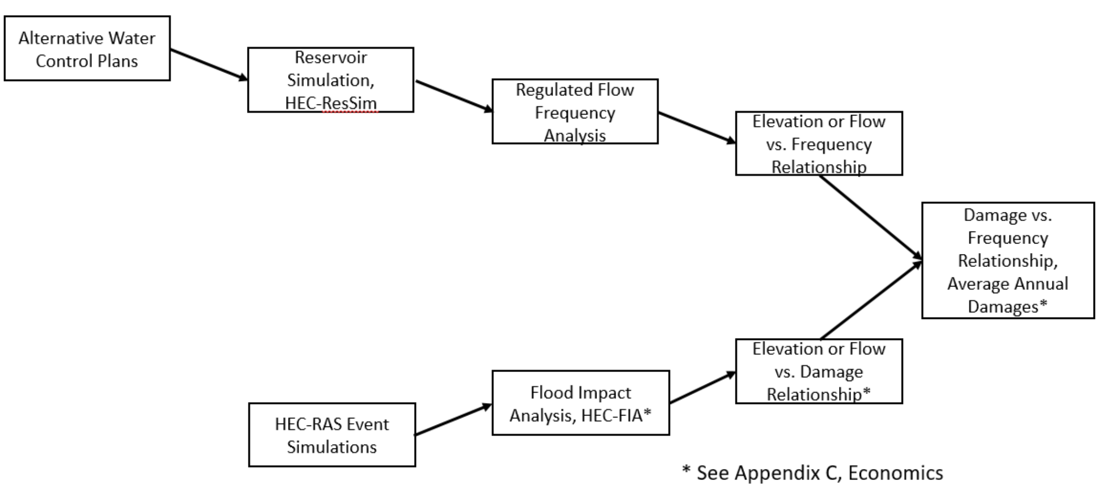
I. GENERAL

The hydrology and hydraulics of the Iowa River Watershed was analyzed to facilitate the evaluation of the identified regulation alternatives. A detailed Hydrologic Engineering Center (HEC) Reservoir Simulator (HEC-ResSim) model was developed and calibrated to the observed record at Coralville Lake. This model was then used to evaluate the 102-year period of record from 1917 to 2019 for all alternatives. The unregulated and regulated model results were used to develop regulated flow frequency estimates for the existing condition and screened alternatives.

The existing HEC River Analysis System (HEC-RAS) model from the 2015 Corps Water Management System (CWMS) effort was utilized to create inundation boundaries and depths downstream of both dams, and these results were integrated into the economic model (Appendix C).

The analyzed area on the Iowa River extends from Coralville Lake to the confluence of the Mississippi River, and on the Mississippi River from the tailwater of Lock and Dam 16 to Burlington, Iowa (Figure B-1). The pertinent river gages are shown in Figure B-2.

The flow chart below shows the relationship, and information flow, between hydrologic and hydraulic study products and the economic evaluation of alternatives. Appendix B details the model creation and calibration process, the processes used to develop the Regulated Flow Frequency relationships, and the alternatives analyzed in this study. All elevations are listed in National Geodetic Vertical Datum (NGVD) of 1929.



II. MODEL SELECTION AND DESCRIPTION

A. Reservoir Simulation Model

1. Legacy Models

a. "CORSIM" Model. The original Des Moines River computer model, "CORSIM", was written in September 1976 by William McDonald in Fortran IV following logic laid out by S.K. Nanda. The program read a binary flow file consisting of daily unregulated flows at the reservoir and downstream constraint locations. The physical reservoir data and regulation plans were "read in" from a text file. The program simulated the regulation of the reservoir by routing "hold outs" from the reservoir down to the control points to calculate a regulated flow. The program used Tatum routing, a coefficient-based routing method developed in the Rock Island District for the Des Moines River Basin.

The unregulated flow record was determined from the U.S. Geological Survey (USGS) daily flow record for the period of time from 1904 until the reservoir was placed in operation in 1959. For that period, the unregulated flow records at Coralville Reservoir, Iowa City, Lone Tree, and Wapello were determined by the USGS daily flow record. The Wapello record was estimated from 1904 until 1956 when the gage was established. For the period of record after Coralville Dam was placed in operation, the unregulated daily record was estimated by routing the 1-day, midnight-to-midnight change in storage (hold out in cfs-days) downstream and adding it to the USGS daily record. The resulting period of record unregulated flows for Coralville Reservoir (inflow), Iowa City, Lone Tree, and Wapello were the base input flow record for CORSIM.

The program then followed the regulation plan for Coralville Dam operation and determined what the regulated outflow would be, calculated the hold outs (inflow minus outflow), and routed the hold outs downstream, subtracting them from the unregulated flow to determine what the regulated flow would have been under the modeled regulation plan. The CORSIM model was in use by the District from its inception in 1976 until the implementation of the original HEC-ResSim model for the Iowa River Basin in 2005, and was the reservoir model used to generate the period of record results that formed the basis for the 2002 Regulated Flow Frequency Study and the "Iowa River Regulated Flow Frequency Study" completed in October 2009 (USACE 2009; hereafter referred to as the 2009 FFS).

b. "IowaPlanning" HEC-ResSim Model. The reservoir's forecasting model transitioned to the HEC-ResSim platform in 2005 and converted the CORSIM logic from the Fortran IV model to the HEC-ResSim software. This forecasting model was used as a baseline and updated for planning purposes following the 2009 FFS. The model, entitled "IowaPlanning" (i.e., the Planning Model), was more detailed than the HEC-ResSim model used for daily forecasting. The Planning Model used inflows to the upstream reservoir and tributary flows along with local flow records and routed flows through the system, instead of the unregulated flows and routed hold outs used by the CORSIM model.

The Planning Model has been in use by the District since implementation, updated as necessary to conform to the newest releases of the HEC-ResSim software. A version of this model is also used for daily reservoir forecasting on the Iowa River by CEMVR-EC-HW (Water Control Section).

2. New HEC-ResSim Model. The HEC-ResSim Planning Model was used as a baseline for creation of the new ResSim model. The new model makes extensive use of downstream controls, seasonal release changes, and Jython scripting to model the reservoir releases from Coralville Lake as accurately as possible. Existing rules were updated to reflect changes in the HEC-ResSim program and more robust downstream and reservoir minimum release rules were put into place. The overall schematic of the HEC-ResSim model is shown in Figure B-2.

Model inflows were added at:

- Coralville Lake (main model inflows)
- Iowa River at Iowa City, Iowa (between Clear and Ralston Creeks in Iowa City) – this is a downstream control point for flash flood operations within Iowa City
- Iowa River near Lone Tree, Iowa (Tri-County Bridge, downstream of the confluence of the Iowa and English Rivers) – this is a downstream control point for Coralville Dam releases
- Iowa River at Wapello, Iowa (downstream of the confluence of the Iowa and Cedar Rivers) – this is a downstream control point for Coralville Dam releases
- Burlington, Iowa (downstream of the confluence of the Mississippi and Iowa Rivers) – this is a downstream control point for Coralville Dam releases

Major changes between the Planning Model and the new HEC-ResSim Model created for this analysis include:

- Updated elevation-storage-area curve to reflect the new reservoir Light Detection and Ranging (LiDAR) and bathymetric surveys completed in 2019
- Updated maximum increasing and decreasing rates of change to reflect cubic feet per second (cfs)/hour instead of cfs/day
- Added the Large Magnitude Flood (LMF) Script to better model how reservoir operations are completed during large events
- Updated the maximum release rules in the "Normal Flood Control" and "Conservation zones to accurately model increased outflows when the Coralville pool is projected to exceed elevation 707 feet ("Projected Pool Releases")
- Reordered rules as necessary for HEC-ResSim priority requirements

3. LMF Script. Storm events which result in reservoir elevations exceeding 707 feet cause the LMF Release schedule to come into effect. Flows increase stepwise as the reservoir elevations rise in an effort to evacuate water from high elevations as quickly as possible. These high flows are held through the duration of the receding limb of the hydrograph and step down as necessary to maintain "maximum fall" requirements (less than one-footdrop in reservoir elevation per day) or lack of head to maintain the release rates.

Creation of a Jython script was necessary to override releases as the model processed high inflow storm events. This script was developed in conjunction with the HEC for the 2018 Des Moines River Regulation Plan Update and was adapted to fit the requirements of Coralville Dam. The goal of this release script it to maintain the higher release rates achieved in the LMF Release Schedule through the duration of a large event, as it would be impractical to reduce to lower flows while inflows are still high (causing the reservoir elevations to rebound to higher levels).

The script achieves this by performing the following:

- When reservoir elevations have not exceeded 707 feet during an event, the script is inactive.
- Once elevation 707 has been passed, the script activates and performs the following:
    - If the reservoir elevation is above 707 feet and rising, Coralville Dam either releases the next higher step on the LMF Release Schedule or maintains the current release rate if that step has not been met.
    - If the reservoir elevation is above 707 feet and either steady or falling, the current release is maintained.
    - If the reservoir elevation decreases below 707 feet, current releases are maintained until 1) there is not sufficient head to maintain that release rate, 2) releases must be decreased to maintain no more than 1 foot of reservoir elevation loss per day, or 3) releases decrease below either 10,000 cfs in the non-growing season or 6,000 cfs in the growing season (this results in the script deactivating, and normal operations resume).
    - Once the reservoir elevation falls below a prescribed elevation (currently set at 687 feet) or release rates drop below 6,000/10,000 cfs release during the growing/non-growing season, the script deactivates, and normal operations resume.

When this script is active, it overrides all downstream control rules and normal operations releases to drain the pool as quickly as possible. These rules restart when the script is deactivated. The script also determines the day of the year and leap year status to determine reservoir releases (growing vs. non-growing season).

4. Calibration

a. Recent and Period of Record Runs. Once the rulesets were completed, the new HEC-ResSim model was run using observed inflows from 1993 through 2019. These inflows were chosen as they reflected the operation since the last Regulation Manual update. The observed flows during that timeframe would most resemble those followed by the model ruleset.

Observed reservoir elevations and releases were added to the model at Coralville Lake to compare to those generated by the HEC-ResSim model runs. Where discrepancies occurred between the observed values and the model results, rules were updated or changed in priority to better match the historic data. For some events, such as the 1993 storms and the 2015-2019 years, operational deviations explain the differences in the observed and model generated data.

The largest deviations between the observed data and simulated results are due to the utilization of downstream control rules. These rules are in effect at four locations downstream of Coralville Dam (Iowa City, Lone Tree, Wapello, and Burlington). When specified flow rates are exceeded at these points, releases from the reservoir are decreased to maintain those flows at the violated control point. While the HEC-ResSim model makes perfect decisions based on the data it is provided, the observed data is a result of decision making by the Water Control Team with the information available at the time of the event, such as forecasts and existing condition reports. There are timesteps in the simulations where the model decided either to reduce or maintain flow due to downstream control rules that were done differently in actual operations. The gage rating curves for the Coralville tailwater, Iowa City, Lone Tree, and Wapello gages are provided in Figure B-3 through Figure B-6.

The effects of these deviations are especially evident in the 2013 simulation, as illustrated in Figure B-7. The model reduced outflows from the reservoir twice preceding the peak inflows, as a downstream control point was violated. These decreased outflows resulted in peak reservoir elevations and release rates that are higher than those seen in the observed data, since the Water Control team did not reduce releases during the actual event.

Following the recent period of record calibration, the existing model was rerun using 103 years of calculated inflows for the Iowa River (1917 to 2019). The results were analyzed to ensure the model obeyed the rules properly and that expected reservoir elevations and releases were created across the period of record. Overall, the model matched elevations and releases as expected. As stated above, discrepancies between the model results and expected values and observed data were explained by either deviation operations at the reservoir, changes in the historic water regulation plan, or utilization of the downstream control rules.

B. Iowa River Hydraulic Model

This study made use of the existing HEC-RAS model created for the 2014 CWMS effort for the Iowa River Watershed. The model spans the Iowa River from immediately downstream of Coralville Dam to the confluence of the Mississippi and Iowa Rivers, and the Mississippi River from the tailwater at Lock and Dam 16 to Burlington, Iowa. Some small changes were made to that model (i.e., updated levee alignment and height information, additional cross sections in areas of particular concern, elevation changes for the tops of inline structures) due to changes since the completion of that modelling effort. An overview of the model geometry is shown in Figure B-8.

Several flow profiles were analyzed for releases from each dam, based on prescribed releases in the current Regulation Manual, the analysis completed in the 2009 FFS, and flows corresponding to recommended releases in analyzed alternatives. The model was run for each set of reservoir releases separately.

The HEC-RAS simulations were completed in unsteady flow with unchanging time series (the same flows for the duration of the simulation), as arrival time and duration of inundation were not of interest for this analysis. Each reservoir release was entered into the Unsteady Flow Data Editor with corresponding downstream flows as needed. Inflows from any watercourse other than Clear Creek, English River, and Cedar River were set as low as possible to maintain model stability while minimizing the effect to release amounts in the river and backwater effects. Mississippi River inflows were also set to low values to minimize backwater effects at the confluence of the Mississippi and Iowa Rivers.

1. Coralville Lake Releases. Releases from Coralville Lake were used to evaluate in-channel and flood inundation extents for the area between Coralville Lake and the confluence of the Mississippi and Iowa Rivers. Thirty release rates from Coralville Dam were simulated. The following list details the most pertinent of those considered:

- 1,000 cfs: This flow was used for an in-channel flow baseline.
- 6,000 cfs: the current maximum growing season release from Coralville Dam when elevations within Coralville Lake are below 707 feet.
- 8,000 cfs: The 50% Annual Exceedance Probability (AEP) (2-year) event from the 2009 FFS

- 9,000 cfs: The 20% AEP (5-year) event from the 2009 FFS.
- 10,000 cfs: The current maximum non-growing season release from Coralville Dam when elevations within Coralville Lake are below 707 feet. This is also nearly the value of the 10% AEP (10-year) event from the 2009 FFS (10,880 cfs).
- 13,000 cfs: This is the observed damaging flow for areas immediately downstream of Coralville Dam (River Front Estates area).
- 15,000 cfs: This flow, combined with the inflows used for Clear Creek, produce the damaging flows triggering flash flood operations in Iowa City, requiring reductions in flows from Coralville Lake.
- 22,200 cfs: The 2% AEP (20-year) event from the 2009 FFS.
- 28,600 cfs: The 1% AEP (100-year) event from the 2009 FFS.
- 35,200 cfs: The 0.5% AEP (200-year) event from the 2009 FFS.
- 40,000 cfs: This flow, combined with the inflows used for Clear Creek, is the overtopping event for the levee system at Iowa River Landing, immediately downstream of Interstate 80 in Iowa City.
- 44,400 cfs: The 0.2% AEP (500-year) event from the 2009 FFS.
- 51,500 cfs: The 0.1% AEP (1000-year) event from the 2009 FFS.

2. Flood Inundation Mapping. Results from the HEC-RAS model runs were entered into ArcGIS. The inundation extents were checked with those seen in the 2009 FFS. Areas of the inundation which were determined to be disconnected from direct river flooding (i.e., existing ponds, quarry areas, etc.) were removed. Depth rasters were created using RAS Mapper and imported into ArcGIS.

The pool areas within Coralville Lake were determined by using the available 0.25-meter LiDAR surface completed in 2019. Contours were generated in ArcGIS for multiple water surface elevations within the lake and used to create depth rasters for pool inundation extents. The elevations used were:

- 683 feet
- 700 feet
- 702 feet
- 707 feet
- 710 feet
- 711 feet
- 712 feet
- 715 feet
- 717 feet
- 720 feet
- 725 feet

The inundation extents for the 0.1% AEP (1000-year) event were buffered 100-feet and used to create a general damage area. This area was split into four polygons based on geographic location, hydrologic boundaries, and drainage area information provided in the USGS gage information to facilitate association of damages to specific areas of study. These damage area polygons covered the following locations:

- Downstream of Coralville Dam (USGS Gage #05453520)
- Iowa River at Iowa City, Iowa (USGS Gage #05454500)
- Iowa River near Lone Tree, Iowa (Tri-County Bridge) (USGS Gage #05455700)
- Iowa River at Wapello, Iowa (USGS Gage #05465500)

The four damages are polygons and the modified depth rasters for the reaches between Coralville Dam and the confluence of the Mississippi and Iowa Rivers were provided to Economics for use within the HEC Flood Impact Analysis (HEC-FIA) tool to assist with analysis of damages. Plates 1 through 12 provide Inundation Maps for select reservoir elevations and downstream discharges.

C. Regulated Flow Frequency Analysis

Regulated flow frequency relationships were developed for Alternatives 1 (the "No Action" alternative, representing the existing water control plan) and Alternatives 2C, 5, and 8 (the screened plans carried through to economic analysis). Screening of other alternatives was accomplished through comparison of regulated flow frequency curves developed using plotting position only. The procedures used in developing the regulated flow frequency relationships follows the procedures used in the 2009 Regulated Flow Frequency Study for the Iowa River (USACE, 2009). The procedures generally consisted of:

- Developing an unregulated flow record based upon the HEC-ResSim simulation using historical reservoir and tributary inflows (1917 through 2019).
- Developing volume-duration-frequency (VDF) curves for flow volumes using the simulated unregulated flow record at each gage.
- Selecting the critical duration for flood inflows at each gaged location.
- Developing a relationship between the 1-day regulated peak reservoir outflow and the unregulated inflow volume for the identified critical duration at each gaged location.
- Combining the unregulated VDF curve for the critical duration with the regulated versus unregulated relationship to obtain the 1-day regulated flow frequency curve at each gaged location.

The VDF analyses were completed using HEC's Statistical Software Package (HEC-SSP) v2.2. The analyses were conducted using the Expected Moments Algorithm (EMA) – log-Pearson Type III Distribution with the Multiple Grubbs-Beck low outlier test. The regulated versus unregulated relationships were developed using regression tools within Microsoft Excel and final plotting of the regulated frequency curves was accomplished using the U.S. Army Corps of Engineers' (USACE) Risk Management Center's (RMC) Probability Scale Plotter Macro within Microsoft Excel.

The regulated flow frequency analyses in Sections III and V utilize the entire period of record (1917-2019). A sensitivity analysis, focusing on the wetter, later portion of the record (1959-2019) is contained in Section VI.

III. EVALUATION OF EXISTING WATER CONTROL PLANS

A. Period of Record Reservoir Simulation

As discussed in Section II.A.2, the HEC-ResSim model was created to simulate the existing conditions on the Iowa River. The results of this calibrated simulation were used as a baseline from which comparisons of all other alternatives were made. The existing water control plan is Alternative 1, the No Action Alternative.

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B. Regulated Flow Frequency Analysis

The HEC-ResSim model developed and calibrated in Section II.A.2 was used to simulate (1) the unregulated flows for the period of record and (2) the daily regulated flows and reservoir elevations for the existing water control plan. The HEC-ResSim model results were used to update the regulated flow frequency estimates for the existing water control plan. Due to the presence of high flows during the fall in some years, calendar year was used for the regulated flow frequency analyses instead of water year.

1. VDF Analysis. A VDF analysis was performed on the simulated, period of record, unregulated flows for each gage location using HEC-SSP. Analyses for the 1, 3, 5, 7, 10, 15, 30, and 60-day peak annual durations were conducted. For the Iowa City 3-day and Lone Tree 7-day curves, the Multiple Grubbs-Beck test identified 41 and 43 low outliers respectively. This resulted in computed standard deviation and skew values significantly different than those computed for other durations as well as at the surrounding gages. As a result, the low outlier test for these two location-duration combinations were overridden based upon a visual evaluation of the plotted data.

Table B-1 shows the computed VDF statistics for each gage and duration on the Iowa River. To obtain VDF curves that are consistent for a particular gage, the computed statistics were adjusted in the following manner:

- The sample means were left unadjusted as across all gages and durations the mean values uniformly decreased with increasing duration.
- The sample standard deviations were adjusted for each gage based upon a paired regression of the sample mean and standard deviation values for each duration.
- The sample skews were adjusted to represent regionalized estimates for each duration by first computing the arithmetic average skew for each duration (based upon the sample skews for the four Iowa River Gages) and then regressing a relationship between duration and the computed average skew.

These adjustment methods are consistent with those used in the 2009 FFS. The resulting adjusted skew values ranged from -0.23 to -0.37. The skew values utilized in the 2009 FFS ranged from -0.17 to -0.20, and an earlier 2002 update utilized skew values of -0.2 to -0.3. Figure B-9 shows the resulting VDF curves for Coralville Lake. While the adjustment methodology utilized is consistent with the 2009 and 2002 studies, the differences in skews relate to changes in the available record as well as changes in low outlier censoring methods. As shown in Table B-1, the Multiple Grubbs-Beck test identified up to 13 low outliers whereas in past analyses no more than 2 were identified. The higher 1-day adjusted skew value of -0.37, computed in this study, is more consistent with the published recommended peak skew value for the State of Iowa of -0.4 (Eash, 2013). Table B-2 shows the resulting unregulated volume-frequency values.

Table B-1. Iowa River Volume-Duration-Frequency Statistics of Log10 Unregulated Annual Maximum Flows

Gage	Duration	Mean	StdDev	Skew	Outliers	$StdDev_{reg}$	Regional Skew
Coralville Release	1-Day	4.056	0.301	-0.401	0	0.306	-0.367
	3-Day	4.015	0.302	-0.374	0	0.302	-0.363
	5-Day	3.982	0.304	-0.433	0	0.299	-0.358
	7-Day	3.951	0.304	-0.509	0	0.297	-0.353
	10-Day	3.918	0.290	-0.351	12	0.294	-0.346
	15-Day	3.863	0.286	-0.297	13	0.289	-0.335
	30-Day	3.746	0.279	-0.365	10	0.279	-0.300
	60-Day	3.634	0.269	-0.301	6	0.269	-0.230
Iowa City	1-Day	4.077	0.299	-0.363	0	0.305	-0.367
	3-Day	4.031	0.299	-0.353	2	0.302	-0.363
	5-Day	3.996	0.302	-0.407	0	0.299	-0.358
	7-Day	3.965	0.303	-0.489	0	0.297	-0.353
	10-Day	3.928	0.296	-0.412	5	0.295	-0.346
	15-Day	3.873	0.294	-0.370	8	0.291	-0.335
	30-Day	3.760	0.283	-0.364	10	0.283	-0.300
	60-Day	3.650	0.271	-0.268	6	0.275	-0.230
Lone Tree	1-Day	4.200	0.295	-0.125	0	0.298	-0.367
	3-Day	4.154	0.298	-0.215	0	0.296	-0.363
	5-Day	4.108	0.296	-0.267	0	0.294	-0.358
	7-Day	4.077	0.291	-0.213	2	0.293	-0.353
	10-Day	4.034	0.292	-0.305	2	0.291	-0.346
	15-Day	3.978	0.288	-0.246	3	0.289	-0.335
	30-Day	3.866	0.288	-0.366	5	0.284	-0.300
	60-Day	3.757	0.277	-0.226	6	0.280	-0.230
Wapello	1-Day	4.602	0.281	-0.463	0	0.281	-0.367
	3-Day	4.567	0.280	-0.446	3	0.277	-0.363
	5-Day	4.535	0.267	-0.274	8	0.274	-0.358
	7-Day	4.502	0.272	-0.412	8	0.270	-0.353
	10-Day	4.465	0.267	-0.402	9	0.266	-0.346
	15-Day	4.411	0.268	-0.402	9	0.261	-0.335
	30-Day	4.323	0.242	-0.077	10	0.251	-0.300
	60-Day	4.218	0.244	-0.116	9	0.240	-0.230

Table B-2. Iowa River Unregulated Annual Maximum Flow (cfs) versus AEP

Gage	Duration	AEP						
		0.5	0.1	0.02	0.01	0.005	0.002	0.001
Coralville	1-Day	11,890	27,200	41,980	48,400	54,850	63,450	69,990
	3-Day	10,800	24,480	37,620	43,310	49,030	56,640	62,430
	5-Day	10,000	22,500	34,470	39,660	44,870	51,810	57,080
	7-Day	9,300	20,830	31,880	36,670	41,480	47,880	52,760
	10-Day	8,600	19,130	29,210	33,580	37,970	43,820	48,280
	15-Day	7,570	16,640	25,310	29,060	32,840	37,870	41,720
	30-Day	5,750	12,400	18,760	21,530	24,330	28,080	30,960
	60-Day	4,410	9,370	14,220	16,370	18,580	21,570	23,890
Iowa City	1-Day	12,460	28,440	43,840	50,510	57,230	66,160	72,960
	3-Day	11,130	25,220	38,760	44,630	50,520	58,370	64,330
	5-Day	10,320	23,210	35,570	40,920	46,300	53,450	58,900
	7-Day	9,600	21,500	32,900	37,830	42,800	49,410	54,440
	10-Day	8,810	19,660	30,060	34,570	39,100	45,150	49,760
	15-Day	7,740	17,120	26,100	30,000	33,930	39,180	43,180
	30-Day	5,940	12,940	19,690	22,650	25,640	29,650	32,730
	60-Day	4,570	9,880	15,140	17,490	19,890	23,170	25,730
Lone Tree	1-Day	16,520	36,990	56,460	64,850	73,260	84,410	92,870
	3-Day	14,850	33,100	50,400	57,900	65,390	75,320	82,860
	5-Day	13,340	29,600	45,040	51,690	58,360	67,220	73,940
	7-Day	13,020	28,840	43,870	50,360	56,880	65,530	72,110
	10-Day	11,230	24,780	37,660	43,230	48,830	56,270	61,930
	15-Day	9,870	21,700	33,000	37,890	42,820	49,380	54,390
	30-Day	7,580	16,570	25,250	29,050	32,900	38,070	42,040
	60-Day	5,860	12,830	19,820	22,950	26,170	30,570	34,010
Wapello	1-Day	41,560	88,880	132,420	150,900	169,280	193,480	211,720
	3-Day	38,370	81,230	120,470	137,090	153,610	175,350	191,730
	5-Day	35,570	74,770	110,560	125,710	140,770	160,590	175,520
	7-Day	32,990	68,660	101,080	114,780	128,400	146,300	159,780
	10-Day	30,250	62,370	91,470	103,750	115,960	132,010	144,110
	15-Day	26,640	54,280	79,250	89,790	100,270	114,060	124,450
	30-Day	21,650	43,200	62,690	70,960	79,210	90,110	98,370
	60-Day	16,860	33,020	47,930	54,350	60,830	69,490	76,140

2. Duration Selection. Selection of the annual maximum unregulated volume-duration frequency curve to use in computing the regulated frequency curve depends on the relative effects of Coralville Lake reservoir storage on reducing flood flows at downstream locations. Selection of the appropriate duration focuses on large volume flood events (~greater than the 10% AEP (10-year) event) that result in releases that exceed the normal flood control release, which is typically around a bank full discharge. For lesser flood events, the inflow volumes are well controlled, and releases are successfully limited to seasonal maximums over a wide range of inflow volumes.

Selection of the duration was accomplished through plotting of the annual peak unregulated flow volumes (for each duration) versus the peak annual one-day regulated flow based upon the existing condition

HEC-ResSim simulation for the period of record flows. The selected duration was chosen as the duration that performed best with regards to:

- For areas immediately below Coralville Lake, producing a consistent break point at which higher volumes of unregulated inflow produced 1-day peak releases above the normal seasonal maximum.
- Producing consistent 1-day peak releases for similar volumes of unregulated inflow (i.e., minimized the degree of scatter in the 1-day regulated versus n-day unregulated relationship, with emphasis on the LMF events).
- Producing high consistency in the ranked order of events for the n-day unregulated volume versus the 1-day regulated flow.

Table B-3 shows the ranked 1-day reservoir releases for Coralville Lake and downstream gages versus the n-day inflow volumes. Figure B-10 through Figure B-14 show the plotted relationship between the 1-day regulated flow versus the unregulated flow volumes (for select durations) at each location. To assist in evaluation of the critical duration, additional scaled events were included to evaluate performance of the durations for rare flood events. Multipliers of 1.25, 1.5, and 1.75 were applied to the 1993, 2008, 2013, and 2014 (Wapello only) flood events using the "Inflow Multipliers" option within HEC-ResSim. The use of multiple major flood events provided for additional data points to capture the influence of varying hydrograph shapes on regulated peak flow releases.

For Coralville Lake release and the Iowa City gage, the 15-day inflow duration was selected. Of the various durations, the 15-day duration correctly orders the largest flood events and minimizes the amount of scatter in the 1-day regulated versus n-day unregulated flow volume. The 2009 study also utilized the 15-day duration for these two locations.

For the Lone Tree and Wapello gages, the 1-day inflow duration was selected due to the significant influence of unregulated tributary flow affecting these gages. As shown in Table B-3, the 1-day duration performs well in ordering the unregulated and regulated flow volumes for the Wapello gage. At Lone Tree, the 15-day unregulated duration comes closest to ordering the events; however it results in significantly greater scatter than the 1-day duration (Figure B-13) for the largest flood events, the area of greatest interest. For this reason, the 1-day duration was used. The 2009 study also utilized the 1-day duration for these two locations.

Table B-3. Unregulated Flow Duration Selection for Computation of Regulated Frequency Curves – Alternative 1
(Years ranked from largest to smallest annual maximum volume)

Coralville							
Unregulated							***Regulated***
1-Day	3-Day	**5-Day**	7-Day	10-Day	15-Day	30-Day	***1-Day***
2008	2008	2008	2008	2008	2008	1993	***2008***
1918	2013	2013	2013	2013	1993	2008	***1993***
2013	1918	1918	1918	1993	2013	1947	***2013***
1960	1993	1993	1993	2014	2014	2013	***2018***
1993	1960	1960	2014	1918	1947	2014	***2014***
2014	2014	2014	1960	1960	1918	2018	***1947***
1947	1947	1947	1979	1947	1960	1918	***1969***

Iowa City							
Unregulated							***Regulated***
1-Day	3-Day	5-Day	7-Day	10-Day	15-Day	30-Day	***1-Day***
2008	2008	2008	2008	2008	2008	1993	***2008***
1918	2013	2013	2013	2013	1993	2008	***1993***
2013	1918	1918	1993	1993	2013	1947	***2013***
1960	1960	1993	1918	2014	2014	2013	***2014***
1993	1993	1960	2014	1918	1947	2014	***2018***
2014	2014	2014	1960	1960	1918	2018	***1947***
1947	1947	1979	1979	1979	2018	1969	***1969***

Lone Tree							
Unregulated							***Regulated***
1-Day	3-Day	5-Day	7-Day	10-Day	15-Day	30-Day	***1-Day***
1993	2008	2008	2008	2008	2008	1993	***1993***
2008	1993	1993	1993	1993	1993	2008	***2008***
1974	1960	1960	2014	2014	2014	2014	***2013***
1960	2014	2014	1960	1960	2013	1947	***2014***
2013	1974	1974	1974	2013	2018	1974	***2018***
2014	2013	2013	2013	2018	1974	2018	***1974***
1990	1979	1990	2018	1974	1979	2013	***1965***

Wapello							
Unregulated							***Regulated***
1-Day	3-Day	5-Day	7-Day	10-Day	15-Day	30-Day	***1-Day***
2008	2008	2008	2008	2008	2008	1993	***2008***
2013	2014	2014	1993	1993	1993	2008	***2013***
2014	1993	1993	2014	2014	2014	2018	***1993***
1993	2013	2013	2013	2013	2013	1969	***2014***
1973	1960	1960	1960	2018	1969	2014	***1973***
1960	1973	1973	1965	1965	2018	2013	***1960***
1974	1974	1965	2018	1960	1965	1979	***1965***

3. Regulated Versus Unregulated Relationship. The regulated versus unregulated relationship is used to compute the annual maximum 1-day regulated frequency curve from the critical duration annual maximum unregulated volume frequency curve. In order to estimate the regulated versus unregulated relationship for rarer events, the regression line was computed based upon the 1993, 2008, 2013 and 2014 (Wapello only) simulated events, including scaled versions of those events as discussed in Section III.B.2, *Duration Selection*.

a. Coralville Lake. The regulated versus unregulated relationship for Coralville Lake is characterized by zones where flows are less than or greater than the seasonal maximum release of 10,000 cfs. For events that exceed the 10,000 cfs release, releases are progressively increased during major flood operations to 21,000 cfs. Above elevation 712 feet, the uncontrolled spillway activates and releases from the spillway and conduit increase with increasing reservoir elevation. The Coralville Lake tailwater gage represents the reach of the Iowa River from Coralville Dam to its confluence with Clear Creek.

Figure B-15 shows the estimated regulated versus unregulated relationship for Coralville Lake. The regulated versus unregulated flow pairs shown are the annual maximum 15-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulation. For regulated releases in excess of 21,000 cfs, the regression line was computed based upon the 1993, 2008, and 2013 simulated events (including scaled versions of those events, discussed in Section III.B.2).

b. Iowa River at Iowa City, IA. The regulated versus unregulated relationship for the Iowa City gage reflects the Coralville Lake release and unregulated contributions from local tributaries in the Iowa City area including Rapid and Clear Creek. The Iowa River gage represents the reach of the Iowa River from its confluence with Clear Creek to its confluence with the English River. Figure B-16 shows the estimated regulated versus unregulated relationship for Iowa City. The regulated versus unregulated flow pairs shown are the annual maximum 15-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulation. The regression line was computed based upon the 1993, 2008, and 2013 simulated events (including scaled versions of those events, discussed in Section III.B.2).

c. Iowa River at Lone Tree, IA. The regulated versus unregulated relationship for the gage located near Lone Tree, IA, is influenced by the significant amount of unregulated flow that enters the river reach between Coralville Lake and the gage. Between Coralville Dam and Lone Tree, the drainage area increases by roughly a third (3,115 versus 4,293 square miles). Therefore, the regulated versus unregulated relationship reflects the combination of the regulated Coralville Lake releases and the unregulated flow from the English River and other local tributaries. The Lone Tree gage represents the reach of the Iowa River from its confluence with the English River to its confluence with the Cedar River. Figure B-17 shows the estimated regulated versus unregulated relationship for the Lone Tree gage. The regulated versus unregulated flow pairs shown are the annual maximum 1-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulation. The regression line was computed based upon the 1993, 2008, and 2013 simulated events (including scaled versions of those events, discussed in Section III.B.2).

d. Iowa River at Wapello, IA. The regulated versus unregulated relationship for the gage located at Wapello, IA, is heavily influenced by the Cedar River which joins the Iowa River upstream of Wapello at Columbus Junction, IA. At Wapello, only 25% of the contributing watershed area is upstream of Coralville Lake. The Wapello gage represents the reach of the Iowa River from its confluence with the Cedar River to its confluence with the Mississippi River. Figure B-18 shows the estimated regulated versus unregulated relationship for the Wapello gage. The regulated versus unregulated flow pairs shown are the annual maximum 1-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulation. The regression line was computed based upon the 1993, 2008, 2013, and 2014 simulated events (including scaled versions of those events, discussed in Section III.B.2).

4. Regulated Flow Frequency Curves. The regulated flow frequency curves were estimated by integrating the regulated versus unregulated relationship with the 1-day or 15-day unregulated VDF curve identified in Section III.B.2

a. Coralville Lake Regulated Flow Frequency Curve. The Coralville Lake regulated flow frequency curve was computed by integrating the 15-day VDF curve (Table B-1) and the regulated versus unregulated relationship (Figure B-15). For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates, and typically are associated with seasonal maximum release rates for normal flood operations at the reservoir. The resulting regulated flow frequency curve is shown in Figure B-19. Table B-4 provides the existing condition (current water control plans) flow frequency estimates for gage locations along the Iowa River.

Table B-4. Regulated 1-Day Flow and Elevation Frequencies - Alternative 1 Existing Conditions. Based on Period of Record Simulations (1917-2019)

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow, cfs)**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	685.9	4,600	4,600	6,700	17,600
1.4	0.7	686.0	6,000	6,900	10,100	28,400
2-yr	0.5	691.7	10,000	10,000	13,300	36,600
5-yr	0.2	706.9	10,000	10,900	18,900	62,600
10-yr	0.1	709.5	10,000	11,900	26,200	74,500
20-yr	0.05	711.7	18,000	19,500	33,800	86,100
50-yr	0.02	713.7	24,000	25,700	48,100	123,600
100-yr	0.01	715.2	29,700	31,400	55,600	140,600
200-yr	0.005	716.3	35,400	37,100	63,000	157,400
500-yr	0.002	717.6	43,100	44,600	72,900	179,700
1000-yr	0.001	718.4	49,000	50,400	80,400	196,400

b. Iowa City, Lone Tree, and Wapello Regulated Flow Frequency Curves. The regulated flow frequency curves for the gages on the Iowa River below Coralville Lake were similarly computed by integrating the applicable 15-day (Iowa City) or 1-day (Lone Tree, Wapello) VDF curve and the regulated versus unregulated relationship. For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates. The resulting regulated flow frequency curves are shown in Figure B-20 through Figure B-22. Table B-4 provides the existing condition (current water control plan) flow frequency estimates for gage locations along the Iowa River.

5. Reservoir Elevation Frequency Analysis. The Coralville Lake reservoir elevation frequencies were computed by integrating the outlet works rating curve (USACE, 2001) and the regulated flow frequency curve for flow releases exceeding the maximum regulated condition (release of 21,000 cfs). Plotting position AEP estimates were used for more frequent events when the reservoir utilizes storage to control flows per the release schedule. Figure B-23 shows the resulting reservoir elevation frequency curve. Table B-4 provides the existing condition (current water control plan) flow and elevation frequency estimates for gage locations along the Iowa River.

6. Comparison to Previous Estimates. This section provides a comparison of the regulated flow frequency estimates at Coralville Lake to those published in 2009 and 2002. The primary differences between the estimates relate to the available period of record upon which the flow frequency estimates were based as well as guidance changes in the low outlier censoring methodology utilized (Single versus Multiple Grubbs-Beck).

As shown in Table B-5 the estimated regulated flow frequency values at Coralville Lake increased over the 2009 estimates for the more frequent events due to the inclusion of several additional flood years within the available record, most notably the Floods of 2013, 2014, and 2018. For the rarer frequencies, the 2009 and current estimates converge around the 0.002 probability event due to the more negative skew values computed in this study (see Section III.B.1).

Table B-5. Comparison of Coralville Lake 1-Day Regulated Flow Frequency Estimates (Values in cfs)

AEP	Current Study	2009 FFS	2002 Study
0.5	10,000	Not Estimated	8,600
0.1	10,000	10,000	10,000
0.02	24,000	21,300	18,400
0.01	29,700	27,700	21,100
0.005	35,400	34,300	23,900
0.002	43,100	43,300	Not Estimated
0.001	49,000	50,500	Not Estimated

IV. EVALUATION OF ALTERNATIVE WATER CONTROL PLANS

This section provides a description of the alternative plans and an evaluation of the hydraulic impacts associated with the changes to the water control plan for Coralville Lake. Evaluation of the hydraulic impacts is accomplished through plotting of the period of record HEC-ResSim results (peak annual flows and reservoir Elevations) and comparison to the existing conditions (Alternative 1) and unregulated condition, where appropriate. For the purposes of this initial evaluation, estimates of AEP were based on Wiebull plotting position. In addition to evaluating the change in peak annual flow and reservoir elevations, the change in duration of flooding within Coralville Lake was evaluated to assess the change in duration of flooding on flowage easement lands within the reservoir. Regulated flow frequency analysis was performed on the screened final array of alternatives and is discussed in Section III.B (for the existing water control plan) and Section V (for the screened alternatives).

A. Alternative 1 – the "No Action" Alternative

This alternative maintains the current water control plan and facilitates no changes towards the current Iowa River Basin Master Reservoir Regulation Manual for Coralville Lake. Under this baseline alternative, the reservoir would continue to be operated under the current regulation plan.

A summary of the current regulation plan is as follows:

- Maintain the normal Conservation Pool level of 683 feet.

- Reservoir releases during normal flood control operations (reservoir elevations between 683 and 707 feet):
  - Growing season maximum release: 6,000 cfs
  - Non-growing season maximum release: 10,000 cfs

- Downstream constraint at Iowa City (flash flood operations): Any date that the flow at the Iowa City gage is at, above, or forecast to exceed 16,000 cfs, reduce the release to not less than 1,000 cfs to keep the flow at or below 16,000 cfs.

- Seasonal downstream constraints as Lone Tree and Wapello: When forecast indicate any of these constraints will be exceeded, reduce the release to control discharges as near as possible to the constraint stages during the peak 3-days of the crest with due allowance for travel time.
  - Growing Season: Release no less than 1,000 cfs when stages at Lone Tree and Wapello exceed 14 and 21 feet, respectively
  - Non-growing Season: Release no less than 1,000 cfs when stages at Lone Tree and Wapello exceed 16 and 22 feet, respectively

- Downstream constraint at Burlington: Any date the Mississippi River is forecast to exceed a stage of 18 feet at Burlington, Iowa, reduce the release to not less than 1,000 cfs during the peak 7-days of the Mississippi River crest with due allowance for travel time.

- LMF begin at elevation 707 feet with 71.5 percent of flood storage capacity being utilized. Prescribed releases, as seen in Table B-6 are followed between elevations 707 and 712 feet and all constraints are relaxed.

Table B-6. Alternative 1 Large Magnitude Flood Operations

<table>
<tr><th>Forecasted Peak Pool Elevation (ft)</th><th>Growing Season Release (cfs)</th><th>Non-growing Season Release (cfs)</th></tr>
<tr><td>707</td><td>7,000</td><td>10,000</td></tr>
<tr><td>708</td><td>8,000</td><td>10,000</td></tr>
<tr><td>709</td><td>9,000</td><td>10,000</td></tr>
<tr><td>710</td><td colspan="2">10,000</td></tr>
<tr><td>711</td><td colspan="2">11,000</td></tr>
<tr><td>711.1</td><td colspan="2">12,000</td></tr>
<tr><td>711.2</td><td colspan="2">13,000</td></tr>
<tr><td>711.3</td><td colspan="2">14,000</td></tr>
<tr><td>711.4</td><td colspan="2">15,000</td></tr>
<tr><td>711.5</td><td colspan="2">16,000</td></tr>
<tr><td>711.6</td><td colspan="2">17,000</td></tr>
<tr><td>711.7</td><td colspan="2">18,000</td></tr>
<tr><td>711.8</td><td colspan="2">19,000</td></tr>
<tr><td>711.9</td><td colspan="2">20,000</td></tr>
<tr><td>712</td><td colspan="2">Gates Fully Open</td></tr>
</table>

B. Alternative 2

This alternative incorporates elements of recent deviations that include a 10,000 cfs year-round release during normal flood operations, tiered downstream constraints with variable minimum releases, altered dates for seasonal downstream constraints and a modified major flood operation schedule eliminating induced surcharge operation. The normal conservation pool will be maintained within a one-foot operating band between elevations 683 and 684 feet, with an allowable fall pool level up to 688 feet, and a spring drawdown to elevation 679 feet.

Summary of the modifications to the existing Coralville regulation plan:

- Elimination of growing season release reduction, holding a maximum of 10,000 cfs all year
- Tiered, seasonal downstream constraints at Lone Tree and Wapello with variable minimum releases
    - Growing Season:
        - Release a maximum of 6,000 cfs when the stages at Lone Tree and Wapello reach 16 feet and 22 feet, respectively
        - Release a maximum of 1,000 cfs when the stages at Lone Tree and Wapello reach 19 feet and 25 feet, respectively
    - Non-Growing Season: Release a maximum of 1,000 cfs when the stages at Lone Tree and Wapello reach 19 feet and 25 feet, respectively
- No changes to the Iowa City and Burlington downstream constraints
- Altered dates for seasonal downstream constraint changes
- Modified LMF Operations release schedule, detailed in Table B-7, and elimination of "Induced Surcharge Operation"

Table B-7. Alternative 2 LMF Operations

Forecasted Peak Pool Elevation (feet)	Release (cfs)
707	12,000
710	14,000
710.5	16,000
711	18,000
711.5	20,000
712	Fully Open

The results of the HEC-ResSim simulations for Alternative 2 are shown in Figure B-24 through Figure B-27. As shown, Alternative 2 reduces peak reservoir elevations within Coralville Lake, preserving flood storage over a wide range of AEPs. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 10% to 4% AEP (10- to 25-year) event. In addition, Alternative 2 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and 2008). Alternative 2 also reduces the duration of flood storage within Coralville Lake for events below the spillway elevation of 712 feet.

However, the flows for Alternative 2 are higher than those seen for Alternative 1 at Lone Tree, IA and Wapello, IA for frequencies below the 10% to 4% AEP (10- to 25-year) events due to the higher maximum flood control releases from Coralville Lake.

C. Alternative 2A

This alternative is a variation of Alternative 2. All of the changes made in Alternative 2 are used with the exception of elimination of the spring drawdown to elevation 679 feet.

The results of the HEC-ResSim simulations for Alternative 2A are shown in Figure B-24 through Figure B-27. As shown, Alternative 2A performs similarly to Alternative 2. The frequency of reservoir elevations below elevation 700 feet is slightly higher than those seen in Alternative 2, as the elimination of the spring drawdown causes storage within the flood pool earlier. However, there are few if any differences between Alternative 2 and Alternative 2A above elevation 700 feet.

D. Alternative 2B

This is another variation of Alternative 2, Alternative 2B includes all of the changes made in Alternative 2, except that the tiered growing season downstream constraints are held all year.

The results of the HEC-ResSim simulations for Alternative 2B are shown in Figure B-24 through Figure B-27. As shown, there are few differences between Alternative 2 and Alternative 2B above elevation 707 feet. However, storage within the flood pool occurs more often below elevation 707 feet, as the more aggressive downstream constraints results in reductions in flows occurring more often. However, this alternative reduces the frequency of higher downstream flows at Lone Tree between 16- and 19-feet back to those seen in Alternative 1, as downstream controls are no longer accounting for stages in that range.

E. Alternative 2C

This is another variation of Alternative 2, Alternative 2C includes all of the changes made in Alternative 2 except that the non-growing season downstream constraints are now held all year.

The results of the HEC-ResSim simulations for Alternative 2C are shown in Figure B-24 through Figure B-27. As shown, Alternative 2C further reduces peak water surface elevations in Coralville Lake from those seen in Alternative 2, preserving flood storage over a wider range of AEPs. The result is a larger reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flood exceeding the 10% to 4% AEP (10- to 25-year) event. However, this alternative increases the frequency of higher downstream flows at Lone Tree between 16- and 19-feet more than Alternative 2, as downstream controls are no longer accounting for stages in that range.

F. Alternative 3

Alternative 3 is the “Maximum Release Plan”. This plan provides an envelope for increasing outflows and constraints in relation to alternatives considered. This alternative consists of the following measures:

- No change to the current conservation pool levels, including the spring drawdown
- Reservoir releases are constrained only by the outlet capacity

- No downstream constraints.

The results of the HEC-ResSim simulations for Alternative 3 are shown in Figure B-28 through Figure B-31. As shown, Alternative 3 reduces peak reservoir elevations within Coralville Lake more than Alternatives 1, 2, 2A, and 2B, preserving flood storage over a wide range of AEPs. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 5% AEP (20-year) event. In addition, Alternative 3 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to one (2008). Alternative 3 also reduces the duration of flood storage events within Coralville Lake for events below 712 feet.

This alternative does increase the magnitude of flows at Iowa City, IA below the 5% AEP (20-year) event, at Lone Tree, IA and Wapello, IA below the 2% AEP (50-year) event. This would result in a higher frequency of flooding for lands downstream of Coralville Lake that are currently protected by Alternative 1, with flows similar than those seen in the unregulated analysis.

G. Alternative 3A

This alternative incorporates the same changes as Alternative 3. However, this is the "Dry Reservoir Scenario". No conservation pool is held at any time, with the exception of holding back floodwaters when inflow exceeds outlet capacity.

The results of the HEC-ResSim simulations for Alternative 3A are shown in Figure B-28 through Figure B-31. As shown, Alternative 3A reduces the peak reservoir elevations within Coralville Lake slightly more than Alternative 3. Frequencies of storage in the flood pool are slightly lower than Alternative 3, as lack of a flood control pool provides more storage space at lower elevations. As releases exceed 13,000 cfs from Coralville Lake, frequencies seen in Alternative 3A converge with those of Alternative 3.

H. Alternative 4

This alternative is another variation of Alternative 2. However, Alternative 4 includes elevation-based growing season releases to reduce downstream impact in the lower elevations of the Flood Control Pool:

- Maximum growing season release determined by reservoir pool elevation:
  - Below Elevation 700 feet – 8,500 cfs
  - Above Elevation 700 feet – 10,000 cfs

- Non-Growing Season Release – 10,000 cfs

The results of the HEC-ResSim simulations for Alternative 4 are shown in Figure B-32 through Figure B-35. As shown, Alternative 4 reduces peak reservoir elevations within Coralville Lake, preserving flood storage over a wide range of AEPs. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 10% to 5% AEP (10- to 20-year) event. Similar to Alternative 2, Alternative 4 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and

2008). Alternative 4 also reduces the duration of flood storage events within Coralville Lake for events below 712 feet.

This alternative does increase the magnitude of flows at Iowa City, IA and Lone Tree, IA below the 5% AEP (20-year) event, Wapello, IA below the 20% AEP (5-year) event.

I. Alternative 4A

Alternative 4A modifies the Alternative 4 plan by allowing a delay of growing season releases if the reservoir water surface elevation is between elevation 700 and 707 feet on May 01. If this criterion is met, 10,000 cfs releases will continue until the water surface elevation returns to Conservation Pool elevation 683 feet, at which point the growing season maximum release schedule in Alternative 4 will begin.

The results of the HEC-ResSim simulations for Alternative 4A are shown in Figure B-32 through Figure B-35. As shown, Alternative 4A is nearly identical to Alternative 4, as there are only three years when the rules differ (1965, 1973, and 1983). The difference between the two alternatives for these three years are negligible and did not have a noticeable effect on the results.

J. Alternative 5

This alternative is another variation of Alternative 2. All of the same changes to the original regulation plan are part of this alternative, with the exception of the maximum growing season release. When the water elevation is below 707 feet, the maximum growing season release is 8,000 cfs.

The results of the HEC-ResSim simulations for Alternative 5 are shown in Figure B-36 through Figure B-39. As shown, Alternative 5 reduces peak reservoir elevations within Coralville Lake, preserving flood storage over a wide range of AEPs. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 10% to 5% AEP (10- to 20-year) event. In addition, Alternative 5 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and 2008). Alternative 5 also reduces the duration of flood storage within Coralville Lake for events below the spillway elevation of 712 feet, but less so than other alternatives due to its lower maximum growing season release.

This alternative does increase the magnitude of flows at Lone Tree, IA below the 4% AEP (25-year) event, and at Wapello, IA below the 20% AEP (5-year) event.

K. Alternative 6

Alternative 6 is a stakeholder alternative provided by the Johnson County Iowa Homeland Security (HS) and Emergency Management Agency (EMA). The changes from the existing Coralville Dam regulation plan are as follows:

- Decrease the summer Conservation Pool elevation from 683 feet to 682 feet

- Maximum growing season release changed to 9,000 cfs. No change to maximum non-growing season release.
- Growing season to start on May 20 and end on Dec 01 (changed from May 01 and Dec 15, respectively)
- Raise the Iowa City flow constraint from 16,000 cfs to 16,500 cfs
- Change the Wapello constraint
  - Increase the growing season maximum stage from 21 feet to 23 feet
  - Increase the non-growing season maximum stage from 22 feet to 25 feet
  - Increase the minimum releases from Coralville Dam from 1,000 cfs to 3,000 cfs
- Eliminate the downstream stage constraints at Lone Tree and Burlington
- Altered LMF Release Schedule, detailed in Table B-8, starting at Elevation 705 feet and increasing flows more rapidly

Table B-8. Alternative 6 LMF Operations

Forecasted Peak Pool Elevation (feet)	Release (cfs)
705	11,000
706	12,000
707	13,000
708	15,000
709	16,000
710	18,000
711	20,000
712	Fully Open

The results of the HEC-ResSim simulations for Alternative 6 are shown in Figure B-40 through Figure B-43. As shown, Alternative 6 reduces peak reservoir elevations within Coralville Lake, preserving flood storage over a wide range of AEPs, more than all alternatives save Alternatives 3, 3A, and 7. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 5% AEP (20-year) event. In addition, Alternative 6 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and 2008). Alternative 6 also reduces the duration of flood storage within Coralville Lake for events below the spillway elevation of 712 feet.

This alternative does increase the magnitude of flows at Lone Tree, IA and Wapello, IA below the 4% AEP (25-year) event.

L. Alternative 7

Alternative 7 is a stakeholder alternative provided by the Two Rivers Levee & Drainage District, which is located in Louisa and Des Moines Counties, downstream of Wapello, Iowa. The changes from the existing Coralville Dam regulation plan are as follows:

- Decrease the summer Conservation Pool elevation from 683 feet to 682 feet

- Reservoir releases only constrained by the capacity of the outlet, up to a maximum release of 16,500 cfs. Above that flow, follow the existing LMF Release Schedule from Alternative 1

- Change the Wapello constraint
  - Increase the growing season maximum stage from 21 feet to 23 feet
  - Increase the non-growing season maximum stage from 22 feet to 25 feet

- Increase the stage constraint at Burlington on the Mississippi River from 18 feet to 20 feet

- Eliminate the stage constraint at Lone Tree

- No change to the flow constraint and Iowa City

The results of the HEC-ResSim simulations for Alternative 7 are shown in Figure B-44 through Figure B-47. As shown, Alternative 7 reduces peak reservoir elevations within Coralville Lake, preserving flood storage over a wide range of AEPs. Only Alternatives 3 and 3A preserve more storage than this alternative. The reduction in frequency of exceeding elevation 707 results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA for flows exceeding the 5% AEP (20-year) event. In addition, Alternative 7 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and 2008). Alternative 7 also reduces the duration of flood storage within Coralville Lake for events below the spillway elevation of 712 feet.

However, as this alternative does not regulate flows until they exceed 16,500 cfs, flows at the Coralville Dam tailwater downstream through Wapello, IA are higher in magnitude than Alternative 1 for frequencies greater than 10% to 5% AEP (10- to 20-year) events. This would result in a higher frequency of flooding for lands downstream of Coralville Lake that are currently protected by Alternative 1, with flows similar than those seen in the unregulated analysis.

M. Alternative 8

Alternative 8 is similar to Alternative 4 but with the same downstream constraints throughout the entire year and a modified LMF schedule. Details of this alternative include:

- Maximum growing season release determined by reservoir pool elevation:
  - Below Elevation 700 feet – 8,500 cfs
  - Above Elevation 700 feet -10,000 cfs

- Maximum non-growing season release is 10,000 cfs

- Move to a single year-round downstream constraint at Lone Tree and Wapello of 18.5 feet and 25 feet, respectively. These values correspond to the updated moderate flood stages at both gages.

- Altered LMF Release Schedule, detailed in Table B-9, starting at Elevation 707 feet and increase rapidly

Table B-9. Alternative 8 LMF Operations

Forecasted Peak Pool Elevation (feet)	Release (cfs)
707	12,000
710	16,000
711	18,000
711.5	20,000
712	Fully Open

The results of the HEC-ResSim simulations for Alternative 8 are shown in Figure B-48 through Figure B-51. As shown, Alternative 8 reduces peak reservoir elevations within Coralville Lake similarly to Alternatives 2 and 4, preserving flood storage over a wide range of AEPs. The reduction in frequency of exceeding elevation 707 feet results in less frequent initiation of LMF operations and uncontrolled spillway releases, respectively. The result is a reduction in peak downstream flows below Coralville Dam and at Iowa City, IA, for flows exceeding the 10% to 5% AEP (10- to 20-year) events. In addition, Alternative 8 reduces the number of simulated events with uncontrolled spillway releases from three (1993, 2008, and 2013) to two (1993 and 2008). Alternative 8 also reduces the duration of flood storage within Coralville Lake for events below the spillway elevation of 712 feet.

However, the flows for Alternative 8 are higher than those seen for Alternative 1 at Lone Tree, IA and Wapello, IA for frequencies below the 10% (10- year) events due to the higher maximum flood control releases from Coralville Lake.

V. REGULATED FLOW FREQUENCY ANALYSIS OF FINAL ARRAY OF ALTERNATIVES

Regulated flow frequency estimates were developed for the final array of alternatives – Alternatives 1, 2C, 5, and 8. The regulated flow frequency values for Alternative 1 are contained in Section III.B. This section presents the results of the regulated flow frequency analysis for Alternatives 2C, 5 and 8. The methodology used to develop the regulated flow frequencies was the same as used for Alternative 1, therefore this section simply presents the results of the analyses, refer to Section III.B for a more detailed description of methodology.

A. VDF Analysis

The VDF analysis was performed on the simulated, period of record, unregulated flows for each gage location using HEC-SSP and is the same for all Alternatives. Table B-1 shows the computed VDF statistics for each gage and duration on the Iowa River.

B. Duration Selection

The peak unregulated flow volumes (for each duration) versus the peak annual 1-day regulated flow based upon the existing condition HEC-ResSim simulation for the period of record flows were plotted to determine if there was a justification for using a different critical duration for Alternative 2C, 5 or 8 then was selected for Alternative 1. Figure B-52 through Figure B-55 show, for each alternative, the plotted relationship between the 1-day regulated annual maximum flow versus the 15-day (Coralville Lake and Iowa City gages) or 1-day (Lone Tree and Wapello gages) unregulated annual maximum flow volumes. To assist in evaluation of the durations, additional scaled events were included to evaluate performance of the durations for rare flood events. Multipliers of 1.25, 1.5, and 1.75 were applied to the 1993, 2008, 2013, and 2014 (Wapello only) flood events using the "Inflow Multipliers" option within HEC-ResSim. The use of multiple major flood events provided for additional data points to capture the influence of varying hydrograph shapes on regulated peak flow releases.

Based upon review of the plotted results, the decision was made to proceed with use of the same critical durations as selected for Alternative 1.

C. Regulated versus Unregulated Relationship

The regulated versus unregulated relationship is used to compute the annual maximum 1-day regulated frequency curve from the critical duration annual maximum unregulated volume frequency curve. In order to estimate the regulated versus unregulated relationship for rarer events, the regression line was computed based upon the 1993, 2008, 2013 and 2014 (Wapello only) simulated events, including scaled versions of those events as discussed in Section III.B.2, *Duration Selection*.

1. Coralville Lake. Figure B-52 shows the estimated regulated versus unregulated relationships for Coralville Lake for each alternative. The regulated versus unregulated flow pairs shown are the annual maximum 15-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulations. For regulated releases in excess of 21,000 cfs, regression lines were computed based upon the 1993, 2008, and 2013 simulated events, including scaled versions of those events as discussed in Section III.B.2, *Duration Selection*.

2. Iowa River at Iowa City, IA. Figure B-53 shows the estimated regulated versus unregulated relationships for Iowa City for each alternative. The regulated versus unregulated flow pairs shown are the annual maximum 15-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulations.

3. Iowa River at Lone Tree, IA. Figure B-54 shows the estimated regulated versus unregulated relationships for Lone Tree for each alternative. The regulated versus unregulated flow pairs shown are the annual maximum 1-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulations.

4. Iowa River at Wapello, IA. Figure B-55 shows the estimated regulated versus unregulated relationships for Wapello for each alternative. The regulated versus unregulated flow pairs shown are the annual maximum 1-day inflow volume and peak 1-day release from the period of record HEC-ResSim simulations.

D. Regulated Flow Frequency Curves

The regulated flow frequency curves were estimated by integrating the regulated versus unregulated relationship with the 1-day or 15-day unregulated VDF curve identified in Section IV, C.

1. Coralville Lake Regulated Frequency Curve. The Coralville Lake regulated flow frequency curve was computed by integrating the 15-day VDF curves (Table B-1) and the regulated versus unregulated relationships (Figure B-52) for each alternative. For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates, and typically are associated with seasonal maximum release rates for normal flood operations at the reservoir. The resulting regulated flow frequency curves are shown in Figure B-56 through Figure B-58. Table B-10 through Table B-12 provide the flow frequency estimates for Alternatives 2C, 5, and 8 at gage locations along the Iowa River.

Table B-10. Regulated 1-Day Flow and Elevation Frequencies - Alternative 2C

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow, cfs)**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	685.7	4,600	4,600	6,700	17,600
1.4	0.7	686.0	8,400	8,500	10,100	28,900
2-yr	0.5	686.6	10,000	10,200	14,500	37,800
5-yr	0.2	705.5	10,000	12,500	22,100	63,400
10-yr	0.1	707.2	12,000	14,900	27,000	74,700
20-yr	0.05	709.5	12,000	16,200	36,100	84,500
50-yr	0.02	712.3	20,600	23,000	46,400	121,800
100-yr	0.01	714.5	26,900	29,100	53,900	138,900
200-yr	0.005	715.9	33,300	35,300	61,500	155,900
500-yr	0.002	717.4	41,800	43,500	71,500	178,300
1000-yr	0.001	718.3	48,300	49,800	79,100	195,200

Table B-11. Regulated 1-Day Flow and Elevation Frequencies – Alternative 5

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow,**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	685.7	4,600	4,600	6,700	17,600
1.4	0.7	686.0	8,000	8,000	10,100	28,600
2-yr	0.5	689.0	9,400	10,000	14,300	37,800
5-yr	0.2	705.6	10,000	12,200	22,200	62,900
10-yr	0.1	707.8	12,000	14,200	27,000	75,600
20-yr	0.05	709.4	14,000	17,200	35,100	87,800
50-yr	0.02	712.9	21,600	23,500	47,100	122,700
100-yr	0.01	714.7	27,700	29,500	54,600	139,600
200-yr	0.005	716.0	33,900	35,600	62,100	156,500
500-yr	0.002	717.4	42,100	43,700	72,000	178,800
1000-yr	0.001	718.4	48,400	49,900	79,600	195,500

2. Iowa City, Lone Tree, and Wapello Regulated Flow Frequency Curves. The regulated flow frequency curves for the gages on the Iowa River below Coralville Lake were similarly computed by integrating the applicable 15-day or 1-day VDF curve and the regulated versus unregulated relationship. For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates. The resulting regulated flow frequency curves are shown in Figure B-59 through Figure B-67. Table B-10 through Table B-12 provide the flow frequency estimates for Alternatives 2C, 5, and 8 at gage locations along the Iowa River.

Table B-12. Regulated 1-Day Flow and Elevation Frequencies – Alternative 8

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow, cfs)**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	685.7	4,600	4,600	6,700	17,600
1.4	0.7	686.0	8,400	8,500	10,100	28,900
2-yr	0.5	686.9	9,600	10,000	14,300	37,600
5-yr	0.2	705.6	10,000	12,000	22,100	63,400
10-yr	0.1	707.5	12,000	14,400	26,800	74,300
20-yr	0.05	709.8	12,000	16,400	36,100	84,500
50-yr	0.02	712.7	21,100	23,400	46,500	122,300
100-yr	0.01	714.6	27,300	29,400	54,100	139,300
200-yr	0.005	715.9	33,400	35,400	61,600	156,200
500-yr	0.002	717.3	41,600	43,400	71,700	178,500
1000-yr	0.001	718.3	47,900	49,500	79,300	195,200

E. Reservoir Elevation Frequency Analysis

The Coralville Dam reservoir elevation frequencies were computed by integrating the outlet works rating curve and the regulated flow frequency curve for flow releases exceeding the maximum regulated condition (release of 21,000 cfs). Plotting position AEP estimates were used for more frequent events when the reservoir utilizes storage to control flows per the release schedule. Figure B-68 through Figure B-70 shows the resulting reservoir elevation frequency curves for Alternatives 2C, 5, and 8.

VI. HYDROLOGIC SENSITIVITY ANALYSIS

A. Period of Record Adjustment

As discussed in the recommendations of Appendix A, the latter, wetter, period of the record was evaluated to test the hydrologic sensitivity of the regulated flow frequency estimates and subsequent economic analysis. The general methodology used to develop the regulated flow frequencies for the 1959-2019 period was the same as used for the full period of record, therefore this section focusses on any differences and presents the results of the analyses; refer to Section III.B for a more detailed description of the methodology used in computation of the regulated flow frequencies.

B. Regulated Flow Frequency Analysis

The HEC-ResSim model results (unregulated flows as well as computed daily regulated flows and reservoir elevations) for the years 1959 to 2019 were used to compute the regulated flow frequency estimates for the existing and alternative water control plans. Due to the presence of high flows during the fall in some years, calendar year was used for the regulated flow frequency analyses instead of water year.

1. VDF Analysis. A VDF analysis was performed on the simulated, 1959 to 2019, unregulated flows for each gage location using HEC-SSP. Analyses for the 1, 3, 5, 7, 10, and 15-day peak annual durations were conducted. For most location and duration combinations, the Multiple Grubbs-Beck test identified no, or a single, low outliers. However, for some durations, particularly for the Lone Tree Gage, 10 or more low outliers were identified. This resulted in computed standard deviation and skew values significantly different than those computed for other durations as well as at the surrounding gages. As a result, the low outlier test for these location-duration combinations were overridden (resulting in fewer outliers) based upon a visual evaluation of the plotted data in order to produce regionally, and gage consistent, VDF curves.

Table B-13 shows the computed VDF statistics for each gage and duration on the Iowa River. To obtain VDF curves that are consistent for a particular gage, the computed statistics were adjusted in the same manner as described in Section III.B.1. The resulting adjusted skew values ranged from -0.31 to -0.47 (compared to the period of record range of -0.23 to -0.37). While the adjustment methodology utilized was the same as for the period of record analysis, the differences in skews relate to the shortened record utilized.

The resulting unregulated volume-frequency values for the 1-day and critical durations (if different) are shown in Table B-14.

Table B-13. Iowa River Volume-Duration-Frequency Statistics of Log10 Unregulated Annual Maximum

Gage	Duration	Mean	StdDev	Skew	Outliers	$StdDev_{reg}$	Regional Skew
Coralville Release	1-Day	4.124	0.281	-0.445	0	0.283	-0.306
	3-Day	4.078	0.286	-0.396	0	0.286	-0.329
	5-Day	4.046	0.291	-0.440	0	0.289	-0.352
	7-Day	4.016	0.291	-0.475	0	0.291	-0.375
	10-Day	3.977	0.295	-0.519	0	0.294	-0.410
	15-Day	3.925	0.296	-0.546	0	0.298	-0.467
Iowa City	1-Day	4.152	0.276	-0.403	0	0.278	-0.306
	3-Day	4.099	0.283	-0.391	0	0.283	-0.329
	5-Day	4.064	0.289	-0.461	0	0.287	-0.352
	7-Day	4.034	0.292	-0.522	0	0.290	-0.375
	10-Day	3.995	0.295	-0.546	0	0.294	-0.410
	15-Day	3.943	0.296	-0.573	1	0.299	-0.467
Lone Tree	1-Day	4.298	0.272	-0.115	0	0.275	-0.306
	3-Day	4.251	0.276	-0.230	0	0.275	-0.329
	5-Day	4.199	0.276	-0.257	0	0.275	-0.352
	7-Day	4.167	0.276	-0.287	0	0.275	-0.375
	10-Day	4.124	0.276	-0.330	0	0.275	-0.410
	15-Day	4.068	0.277	-0.377	0	0.276	-0.467
Wapello	1-Day	4.677	0.262	-0.186	0	0.267	-0.306
	3-Day	4.644	0.263	-0.21	0	0.265	-0.329
	5-Day	4.605	0.263	-0.231	0	0.262	-0.352
	7-Day	4.575	0.264	-0.308	0	0.261	-0.375
	10-Day	4.539	0.261	-0.36	0	0.258	-0.410
	15-Day	4.490	0.260	-0.413	0	0.255	-0.467

Table B-14. Iowa River Unregulated Annual Maximum Flow (cfs) Versus AEP

		AEP						
Gage	**Duration**	**0.5**	**0.1**	**0.02**	**0.01**	**0.005**	**0.002**	**0.001**
Coralville	1-Day	13,750	29,900	45,410	52,170	59,000	68,160	75,180
	15-Day	8,870	19,420	28,800	32,670	36,440	41,300	44,880
Iowa City	1-Day	14,680	31,520	47,550	54,500	61,520	70,900	78,080
	15-Day	9,250	20,330	30,200	34,260	38,230	43,350	47,130
Lone Tree	1-Day	20,510	43,650	65,520	74,980	84,510	97,230	106,950
Wapello	1-Day	49,040	102,190	151,670	172,930	194,270	222,660	244,270

2. Duration Selection. The duration of the annual maximum unregulated flow frequency curve to use in computing the regulated frequency curve depends on the relative effects of Coralville Lake reservoir storage on reducing flood flows at downstream locations. Reduction in the period of record utilized for the sensitivity analysis does not alter the critical duration determined based on the period of record analysis.

Per Section III.B.2, *Duration Selection,* for the Coralville Lake release and the Iowa City gage, the 15-day unregulated flow duration was selected. For the Lone Tree and Wapello gages, the 1-day unregulated flow duration was selected due to the significant influence of unregulated tributary flow affecting these gages.

3. Regulated Versus Unregulated Relationship. The regulated versus unregulated relationships associated with each alternative does not change as a result of utilizing a shortened period of record in this analysis. Development of the regulated versus unregulated relationships for the base and alternative water control plans are described in Sections III.B.3 and V.C.

4. Regulated Flow Frequency Curves. The regulated flow frequency curves were estimated by integrating the regulated versus unregulated relationship with the 1-day or 15-day unregulated VDF curve.

a. Coralville Lake Regulated Flow Frequency Curve. The Coralville Lake regulated flow frequency curve was computed by integrating the (1959-2019) 15-day VDF curve (Table B-13) and the regulated versus unregulated relationship (Figure B-10 through Figure B-11). For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates, and typically are associated with seasonal maximum release rates for normal flood operations at the reservoir. The resulting regulated flow frequency curves for each alternative are shown in Figure B-71 to Figure B-74. Table B-15 through Table B-18 provide the existing condition (current water control plans) and alternative flow frequency estimates for gage locations along the Iowa River.

Table B-15. Regulated 1-Day Flow and Elevation Frequencies - Alternative 1 Existing Conditions. Based on 1959-2019 Simulations

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow,**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	686.0	5,100	5,300	7,700	21,100
1.4-yr	0.7	689.3	6,700	8,100	12,400	28,700
2-yr	0.5	697.6	10,000	10,300	15,700	40,600
5-yr	0.2	708.1	10,000	11,200	23,000	72,700
10-yr	0.1	711.1	12,000	14,500	31,600	80,200
20-yr	0.05	712.6	21,000	22,700	45,800	104,000
50-yr	0.02	715.2	29,300	31,700	56,200	141,000
100-yr	0.01	716.2	35,200	37,500	64,600	161,000
200-yr	0.005	717.2	40,900	43,300	73,000	180,000
500-yr	0.002	718.4	48,300	50,700	84,300	206,000
1000-yr	0.001	719.1	53,800	56,100	92,900	226,000

Table B-16. Regulated 1-Day Flow and Elevation Frequencies - Alternative 2C. Based on 1959-2019 Simulations.

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow,**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	686.0	5,200	5,300	7,800	21,100
1.4-yr	0.7	686.0	10,000	10,300	13,100	31,300
2-yr	0.5	694.2	10,000	10,900	17,800	42,600
5-yr	0.2	707.0	12,000	14,100	26,800	71,900
10-yr	0.1	708.0	12,000	16,000	34,200	81,200
20-yr	0.05	710.5	16,000	17,700	45,000	105,000
50-yr	0.02	714.4	26,500	29,400	54,500	140,000
100-yr	0.01	715.8	33,000	35,800	63,000	159,000
200-yr	0.005	717.0	39,400	42,100	71,600	179,000
500-yr	0.002	718.3	47,600	50,100	83,000	205,000
1000-yr	0.001	719.1	53,700	56,100	91,800	225,000

Table B-172. Regulated 1-Day Flow and Elevation Frequencies - Alternative 5.
Based on 1959-2019 Simulations.

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow,**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	686.0	5,200	5,300	7,800	21,100
1.4-yr	0.7	686.4	8,000	9,100	13,100	30,100
2-yr	0.5	696.5	10,000	10,700	16,300	41,900
5-yr	0.2	707.2	12,000	13,400	26,700	71,800
10-yr	0.1	708.8	12,000	14,900	30,500	81,200
20-yr	0.05	711.5	18,000	19,600	41,000	109,000
50-yr	0.02	714.6	27,300	29,800	55,200	140,000
100-yr	0.01	715.9	33,600	36,100	63,600	160,000
200-yr	0.005	717.0	39,800	42,300	72,100	179,000
500-yr	0.002	718.3	47,700	50,200	83,500	206,000
1000-yr	0.001	719.1	53,500	56,100	92,100	225,000

Table B-18. Regulated 1-Day Flow and Elevation Frequencies - Alternative 8.
Based on 1959-2019 Simulations.

		Gage Location				
Recurrence Interval	**AEP**	**Coralville Lake (Elevation, ft)**	**Coralville Release (Flow,**	**Iowa City (Flow, cfs)**	**Lone Tree (Flow, cfs)**	**Wapello (Flow, cfs)**
1.1-yr	0.9	686.0	5,200	5,300	7,800	21,100
1.4-yr	0.7	686.2	8,500	9,900	13,100	30,500
2-yr	0.5	694.6	10,000	10,700	17,500	42,600
5-yr	0.2	707.0	12,000	13,600	25,300	71,800
10-yr	0.1	708.2	12,000	15,400	34,200	81,200
20-yr	0.05	710.3	18,000	19,500	45,500	106,000
50-yr	0.02	714.5	26,800	29,700	54,700	140,000
100-yr	0.01	715.9	33,100	35,900	63,200	160,000
200-yr	0.005	717.0	39,300	42,000	71,800	179,000
500-yr	0.002	718.2	47,200	49,800	83,200	205,000
1000-yr	0.001	719.0	53,100	55,500	91,900	225,000

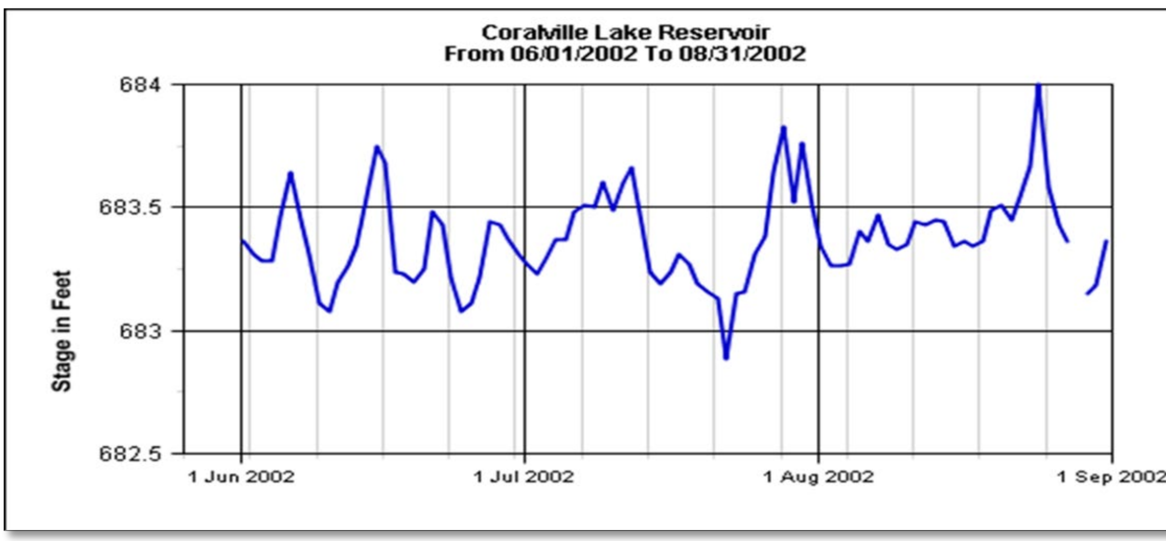
b. Iowa City, Lone Tree, and Wapello Regulated Flow Frequency Curves. The regulated flow frequency curves for the gages on the Iowa River below Coralville Lake were similarly computed by integrating the applicable (1959-2019) 15-day or 1-day VDF curve and the regulated versus unregulated relationship. For flood frequencies less than approximately the 10% AEP (10-year) event, the regulated versus unregulated flow pairs from the period of record HEC-ResSim simulation (plotted using Weibull plotting position) were used to inform the flow frequency estimates. The resulting regulated flow frequency curves for each alternative are shown in Figure B-75 through Figure B-86. Table B-15 through Table B-18 provide the existing condition (current water control plans) and alternative flow frequency estimates for gage locations along the Iowa River.

5. Reservoir Elevation Frequency Analysis. The Coralville Lake reservoir elevation frequencies were computed by integrating the outlet works rating curve and the regulated flow frequency curve for flow releases exceeding the maximum regulated condition (release of 21,000 cfs). Plotting position AEP estimates were used for more frequent events when the reservoir utilizes storage to control flows per the release schedule. Figure B-87 through Figure B-90 show the resulting reservoir elevation frequency curves for each alternative. Table B-15 through Table B-18 provide the existing condition (current water control plans) and alternative flow frequency estimates for gage locations along the Iowa River.

6. Comparison to Period of Record Estimates. Figure B-87 through Figure B-90 show a graphic comparison of the regulated flow and elevation frequency curves along the Iowa River. As shown, the regulated and unregulated flow frequency estimates increase, at all locations, in the 1959 to 2019 record as compared to the full period of record (1917-2019). In general, for rarer events, the estimated frequency of a given peak flow is approximately twice as likely in the 1959 to 2019 record as compared to the full period of record.

VII. ESTABLISHMENT OF AN ALLOWABLE OPERATING BAND AND EVALUATION OF FISH AND WILDLIFE MEASURES

The current operating plan for Coralville Lake utilizes a single elevation to define the conservation pool level to be maintained during normal (non-flood or drought) operations. In reality, the reservoir level fluctuations daily due to natural (rain, wind) and operational (discrete gate settings based upon forecasted flow conditions) reasons. The following chart shows the type of normal fluctuations that occur within the reservoir during non-flooding periods.



As shown in the chart, the reservoir elevation fluctuated within approximately a one-foot band above the stated conservation pool level of 683 feet. In general, the reservoir is operated to avoid falling below this elevation due to access impacts at infrastructure around the lake and to not impact available conservation storage (used for low-flow augmentation during periods of drought) which has been reduced due to ongoing reservoir sedimentation. In updating the water control plan, it is desired to formally accommodate these fluctuations into an identified operating band (as opposed to continuing to identify a single elevation). Operating within a defined band, as opposed to a single target value, is currently incorporated into the water control plans at the other reservoir and lock and dam projects within the Rock

Island District. Use of an operating band accounts for operational uncertainties inherently related to forecasting reservoir inflows as well as provides the operational flexibility to support:

- Completion of routine, minor maintenance activities
- Accommodating minor (short-term) stakeholder requests
- Management for fish and wildlife resources during non-flood or drought periods

Examples of routine, minor maintenance activities include short term reductions in dam releases to accomplish inspection activities (e.g., condition survey of the stilling basin) and similar reductions to facilitate removal of debris from the upstream trash racks. An example of a minor stakeholder request received in the past is to temporarily reduce dam releases to assist search and rescue operations in the river downstream of the reservoir. These types of operations result in short term usage of a small amount of reservoir storage that can immediately be released following the event (often within the same day), while maintaining the reservoir elevation within a defined operating band. Management for fish and wildlife resources during non-flood or drought periods is discussed in the section below.

A. Evaluation of Potential Fish and Wildlife Measures

Operation of Coralville Lake for fish and wildlife resources was authorized as part of the 1958 Fish and Wildlife Coordination Act (Public Law No. 624, 85th Congress). The Act authorizes such operations provided that they are "compatible with the purposes for which the project was authorized." Under the current water control plan, the primary operational consideration included for fish and wildlife management is the allowance for up to a 3-foot fall pool raise to be conducted between September 15 and December 15. As part of this study effort, the study team met with the state and federal resource agency partners to identify potential additional measures to include in the study. The natural resource partners identified the following potential measures:

- Increasing the allowable fall pool raise to provide greater benefits to migratory waterfowl.
- Allowing the fall pool raise to be held through the winter months (ending May 1) to reduce the impacts to herptiles associated with drawing the pool down in mid-December.
- Allowing for not drawing the conservation pool down to 679 in spring to improve conditions for fish in the reservoir.

The identified measures are designed to provide operational flexibilities to support fish and wildlife resources during non-flood or drought periods. Historically, Coralville Lake has been in normal (non-flood or drought) operations in excess of 90% of the time (Figure B-27). By identifying and incorporating operational flexibilities in the form of an operating band (rather than identifying highly specific seasonal operations), the project is better able to support a range of potential management actions and allows for adaptive management. This flexibility is critical due to:

- Fish and wildlife priorities and concerns can and will change over time;
- The same management actions may not be needed or desired every year;

- Opportunities are likely to be dictated by flow conditions within an individual year; and
- Ongoing reservoir sedimentation may change needs and/or opportunities over time

To test whether the potential fish and wildlife measures could be incorporated within a proposed operating band without negatively impacting flood risk management, sensitivity analyses were run in HEC-ResSim by conducting period of record analyses (1917-2019) with the preferred flood risk management plan, Alternative 2C, and using 2 different conservation pool levels: (1) the target reservoir elevation in the current water control plan; and (2) the upper limit of the potential operating band if all of the fish and wildlife measures were incorporated. The results of the analysis are summarized below for each potential measure:

- Increasing the allowable fall pool raise. Raising the allowable fall pool raise by 2 feet in the HEC-ResSim model produced no impact to downstream peak discharges. While fall flood events (or summer events that extend into the fall season) have occurred, the flooding overrides (rather than adds to) the fall pool raise operations. The one year that did show a minor impact was in 2015 where a unique December heavy rainfall event occurred. For this one event, the resulting reservoir elevation would have been increased due to the higher fall pool raise in place at the time of the rain event; however, the resulting peak reservoir elevation was still below that which would have resulted in any increase in reservoir release.
- Holding the fall pool raise through the winter months. Holding the fall pool raise through winter (until March 1) resulted in a few years where the reservoir could not be fully brought down to normal conservation levels before the start of spring flooding. This resulted in higher peak reservoir levels that in one year (2010) resulted in a higher peak reservoir release (in the other impacted years, it resulted in higher reservoir levels but did not change the peak release). Attempting to mitigate this risk (by monitoring snowpack and precipitation forecasts) through proactively drawing the reservoir back down earlier than March 1 would be difficult due to the presence of ice cover on the lake during the winter months. Attempting to draw down the lake with an intact ice cover would result in public safety concerns. For these reasons, this measure is not recommended for implementation.
- Allowing the option to not draw down the reservoir level to 679 feet (4 feet below normal conservation levels). While the value of the storage created by the spring drawdown has been diminished due to reservoir sedimentation, in the right year, it can make a difference. Completely eliminating the 4-foot spring drawdown of the reservoir resulted in one year (1973) where the higher starting conditions resulted in an increase in the peak release from the reservoir. Unlike the winter operations discussed above, the spring reservoir level could be managed in response to observed snow pack, streamflows, and forecasted precipitation to balance needs across the authorized operating purposes (flood risk management, low-flow augmentation, and fish and wildlife management).

B. Recommended Operating Band

Figure B-91 shows the recommended operating limits for Coralville Lake during normal (non-flood or drought) conditions. For much of the year, the allowable operating band would be between elevation 683 and 684 feet; reflecting the range over which reservoir levels have historically been managed. During the late winter and spring (February 15 – May 20), the operating limits would expand to incorporate, but not require, the current spring drawdown to elevation 679 feet. In the fall (15 September through 15 December) the current allowable fall pool raise would be increased by two feet (from elevation 686 feet to elevation 688 feet).

The flexibility in late winter and spring operations would allow for situational management of water levels based upon observed conditions. During wet conditions, characterized by heavier than normal snowpack or significant forecasted rainfall events, the reservoir could be lowered within the band in advance of the runoff to increase available storage. During dry to normal conditions, the normal conservation level (elevation 683 feet) can be maintained to preserve full conservation storage, benefit fish and wildlife, and to improve public safety (in recent years, reservoir sedimentation has result in boaters becoming stuck in the drawn down lake necessitating local rescue response). The flexibility to preserve the normal conservation level during periods of drought has become more critical due to ongoing reservoir sedimentation. Since being placed into operation in 1958, 62% of the available conservation storage below elevation 683 feet has been lost due to sedimentation. Automatically drawing down the lake to elevation 679 would eliminate an additional 54% of the remaining conservation storage available to meet the low-flow augmentation (drought management) mission, greatly reducing the reliability of the project to meet conservation releases during a drought.

VIII. REFERENCES

Eash, D.A., Barnes, K.K., and Veilleux, A.G., 2013, Methods for estimating annual exceedance-probability discharges for streams in Iowa, based on data through water year 2010: U.S. Geological Survey Scientific Investigations Report 2013–5086, 63 p. with appendix. U.S.

U.S. Army Corps of Engineers; 2001; Water Control Manual, Coralville Lake, Iowa River Basin, Coralville, Iowa; Rock Island District, Rock Island, IL.

U.S. Army Corps of Engineers; 2009; Iowa River Regulated Flow Frequency Study; Rock Island District, Rock Island, IL.

Figure B-1. Iowa River Location Map, Extending from Upstream of Coralville Lake to Burlington, Iowa on the Mississippi River.

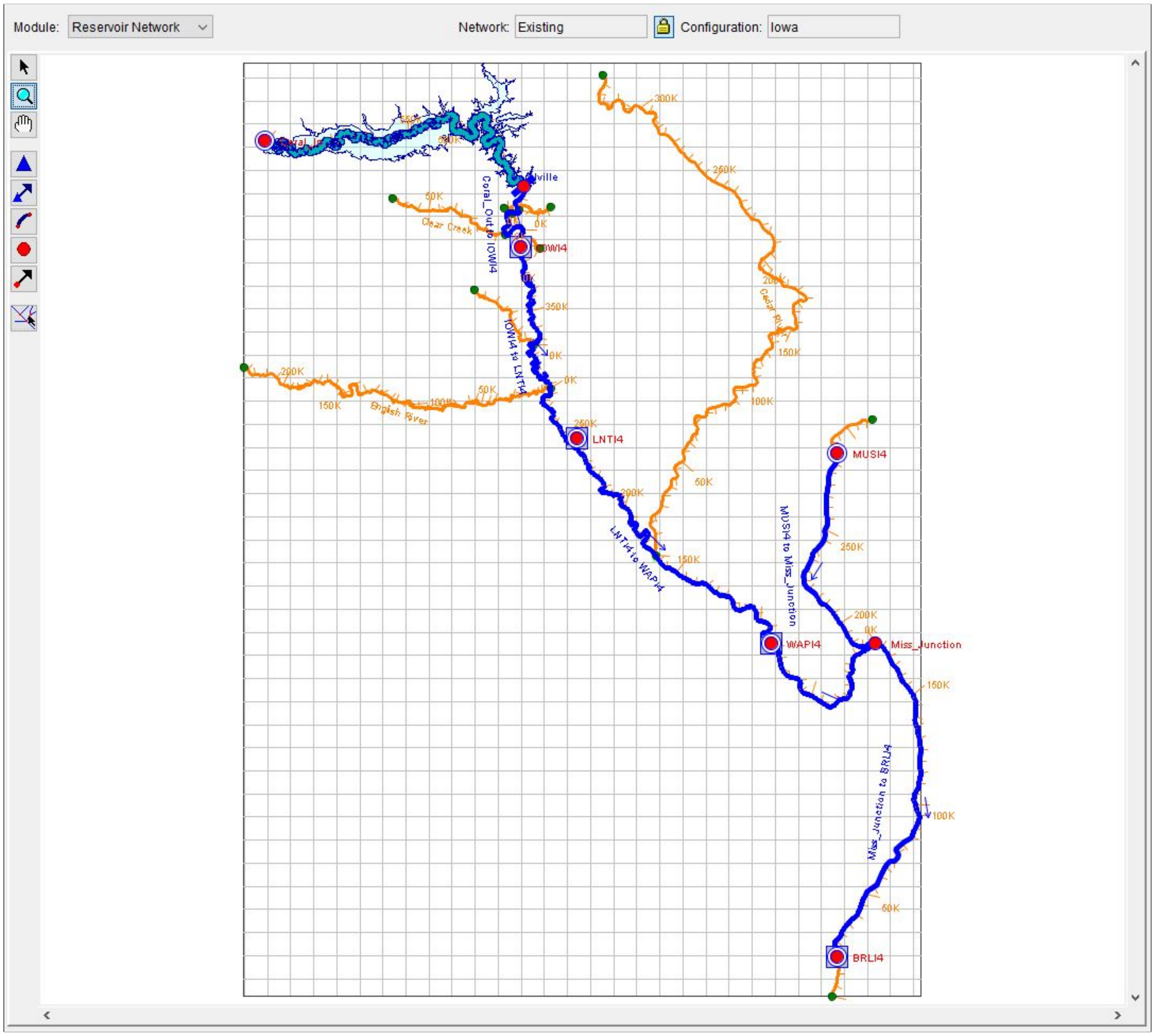


Figure B-2. The HEC-ResSim model schematic for the Existing Conditions between Coralville Lake on the Iowa River and Burlington, Iowa on the Mississippi River. The schematic shows the location of the Coralville Lake inflow and outflow points, as well as the common computation points (CCPs) on the Iowa River at Iowa City (IOWI4), Lone Tree (LNTI4), and Wapello (WAPI4), and on the Mississippi River at Muscatine (MUSI4) and Burlington (BRLI4).

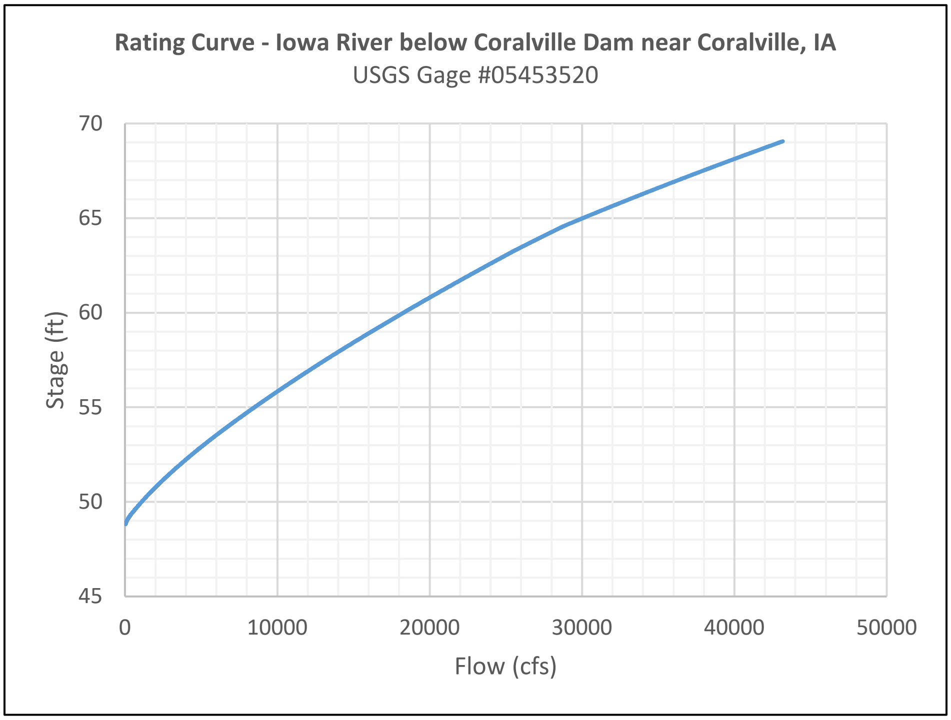


Figure B-3. Rating curve for the Iowa River Below Coralville Dam near Coralville, IA, USGS Gage #05453520

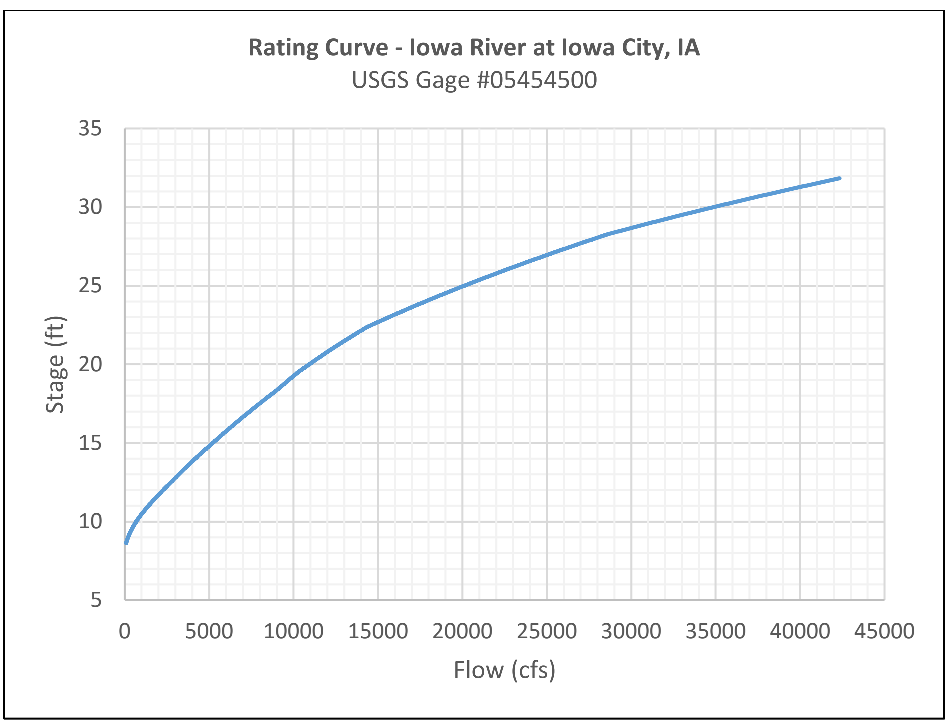


Figure B-4. Rating Curve for the Iowa River at Iowa City, Iowa Gage, USGS Gage #05454500

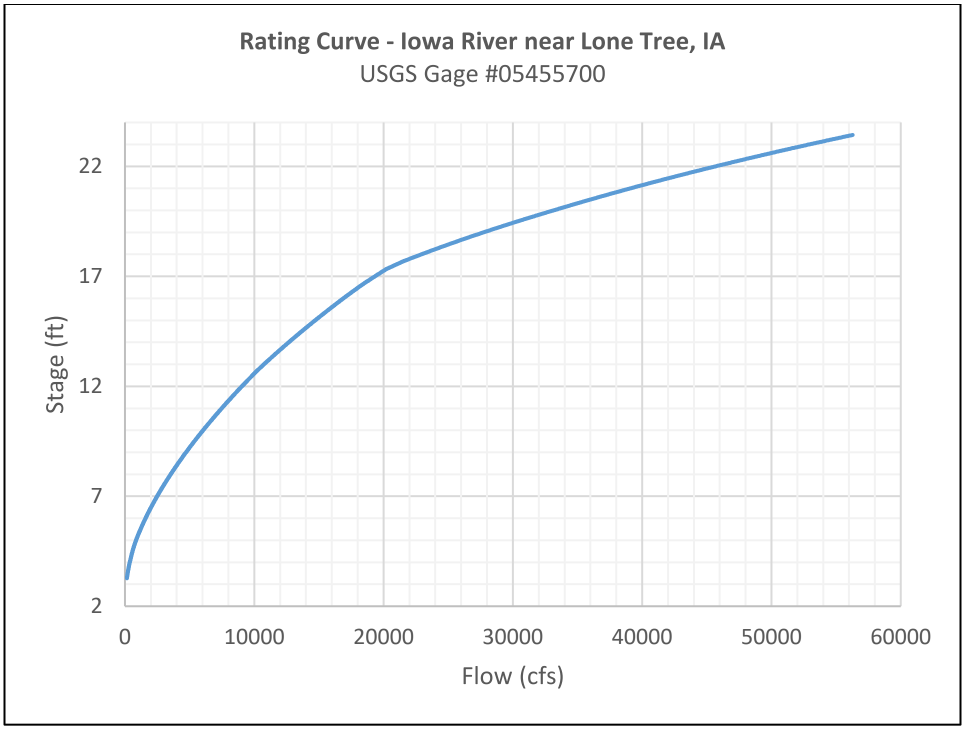


Figure B-5. Rating Curve for the Iowa River near Lone Tree, Iowa Gage, USGS Gage #05455700

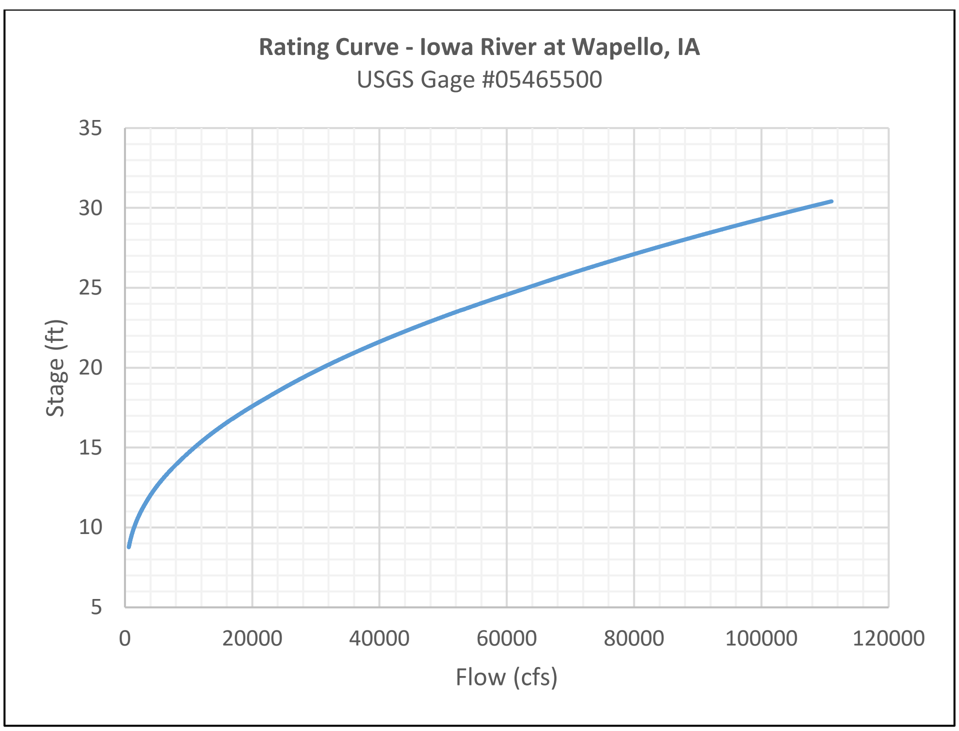


Figure B-6. Rating Curve for the Iowa River at Wapello, IA Gage, USGS Gage #05465500

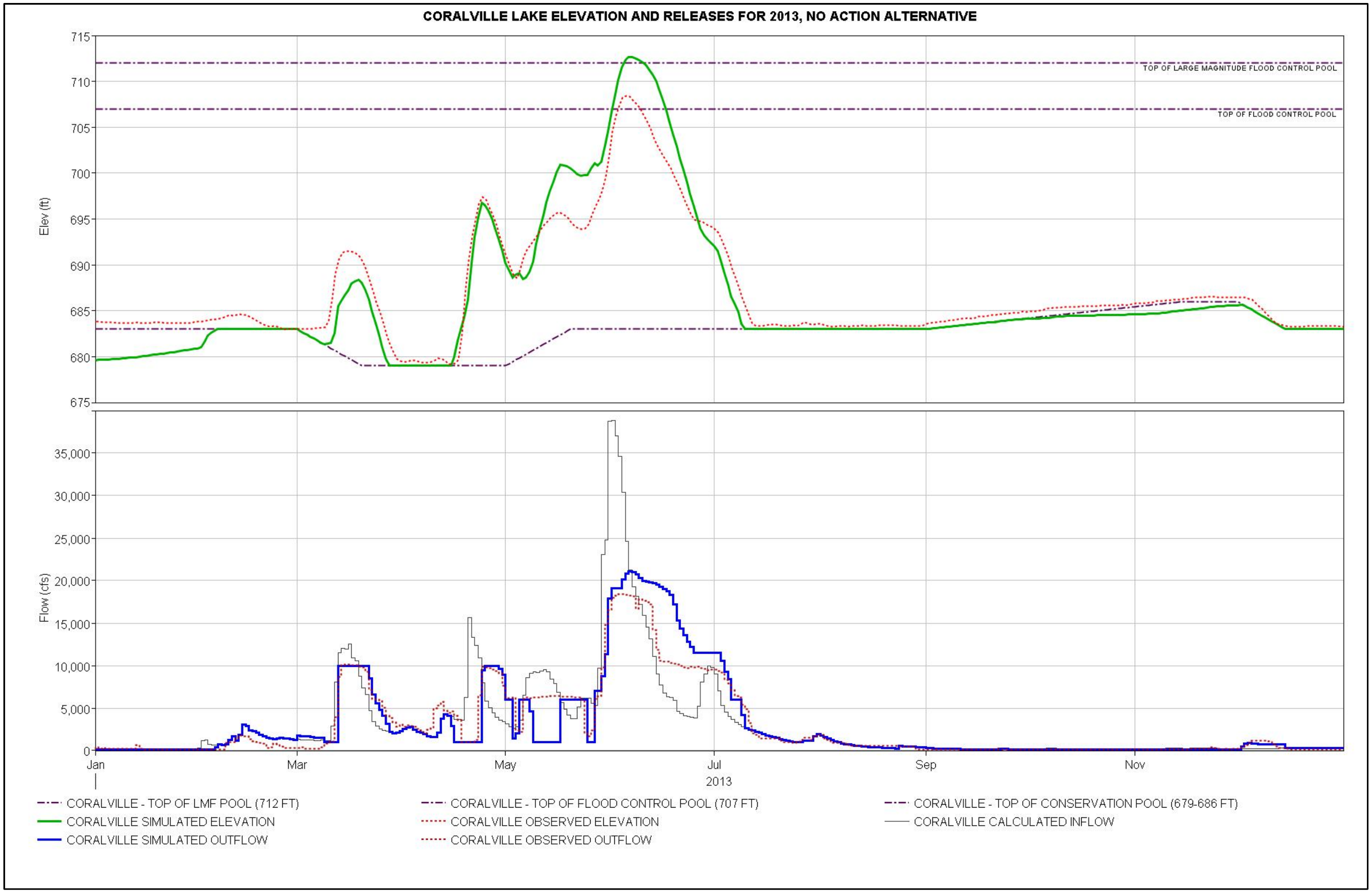


Figure B-7. Coralville Lake reservoir elevation and releases for 2013 calibration. Note the decrease in simulated releases prior to the event peak that was not replicated in the observed data.

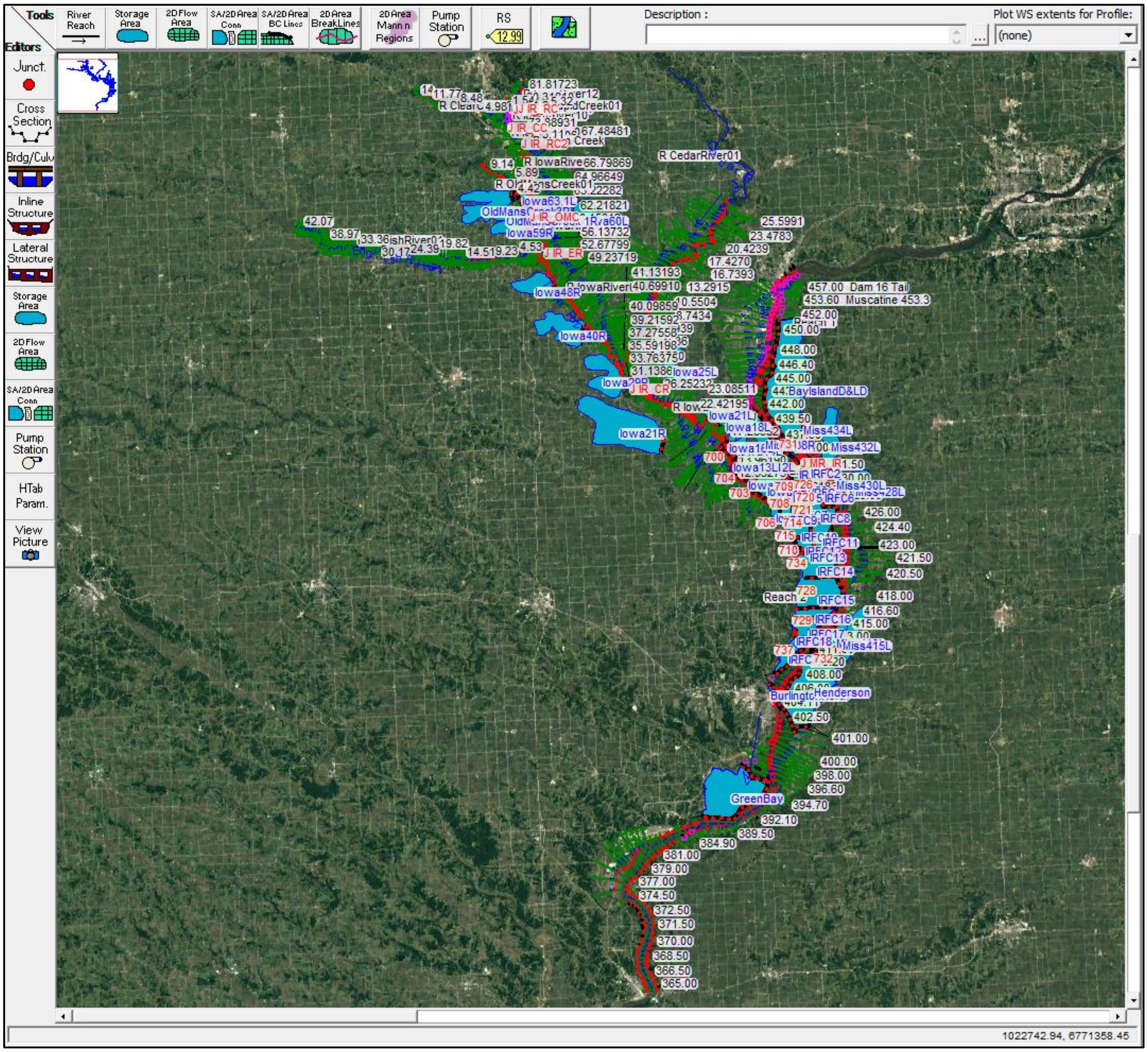


Figure B-8. Overview of the HEC-RAS model geometry. The model spans from immediately downstream of Coralville Dam to the confluence of the Mississippi and Iowa Rivers, and on the Mississippi River from the Dam 16 tailwater to Burlington, Iowa.

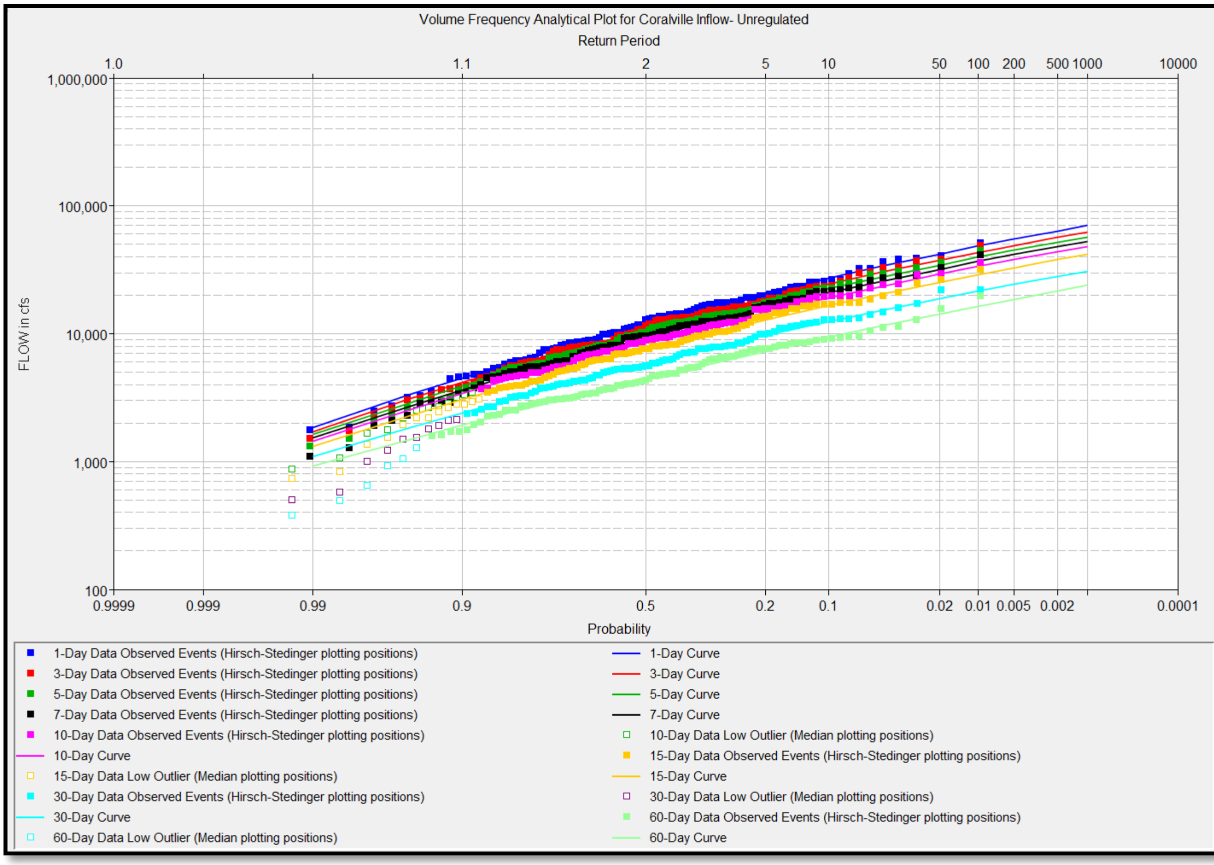
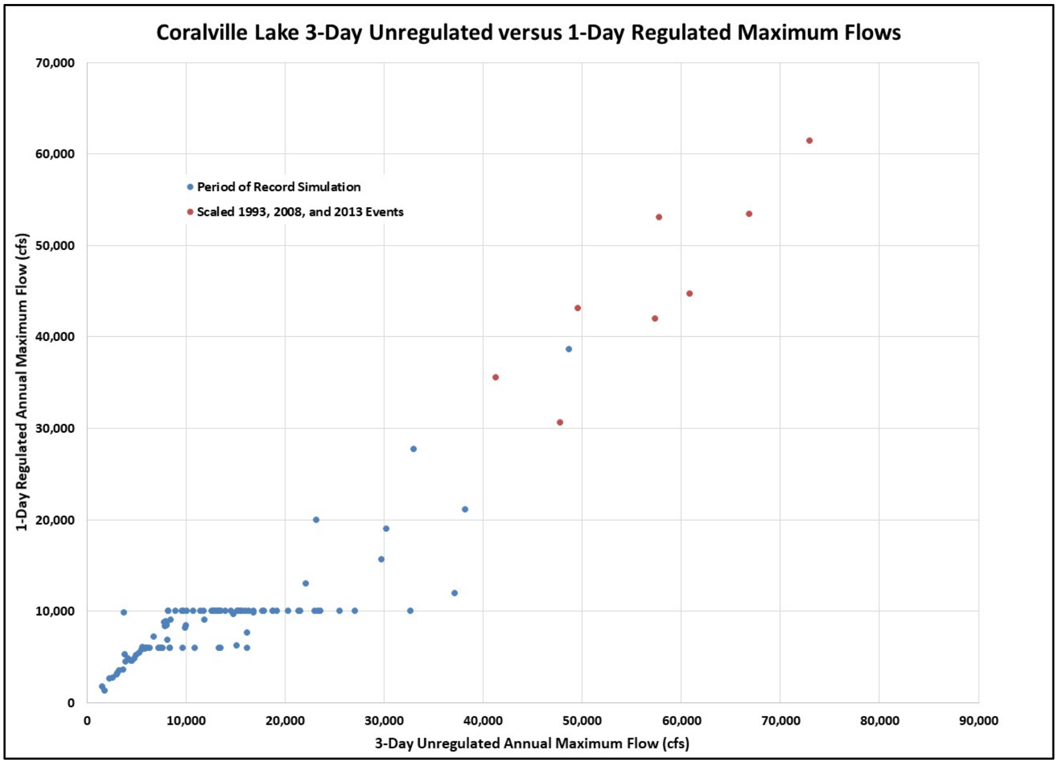


Figure B-9. Coralville Dam VDF Curves



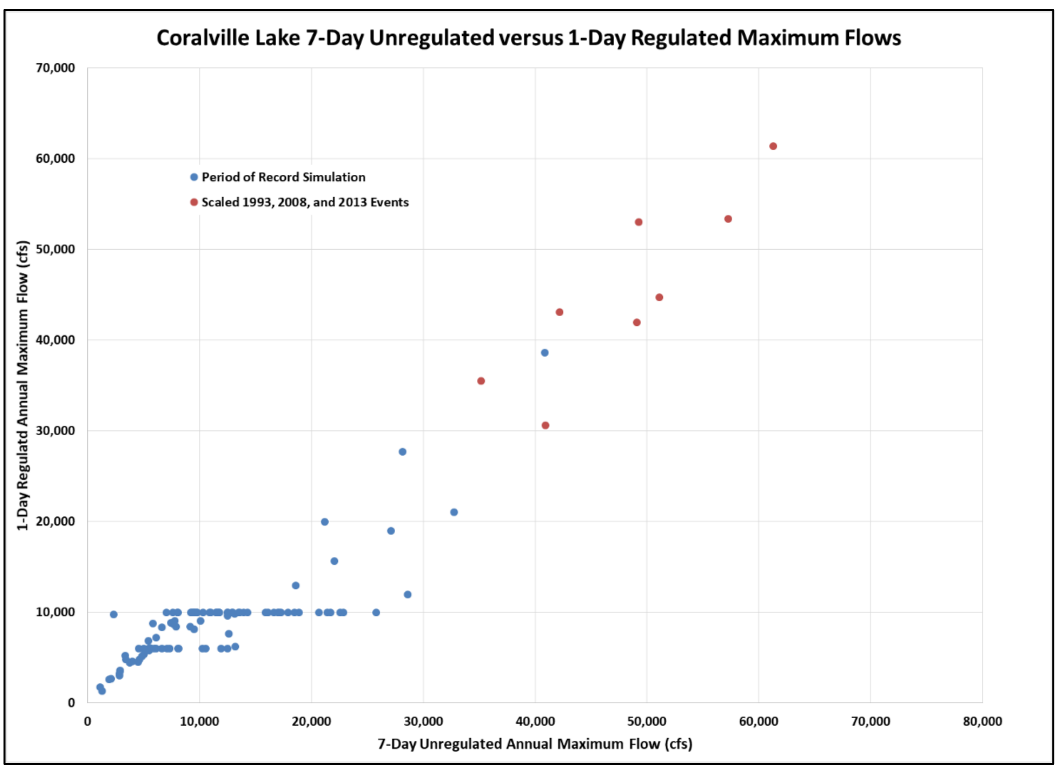
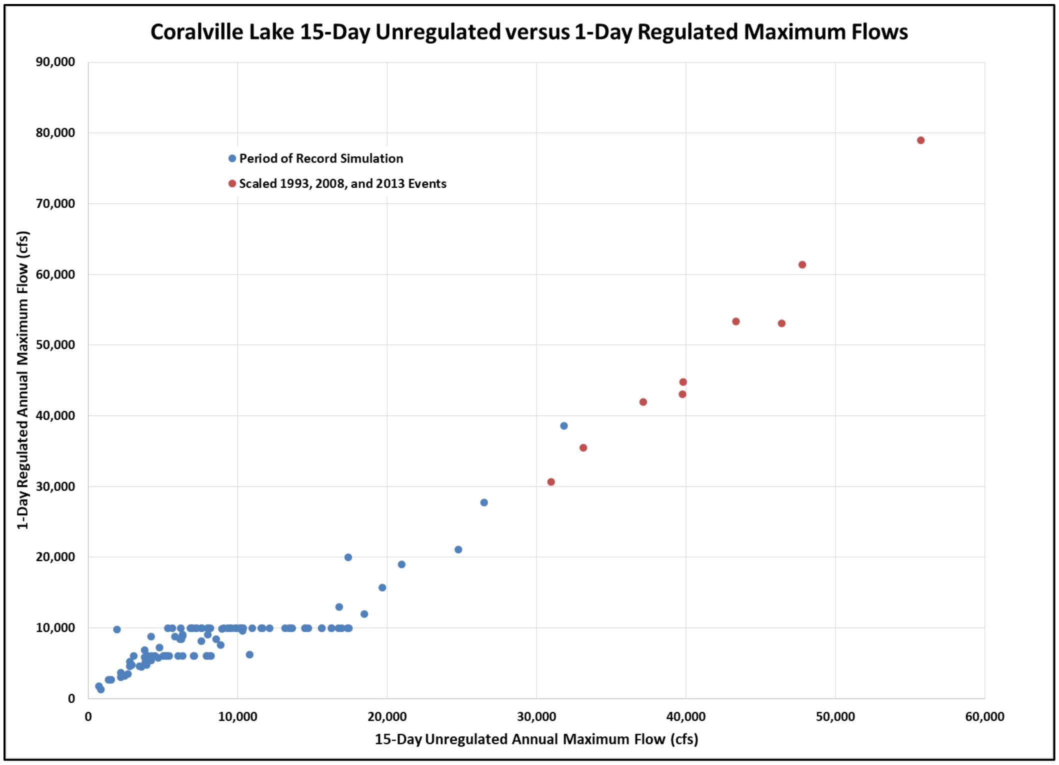


Figure B-10. Coralville Lake 3-Day and 7-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)



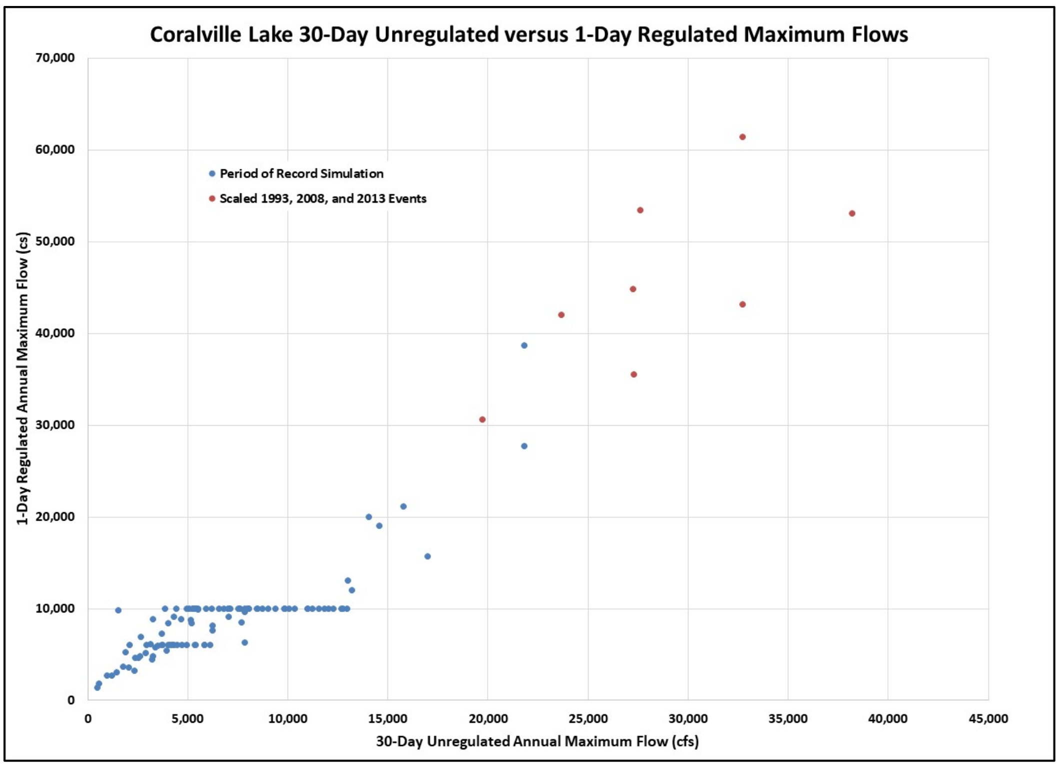
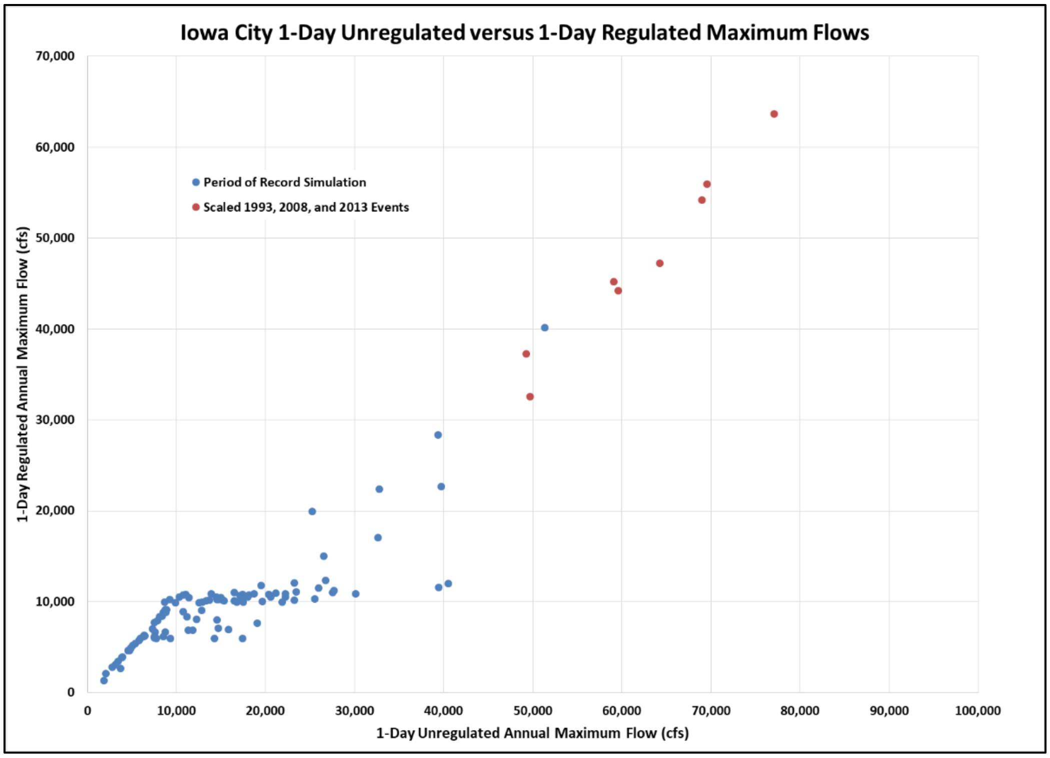


Figure B-11. Coralville Lake 15-Day and 30-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)



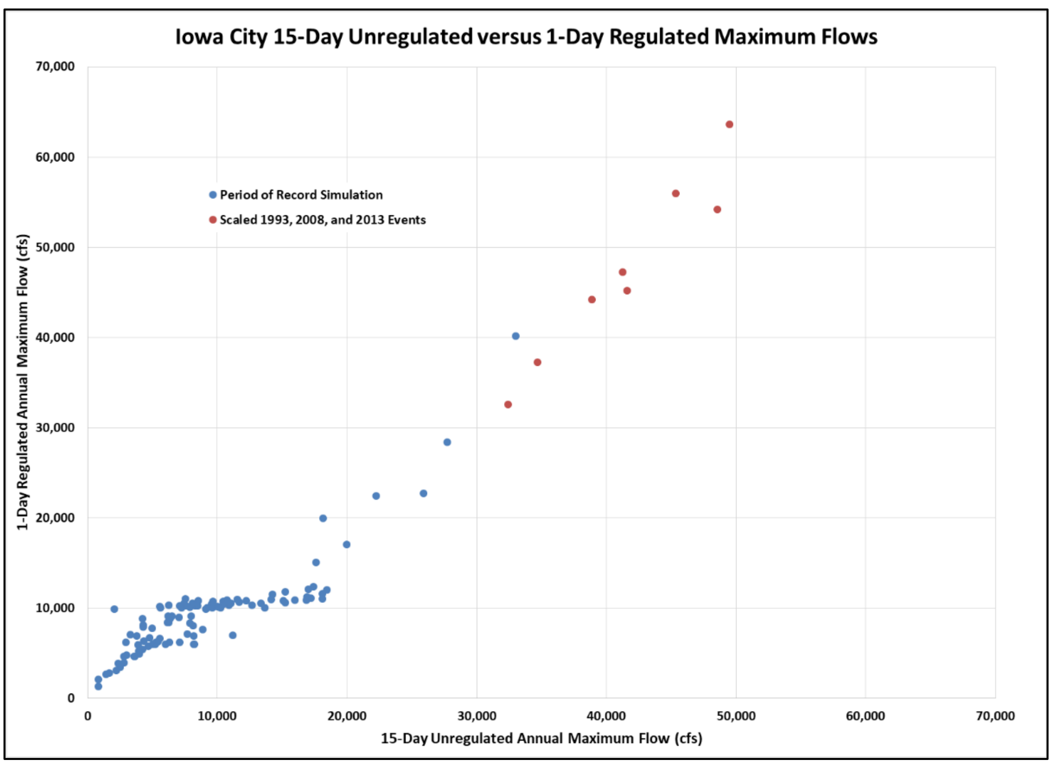
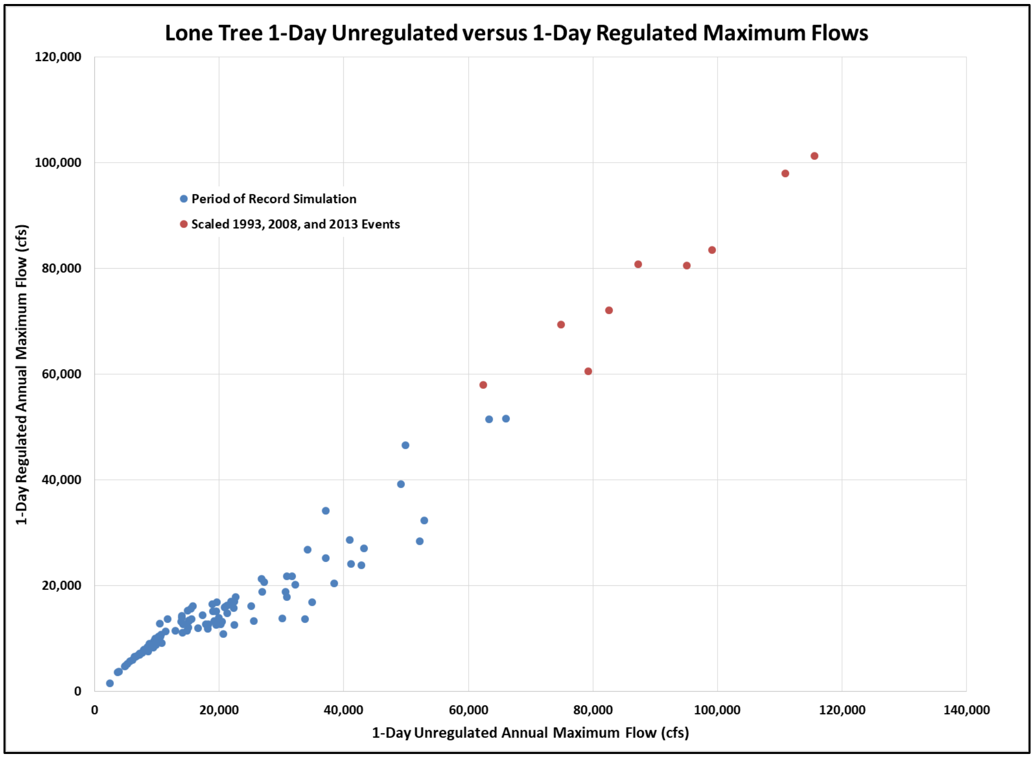


Figure B-12. Iowa River at Iowa City 1-Day and 15-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)



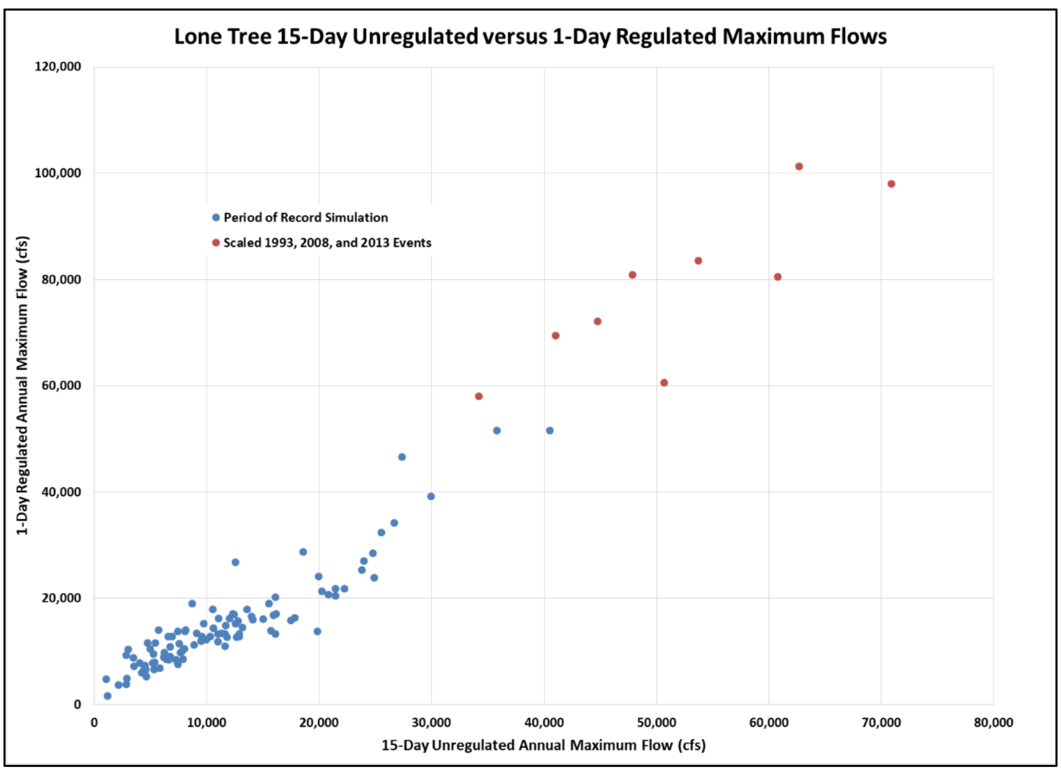


Figure B-13. Iowa River at Lone Tree 1-Day and 15-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)

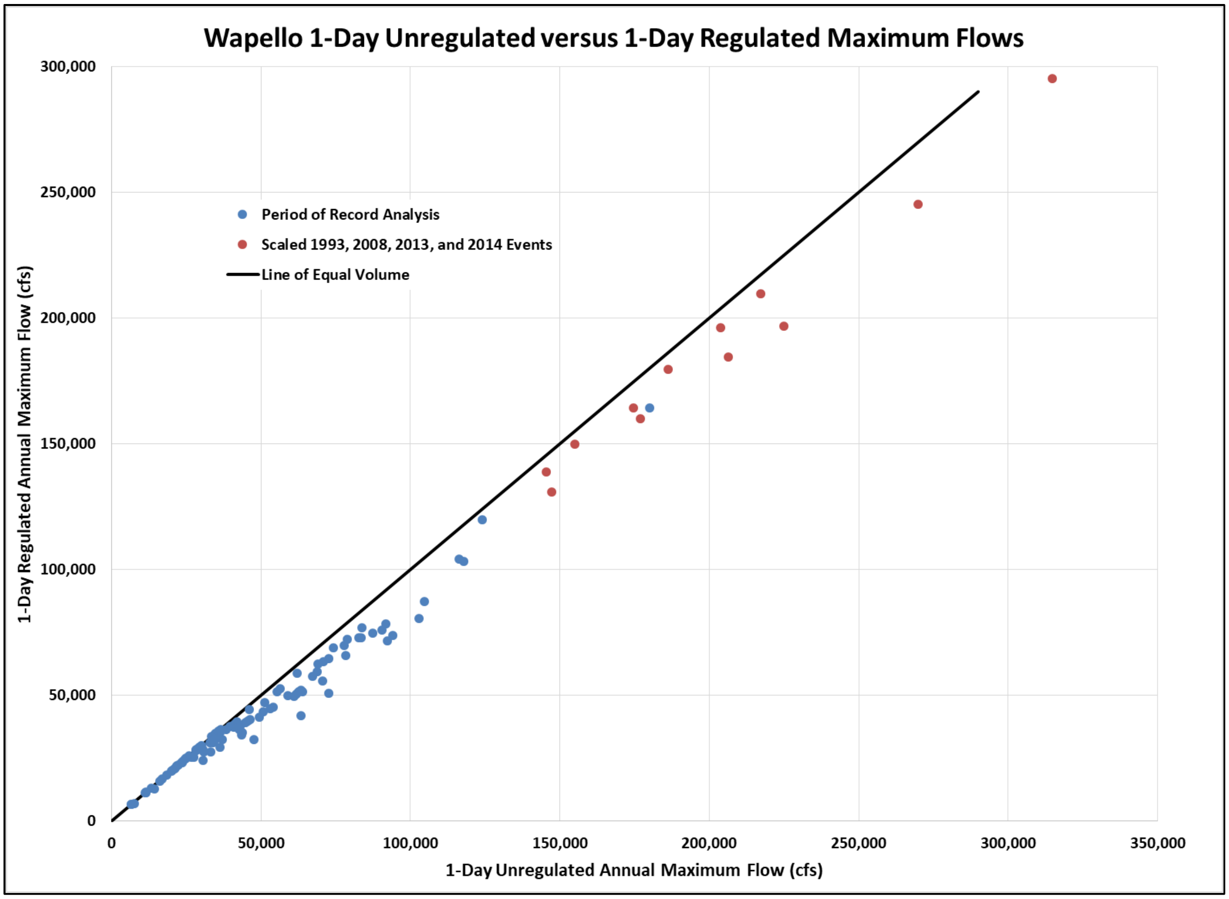


Figure B-14. Iowa River at Wapello 1-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)

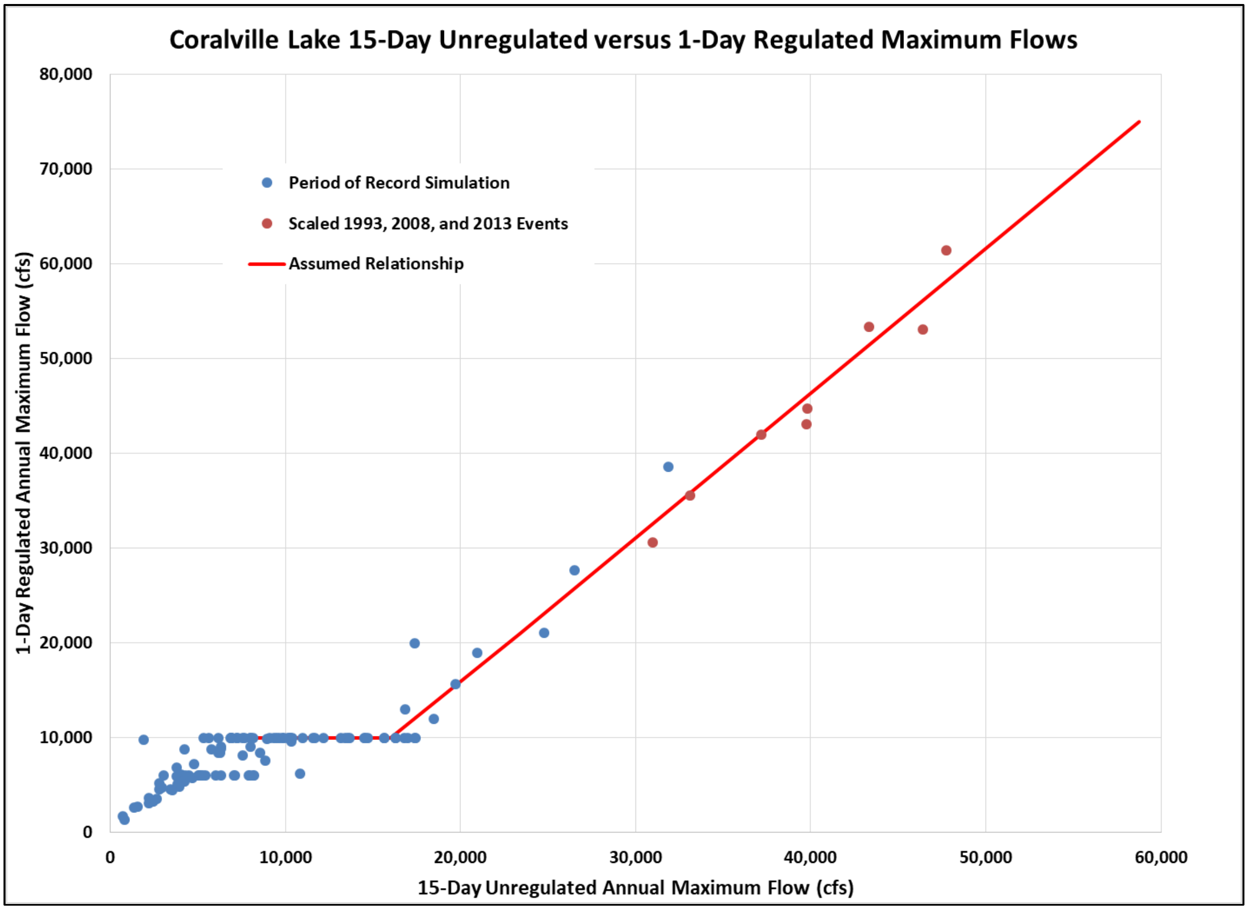


Figure B-15. Coralville Lake 15-Day Unregulated versus 1-Day Regulated Relationship – Existing Water Control Plan (Alternative 1)

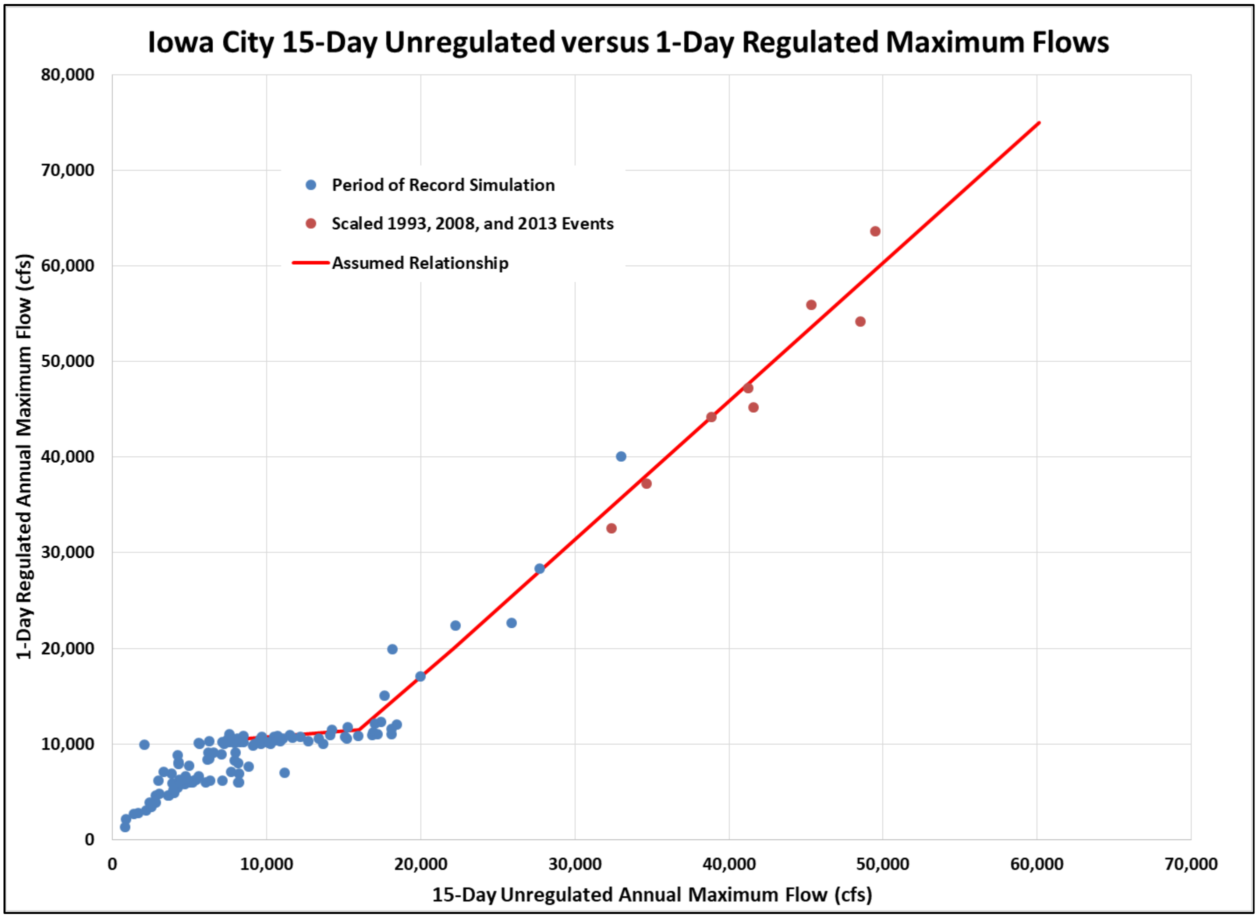


Figure B-16. Iowa River at Iowa City 15-Day Unregulated versus 1-Day Regulated Relationship – Existing Water Control Plan (Alternative 1)

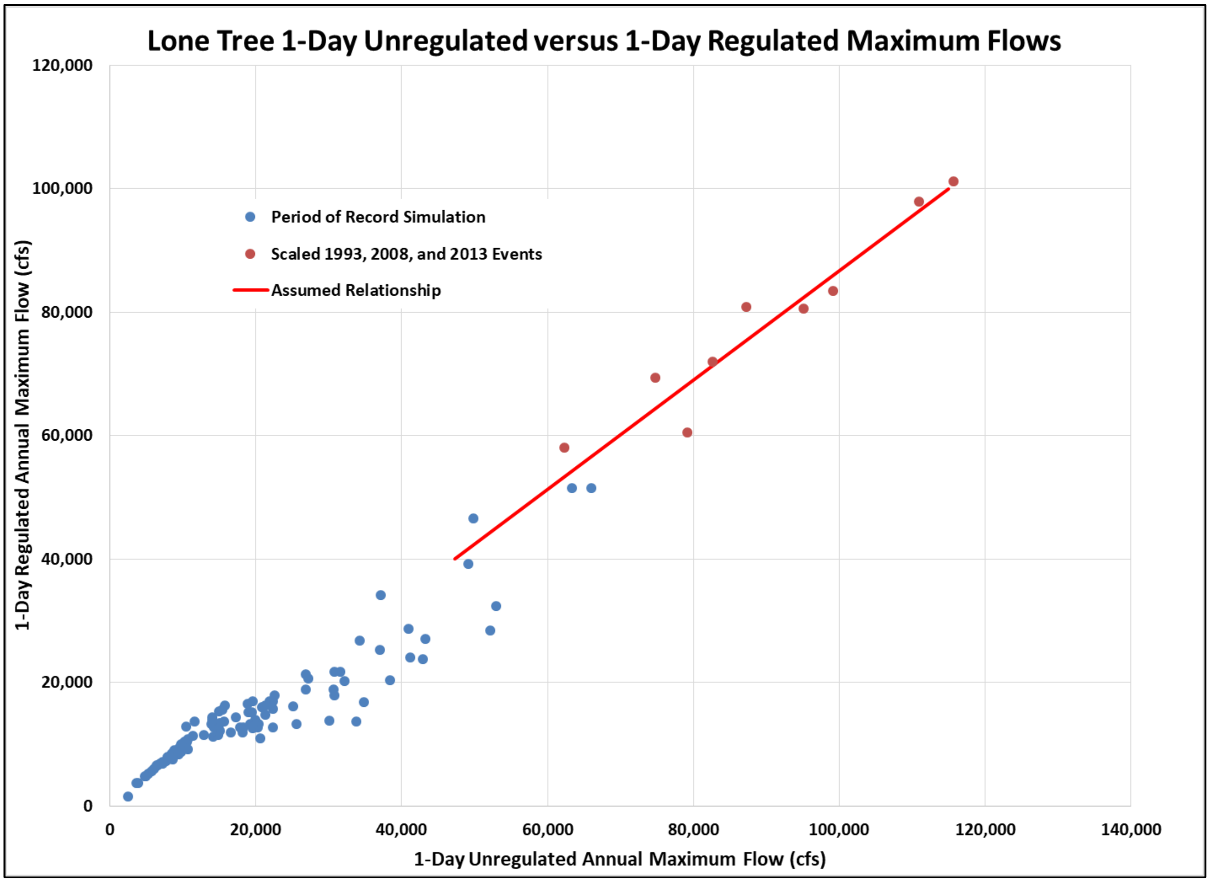


Figure B-17. Iowa River at Lone Tree 1-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)

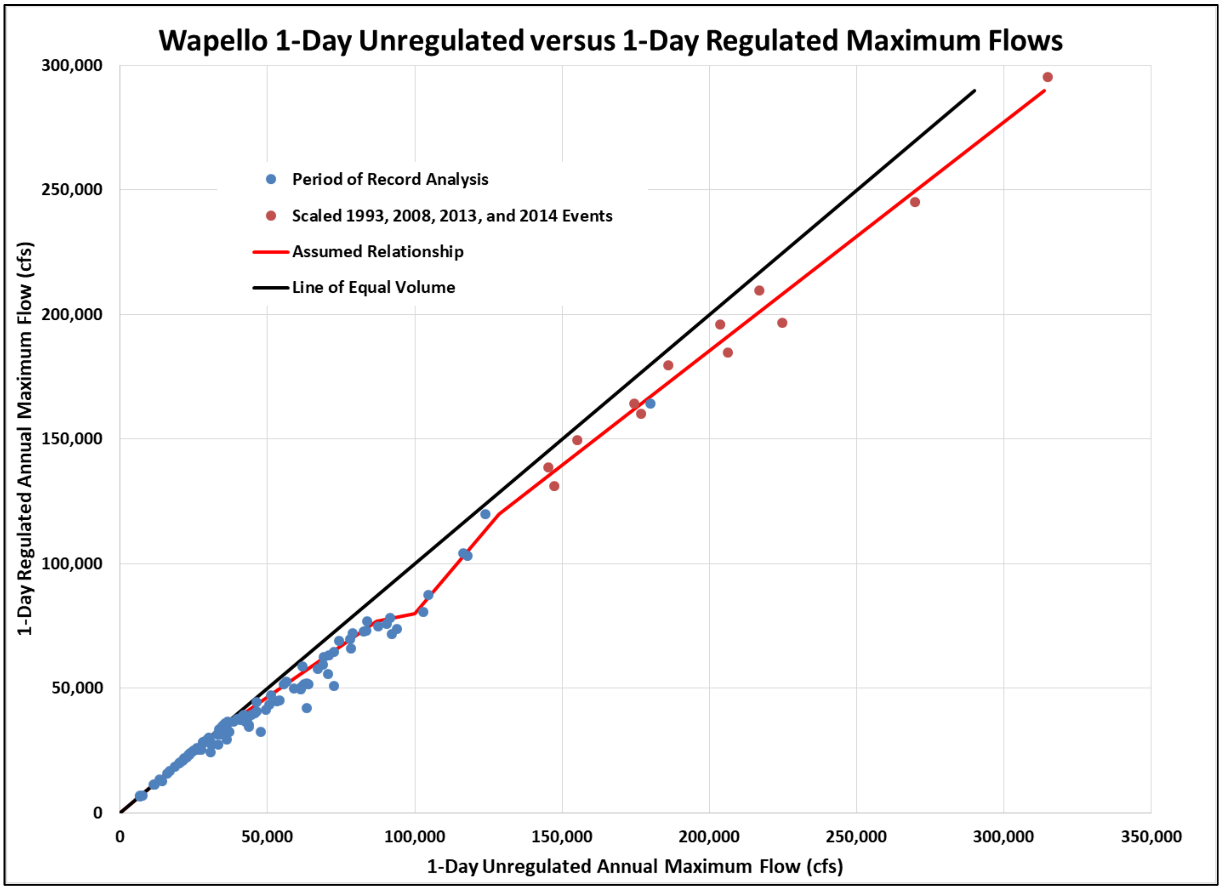


Figure B-18. Iowa River at Wapello 1-Day Unregulated versus 1-Day Regulated Relationships – Existing Water Control Plan (Alternative 1)

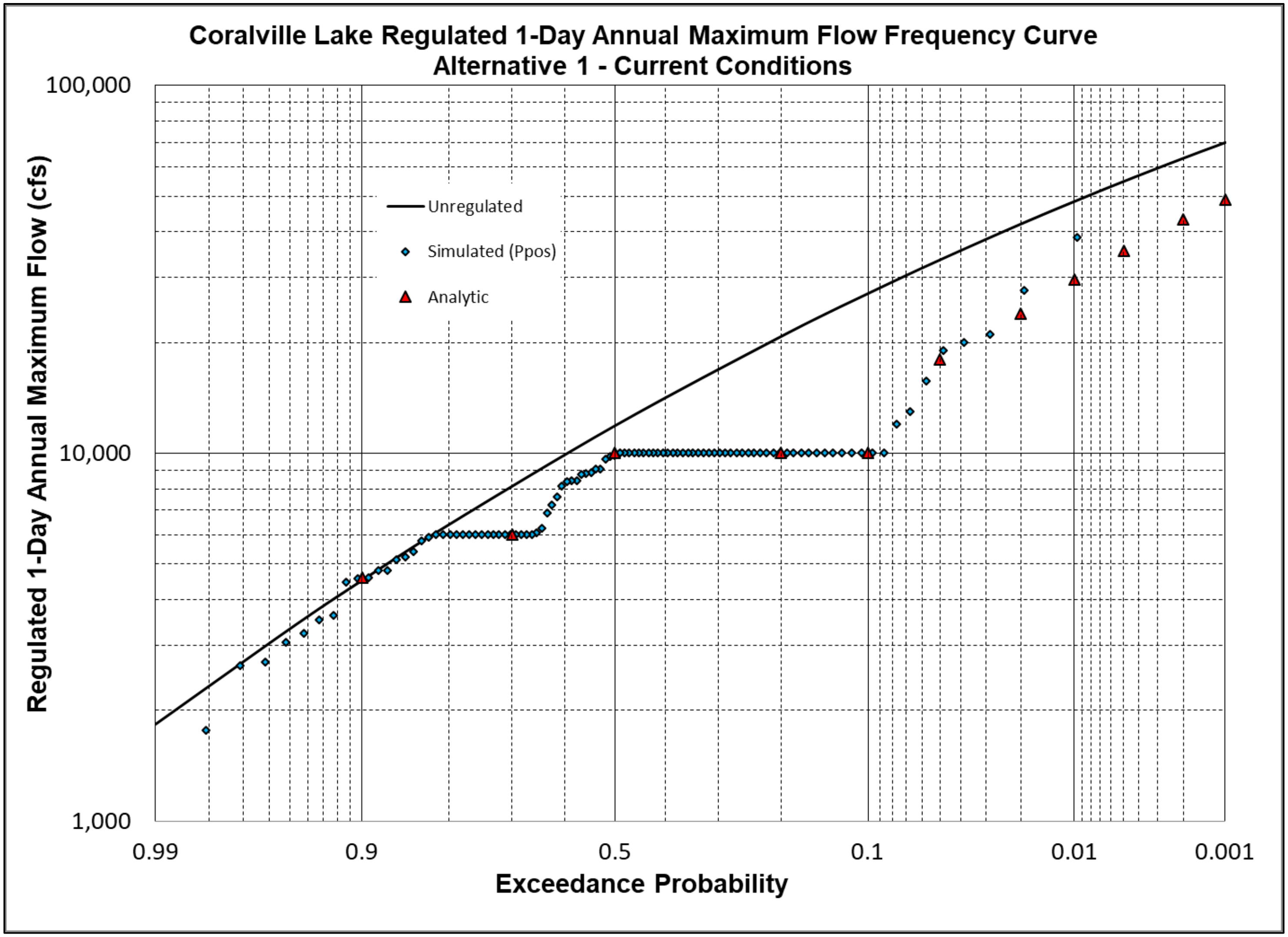


Figure B-19. Coralville Lake Regulated Flow Frequency Curve – Alternative 1, Existing Water Control Plans. AEPs for simulated events estimated using Weibell plotting position (Ppos).

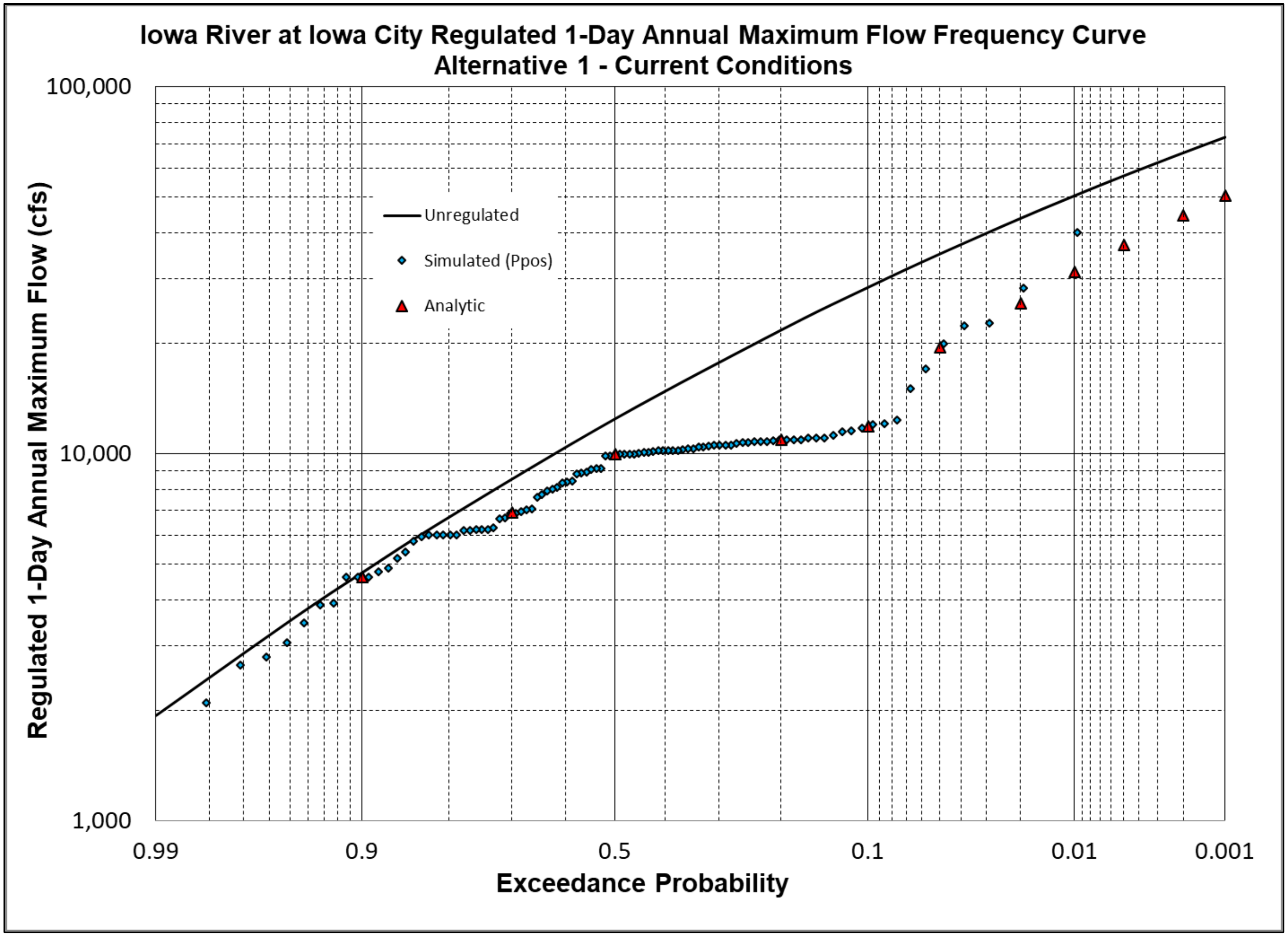


Figure B-20. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternative 1, Existing Water Control Plans. AEPs for simulated events estimated using Weibell plotting position (Ppos).

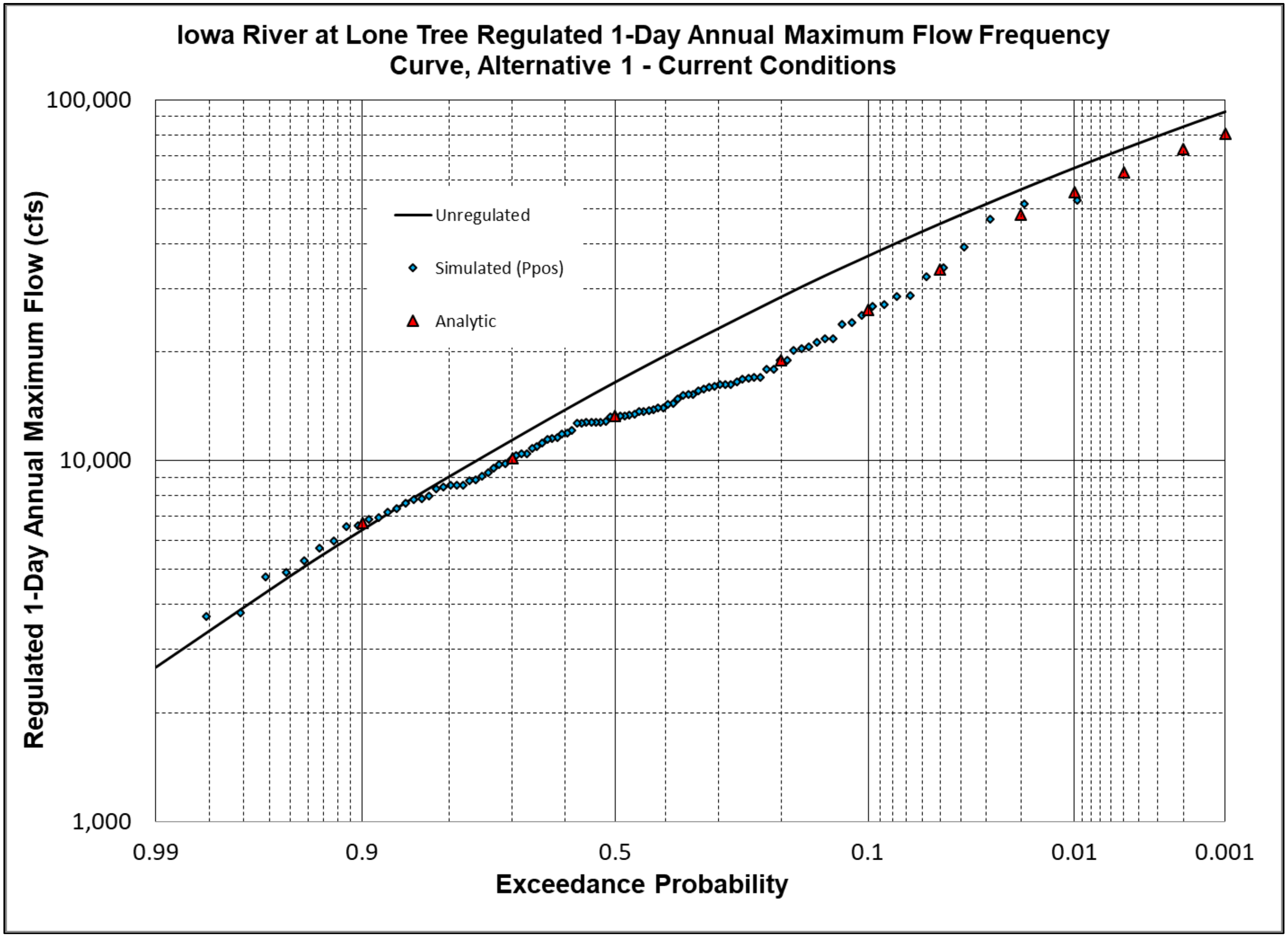


Figure B-21. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternative 1, Existing Water Control Plans. AEPs for simulated events estimated using Weibell plotting position (Ppos).

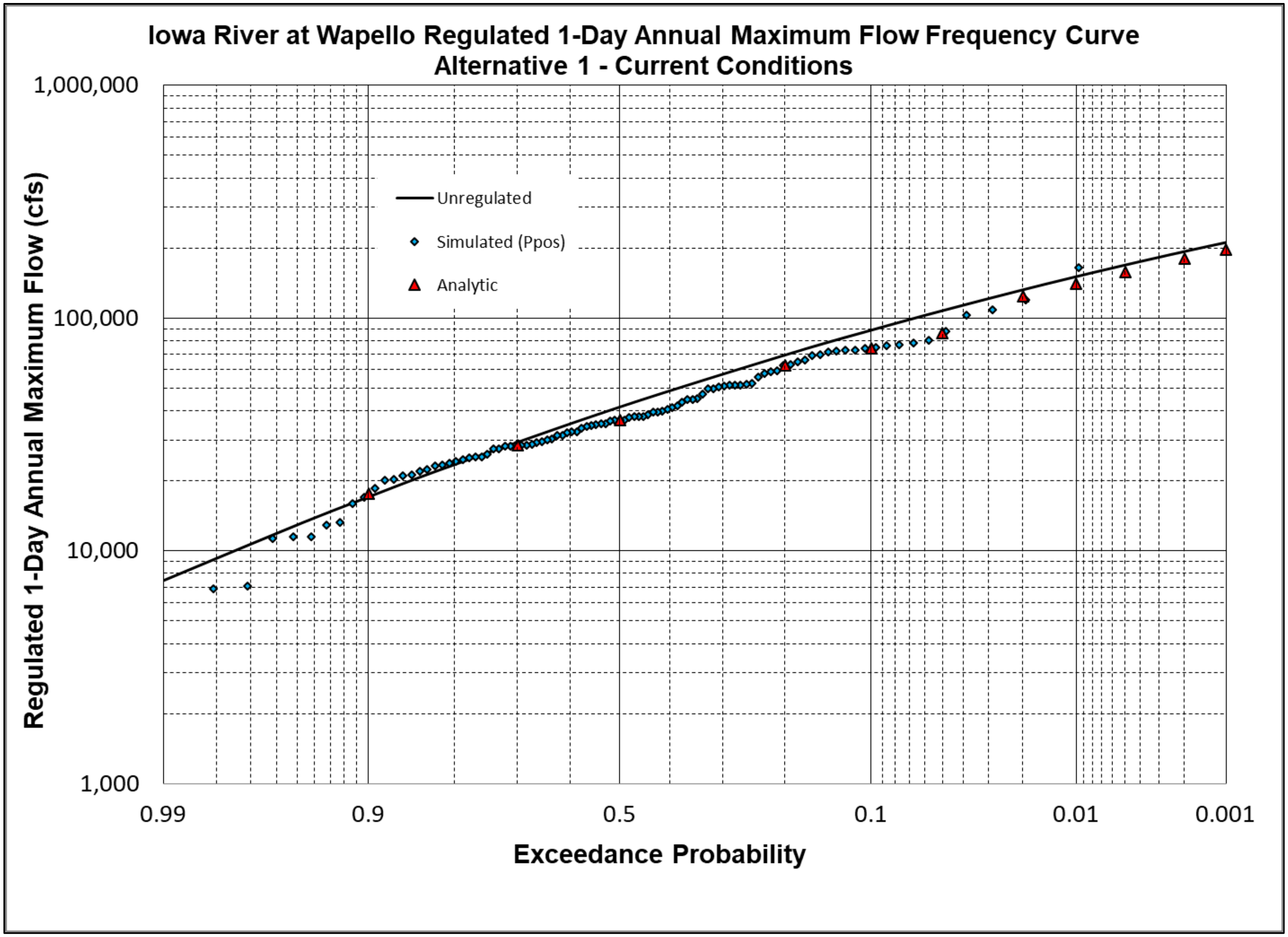


Figure B-22. Iowa River at Wapello Regulated Flow Frequency Curve – Alternative 1, Existing Water Control Plans. AEPs for simulated events estimated using Weibell plotting position (Ppos).

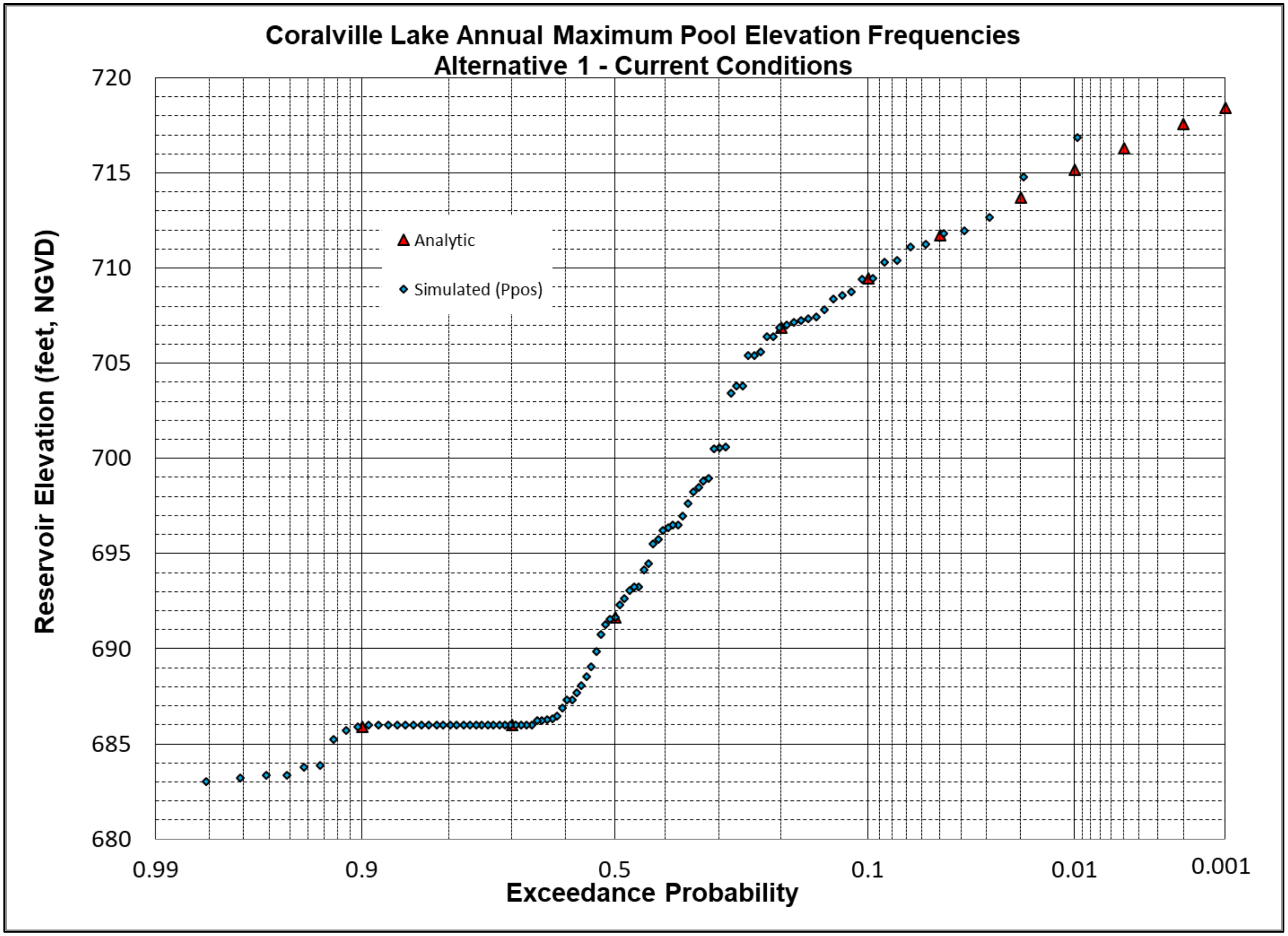
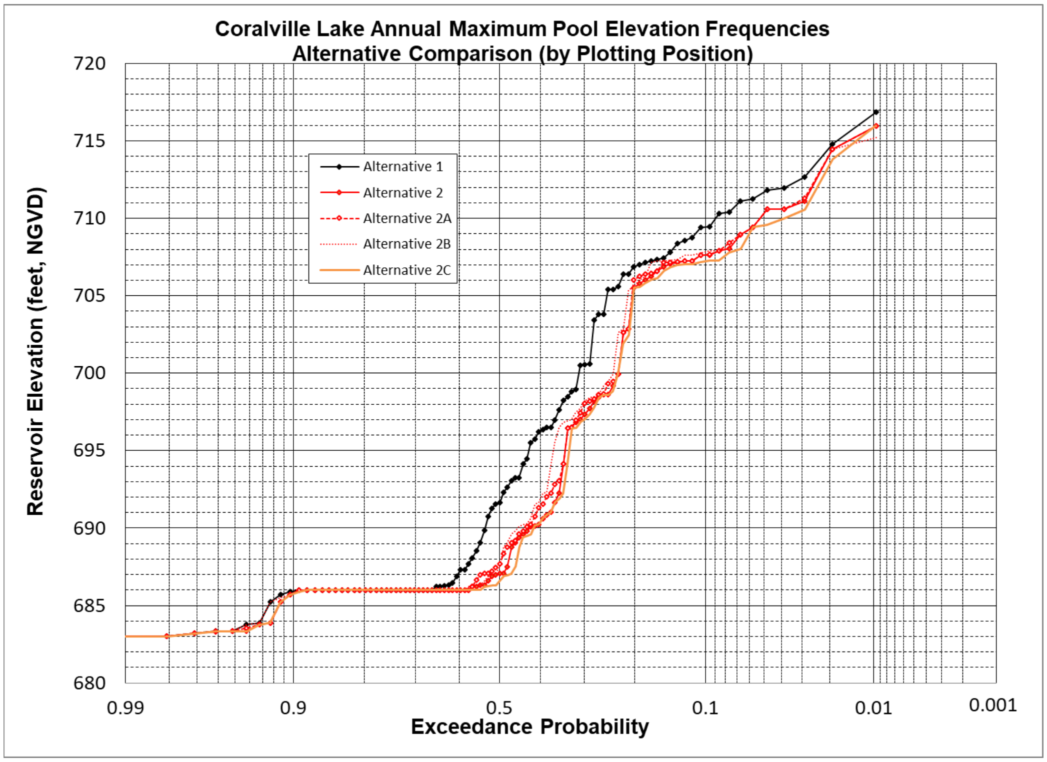


Figure B-23. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternative 1, Existing Water Control Plans. AEPs for simulated events estimated using Weibell plotting position (Ppos).



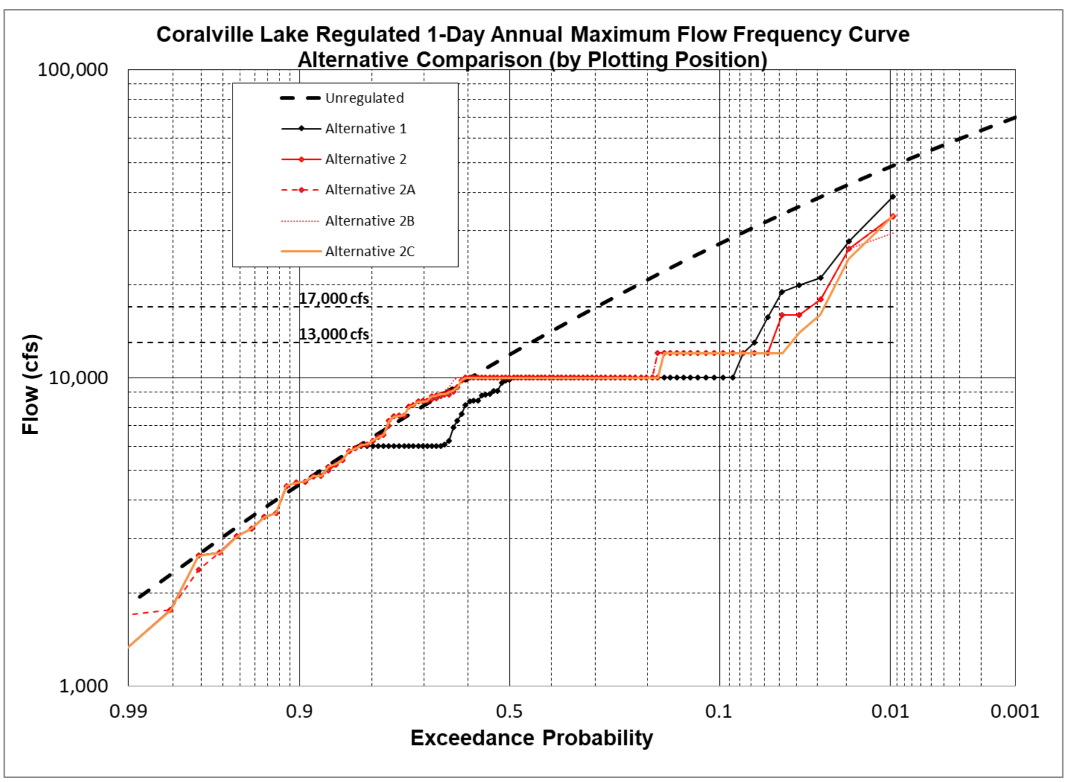
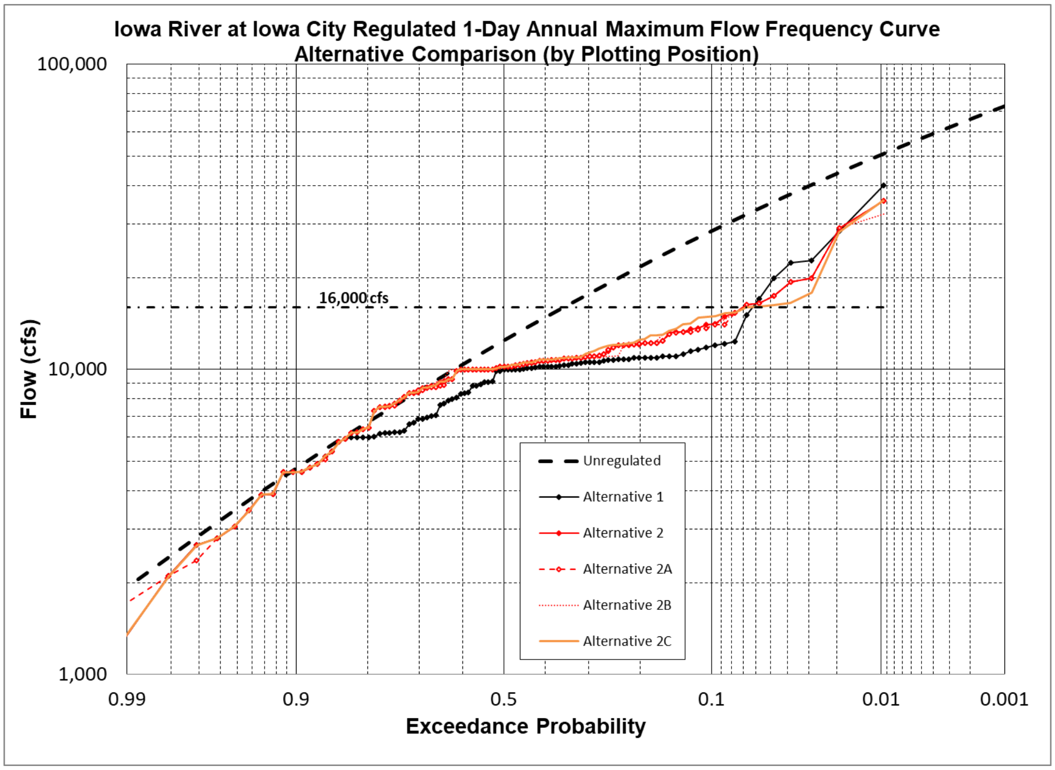


Figure B-24. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 2



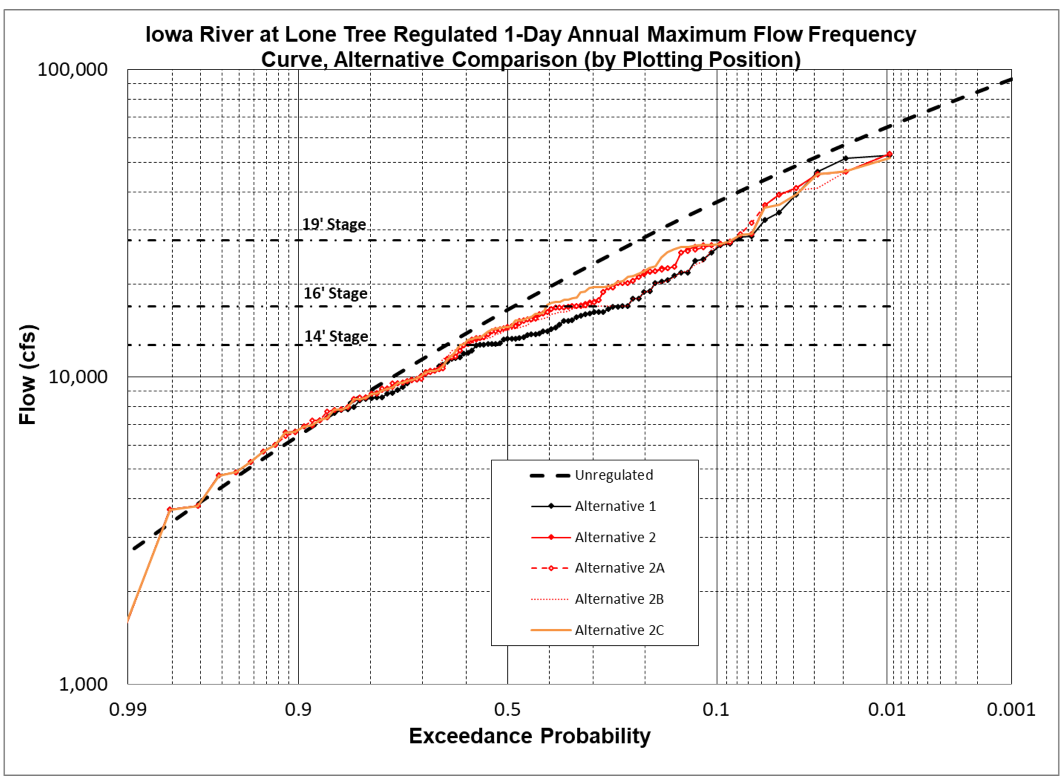
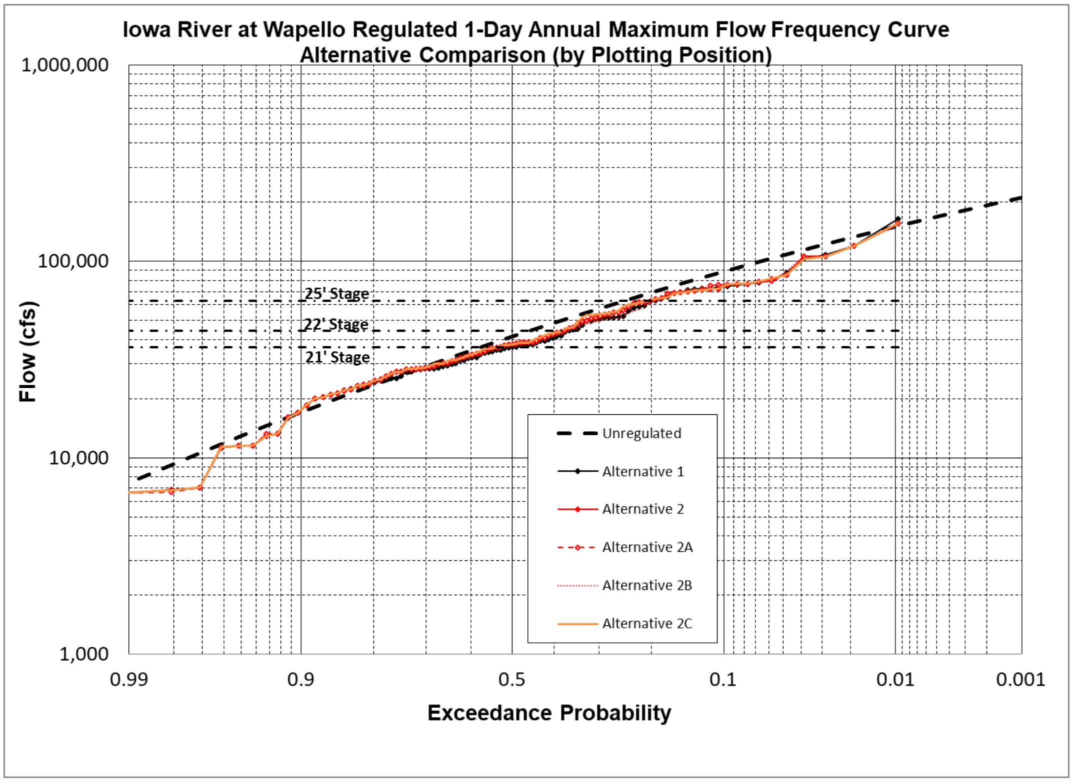


Figure B-25. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 2



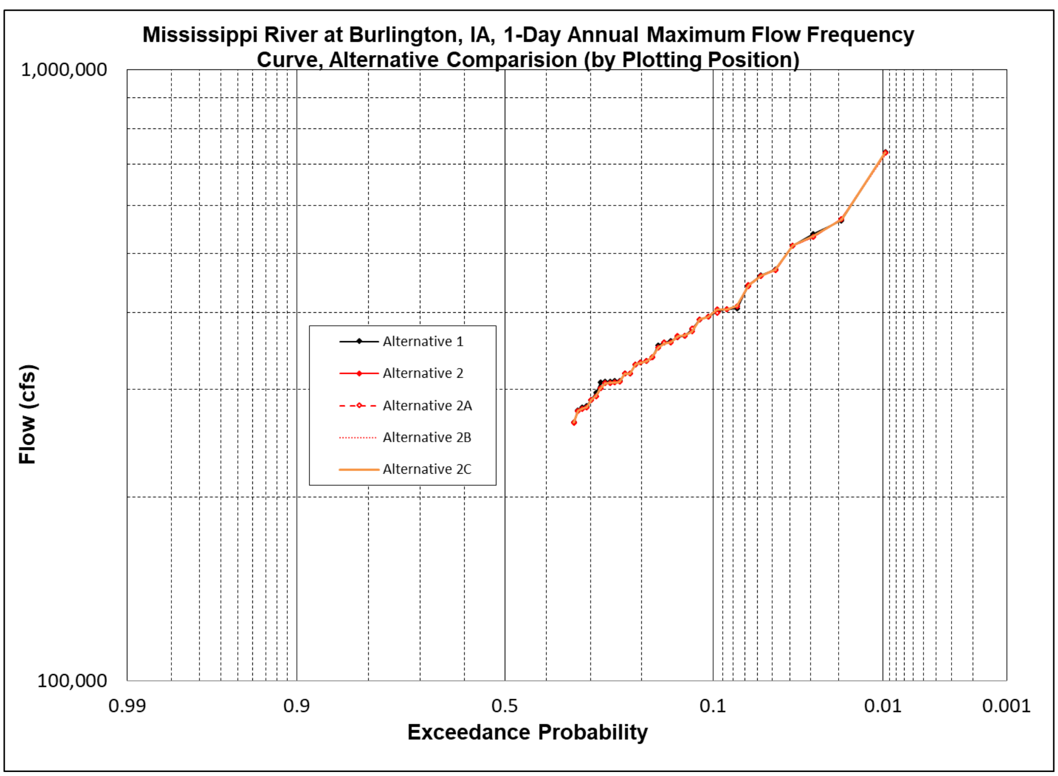


Figure B-26. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 2

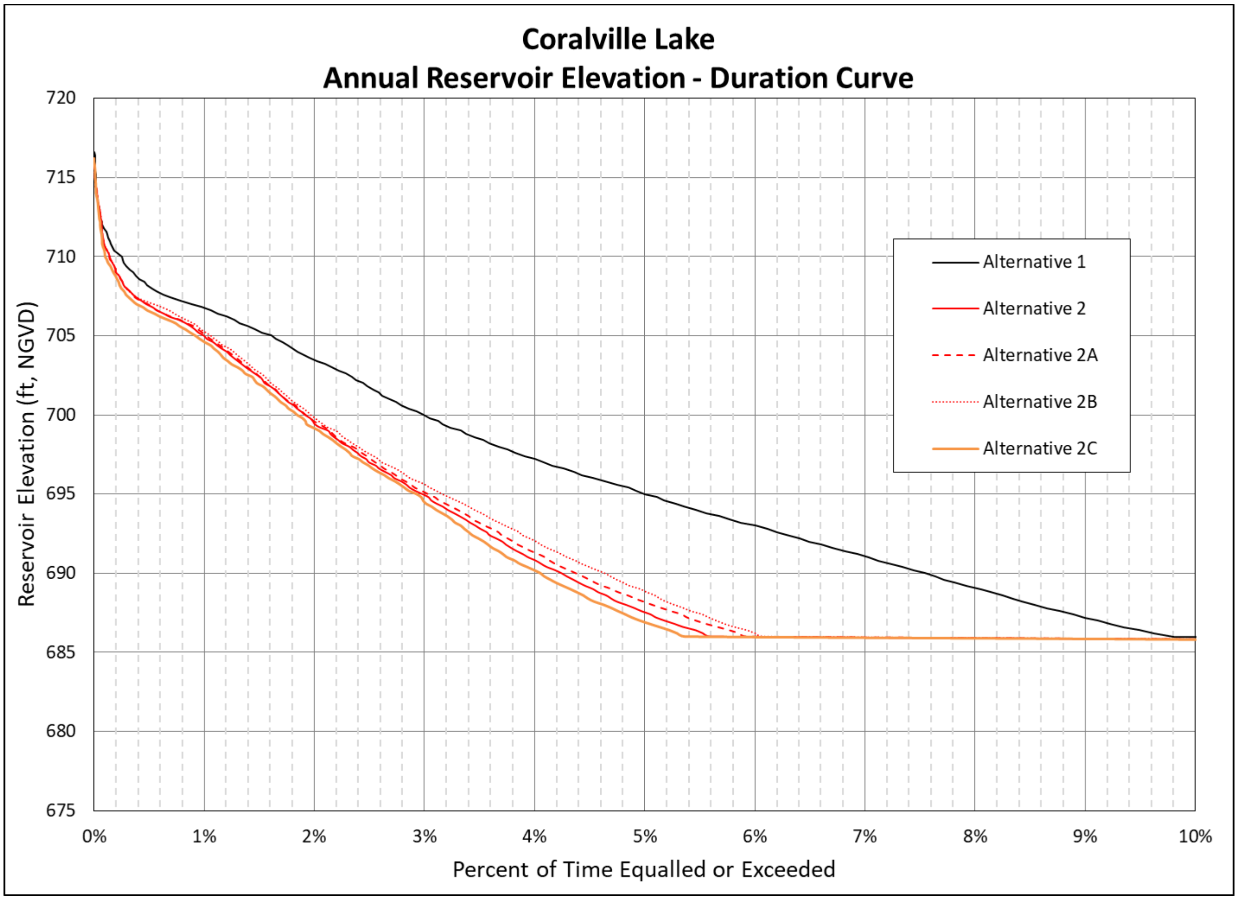
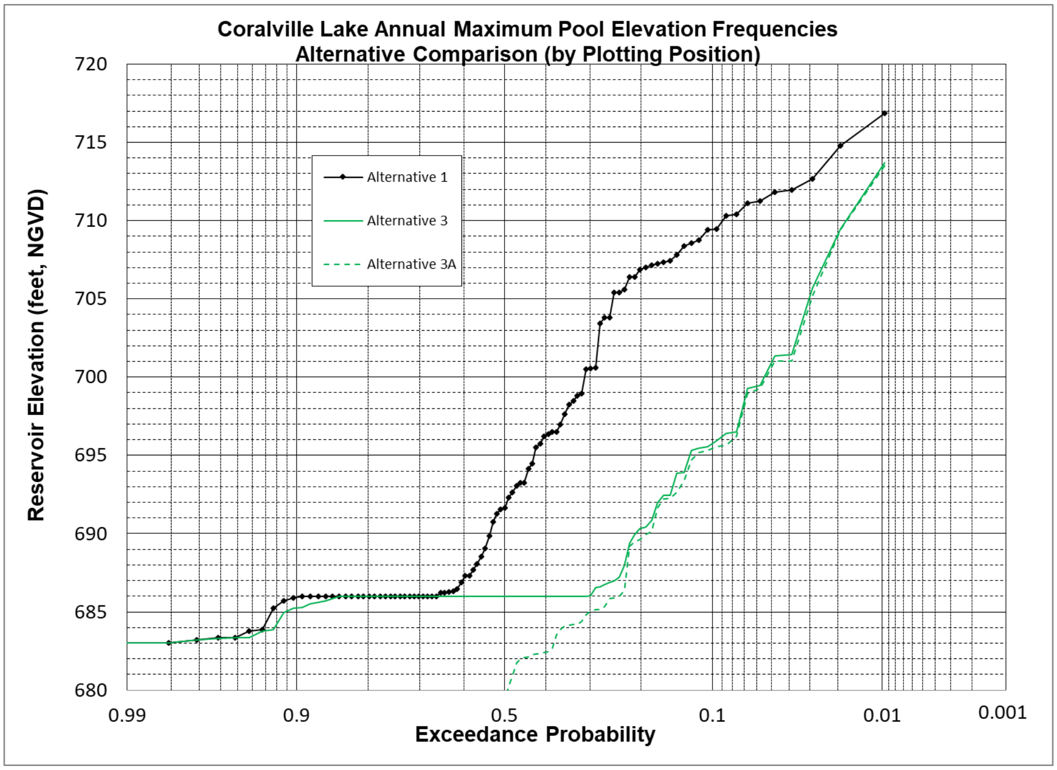


Figure B-27. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 2



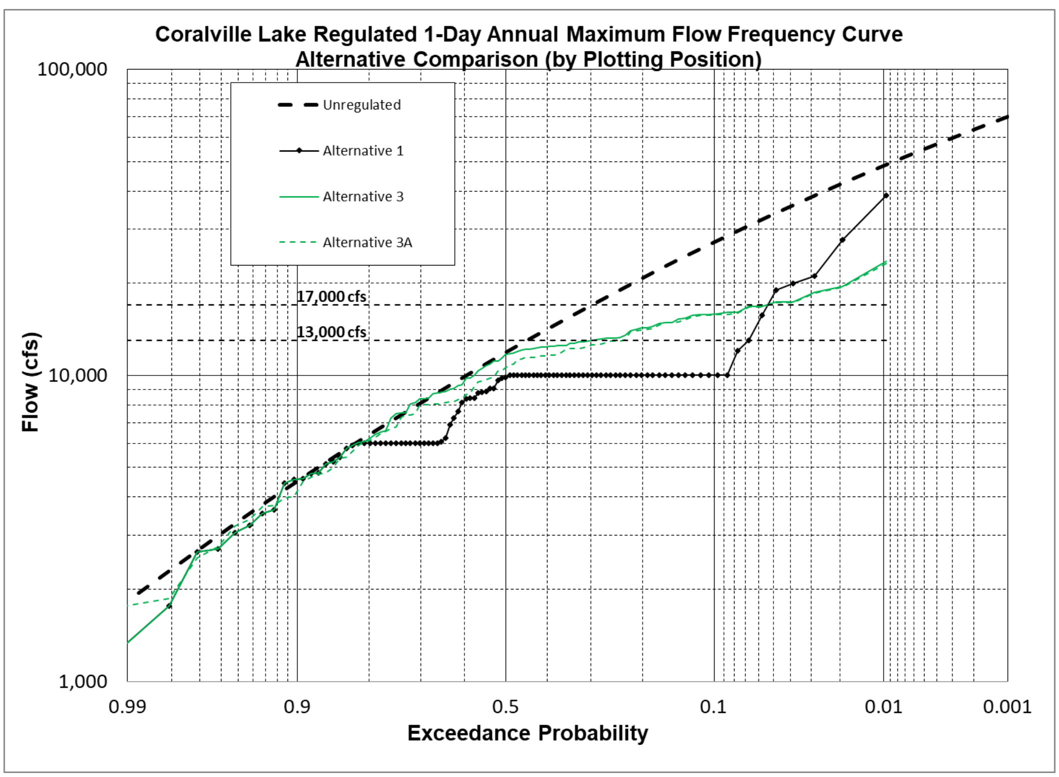
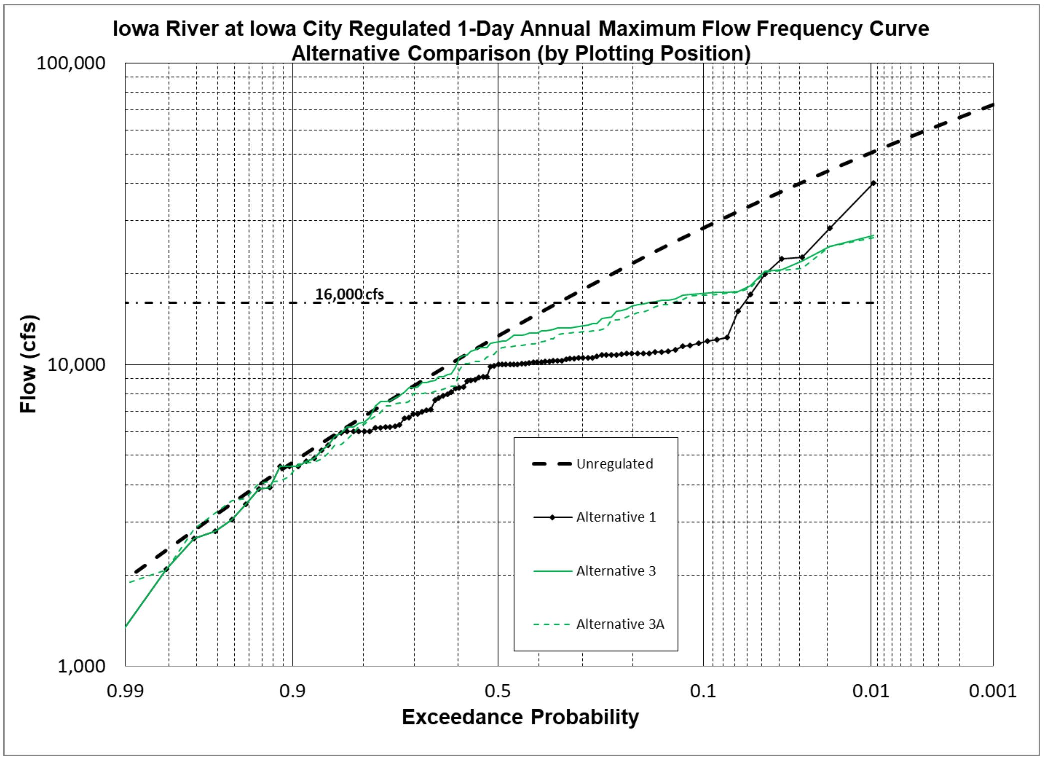


Figure B-28. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 3



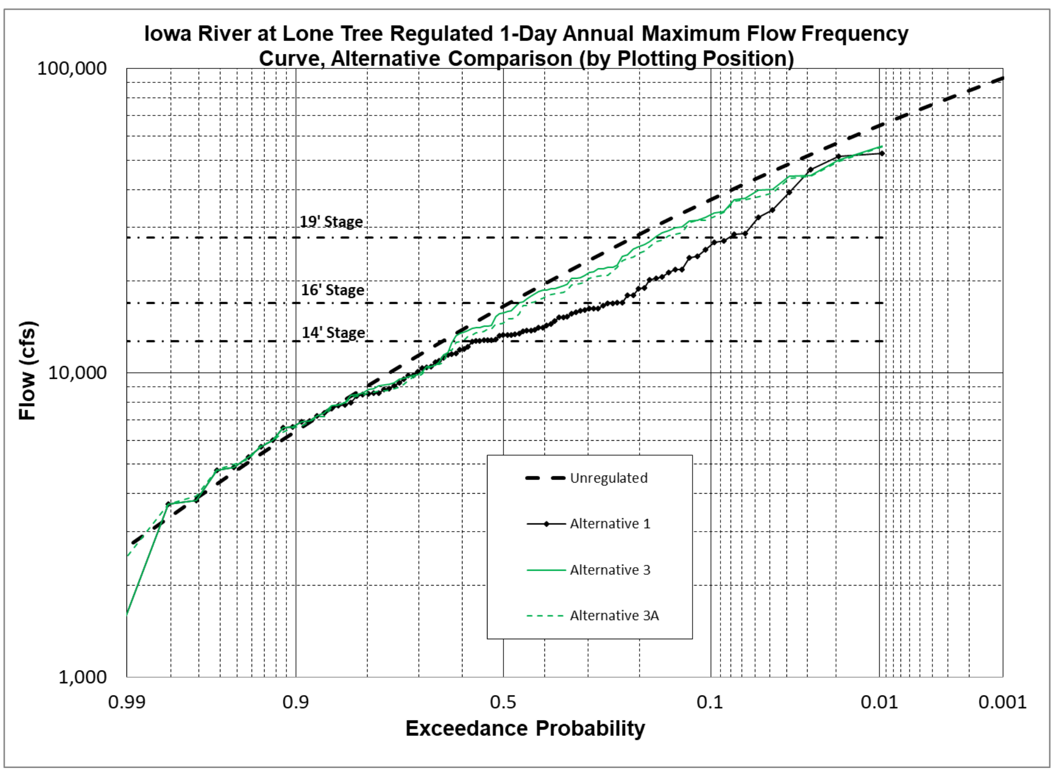
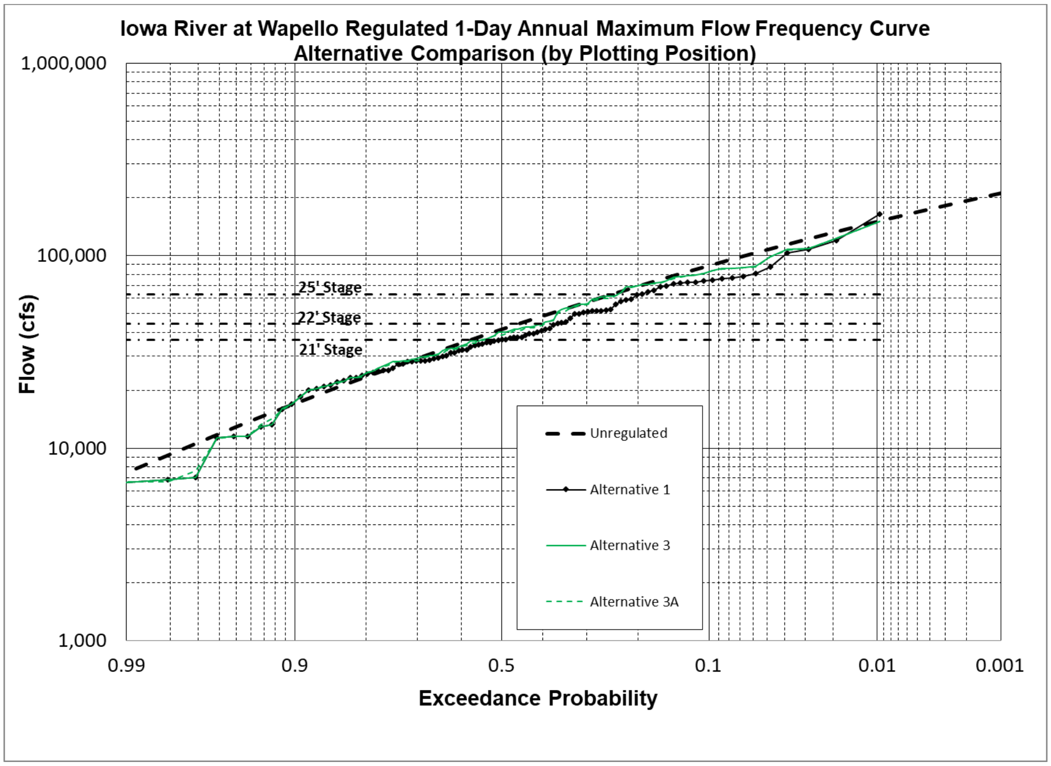


Figure B-29. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 3



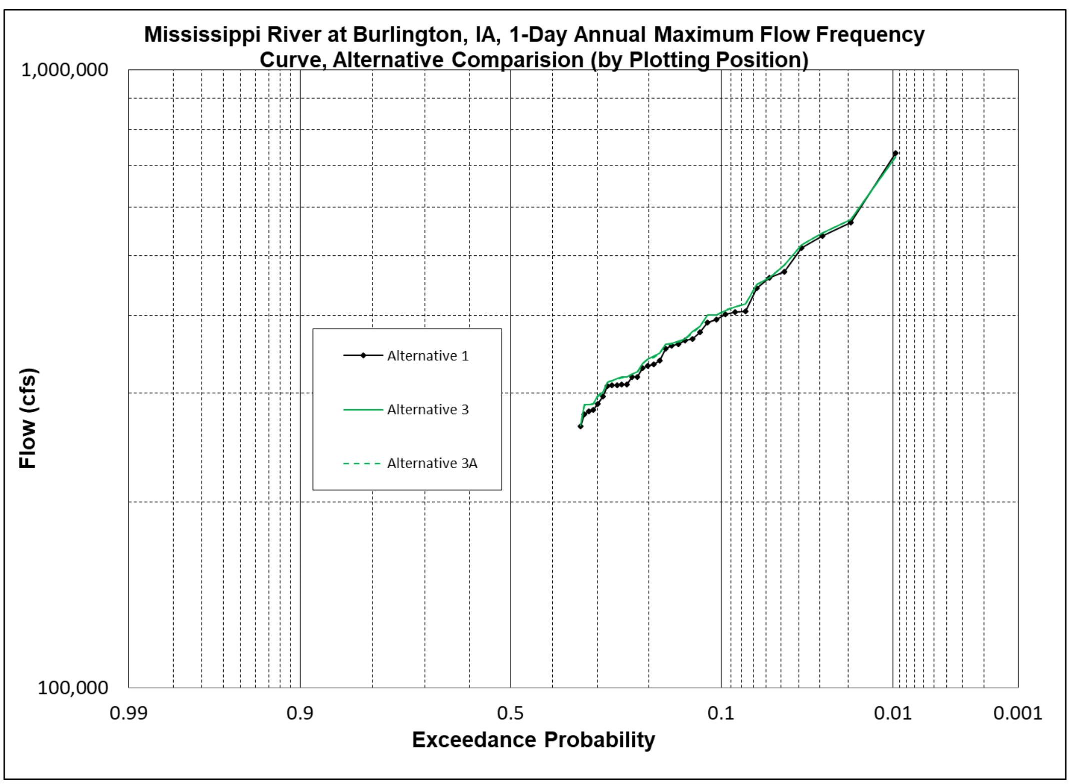


Figure B-30. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 3

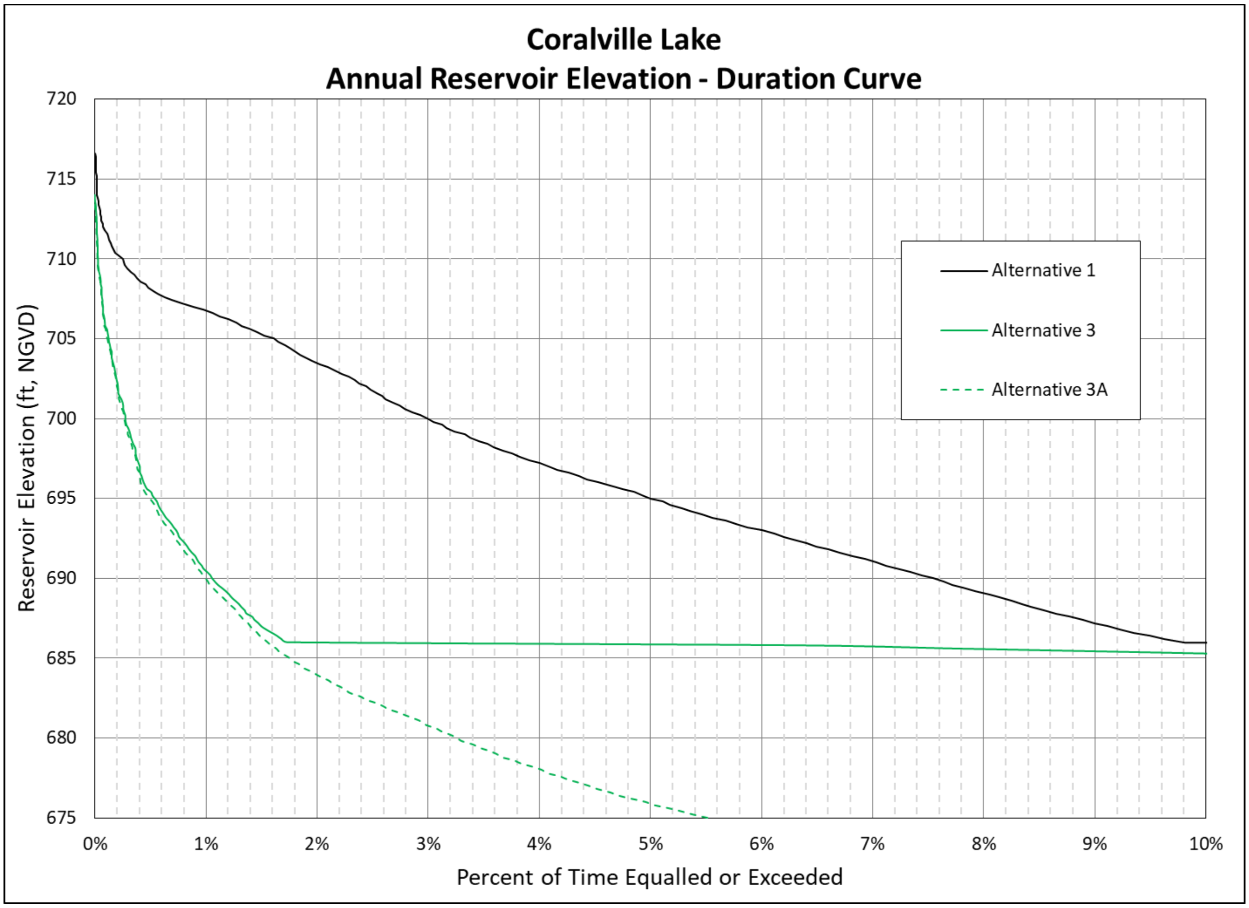
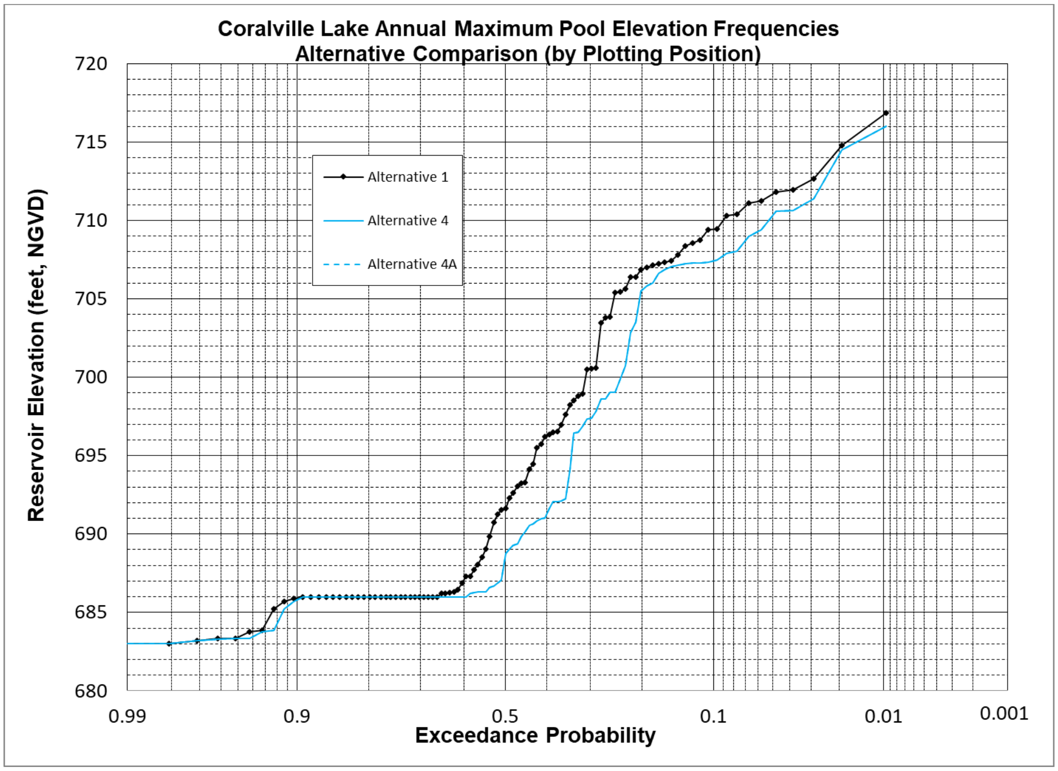


Figure B-31. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 3



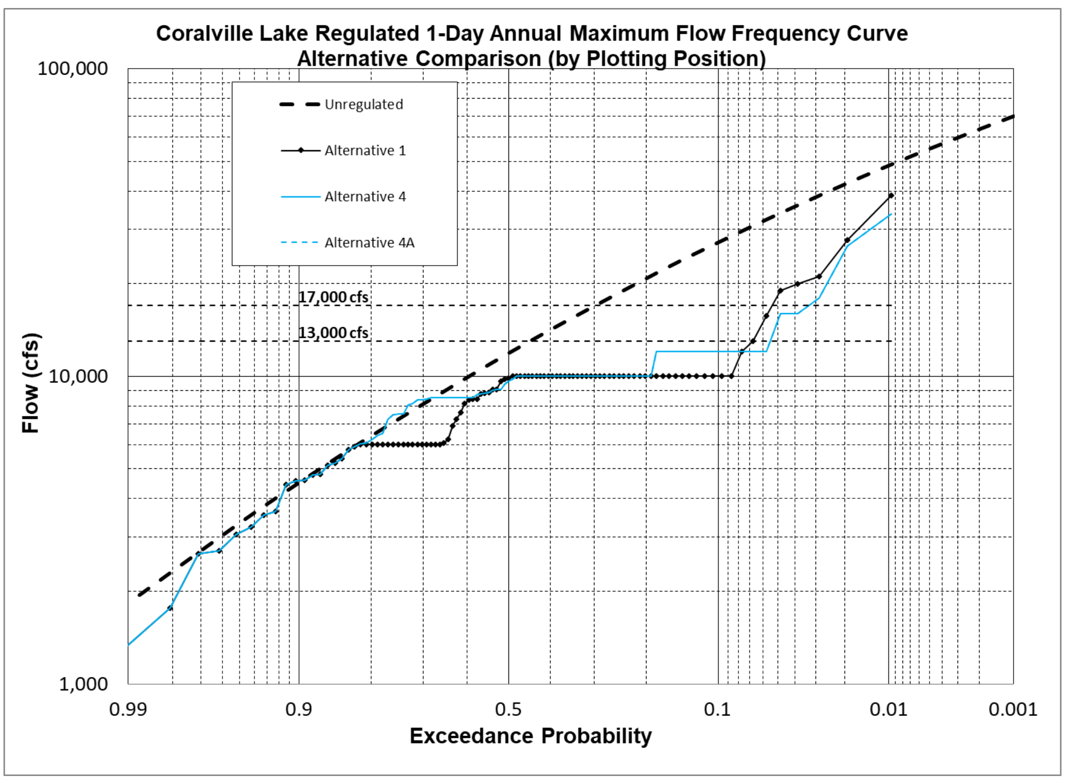
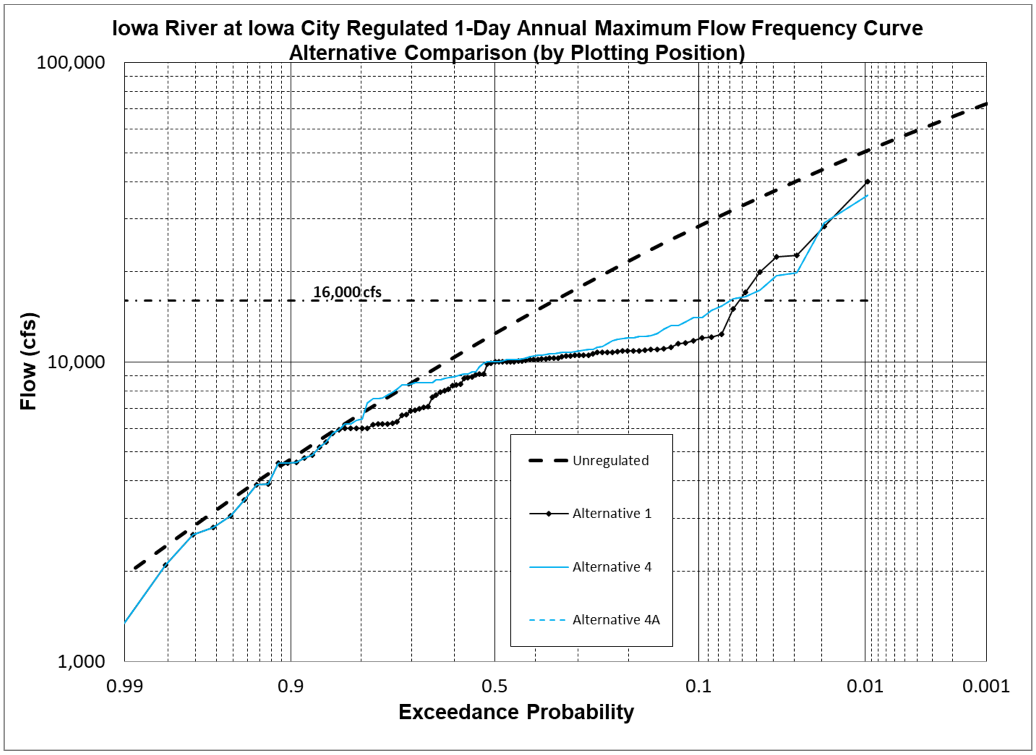


Figure B-32. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 4



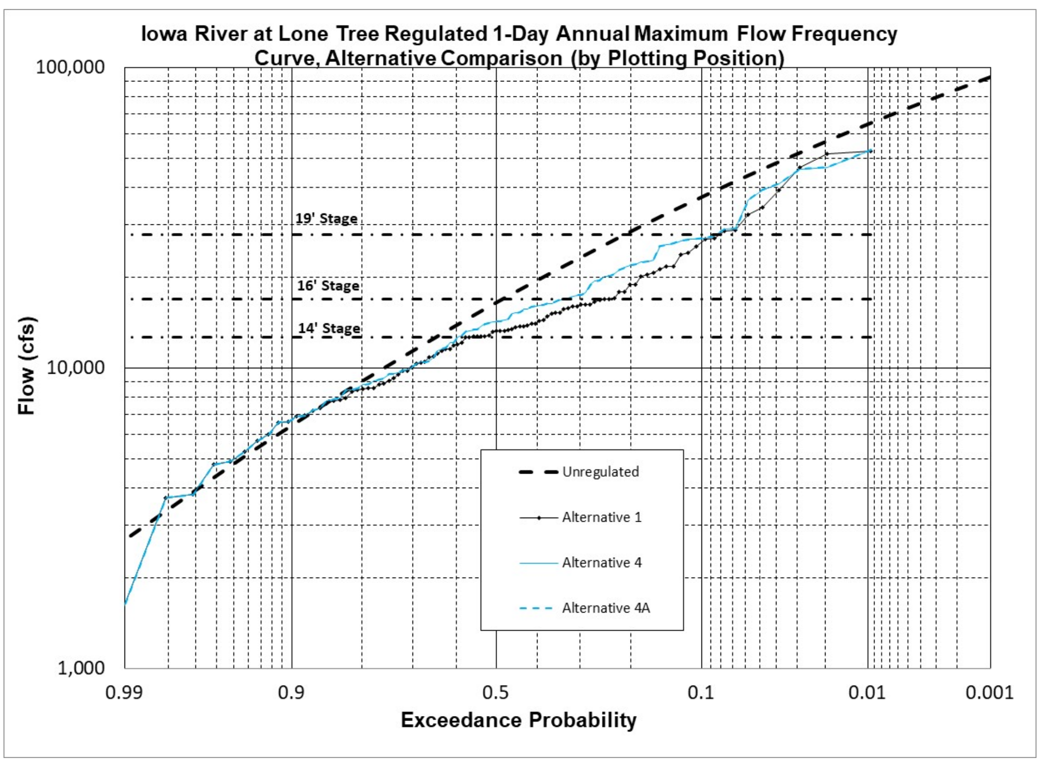
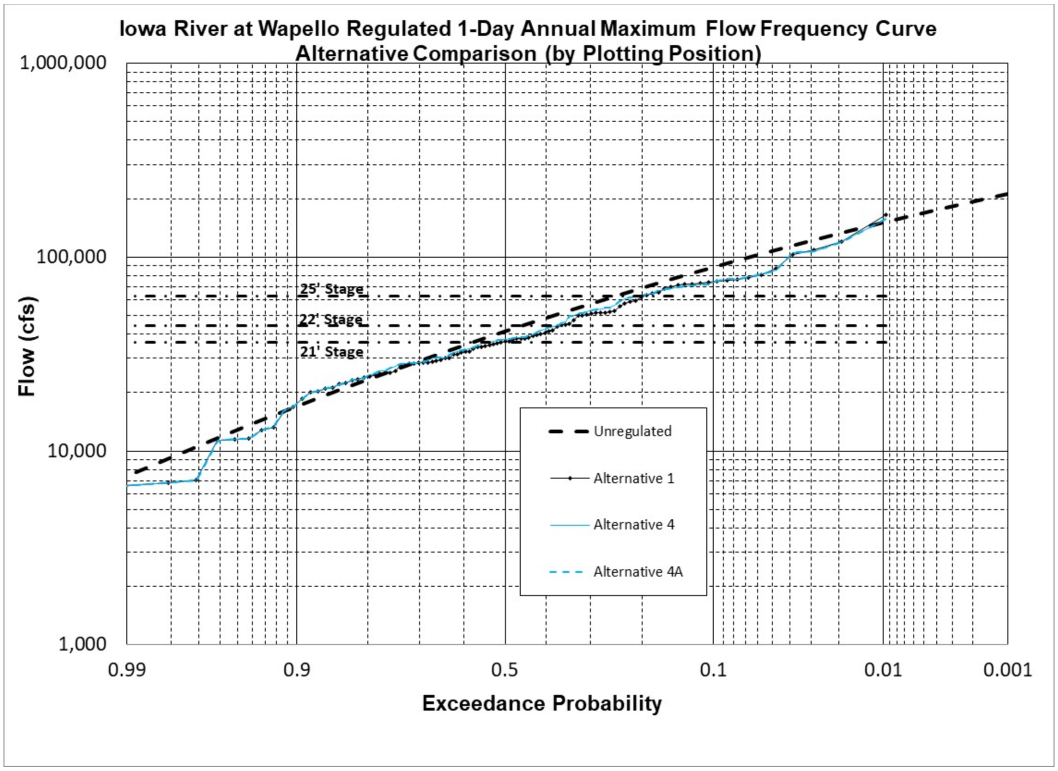


Figure B-33. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 4



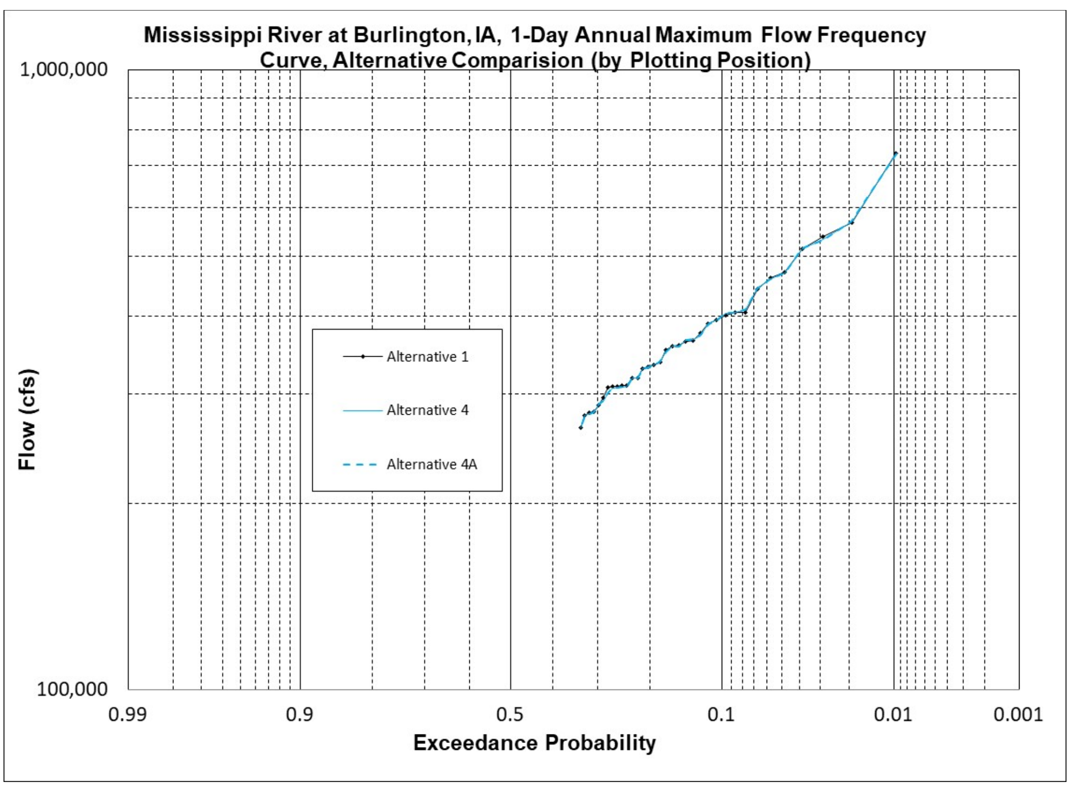


Figure B-34. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 4

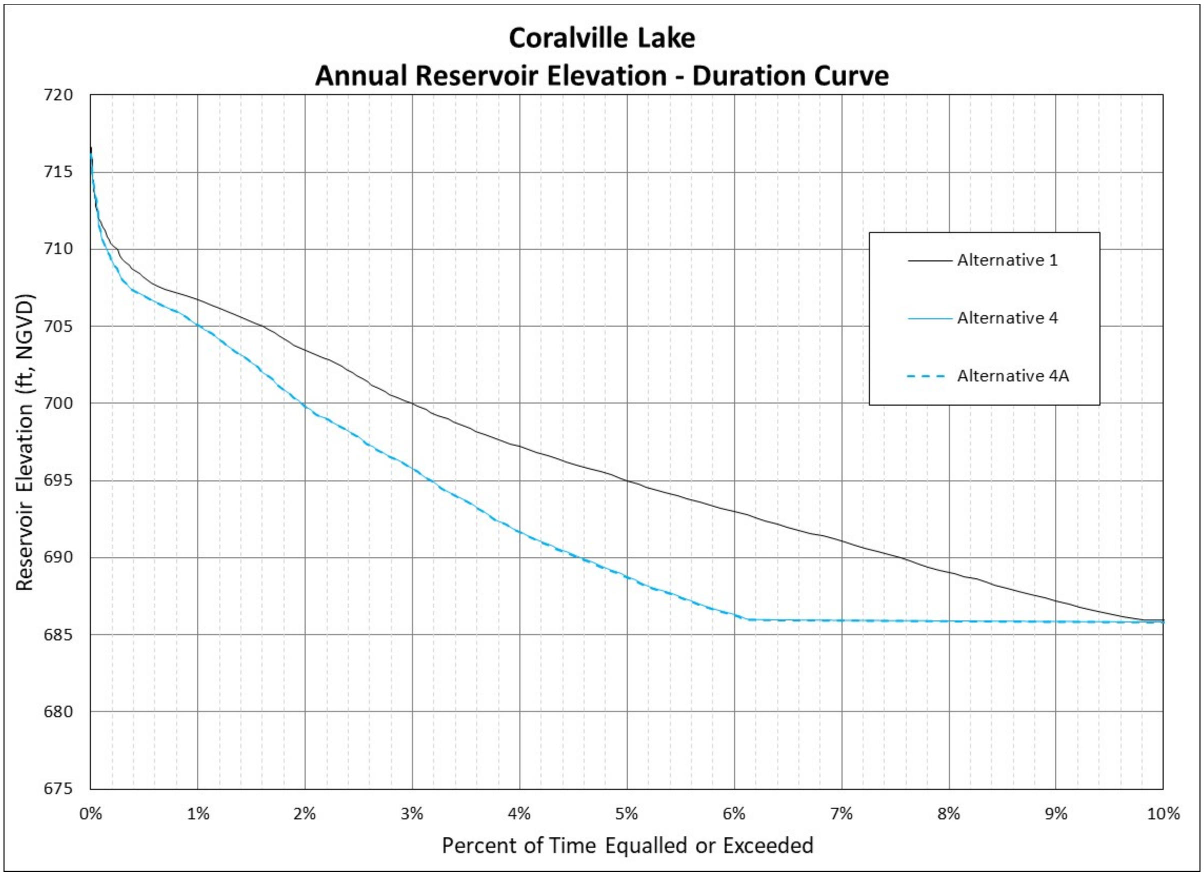
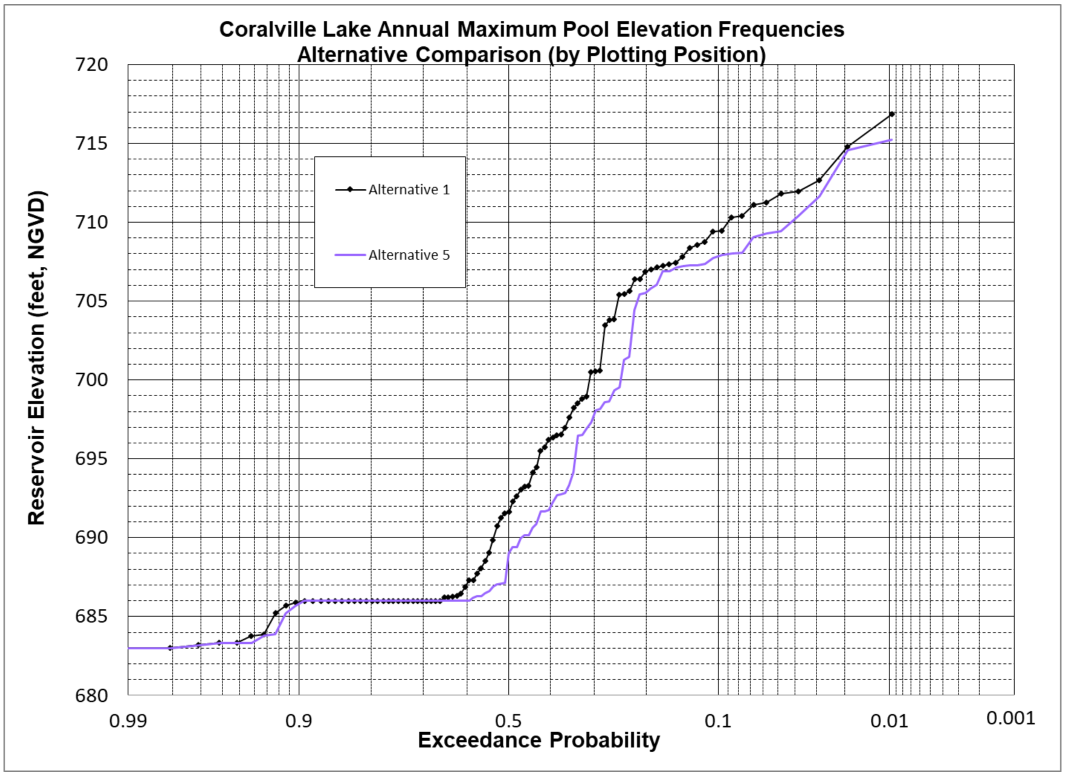


Figure B-35. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 4



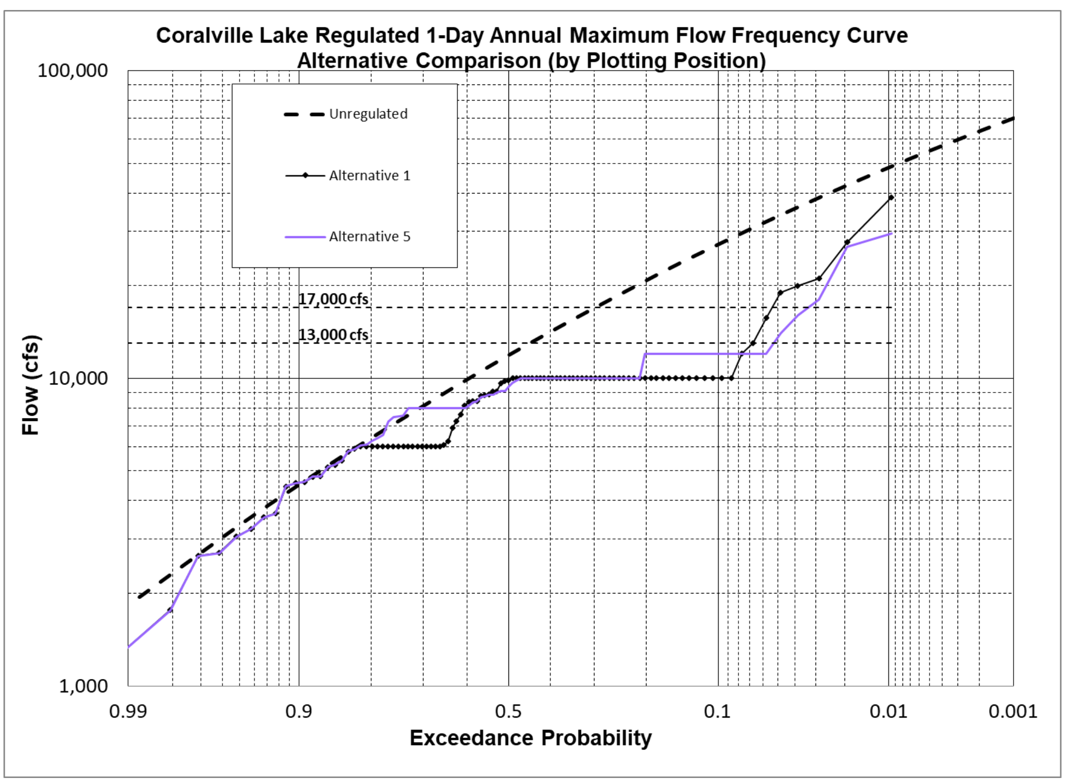
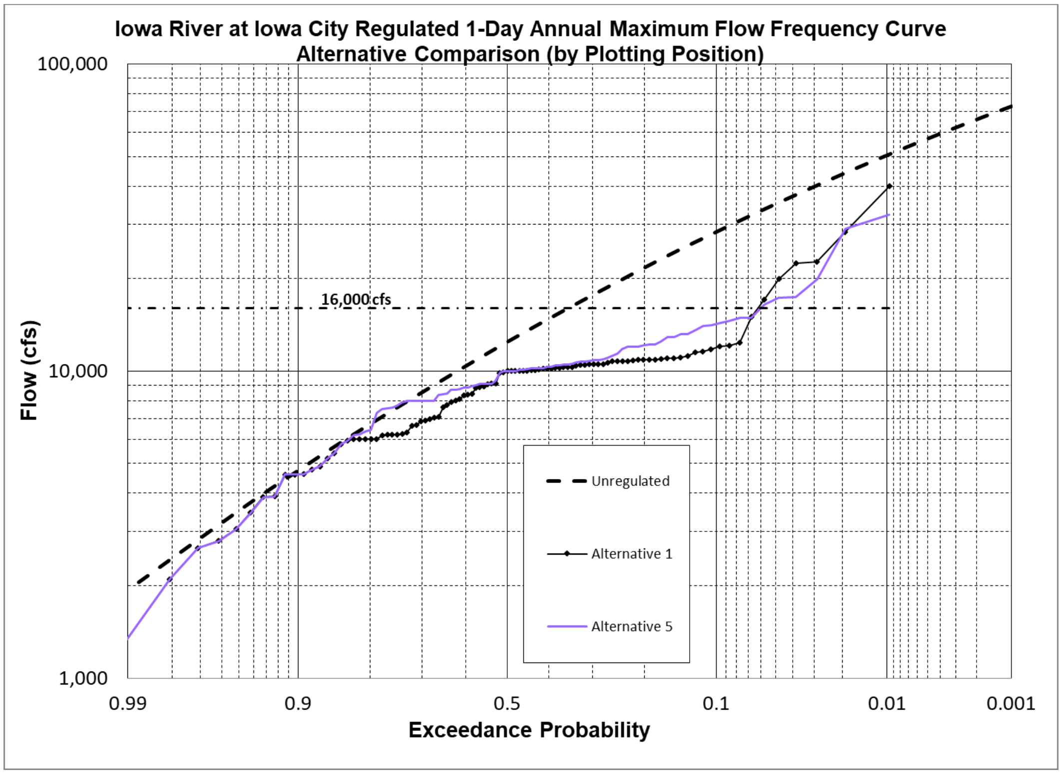


Figure B-36. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 5



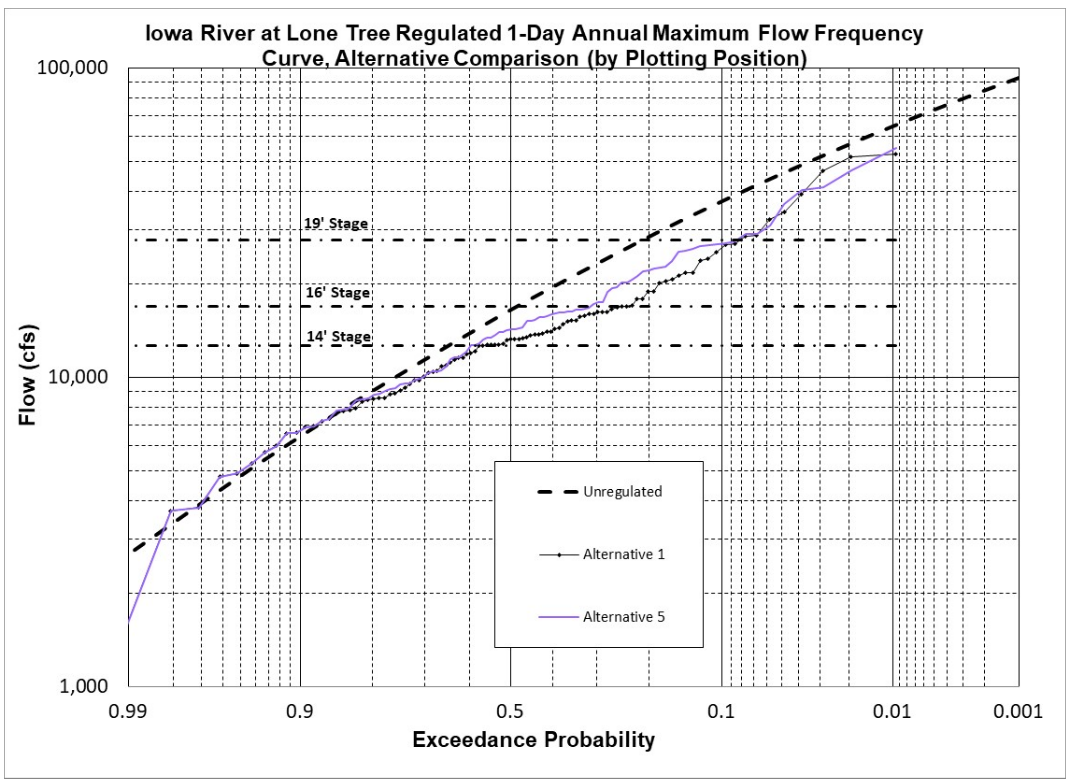
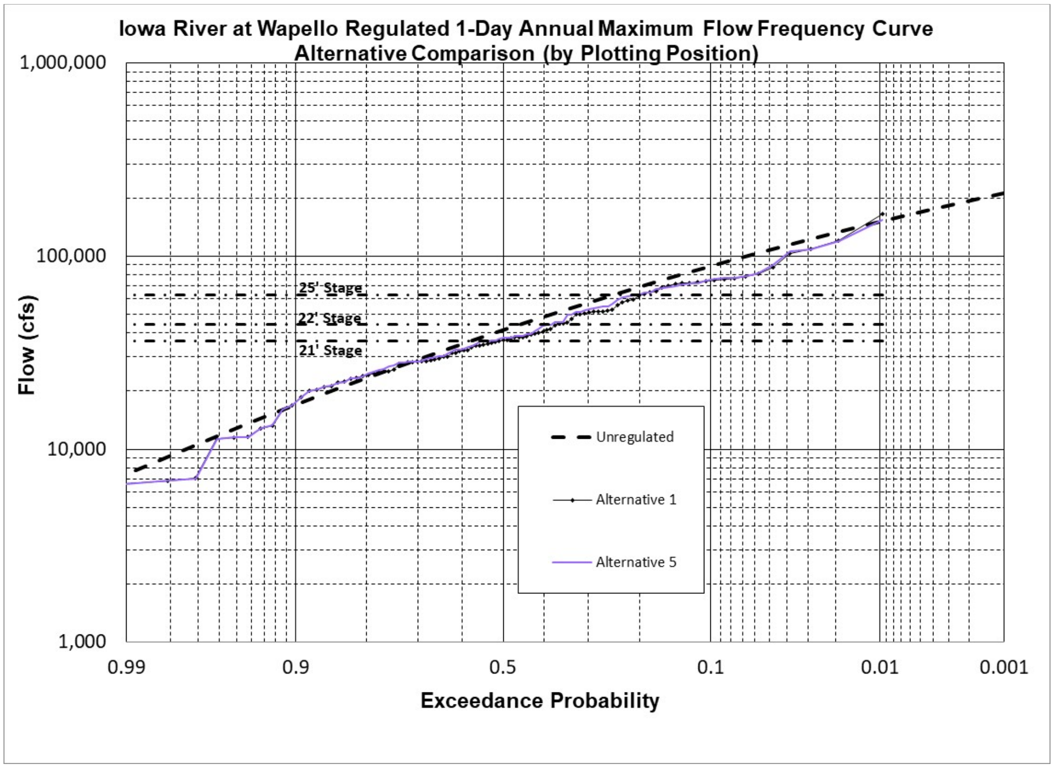


Figure B-37. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 5



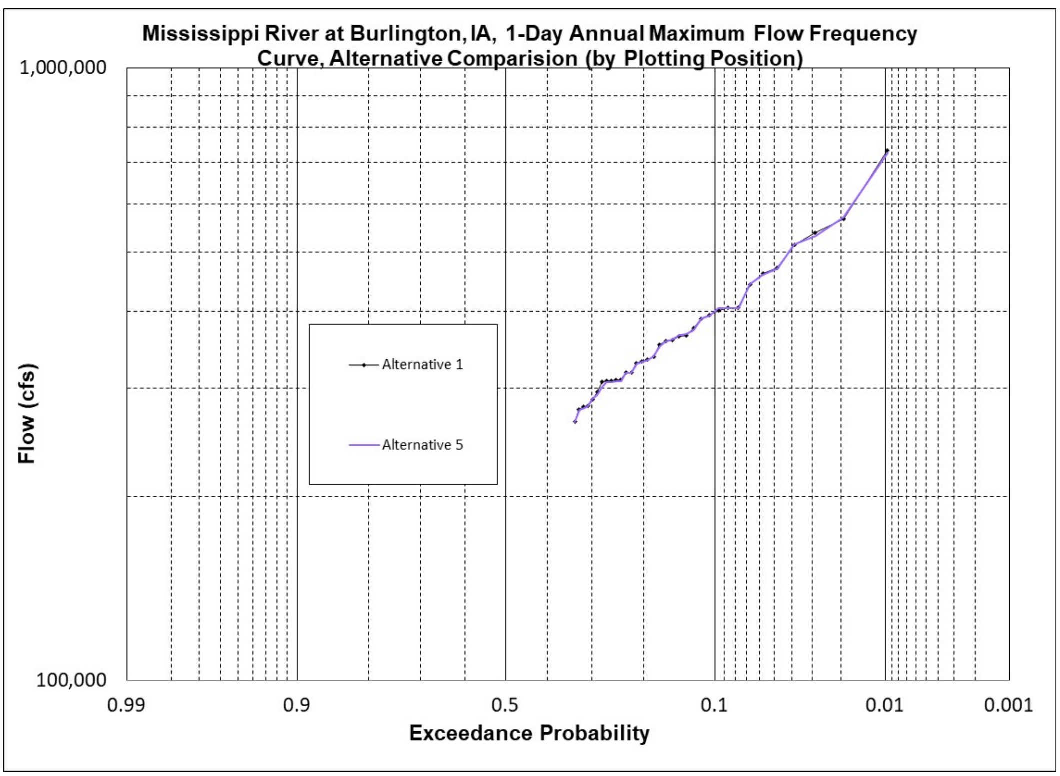


Figure B-38. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 5

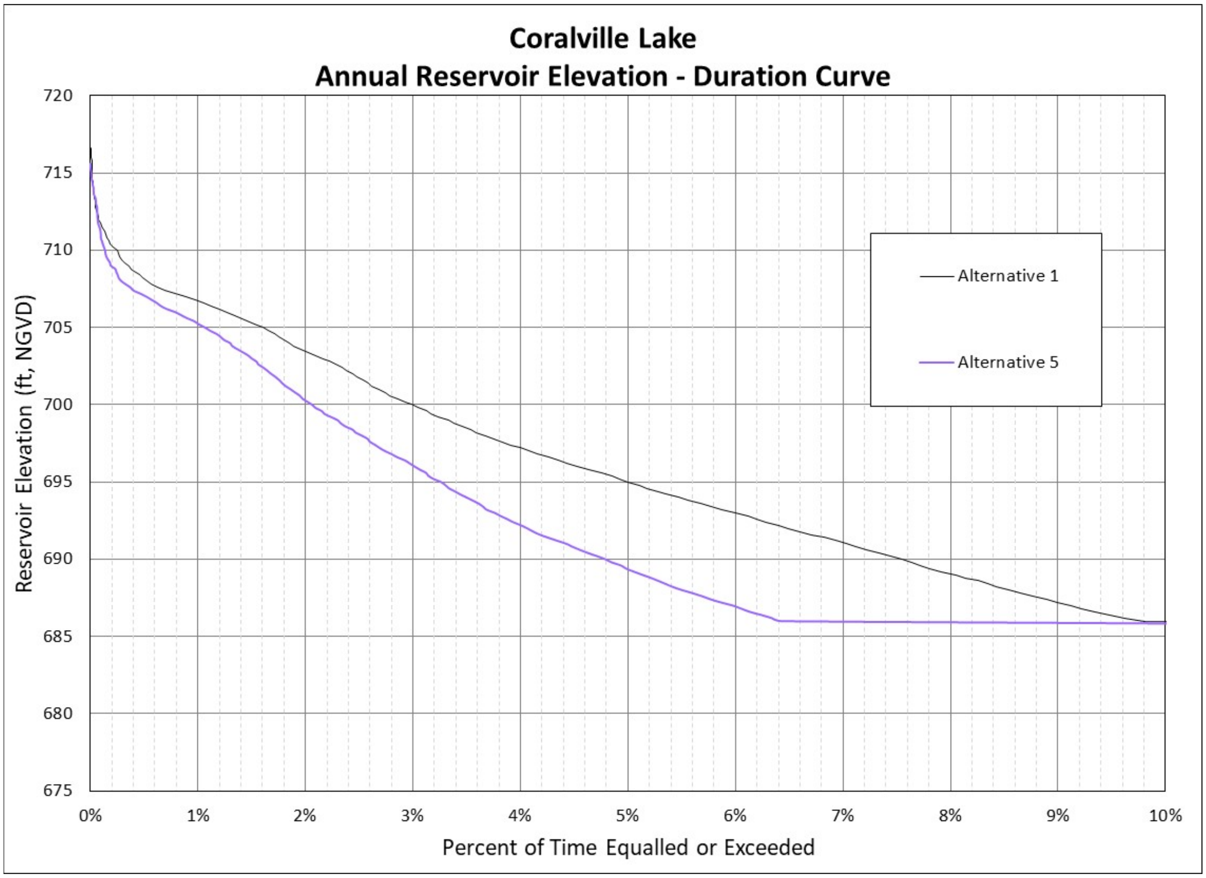
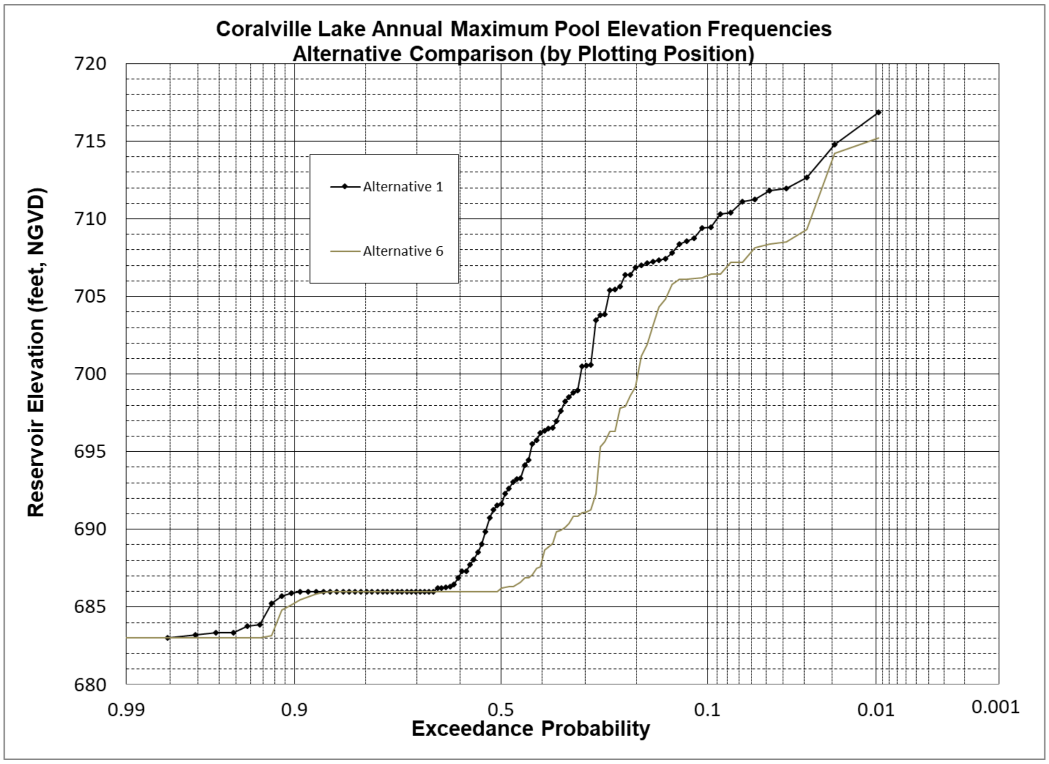


Figure B- 39. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 5



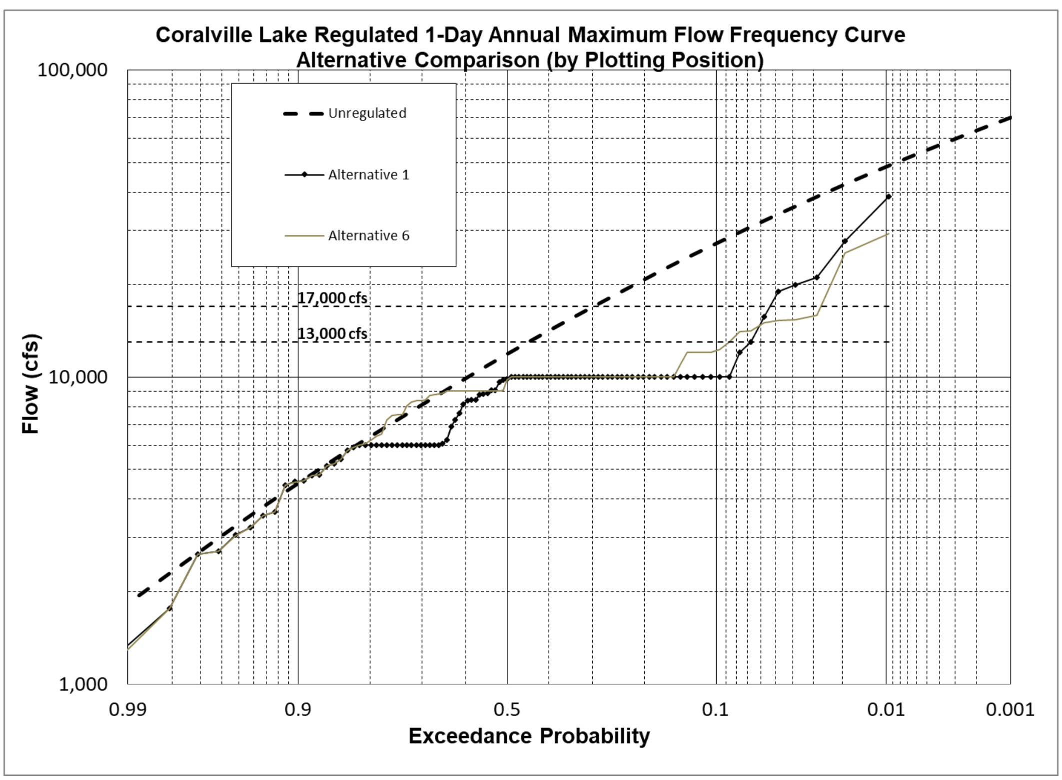
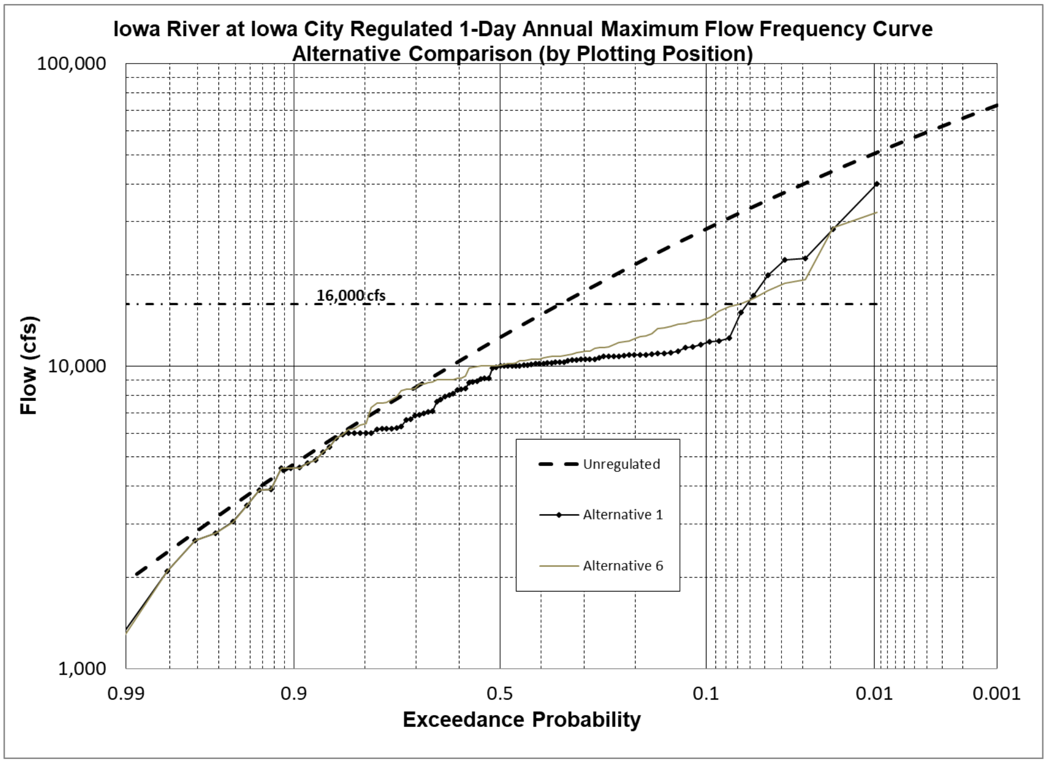


Figure B-40. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 6



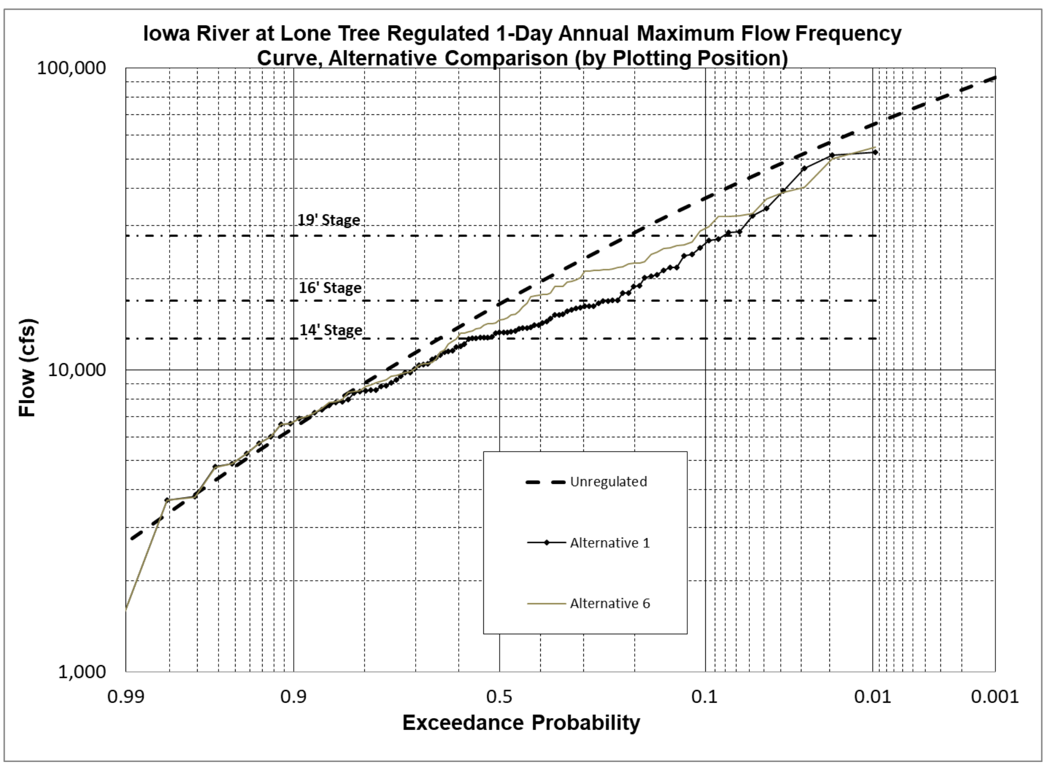
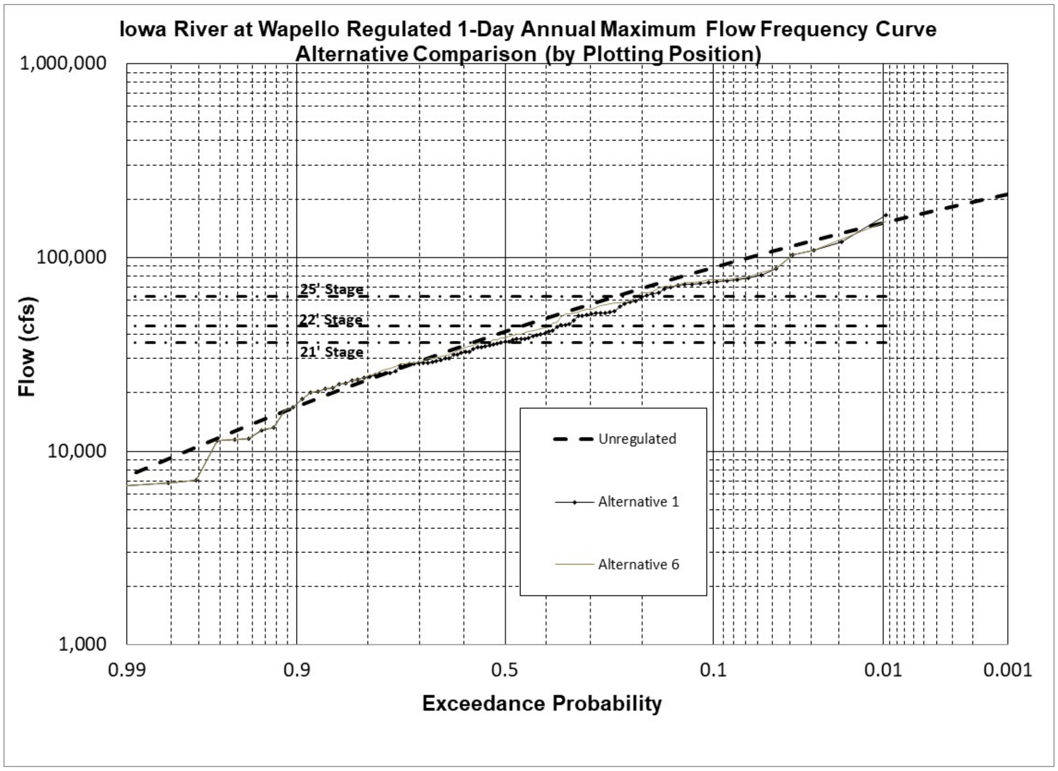


Figure B-41. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 6



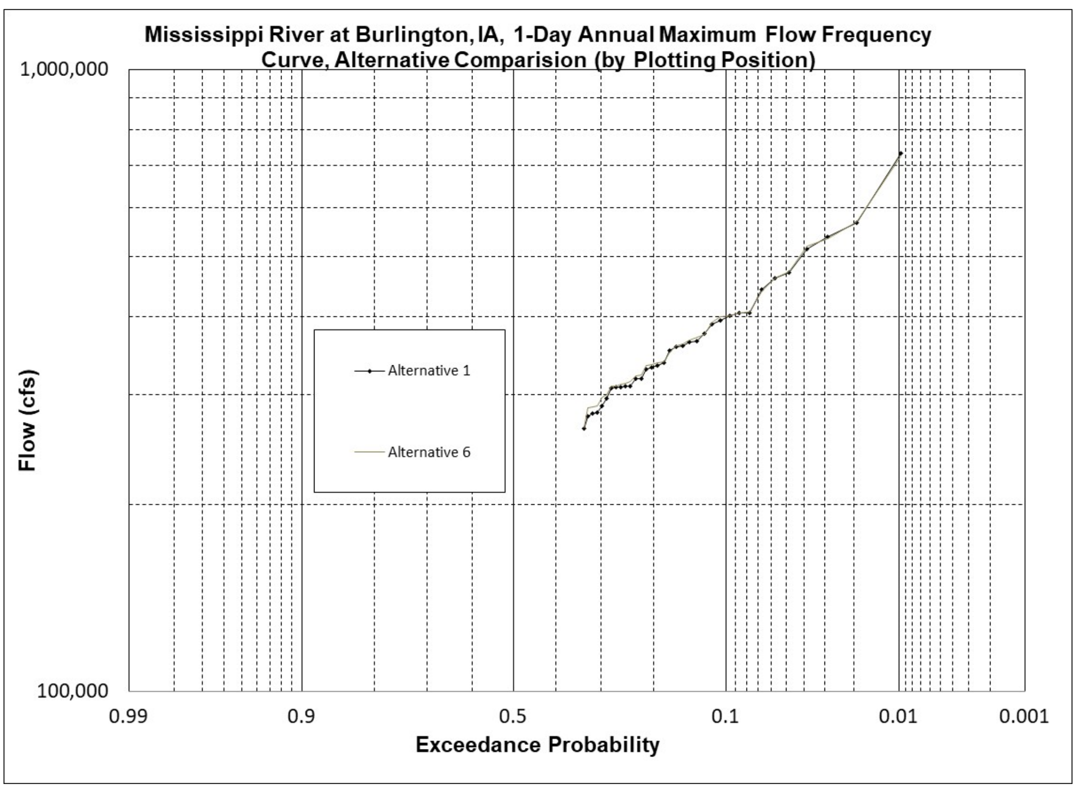


Figure B-42. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 6

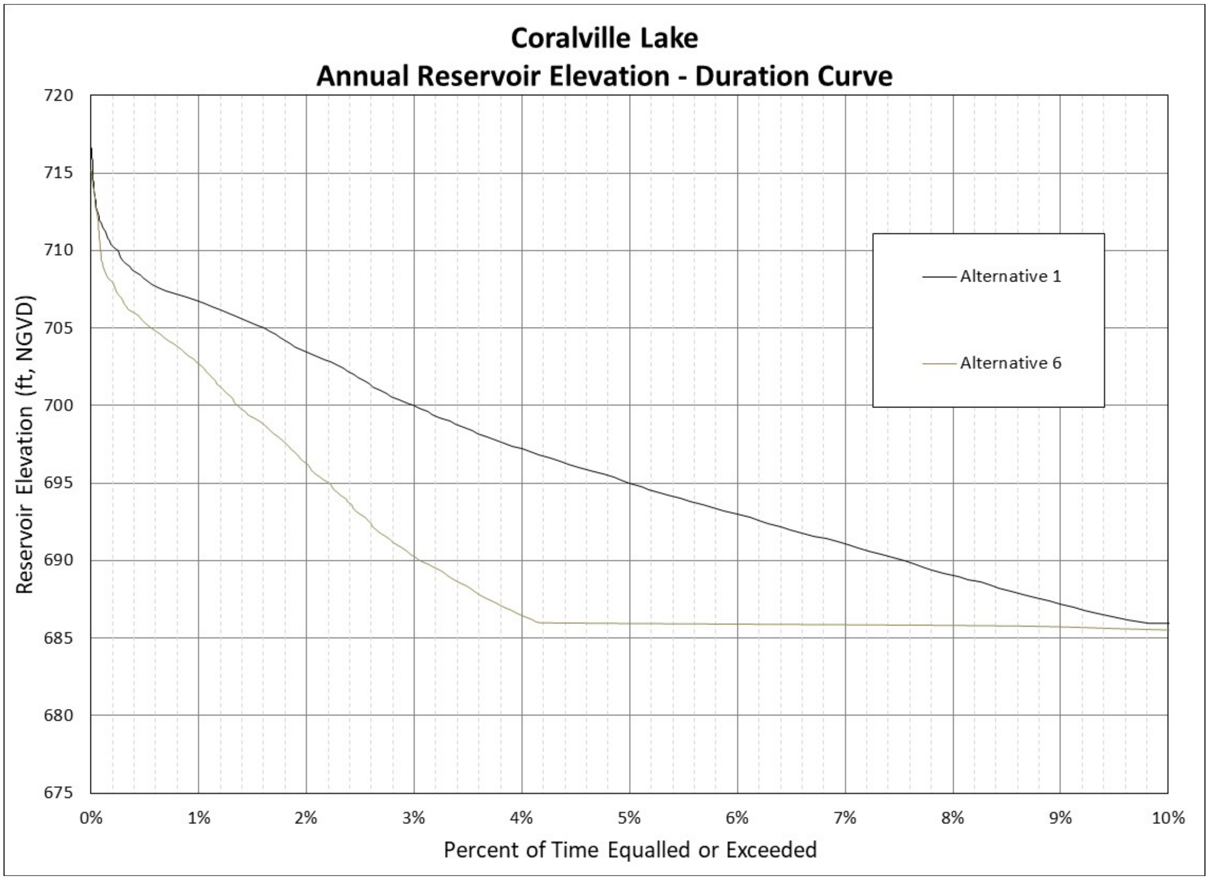


Figure B-43. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 6

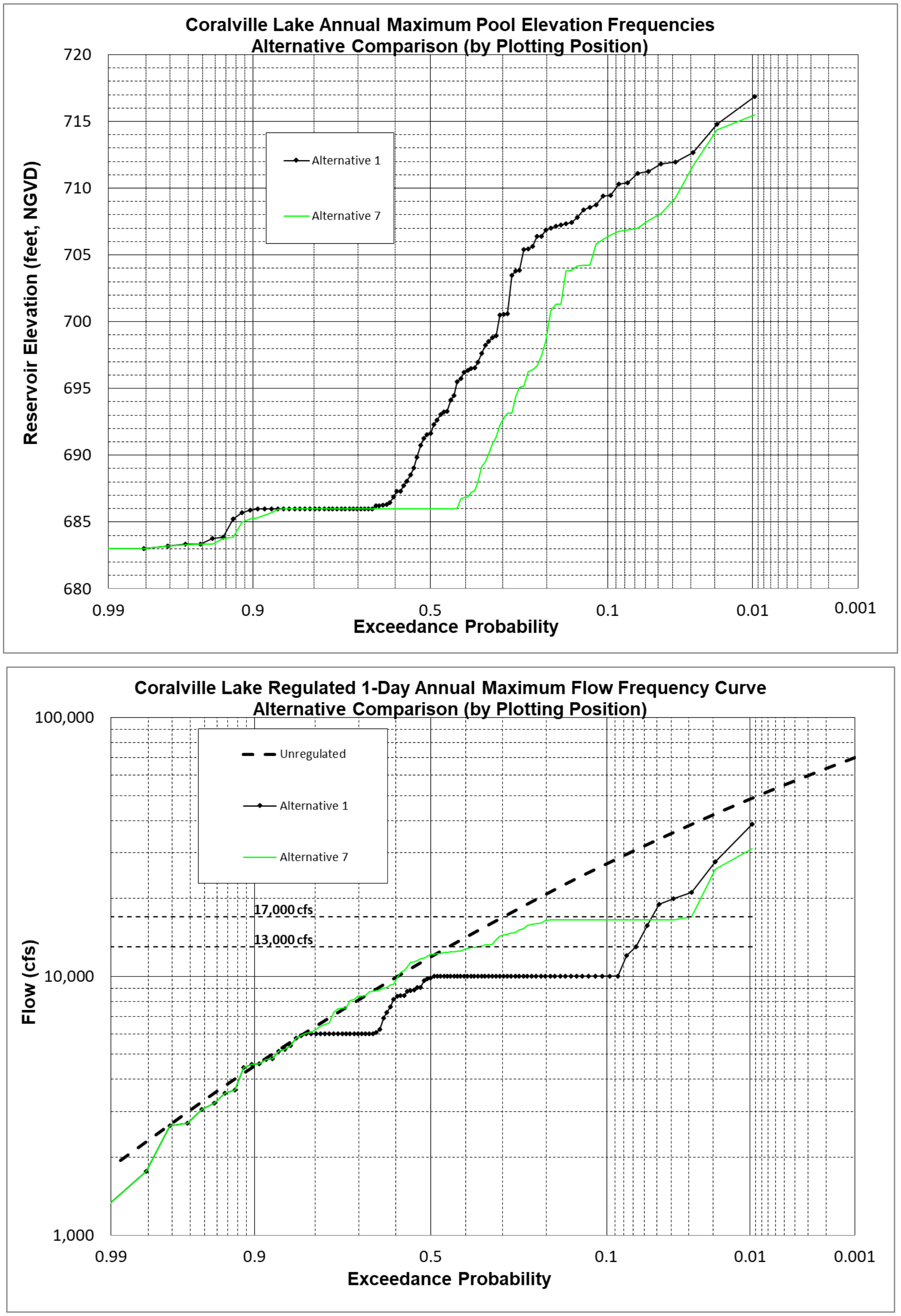
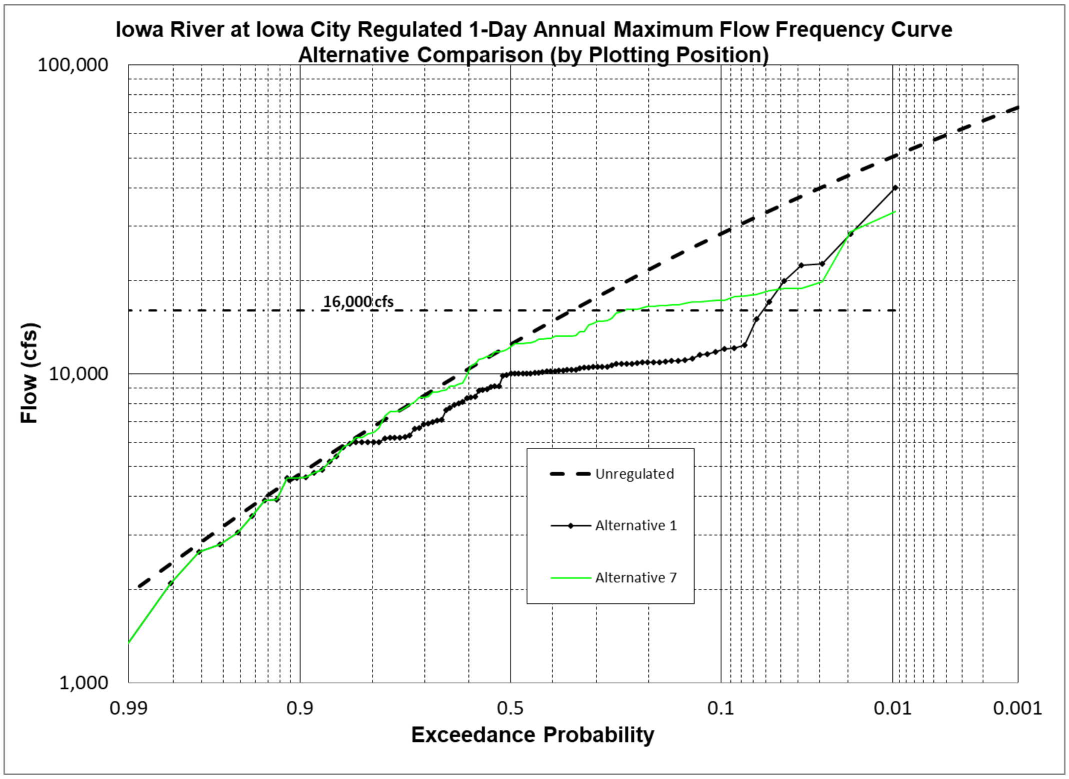


Figure B-44. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 7



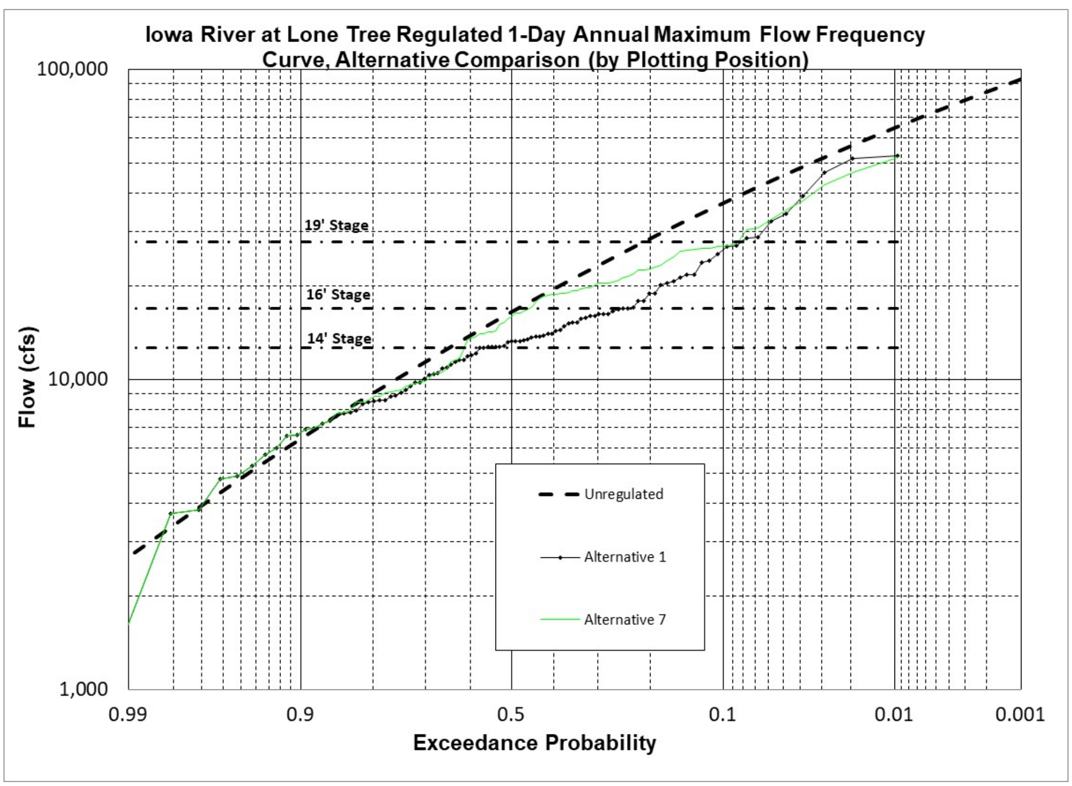
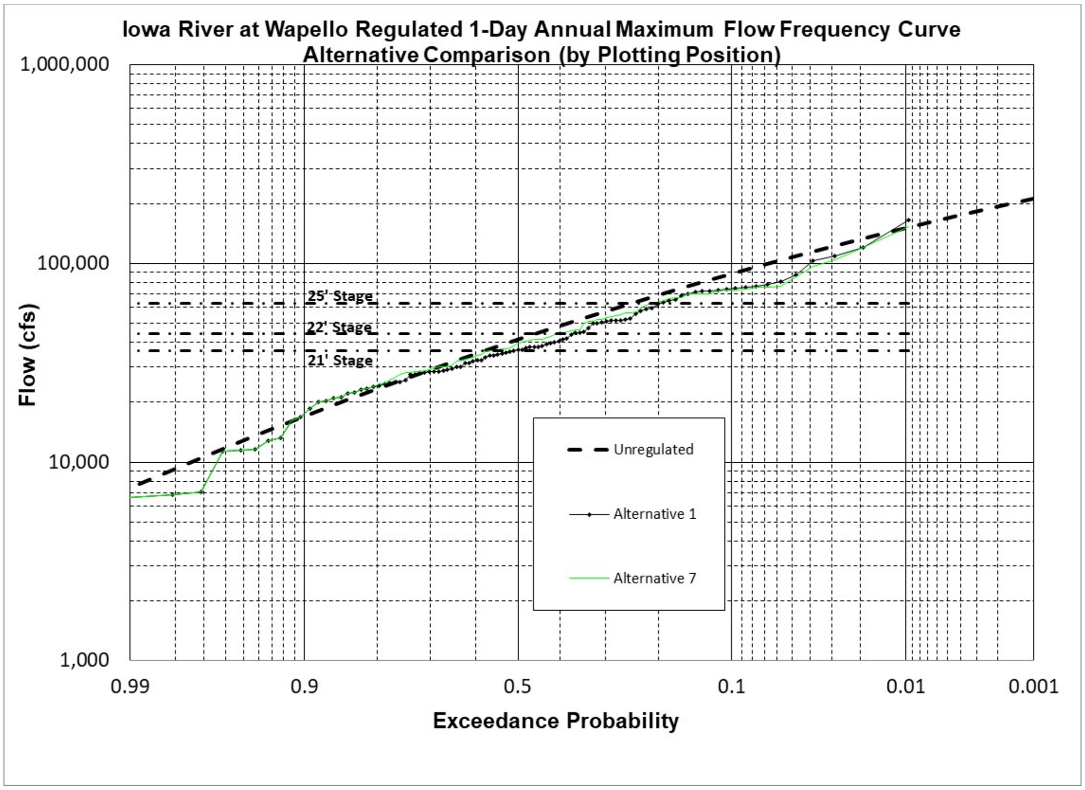


Figure B-45. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 7



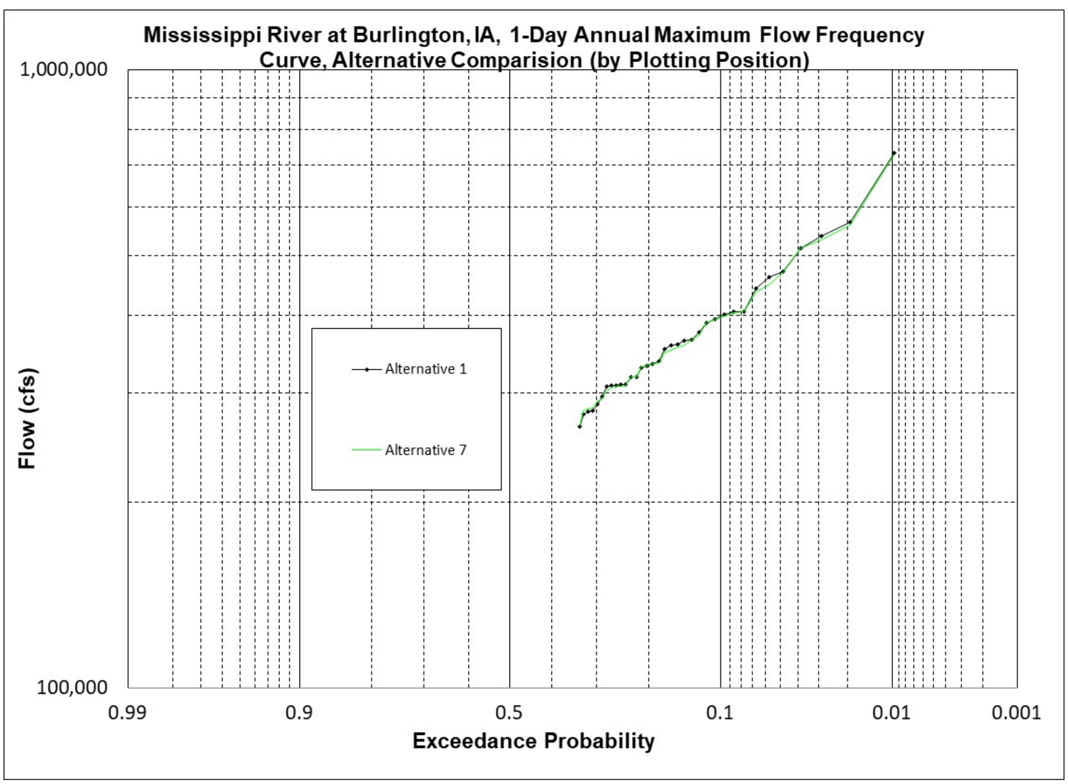


Figure B-46. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 7

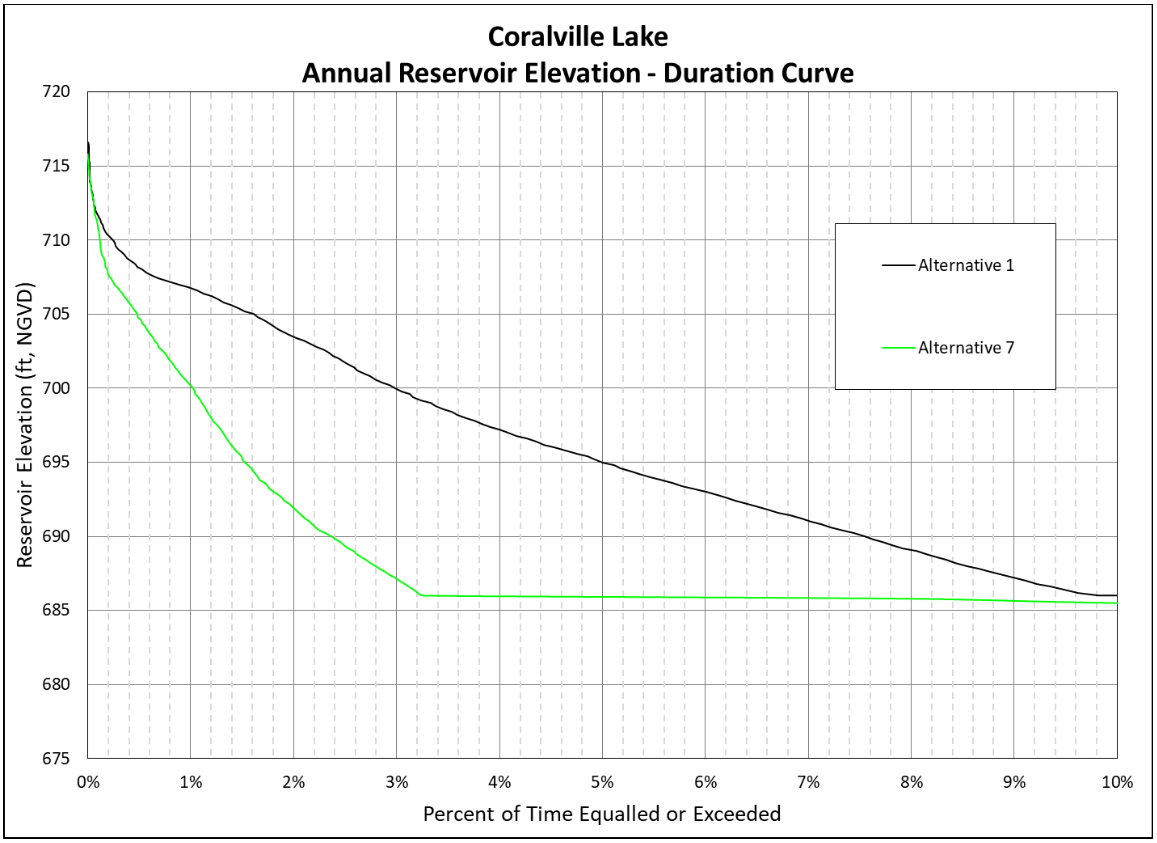
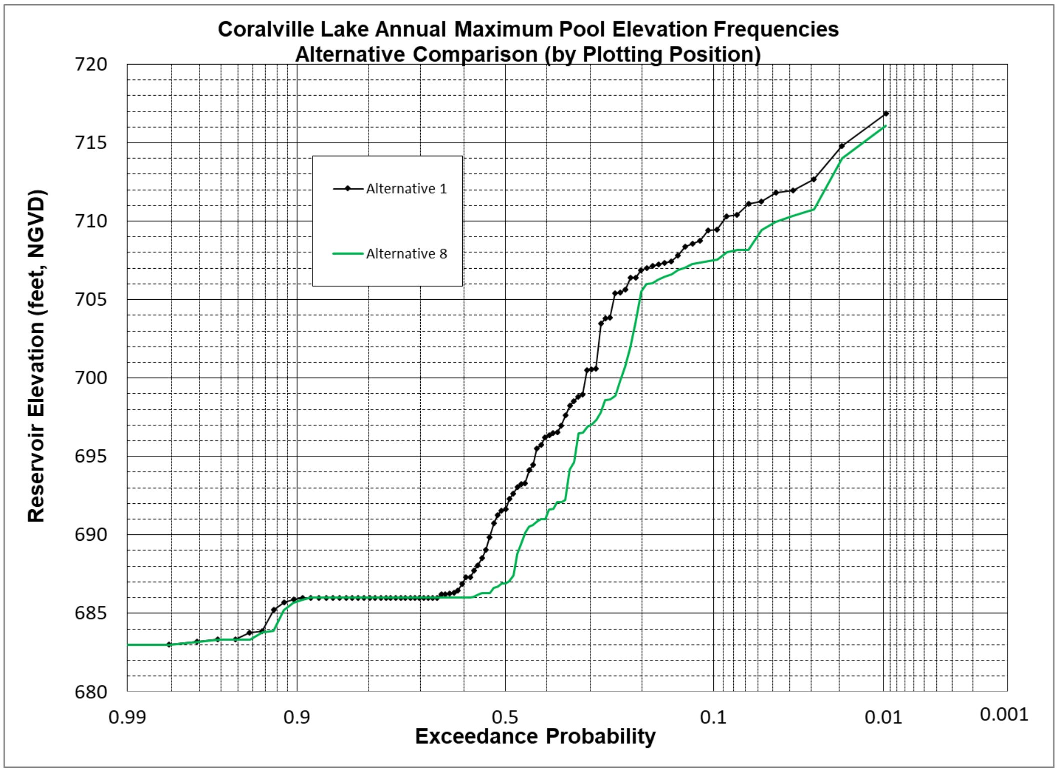


Figure B-47. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 7



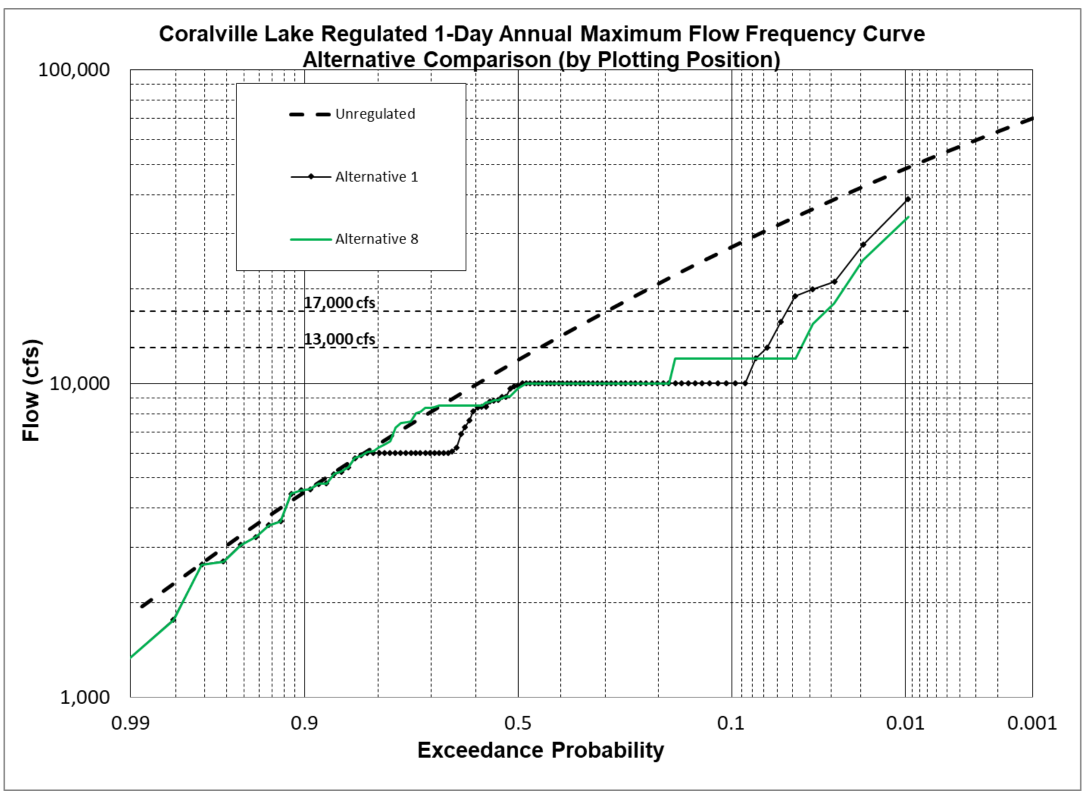
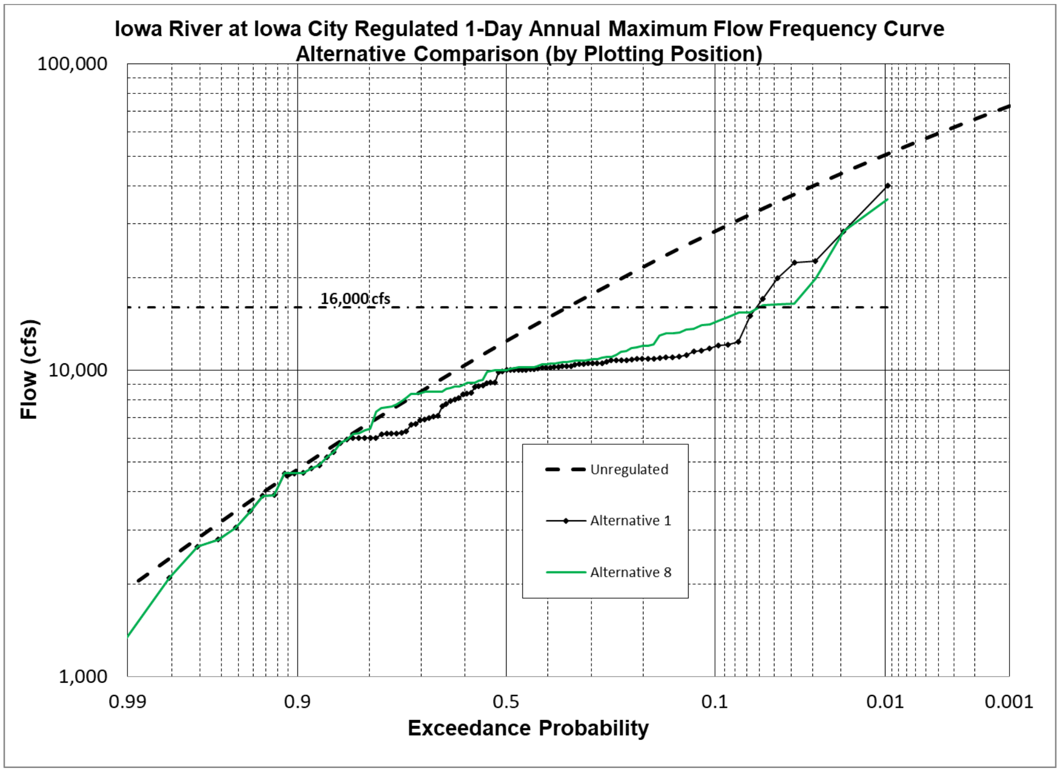


Figure B-48. Coralville Annual Maximum Pool Elevation and Regulated Flow Frequencies – Comparison of Alternatives 1 and 8



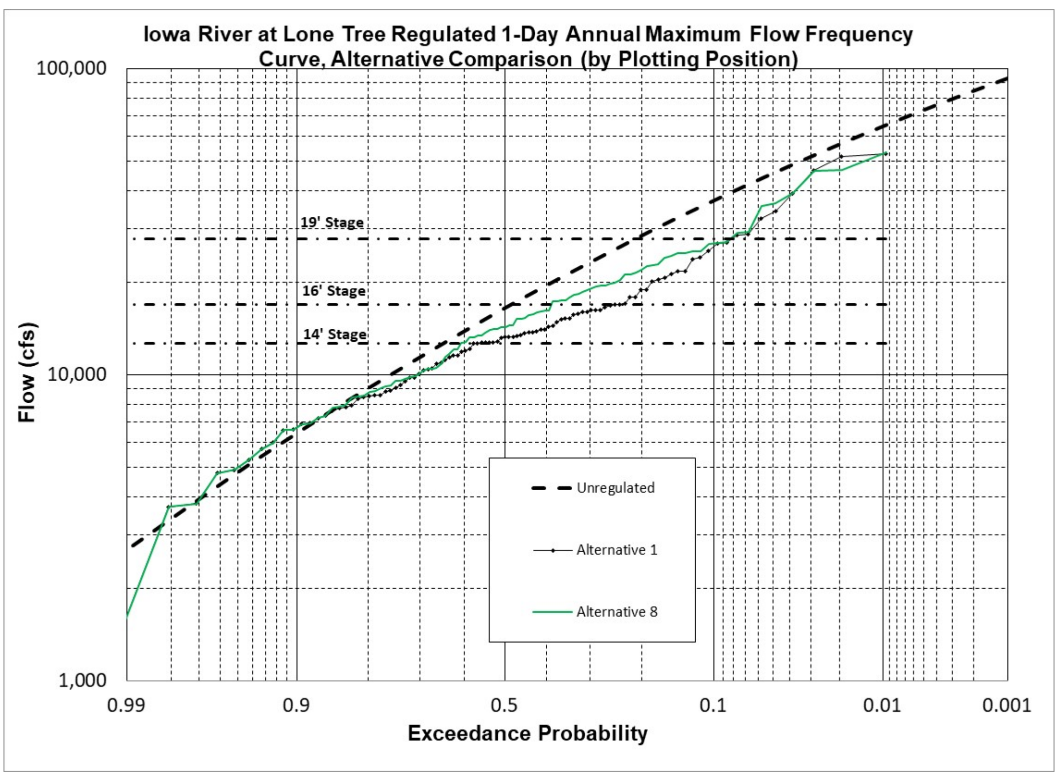
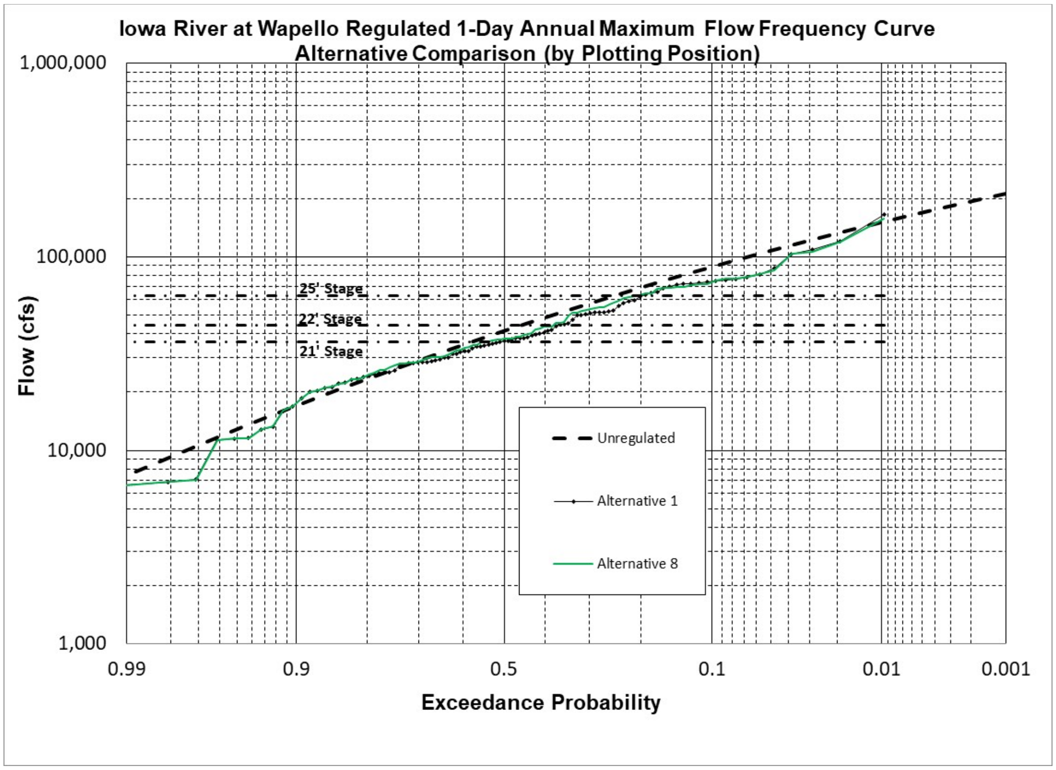


Figure B-49. Iowa City and Lone Tree Flow Regulated Annual Maximum Frequencies – Comparison of Alternatives 1 and 8



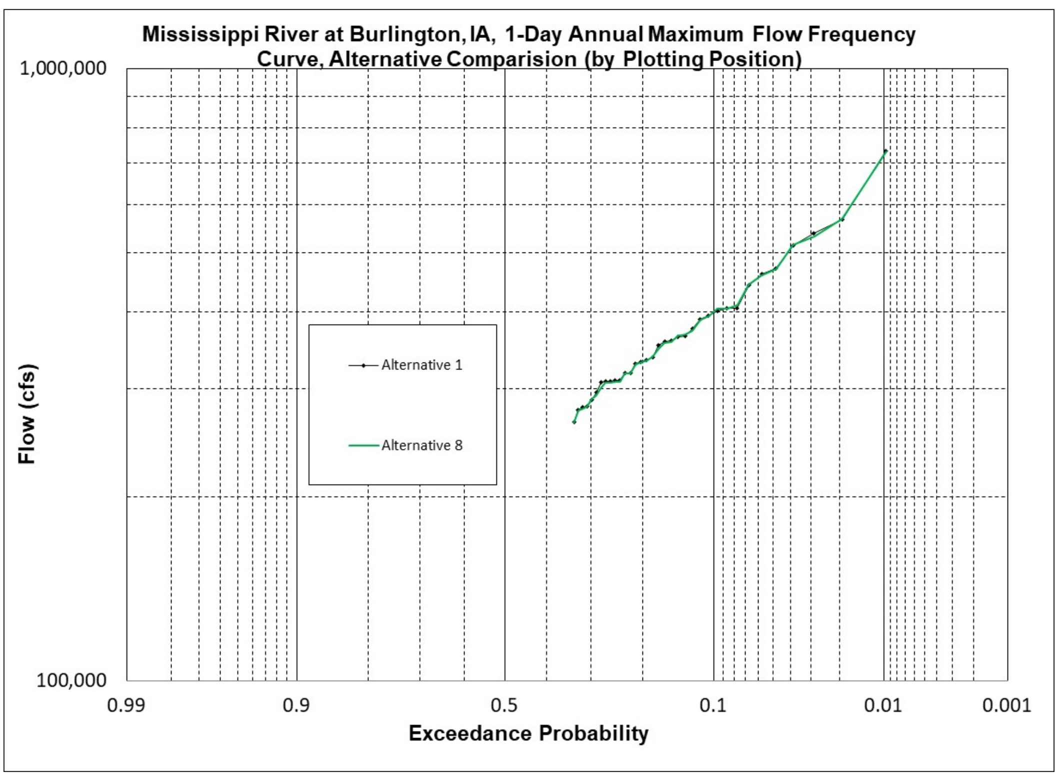


Figure B-50. Wapello and Burlington, IL, Regulated Annual Maximum Flow Frequencies – Comparison of Alternatives 1 and 8

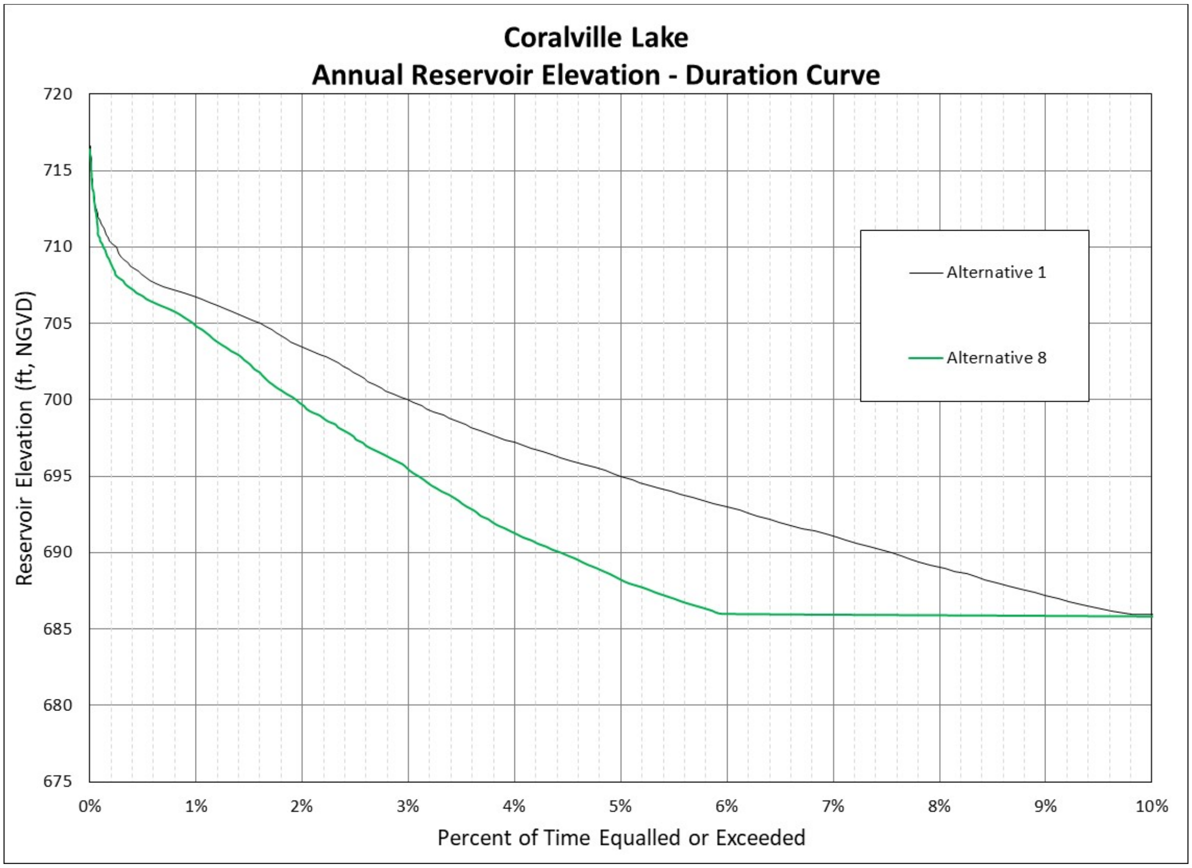
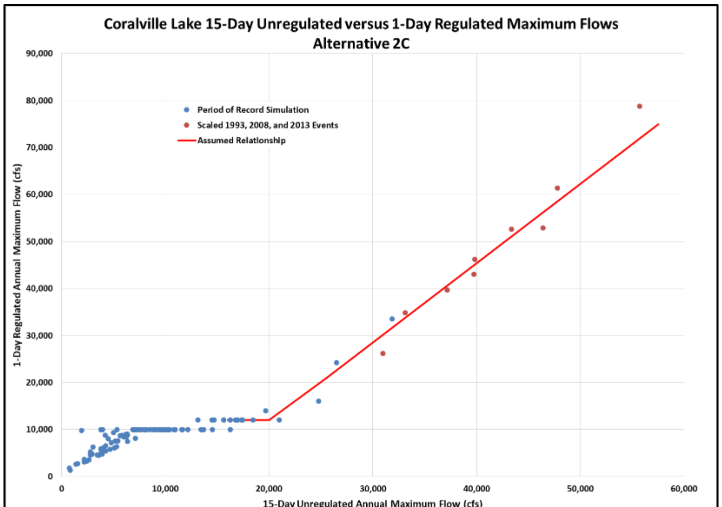
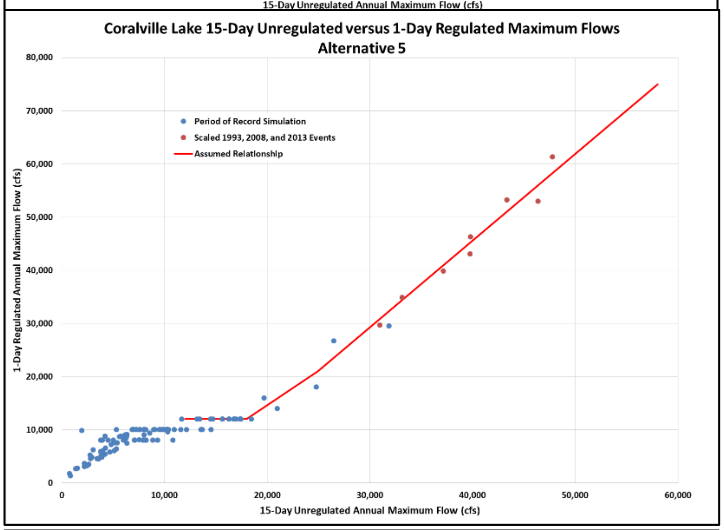


Figure B-51. Coralville Lake Annual Elevation-Duration Curves – Comparison of Alternatives 1 and 8





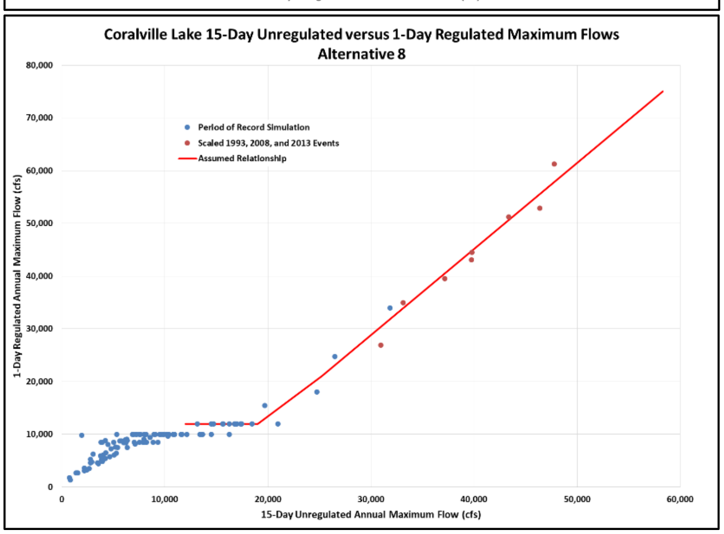
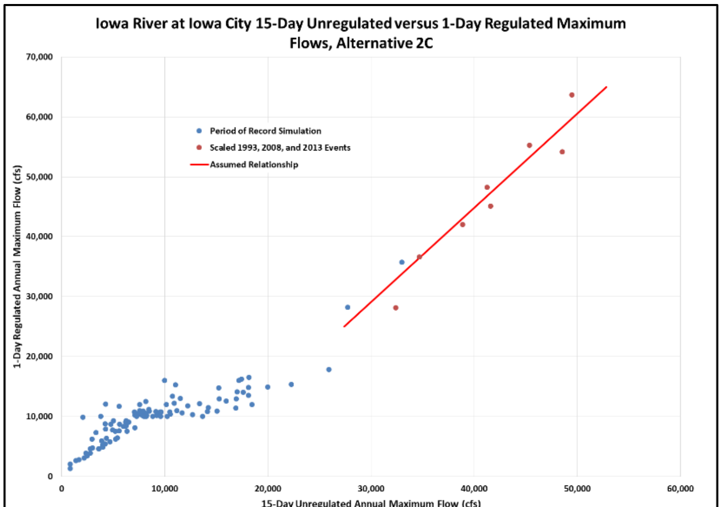
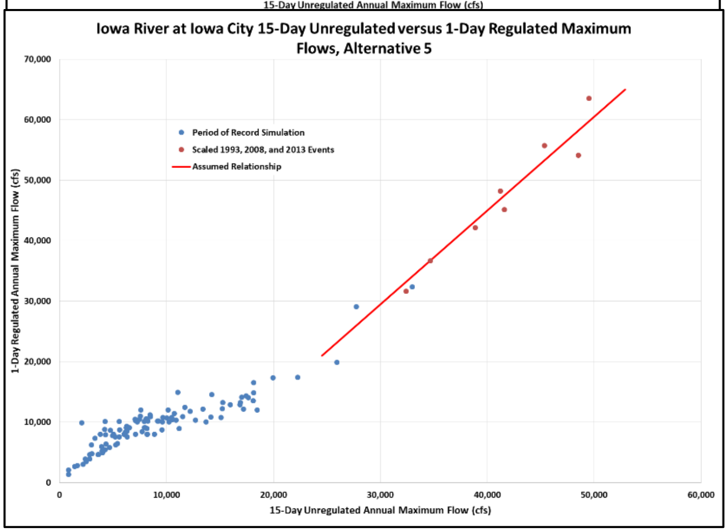


Figure B-52. Coralville Lake 15-Day Unregulated versus 1-Day Regulated Relationships – Alternatives 2C, 5 and 8





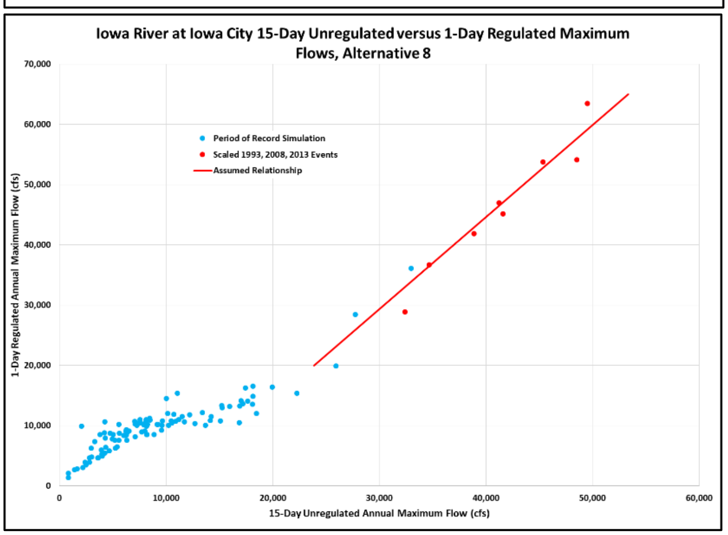


Figure B-53. Iowa River at Iowa City 15-Day Unregulated versus 1-Day Regulated Relationships – Alternatives 2C, 5 and 8

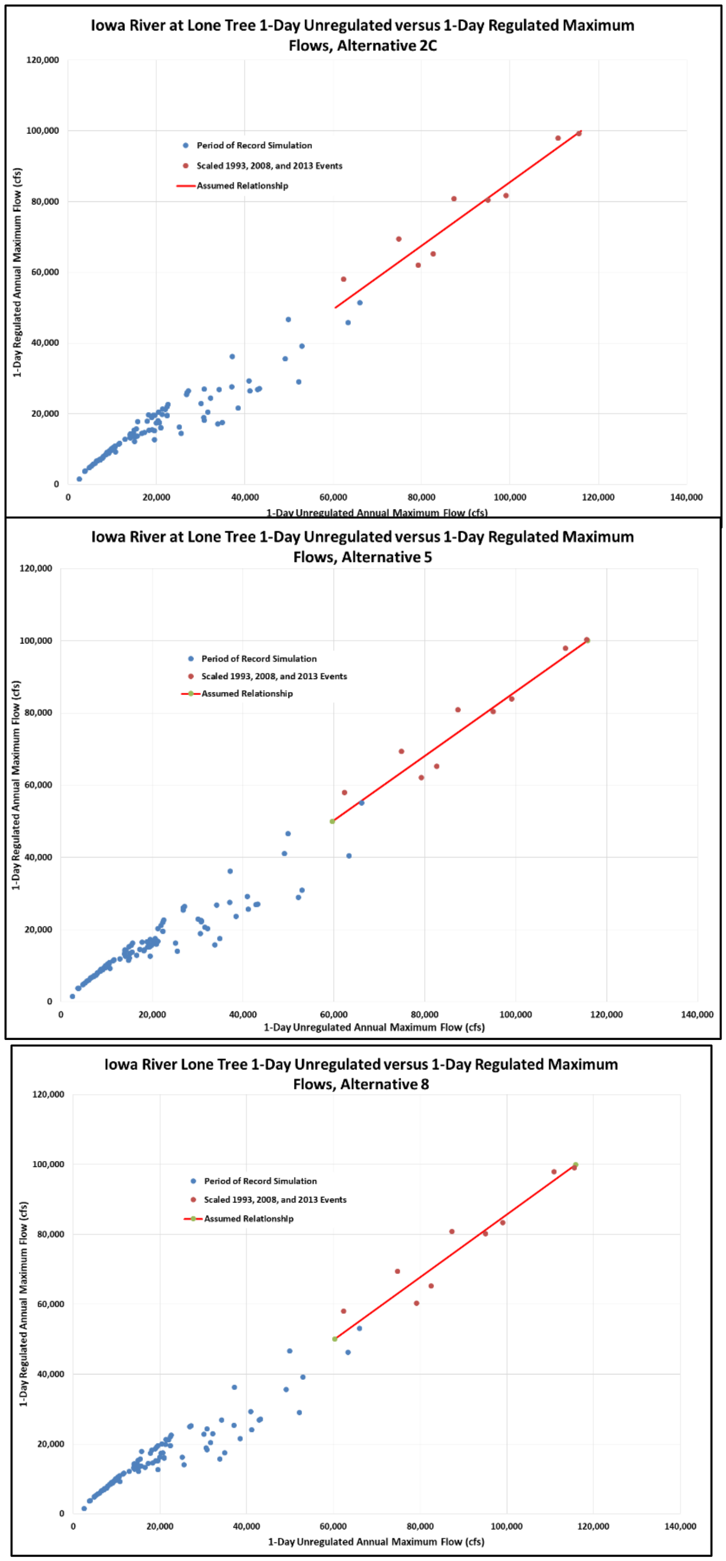
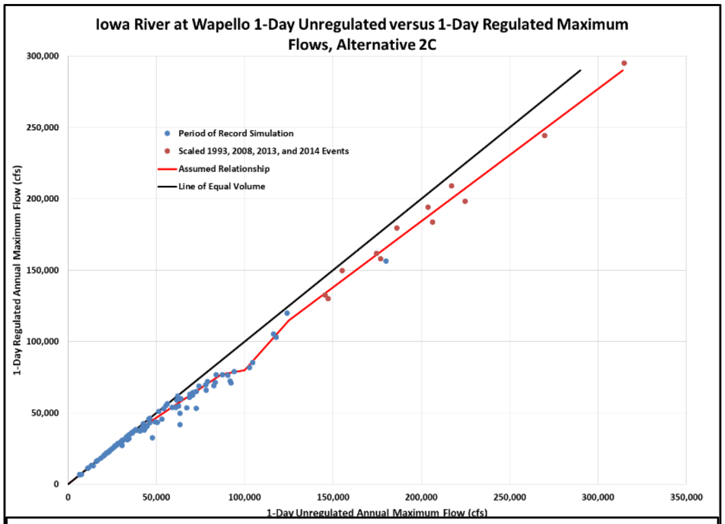
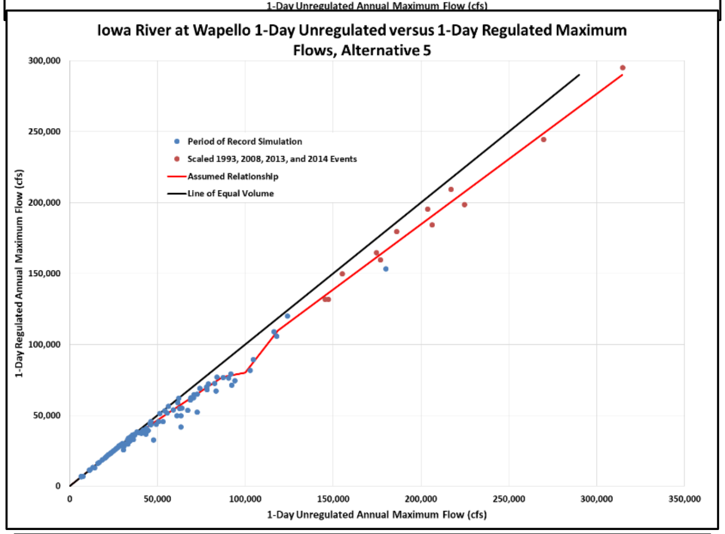


Figure B-54. Iowa River at Lone Tree 1-Day Unregulated versus 1-Day Regulated Relationships – Alternatives 2C, 5 and 8





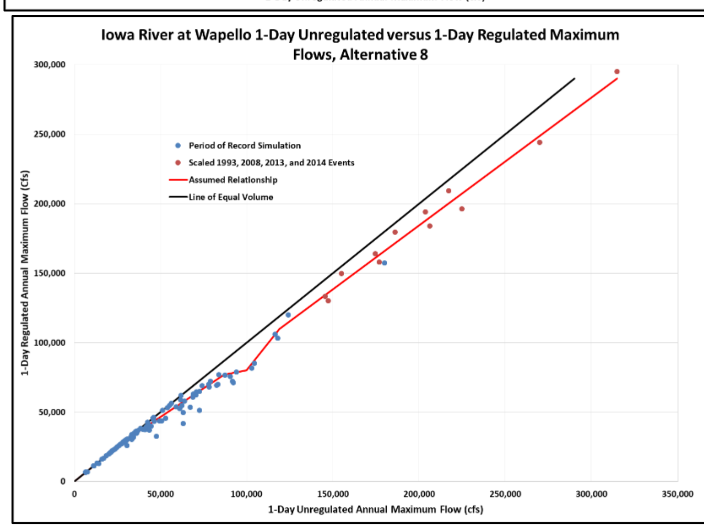


Figure B-55. Iowa River at Wapello 1-Day Unregulated versus 1-Day Regulated Relationships – Alternatives 2C, 5 and 8.

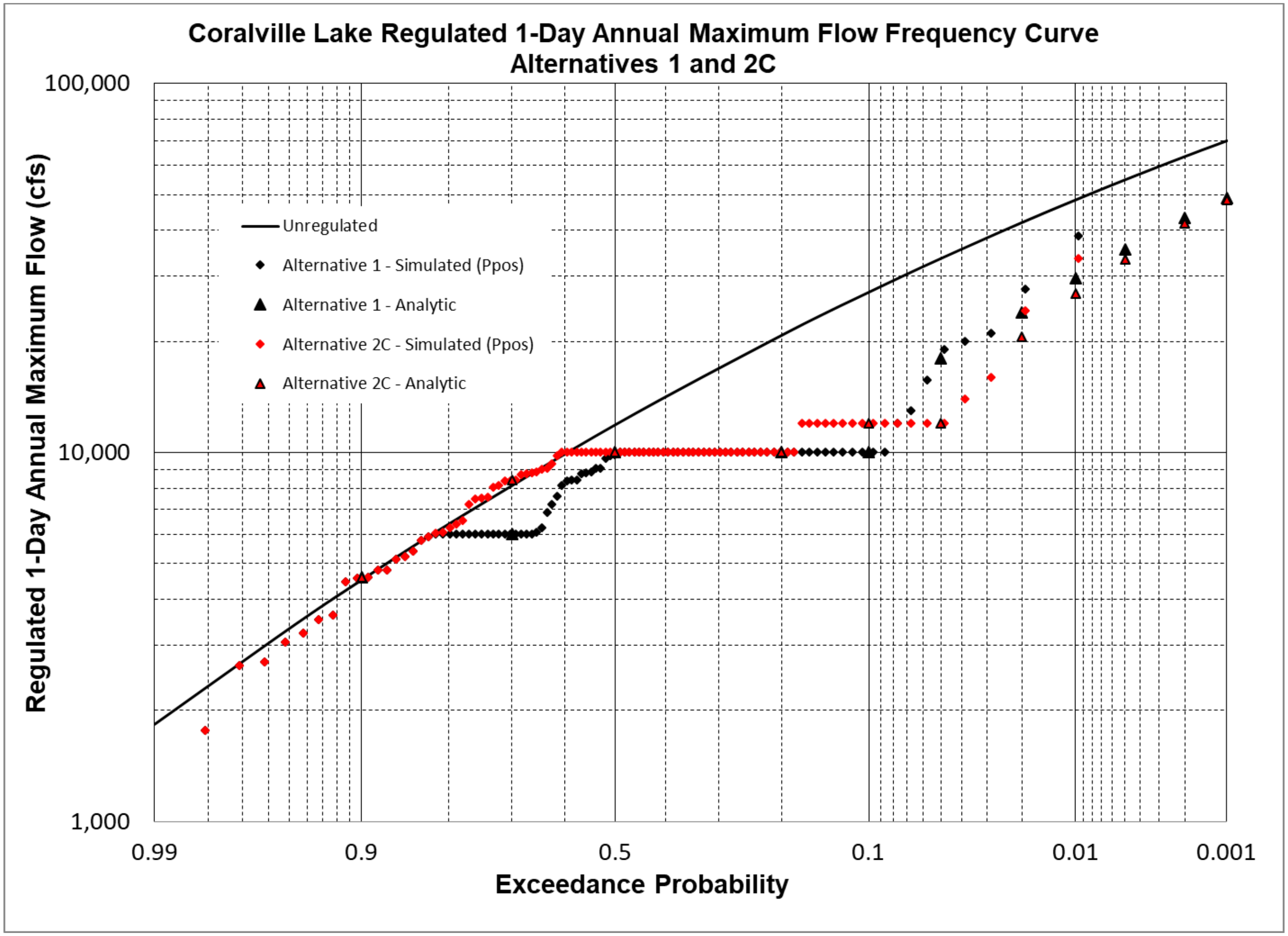


Figure B-56. Coralville Lake Regulated Flow Frequency Curve – Alternatives 1 and 2C. AEPs for simulated events estimated using Weibell plotting position (Ppos).

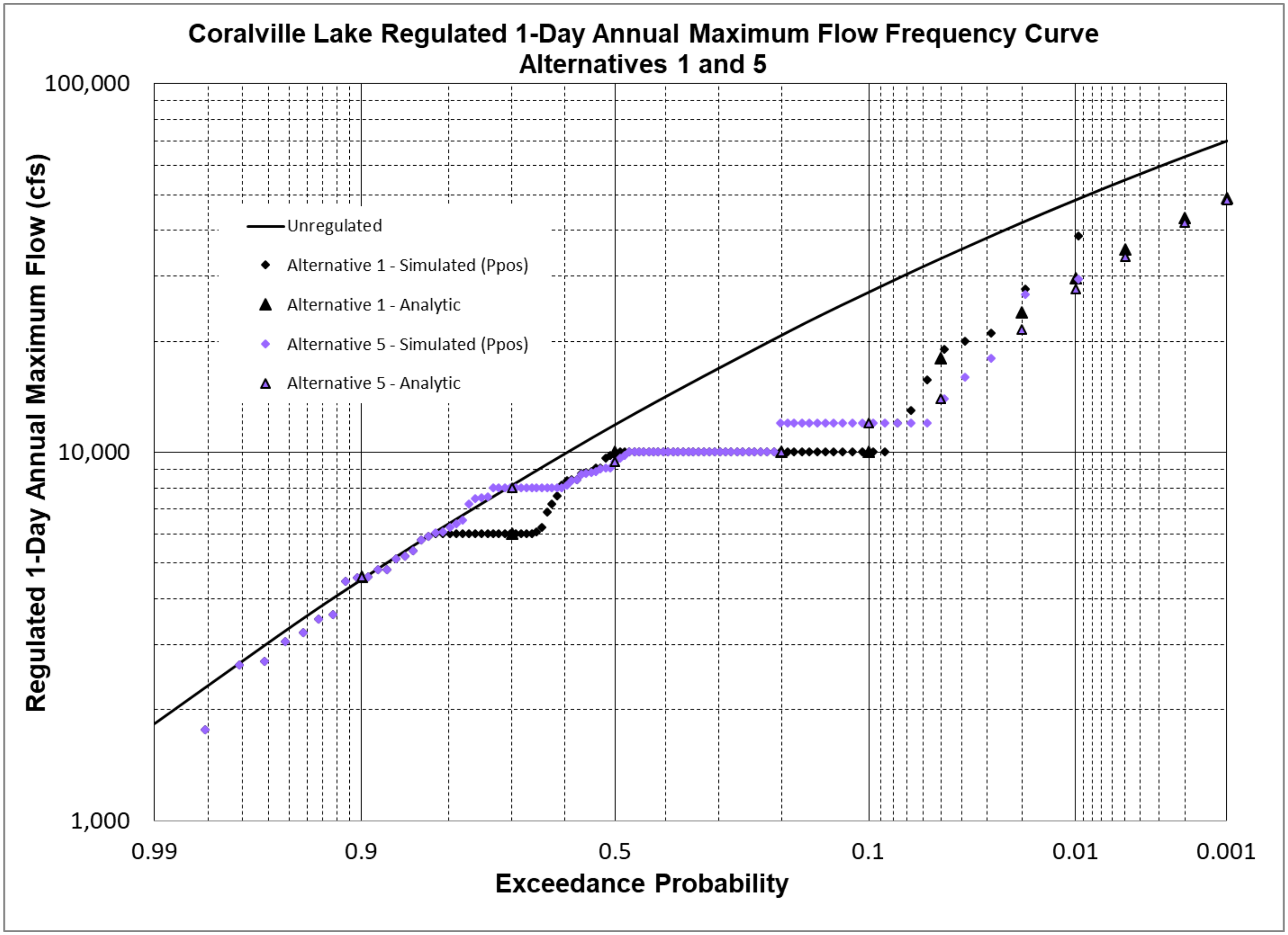


Figure B-57. Coralville Lake Regulated Flow Frequency Curve – Alternatives 1 and 5. AEPs for simulated events estimated using Weibell plotting position (Ppos).

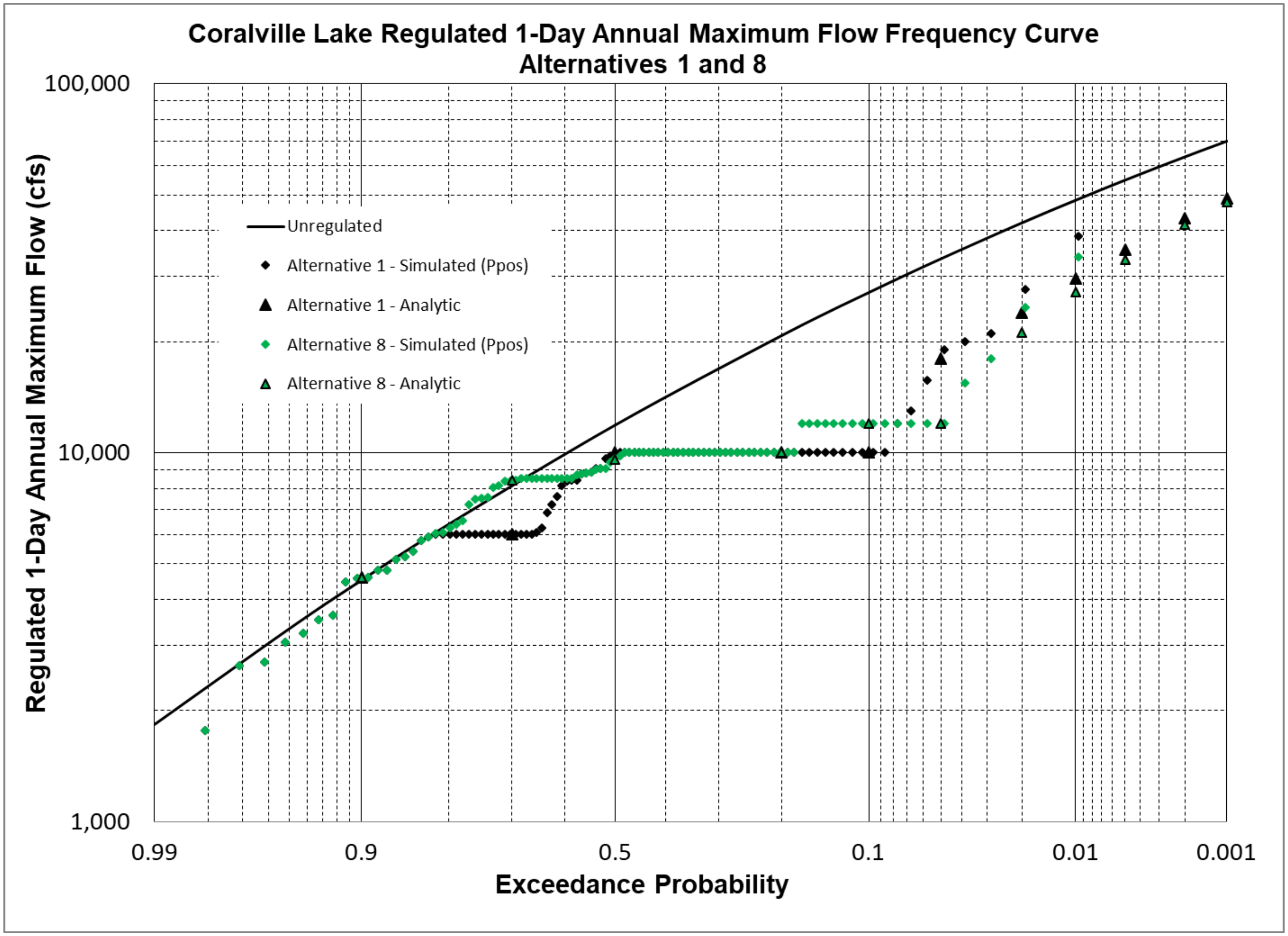


Figure B-58. Coralville Lake Regulated Flow Frequency Curve – Alternatives 1 and 8. AEPs for simulated events estimated using Weibell plotting position (Ppos).

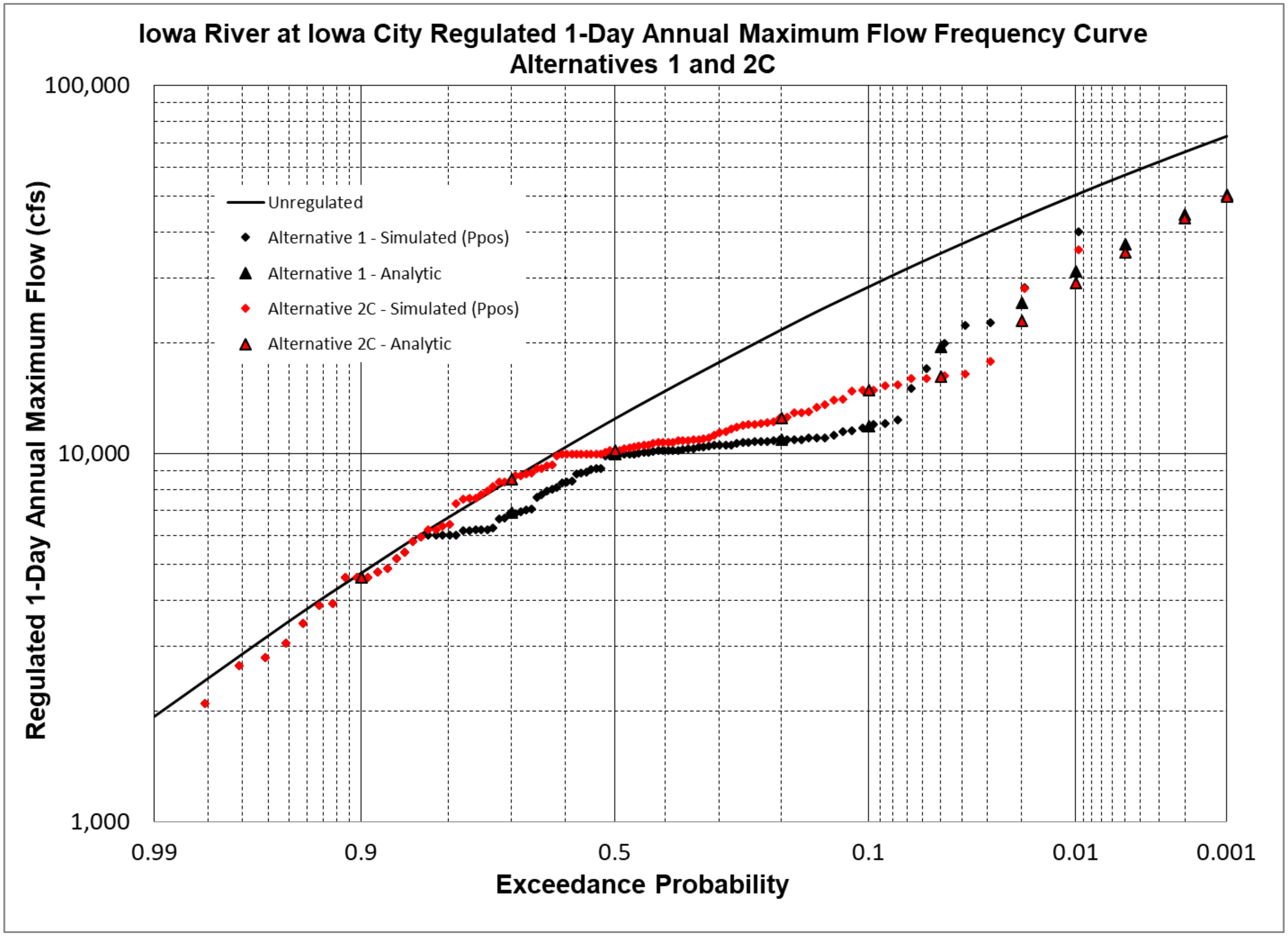


Figure B-59. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternatives 1 and 2C. AEPs for simulated events estimated using Weibell plotting position (Ppos).

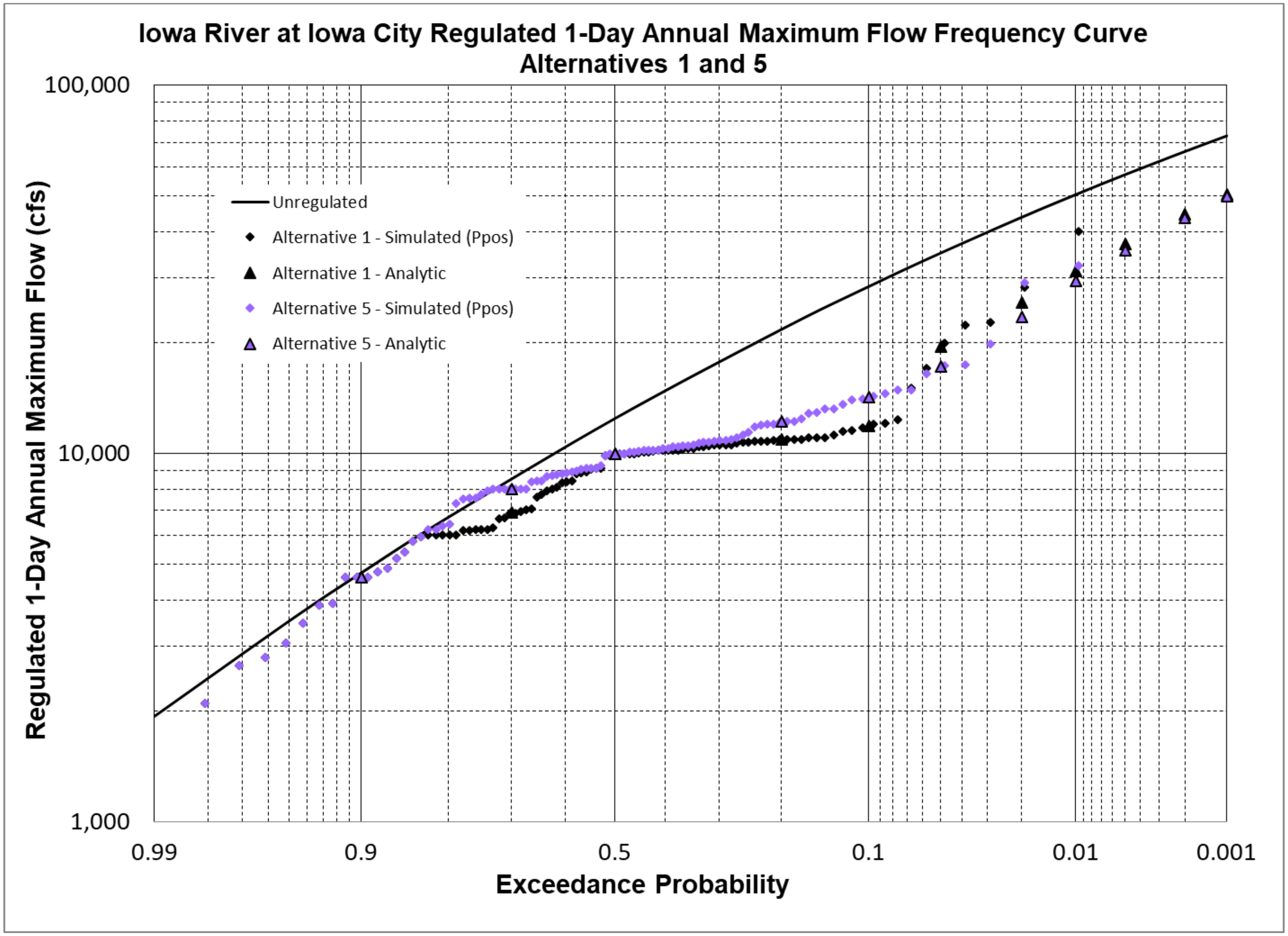


Figure B-60. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternatives 1 and 5. AEPs for simulated events estimated using Weibell plotting position (Ppos).

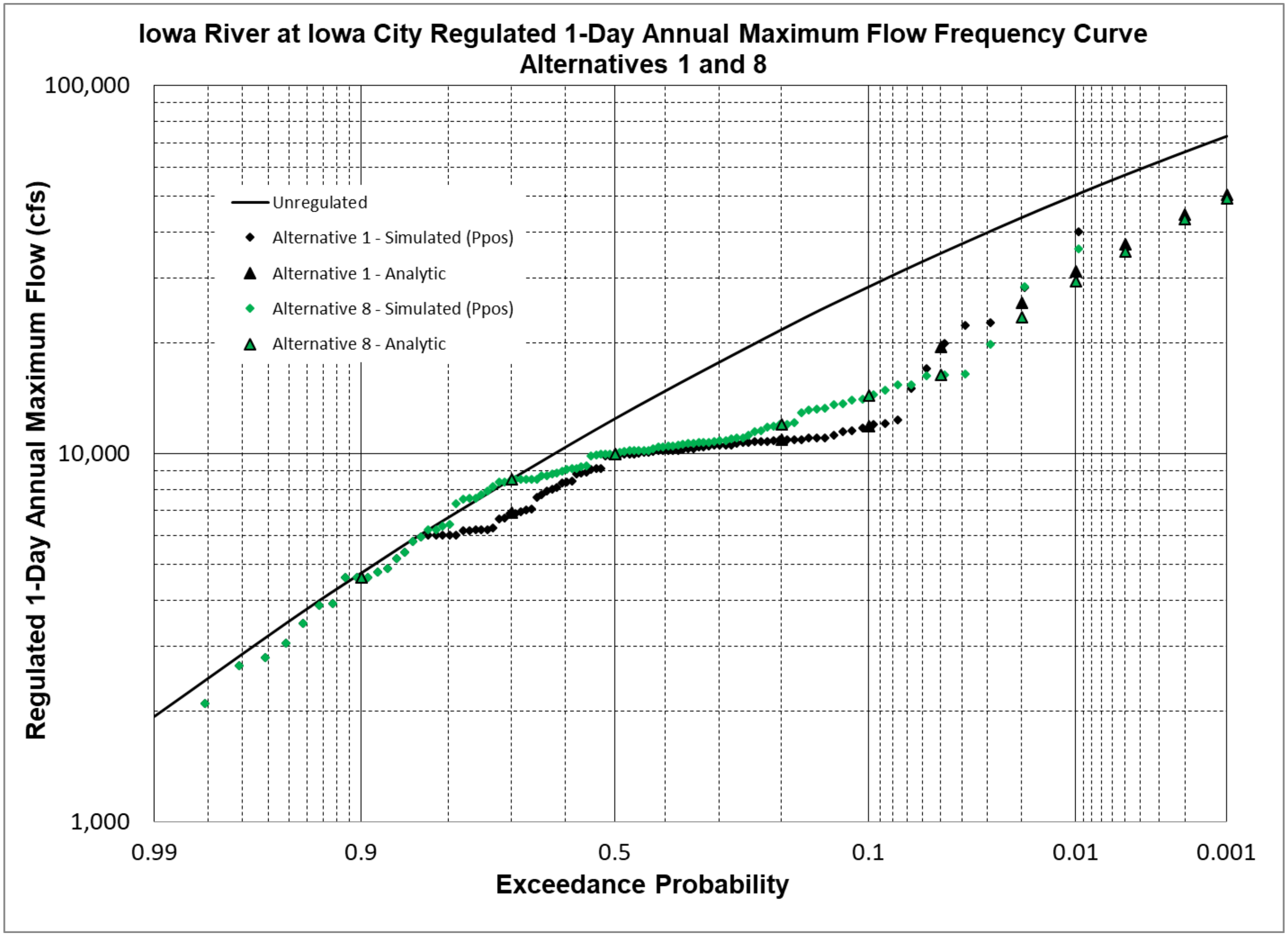


Figure B-61. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternatives 1 and 8. AEPs for simulated events estimated using Weibell plotting position (Ppos).

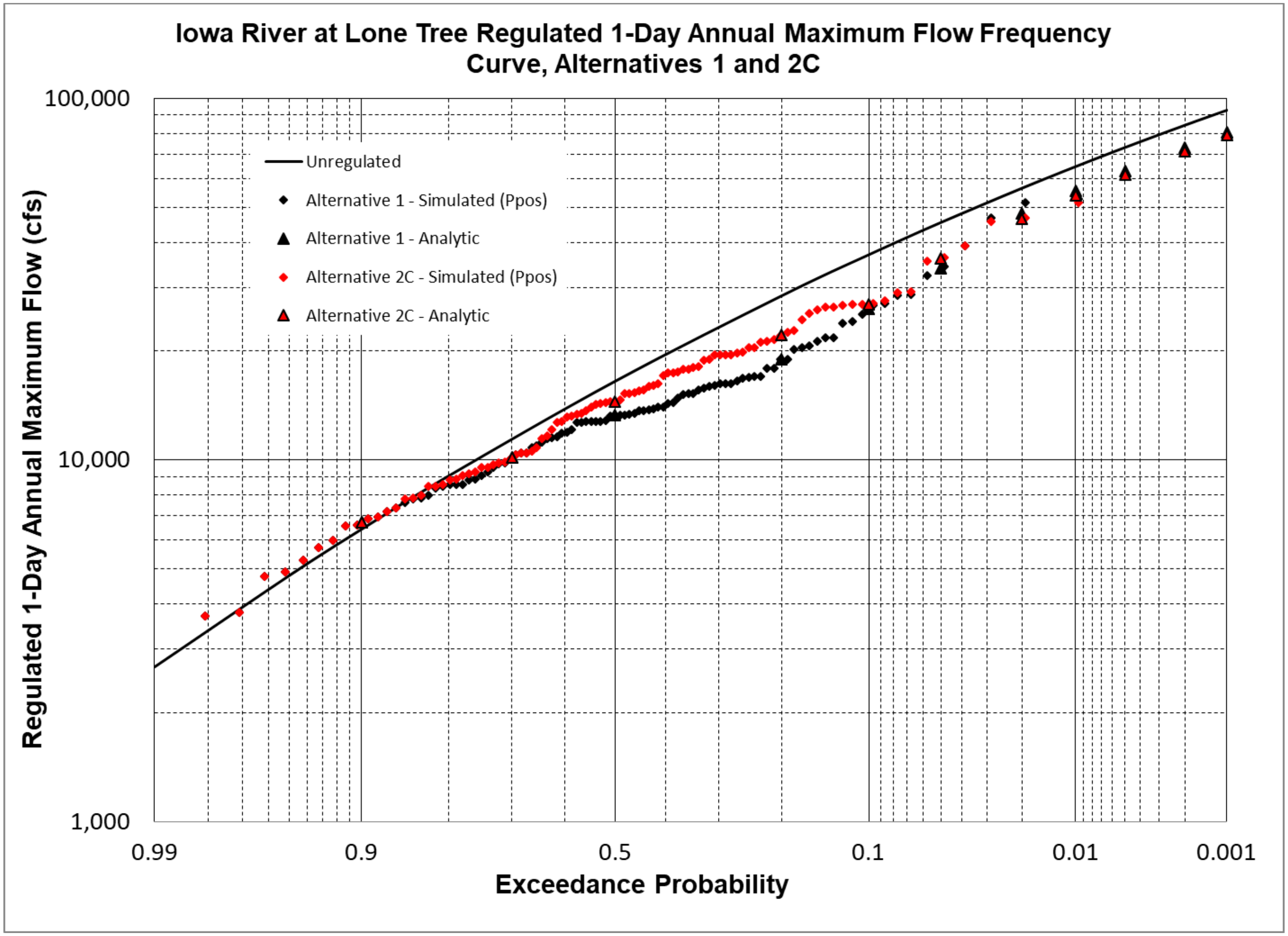


Figure B-62. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternatives 1 and 2C. AEPs for simulated events estimated using Weibell plotting position (Ppos).

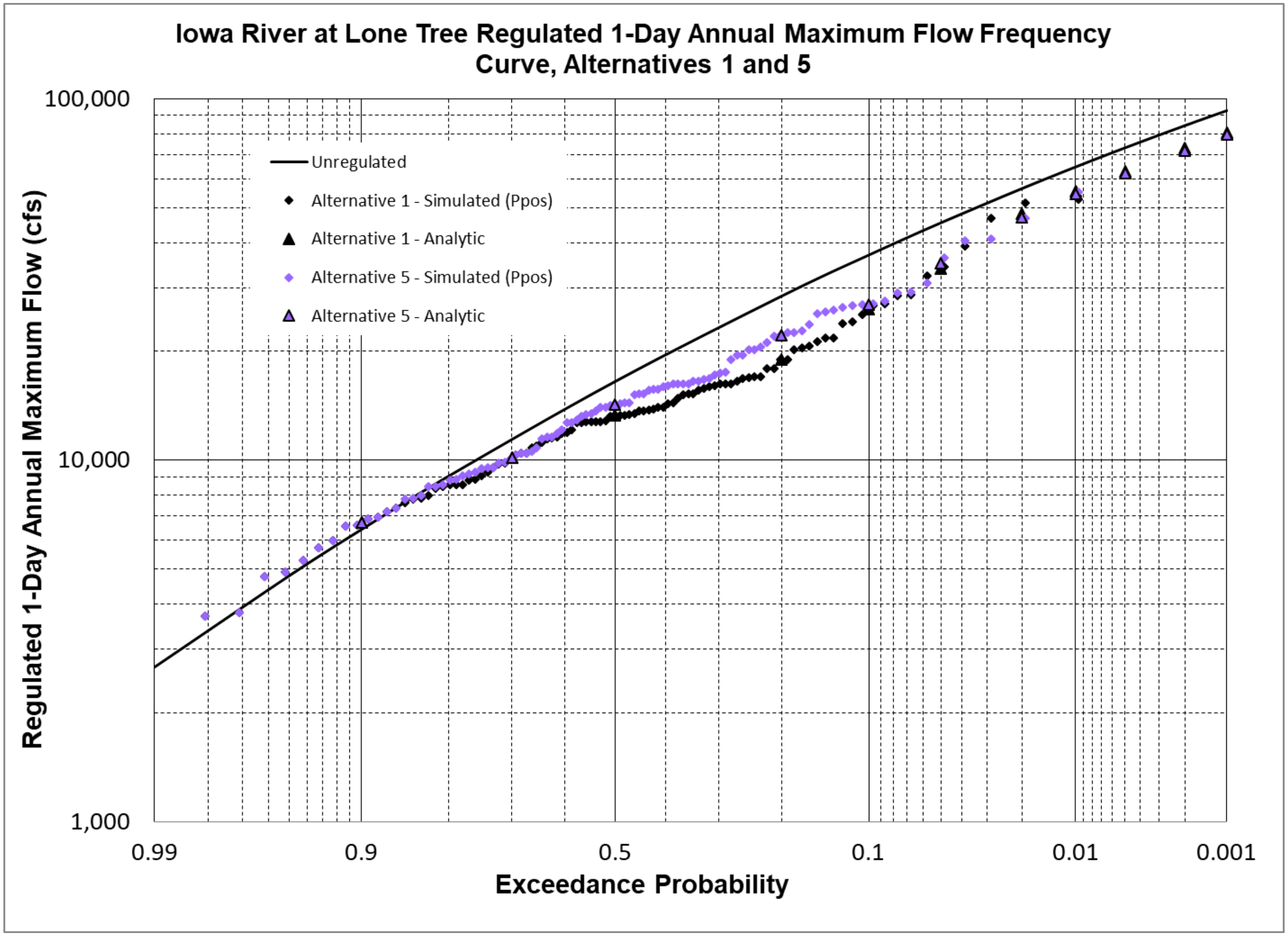


Figure B-63. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternatives 1 and 5. AEPs for simulated events estimated using Weibell plotting position (Ppos).

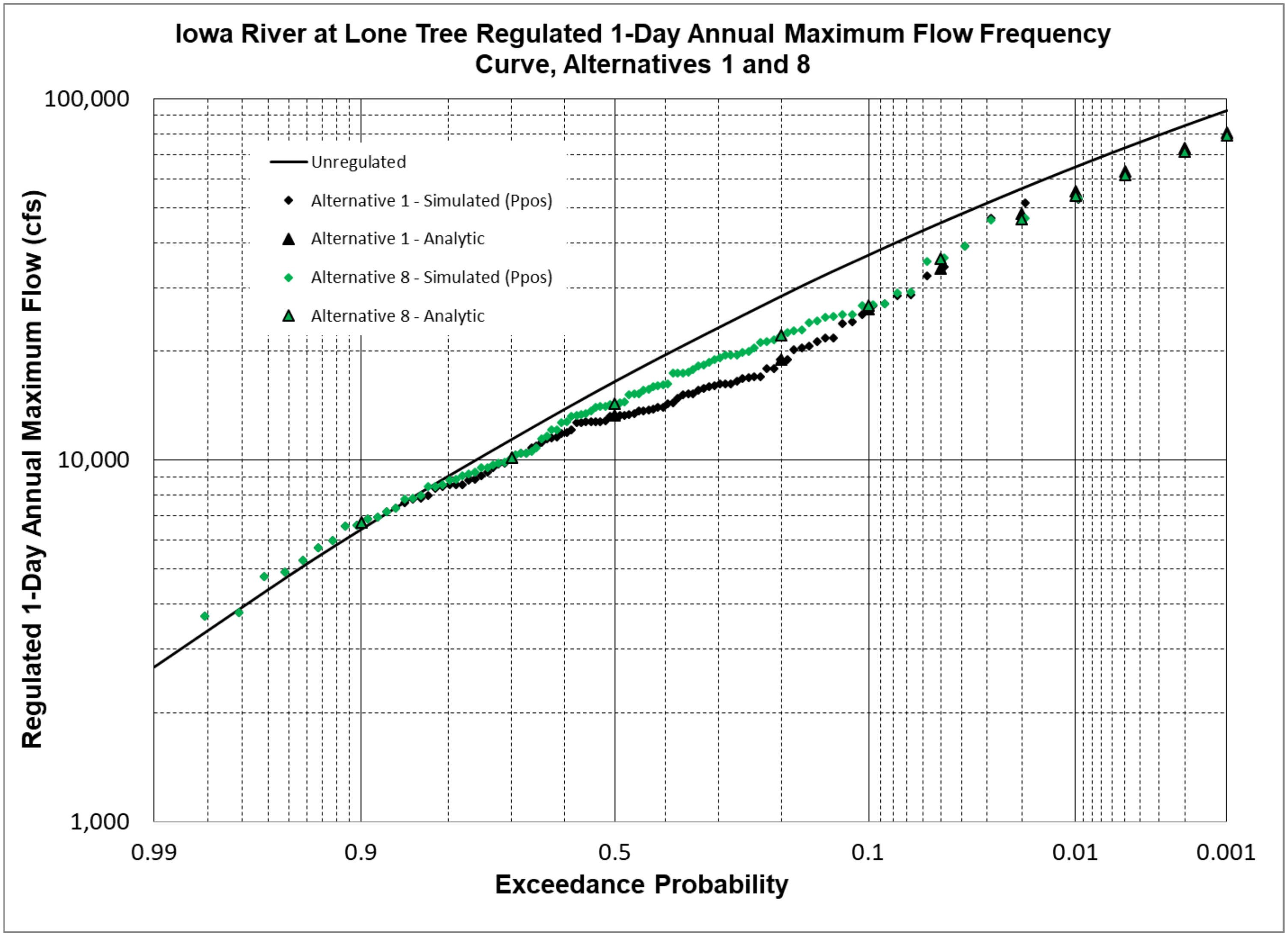


Figure B-64. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternatives 1 and 8. AEPs for simulated events estimated using Weibell plotting position (Ppos).

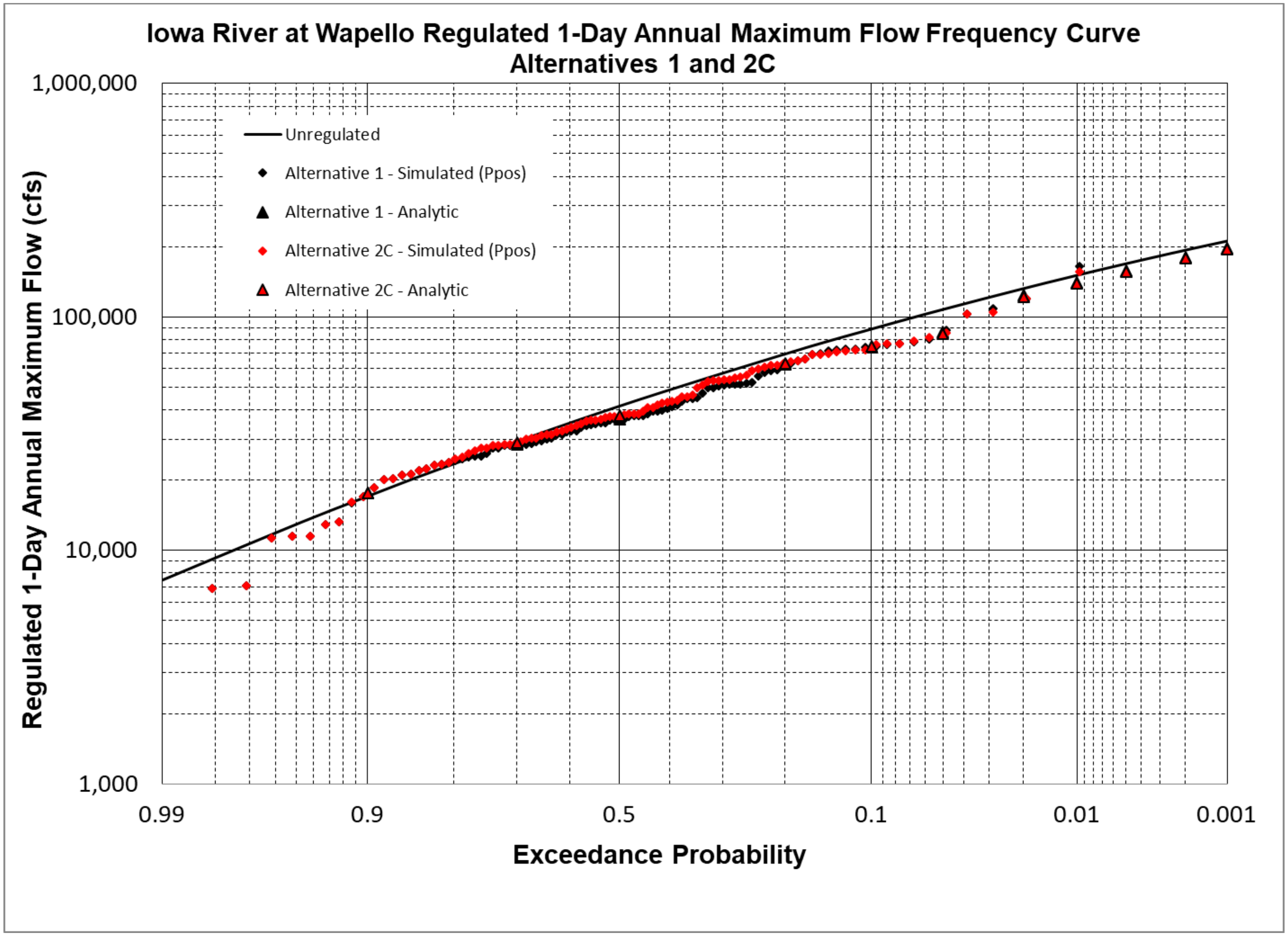


Figure B-65. Iowa River at Wapello Regulated Flow Frequency Curve – Alternatives 1 and 2C. AEPs for simulated events estimated using Weibell plotting position (Ppos).

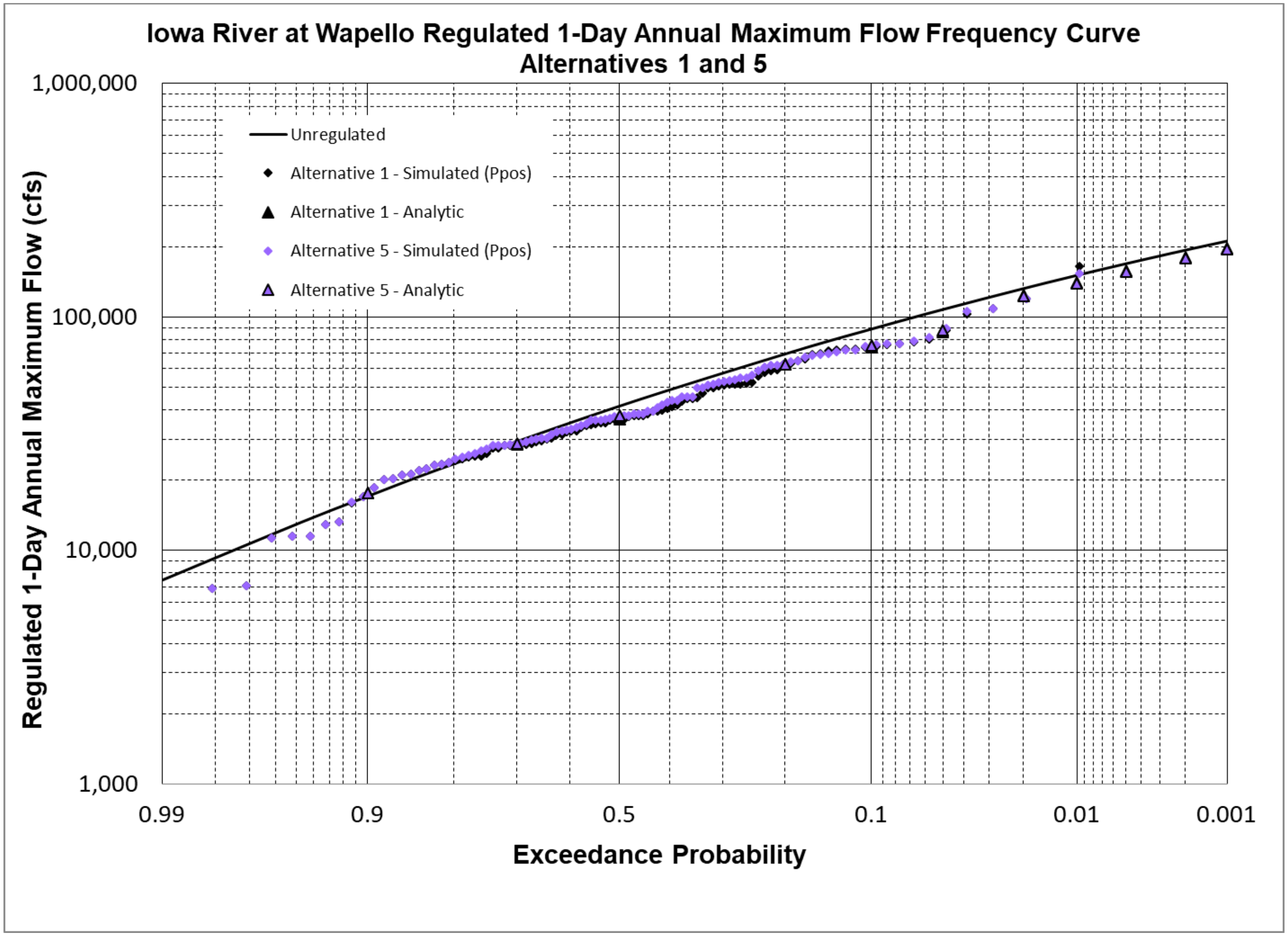


Figure B-66. Iowa River at Wapello Regulated Flow Frequency Curve – Alternatives 1 and 5. AEPs for simulated events estimated using Weibell plotting position (Ppos).

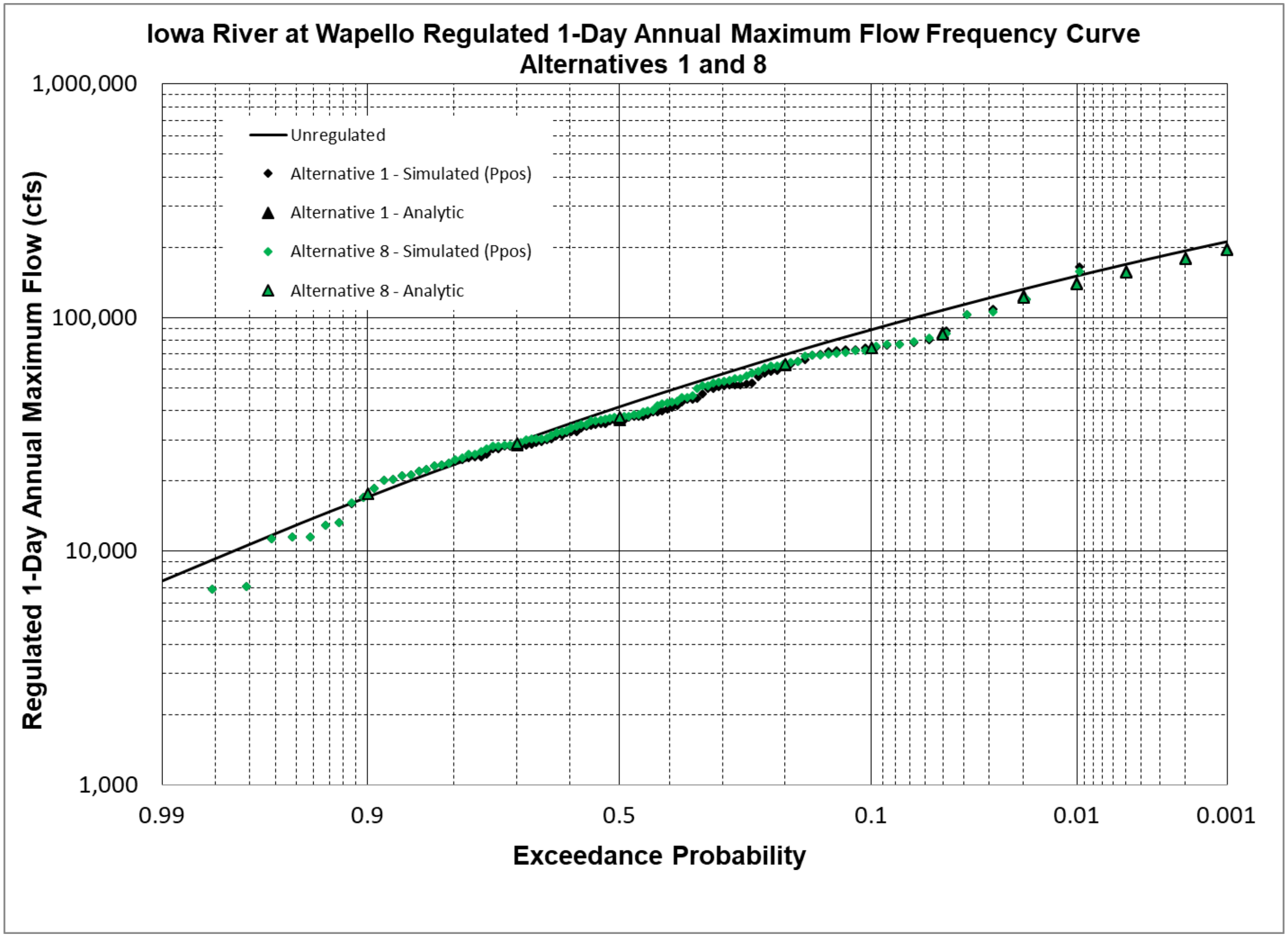


Figure B-67. Iowa River at Wapello Regulated Flow Frequency Curve – Alternatives 1 and 8. AEPs for simulated events estimated using Weibell plotting position (Ppos).

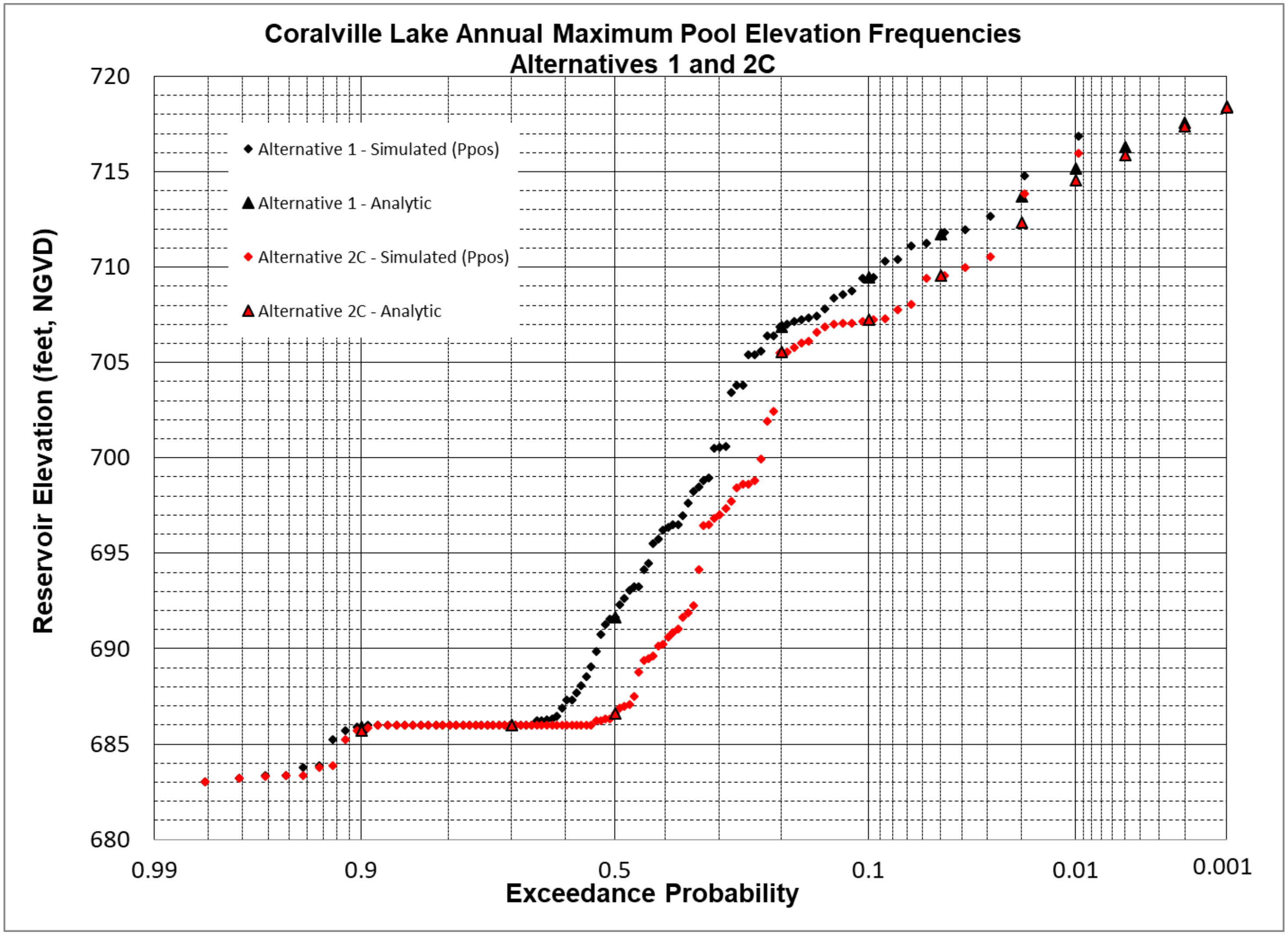


Figure B-68. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 1 and 2C. AEPs for simulated events estimated using Weibell plotting position (Ppos).

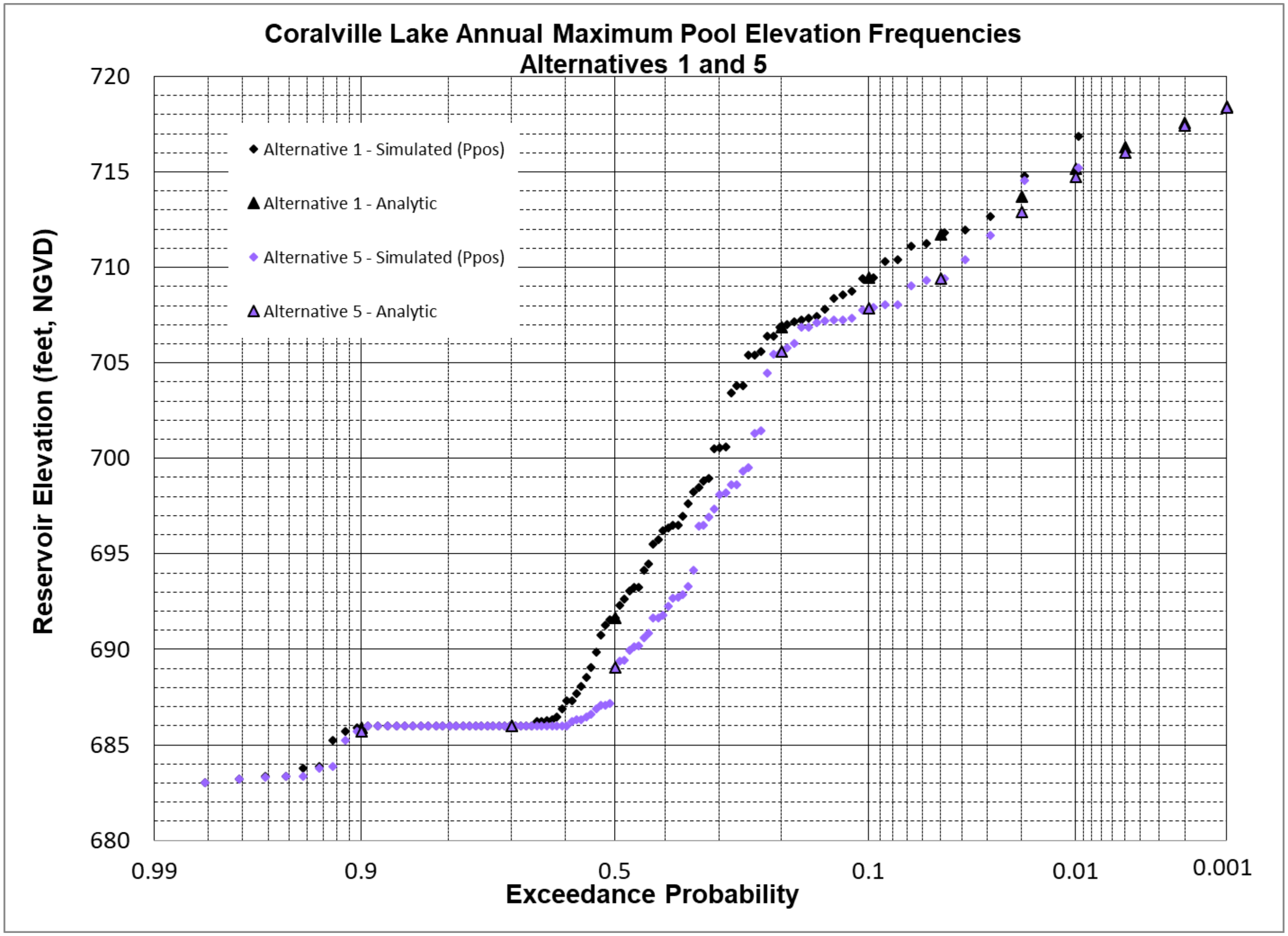


Figure B-69. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 1 and 5. AEPs for simulated events estimated using Weibell plotting position (Ppos).

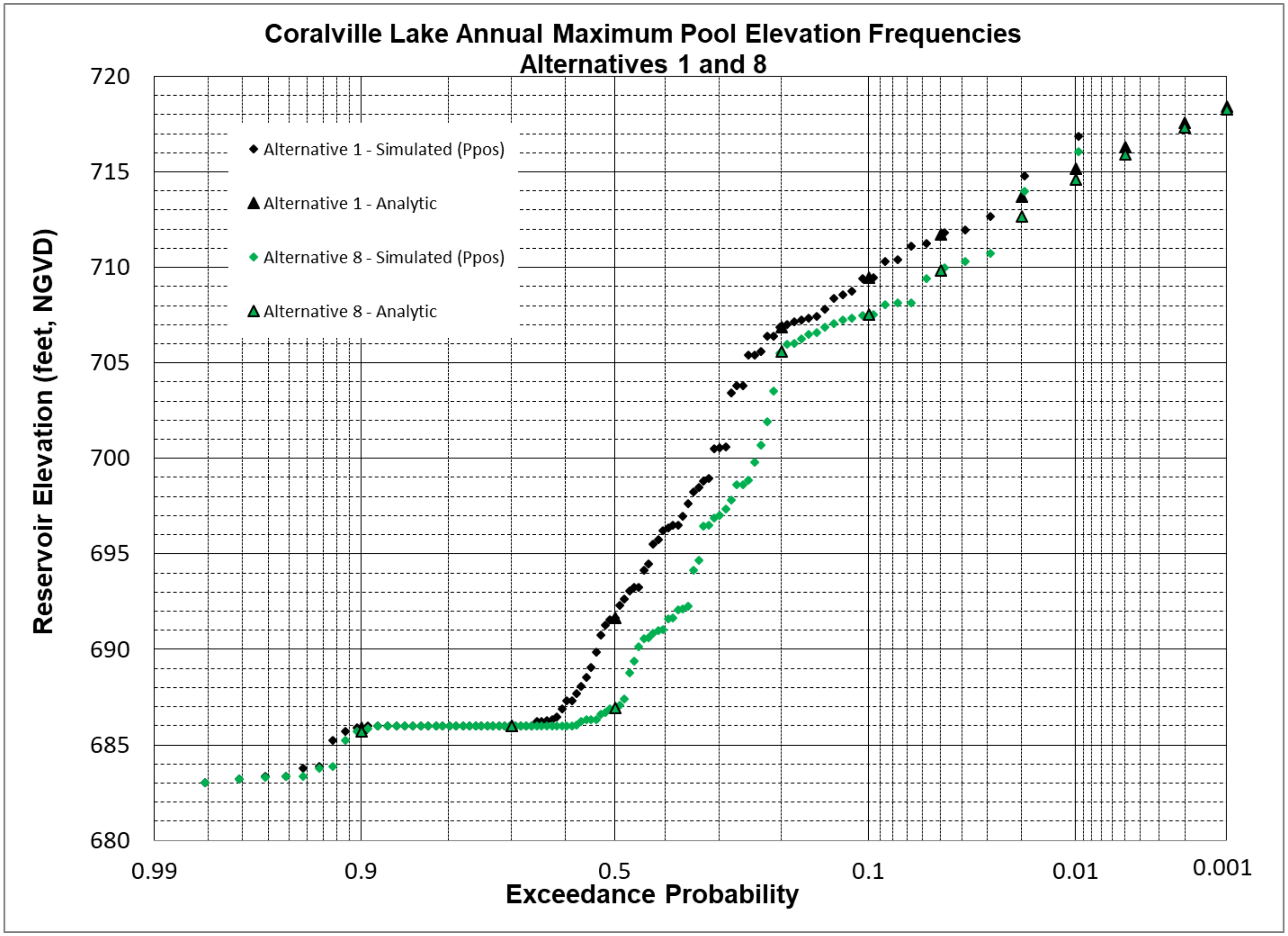


Figure B-70. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 1 and 8. AEPs for simulated events estimated using Weibell plotting position (Ppos).

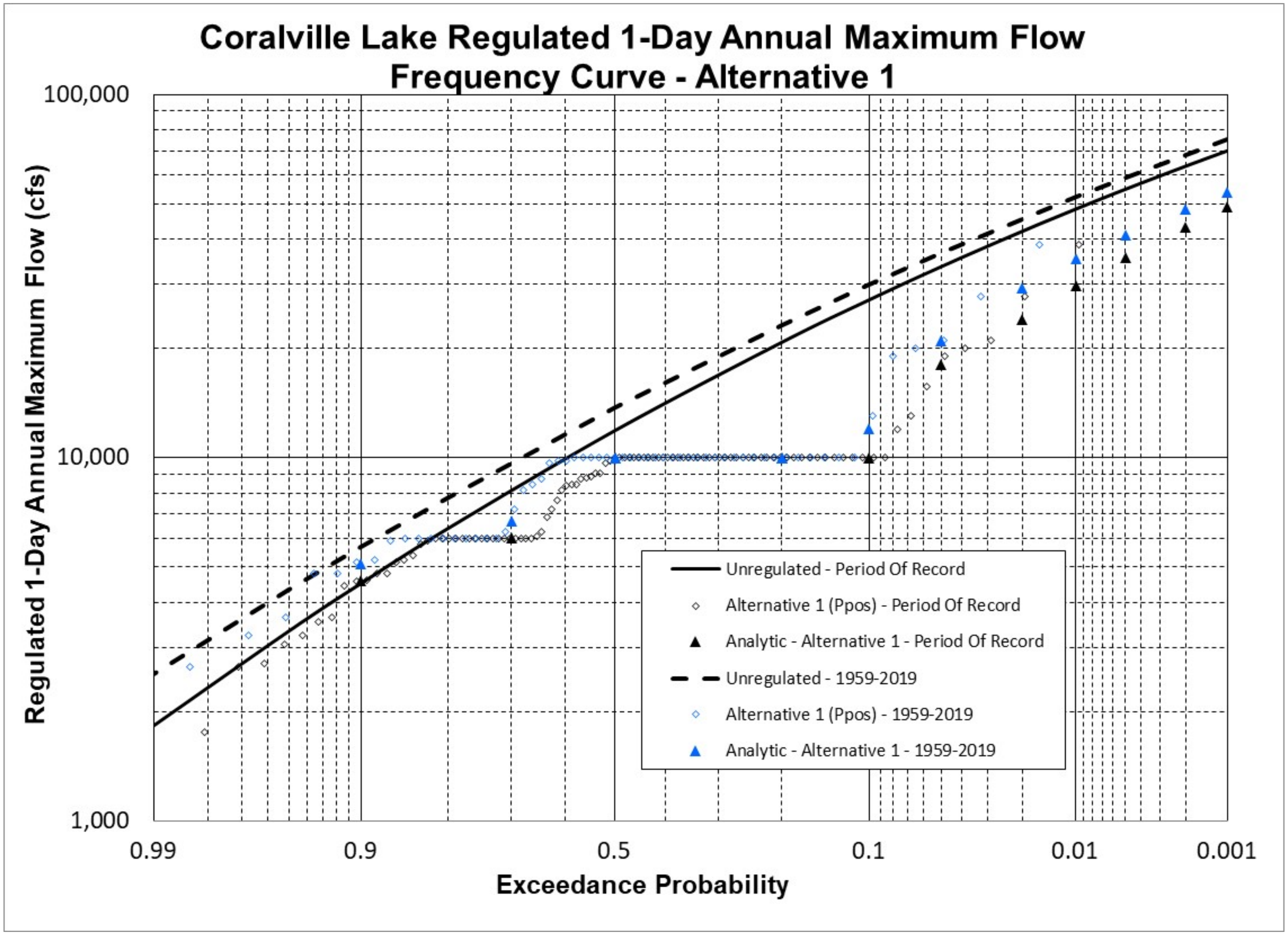


Figure B-71. Coralville Lake Regulated Flow Frequency Curve – Alternative 1. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

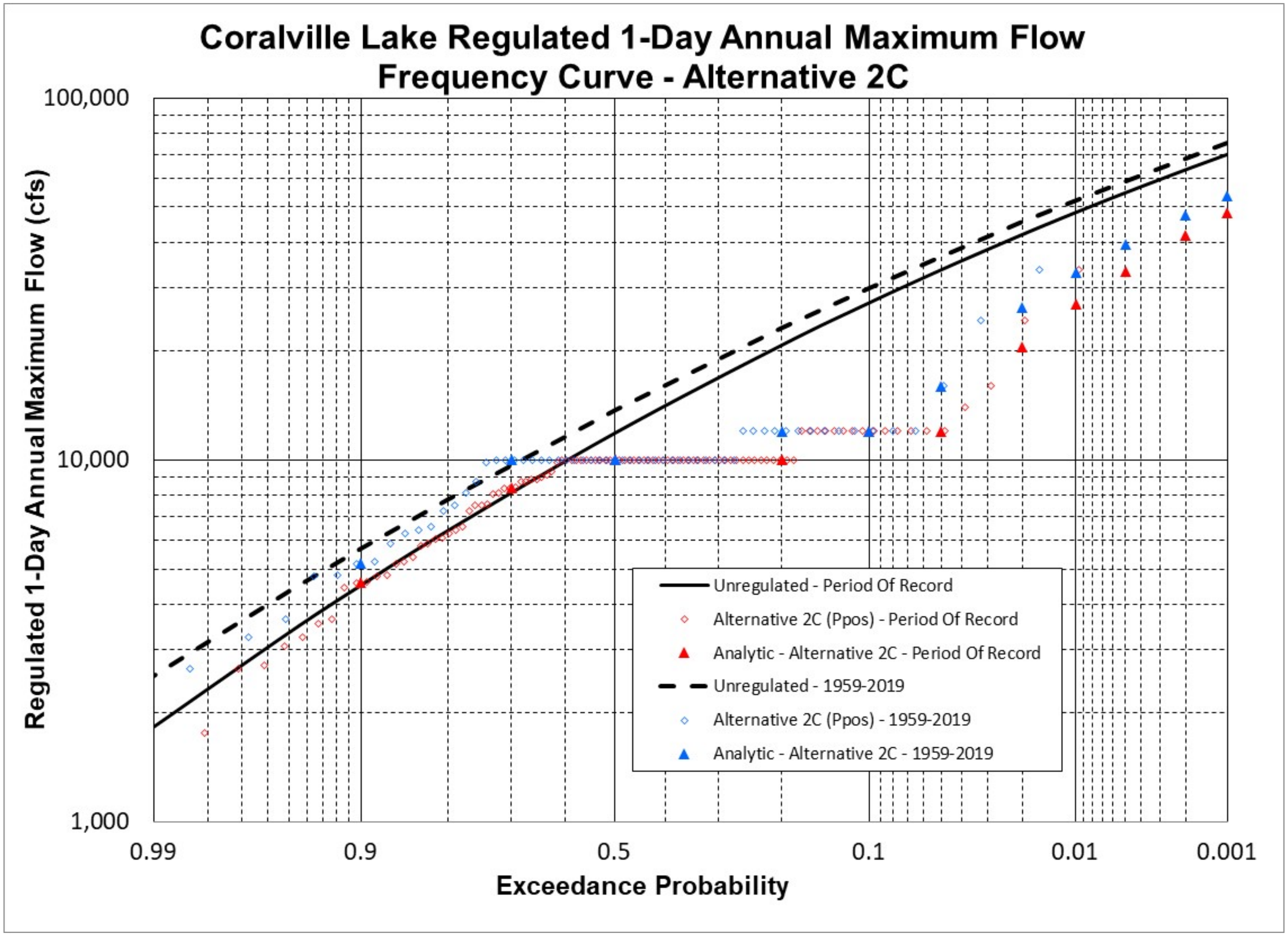


Figure B-72. Coralville Lake Regulated Flow Frequency Curve – Alternative 2C. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

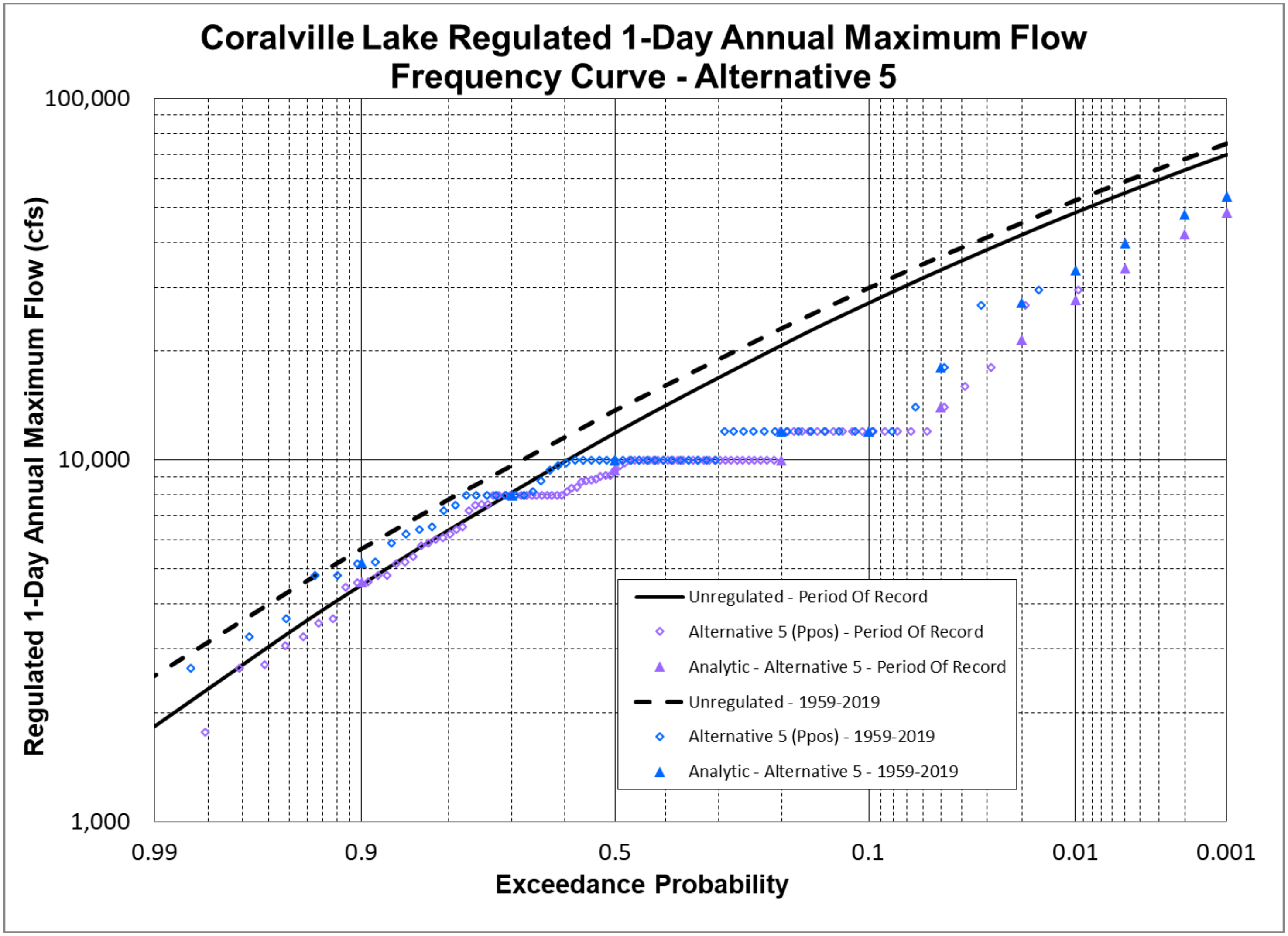


Figure B-73. Coralville Lake Regulated Flow Frequency Curve – Alternative 5. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

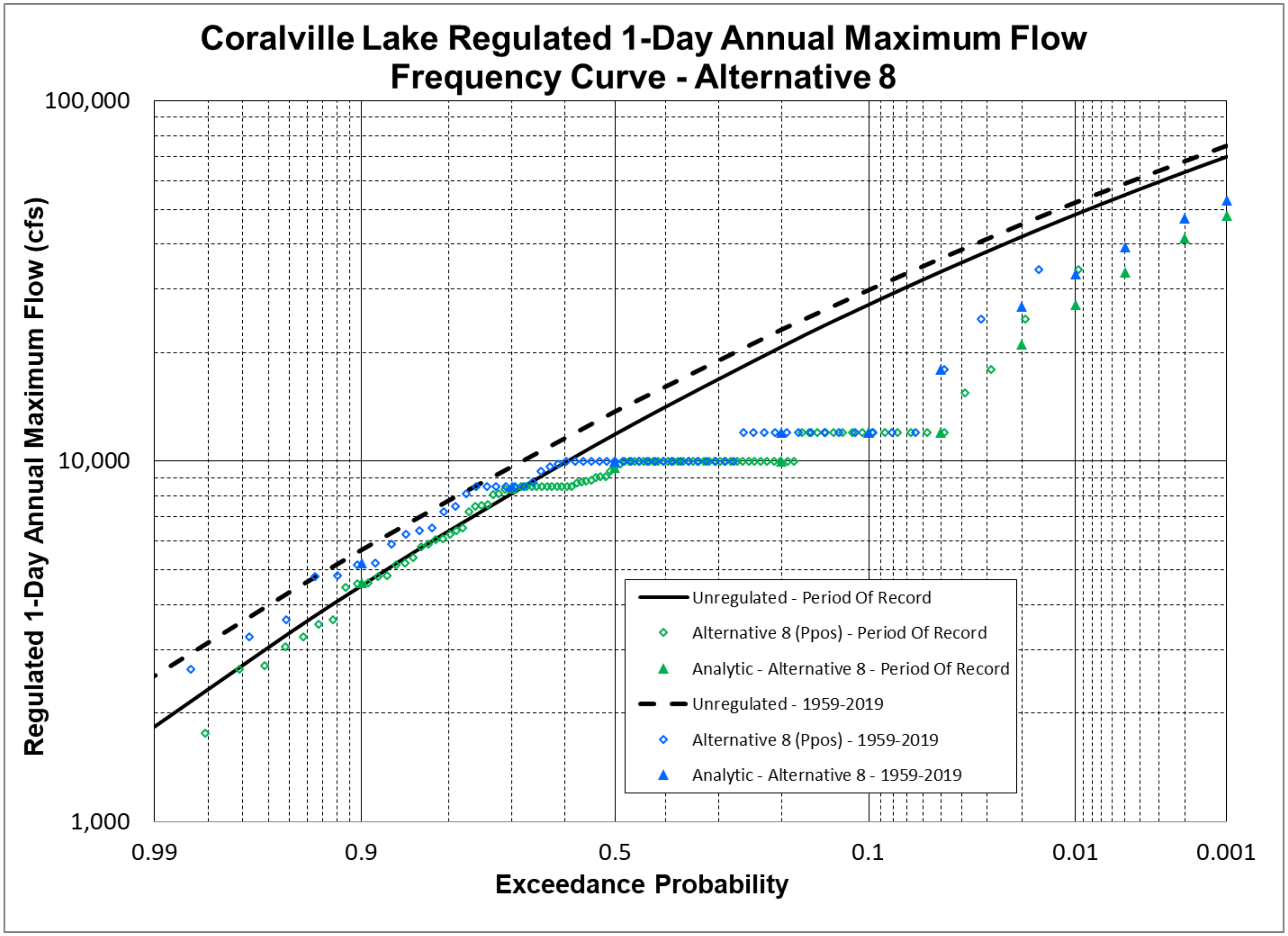


Figure B-74. Coralville Lake Regulated Flow Frequency Curve – Alternative 8. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

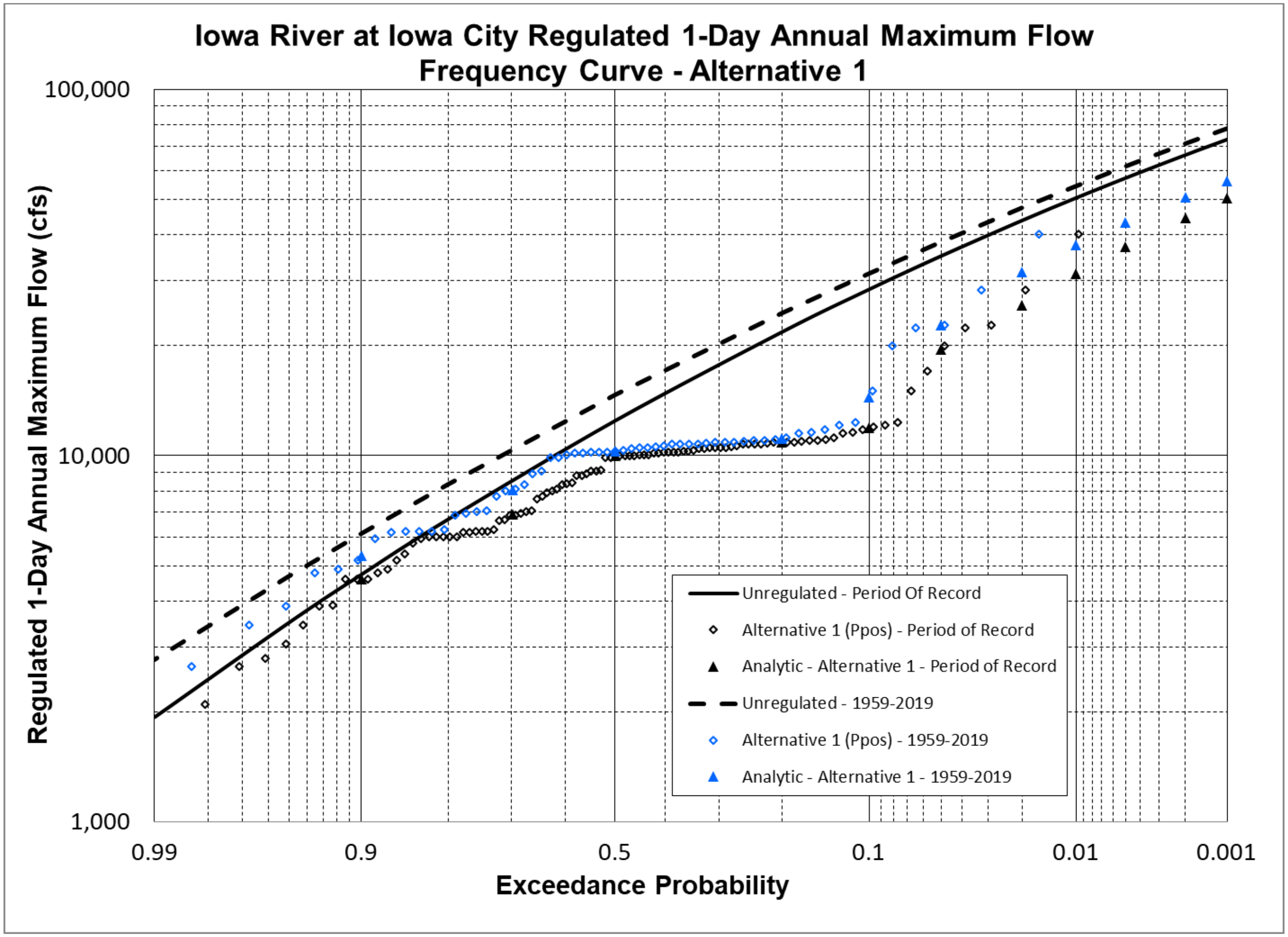


Figure B-75. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternative 1. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

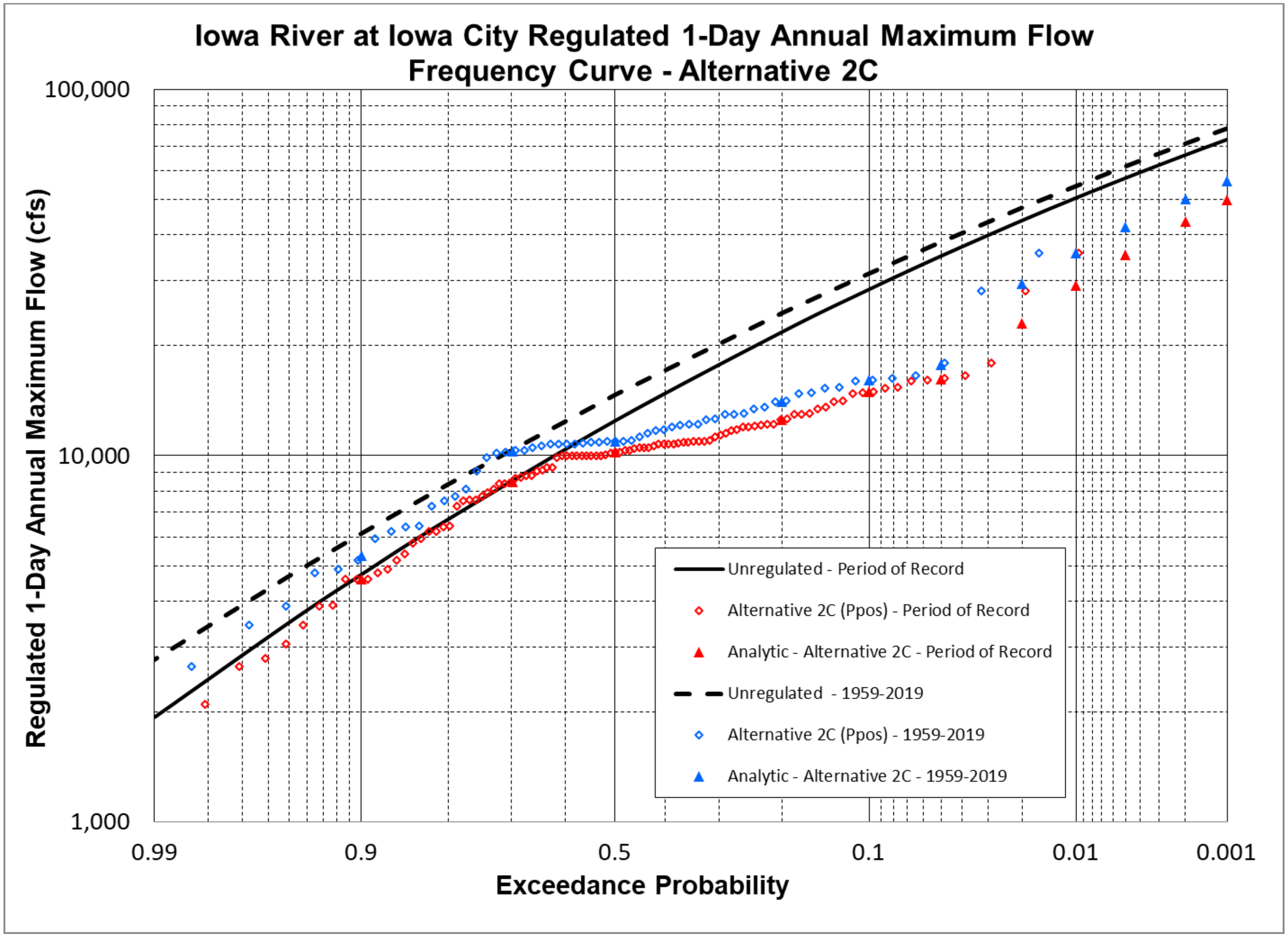


Figure B-76. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternative 2C. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibull plotting position (Ppos).

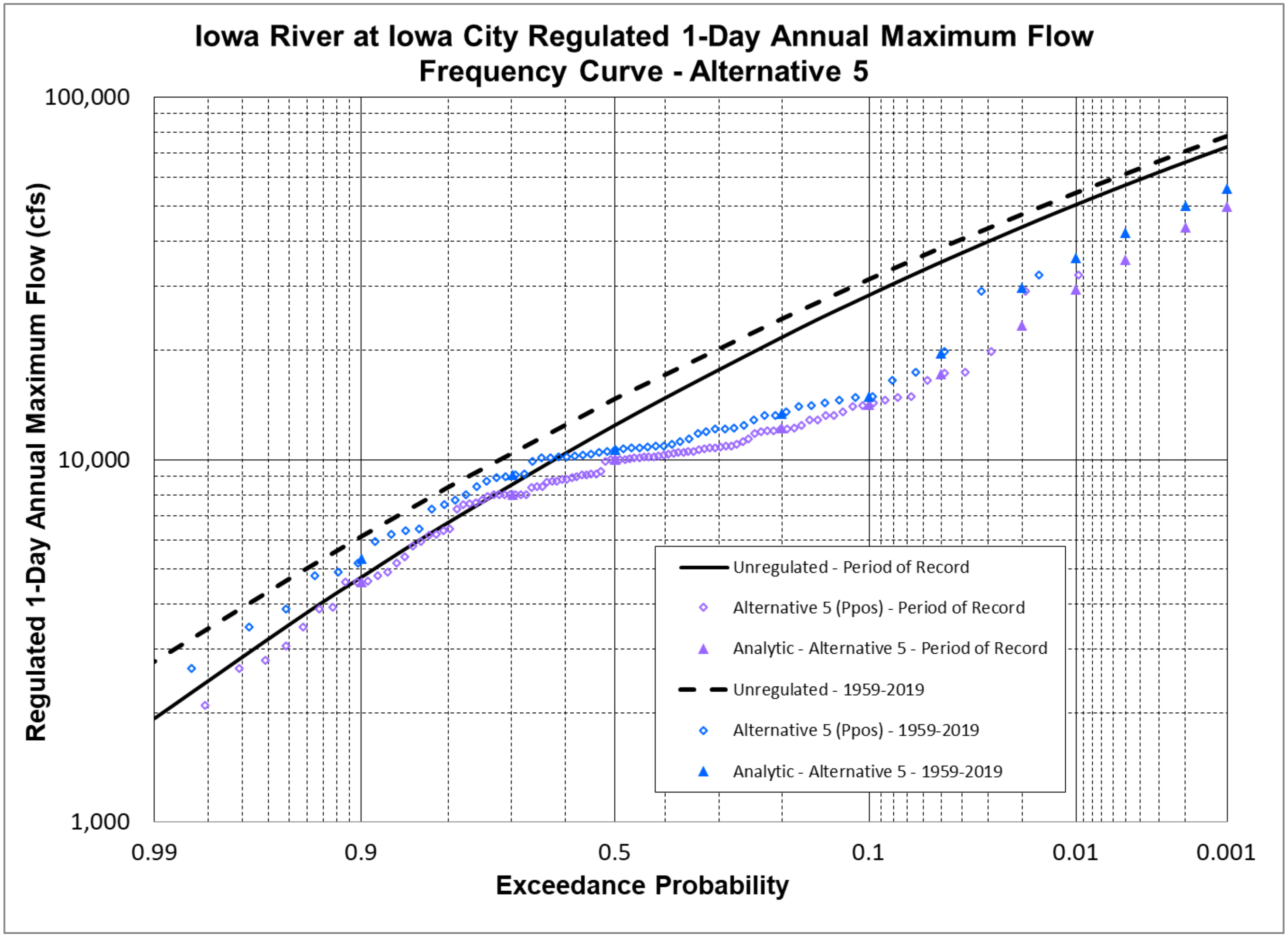


Figure B-77. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternative 5. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

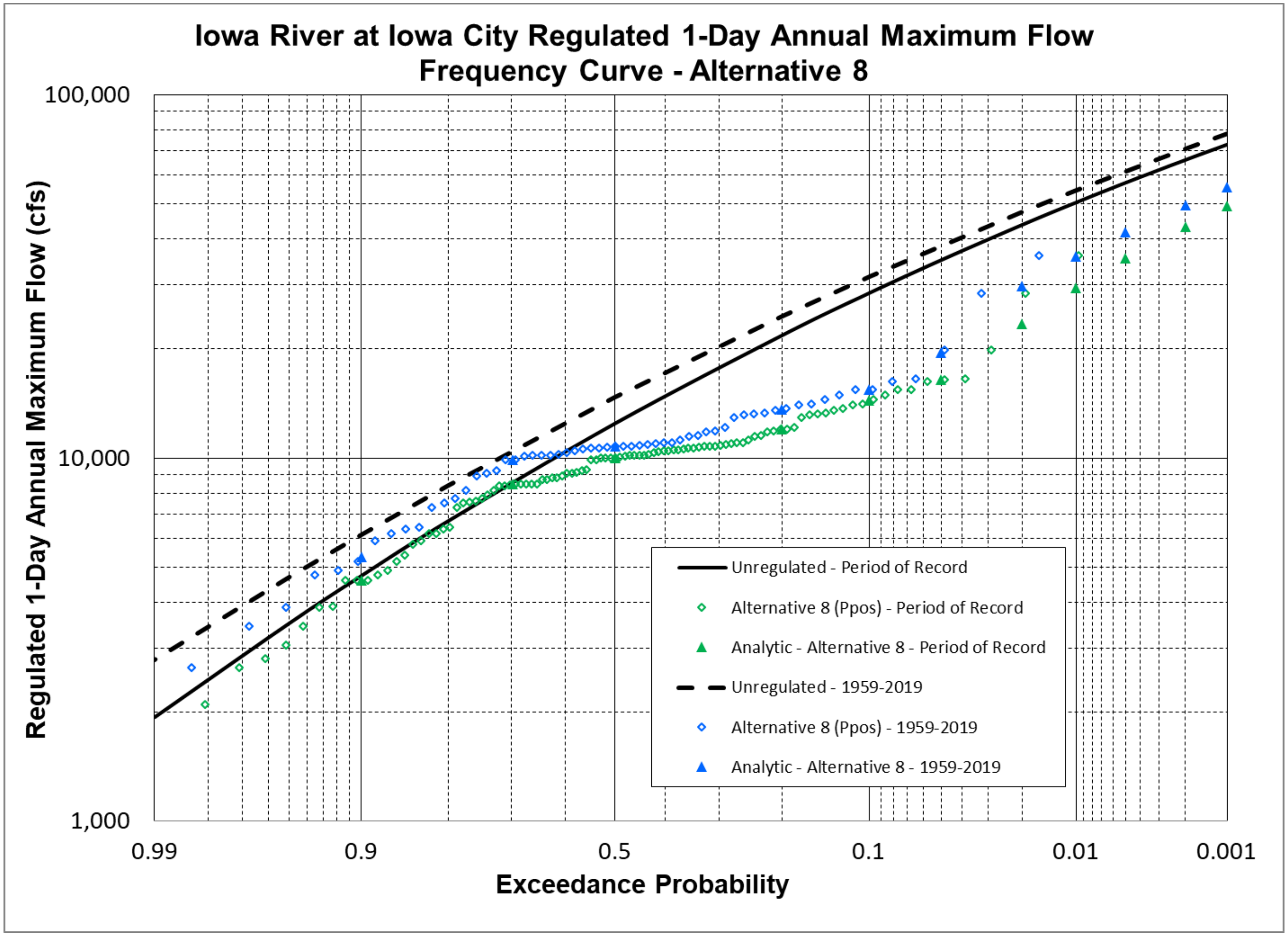


Figure B-78. Iowa River at Iowa City Regulated Flow Frequency Curve – Alternative 8. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibull plotting position (Ppos).

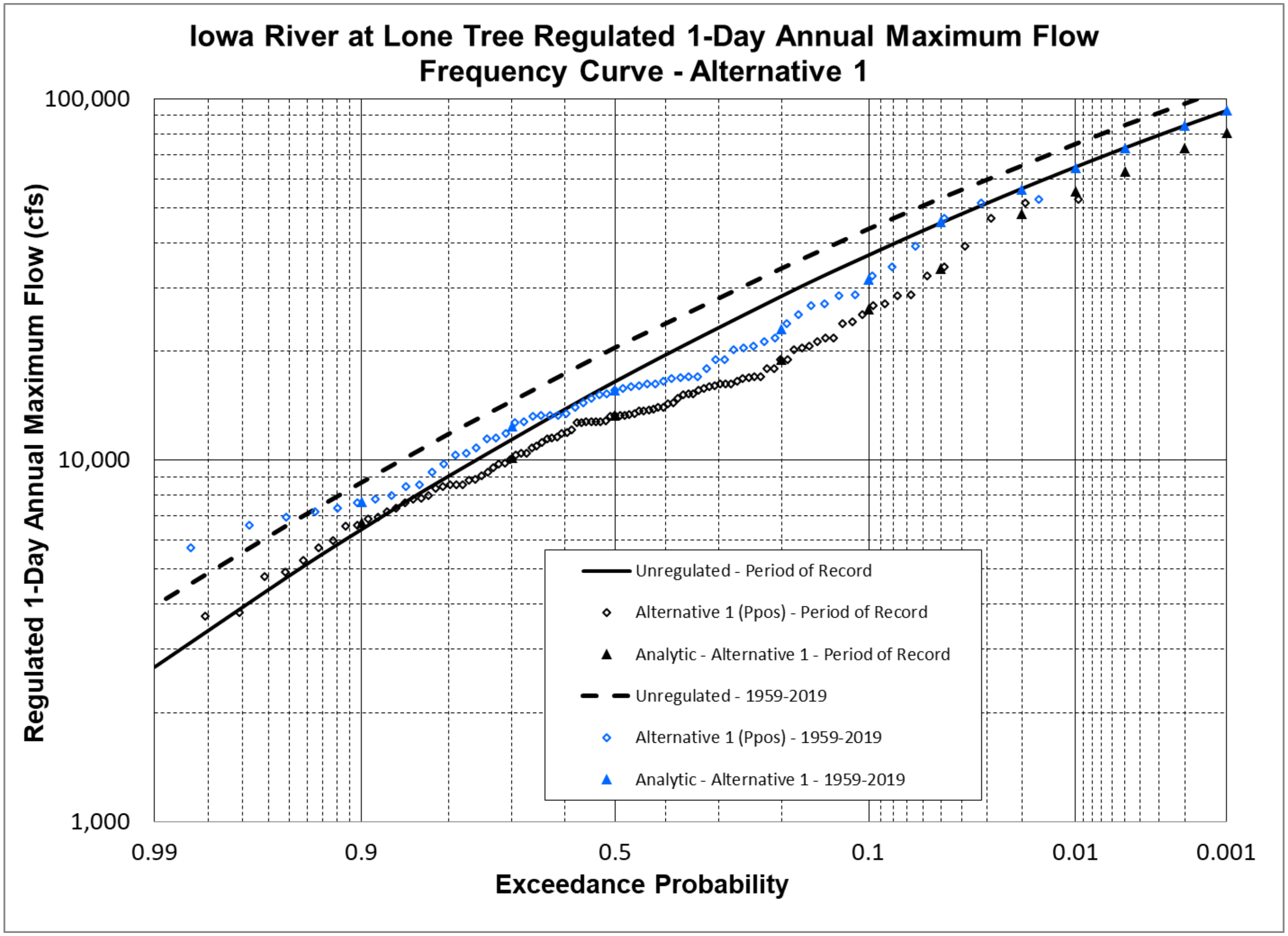


Figure B-79. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternative 1. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

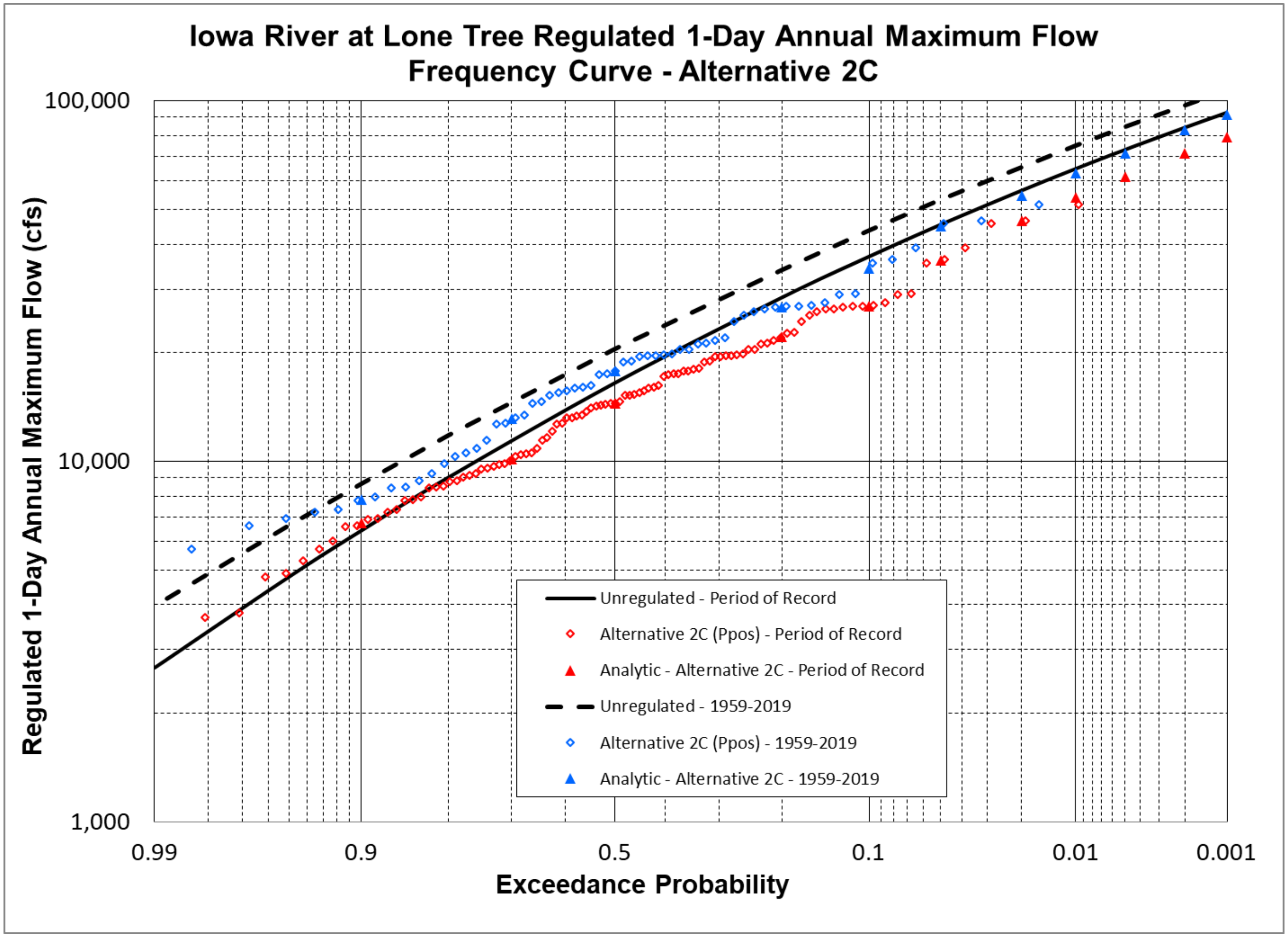


Figure B-80. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternative 2C. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

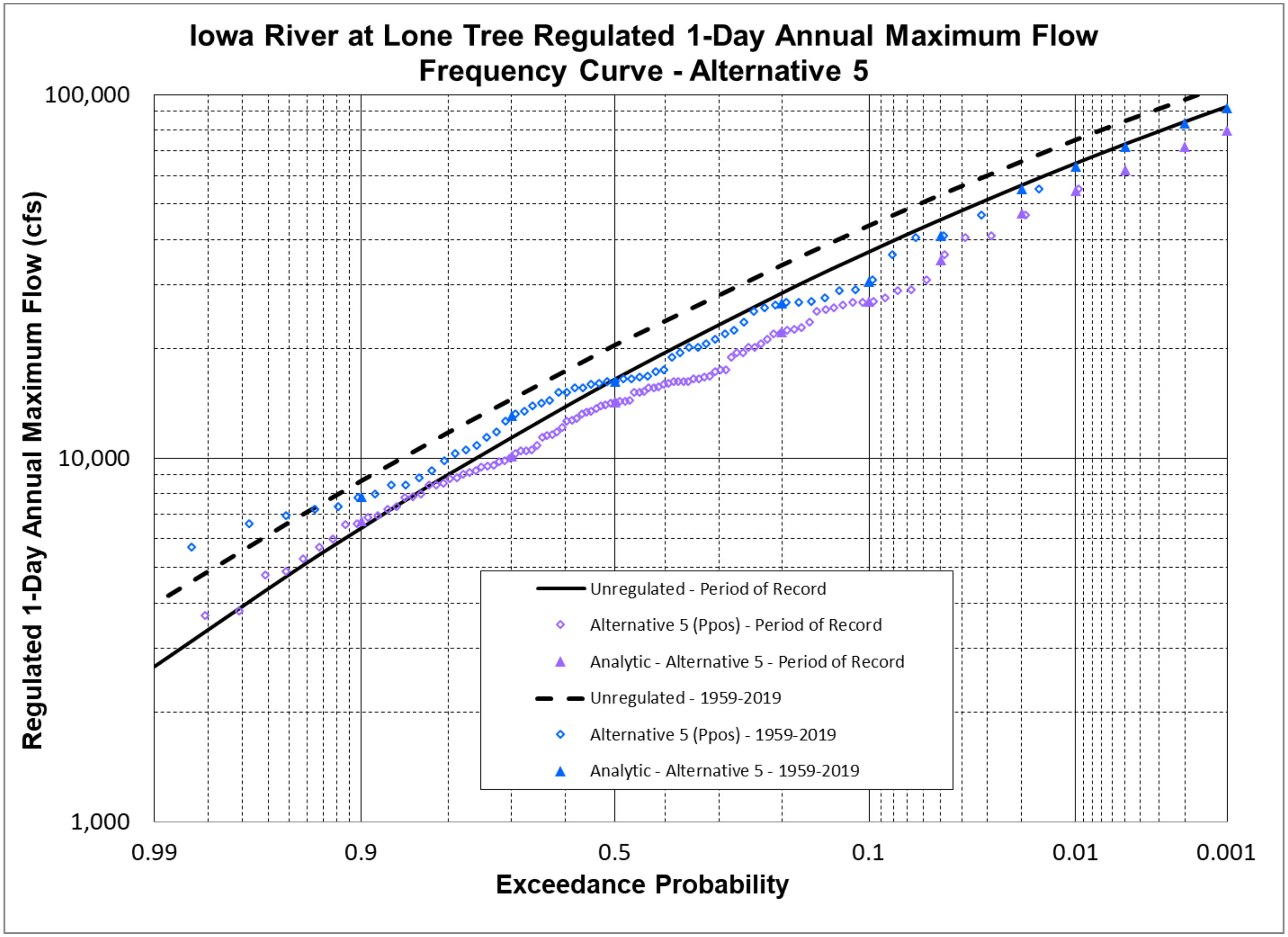


Figure B-81. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternative 5. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

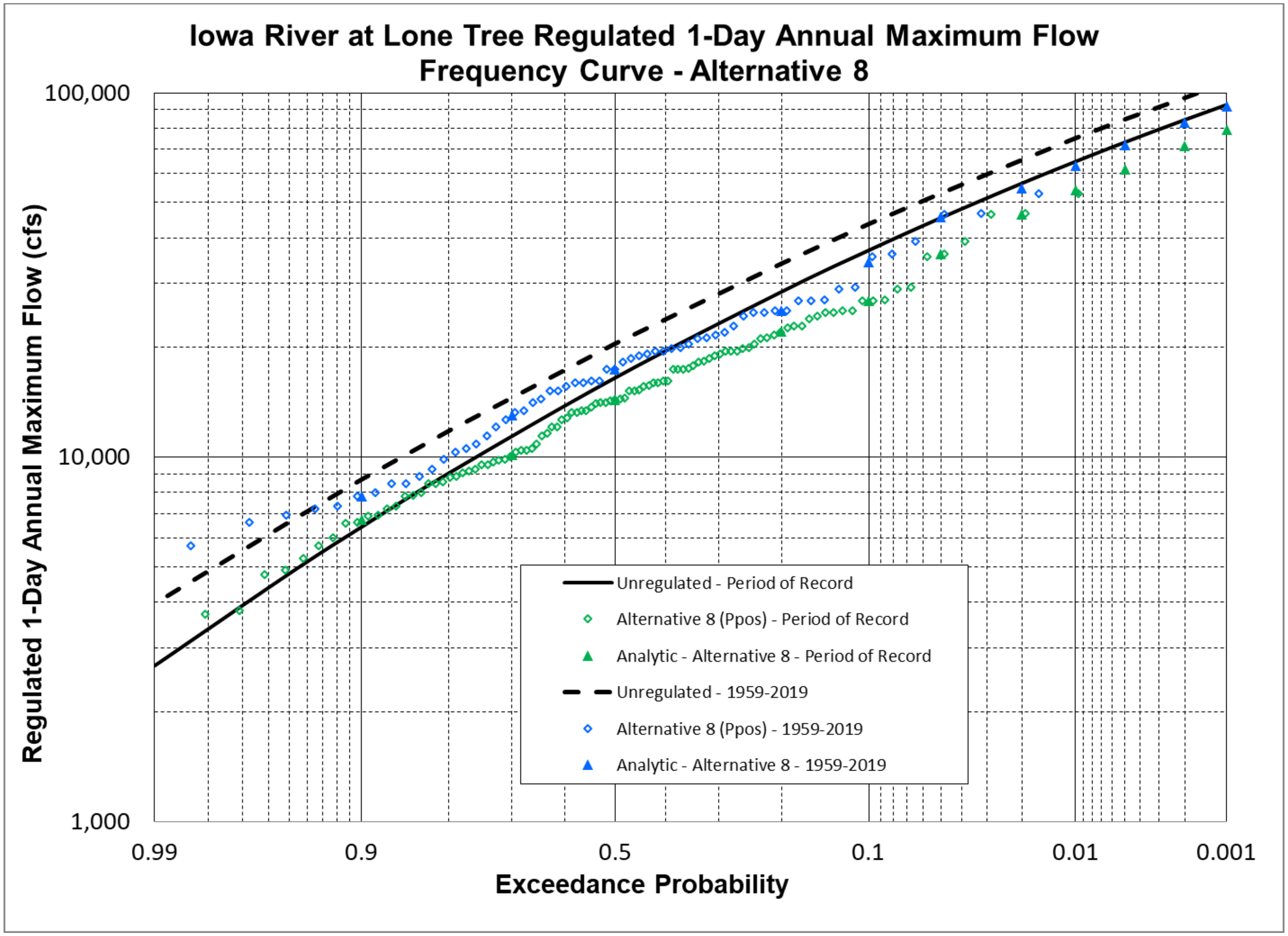


Figure B-82. Iowa River at Lone Tree Regulated Flow Frequency Curve – Alternative 8. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibull plotting position (Ppos).

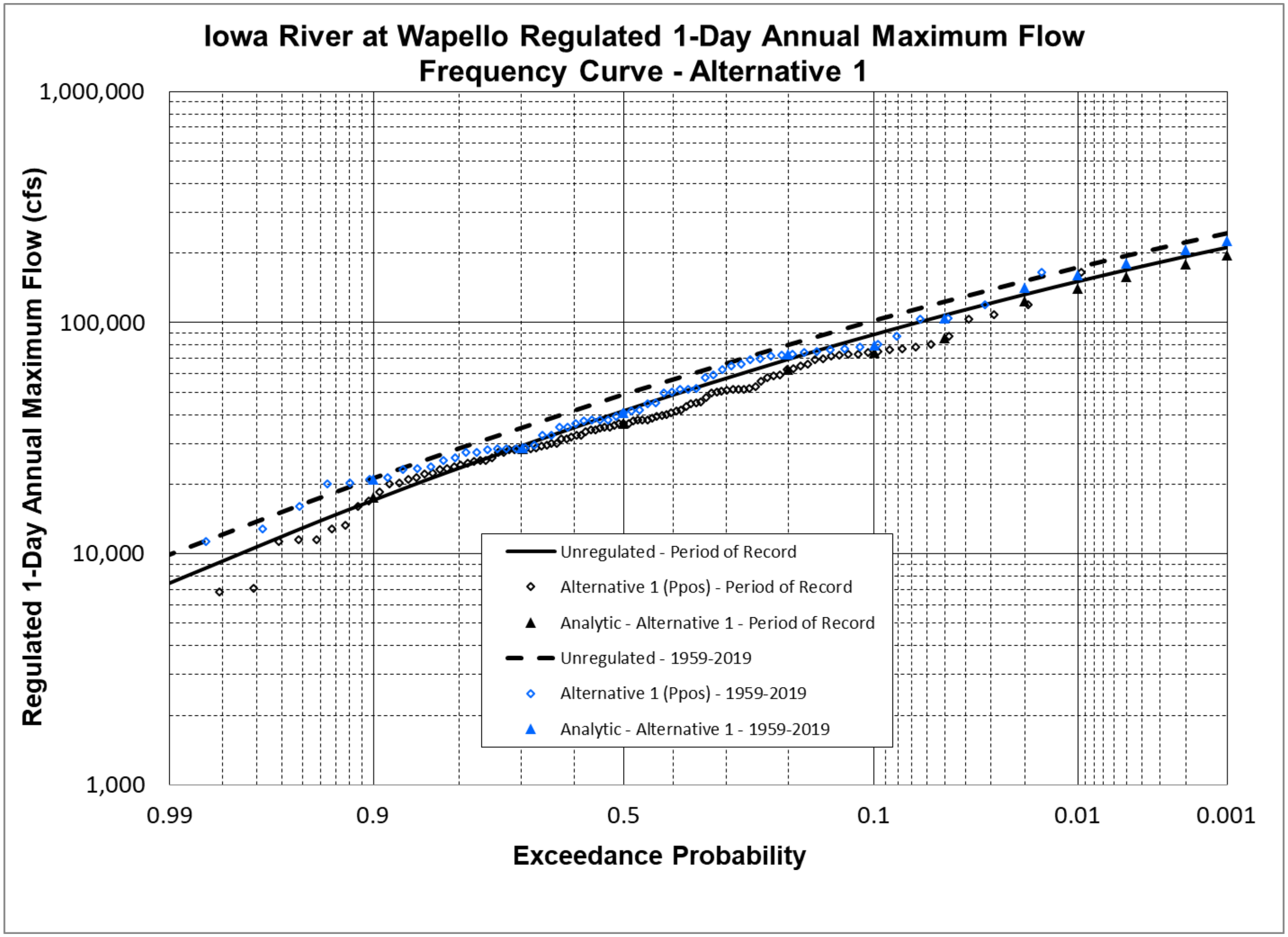


Figure B-83. Iowa River at Wapello Regulated Flow Frequency Curve – Alternative 1. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

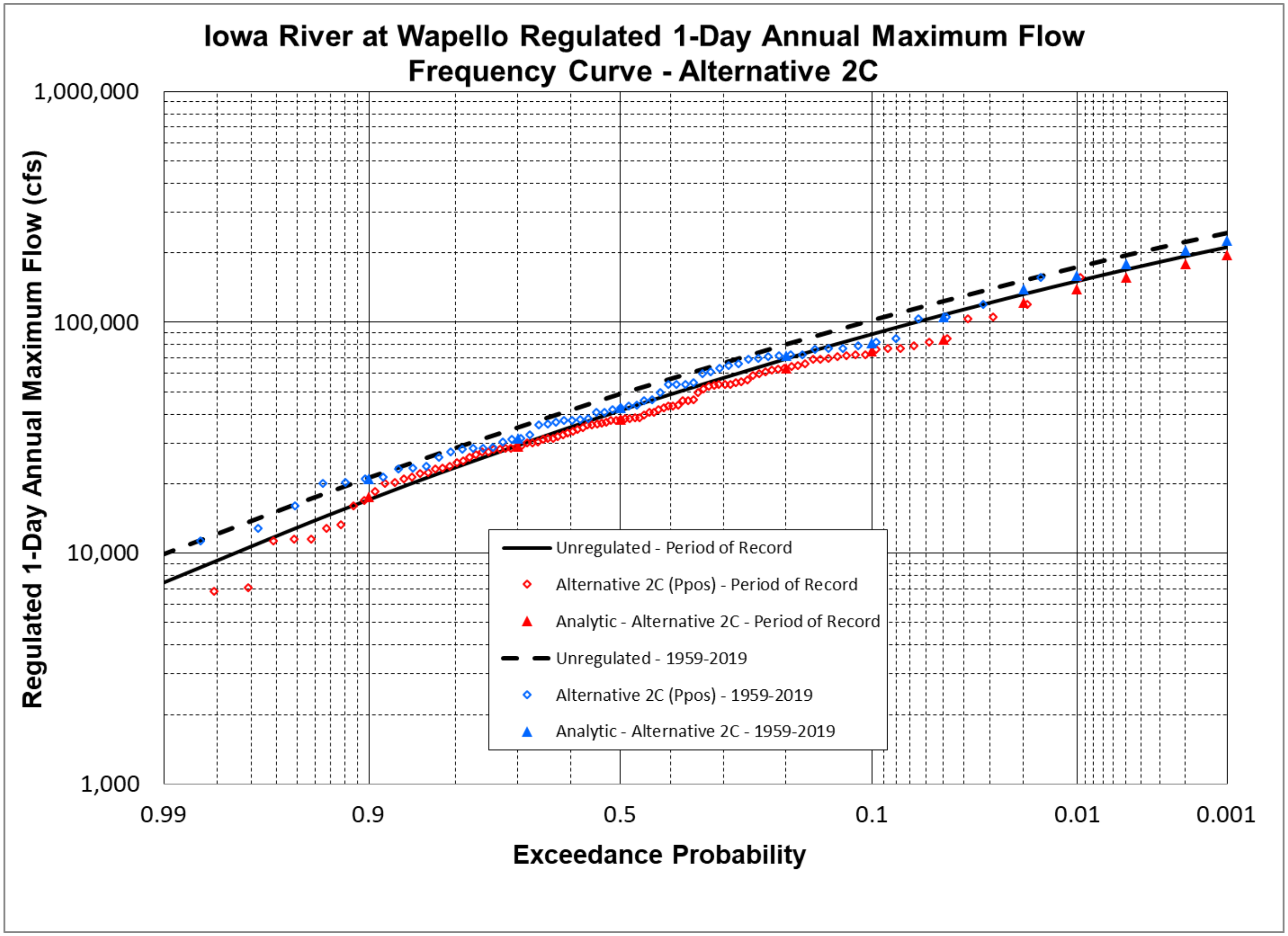


Figure B-84. Iowa River at Wapello Regulated Flow Frequency Curve – Alternative 2C. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

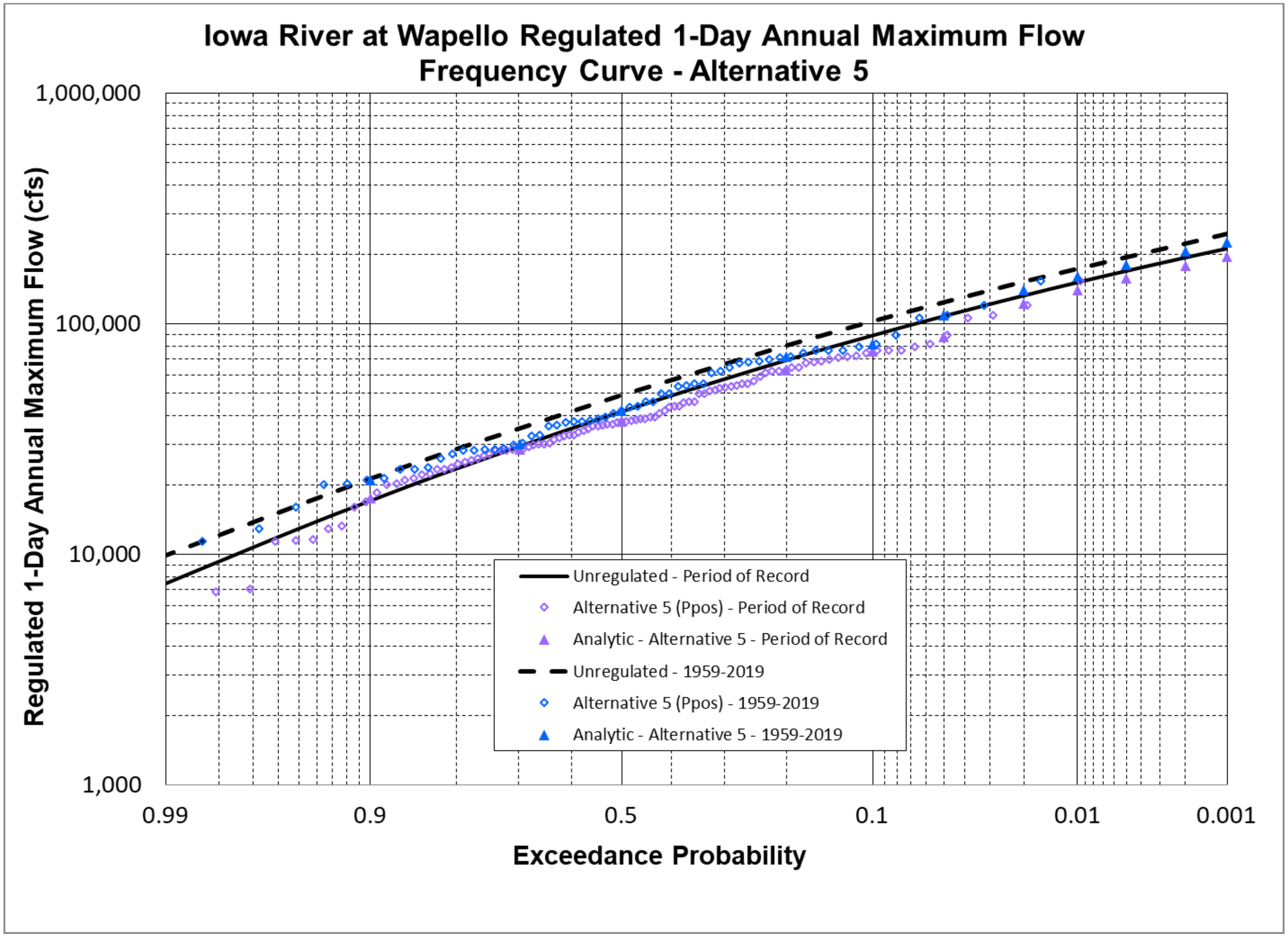


Figure B-85. Iowa River at Wapello Regulated Flow Frequency Curve – Alternative 5. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibull plotting position (Ppos).

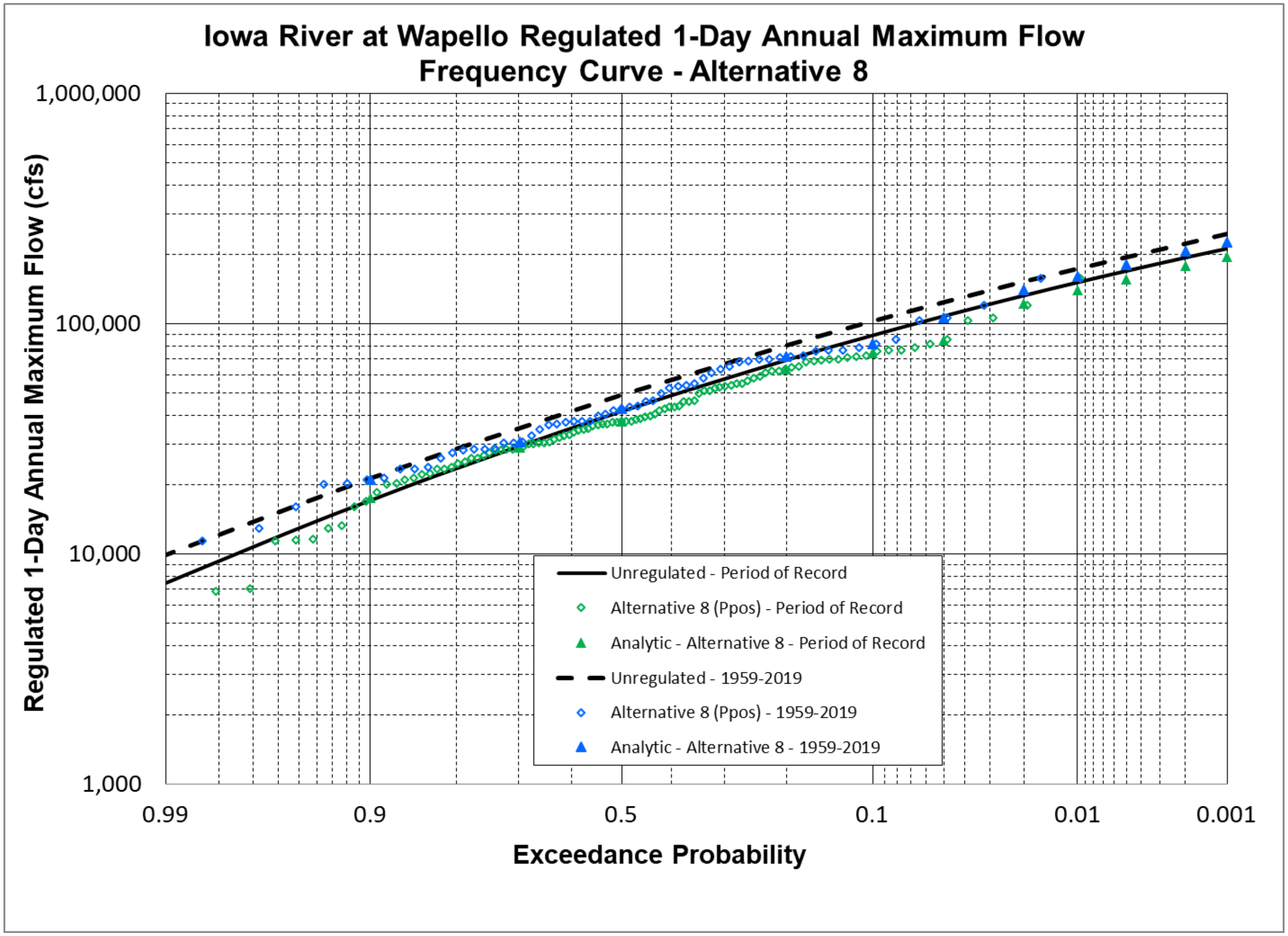


Figure B-86. Iowa River at Wapello Regulated Flow Frequency Curve – Alternative 8. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

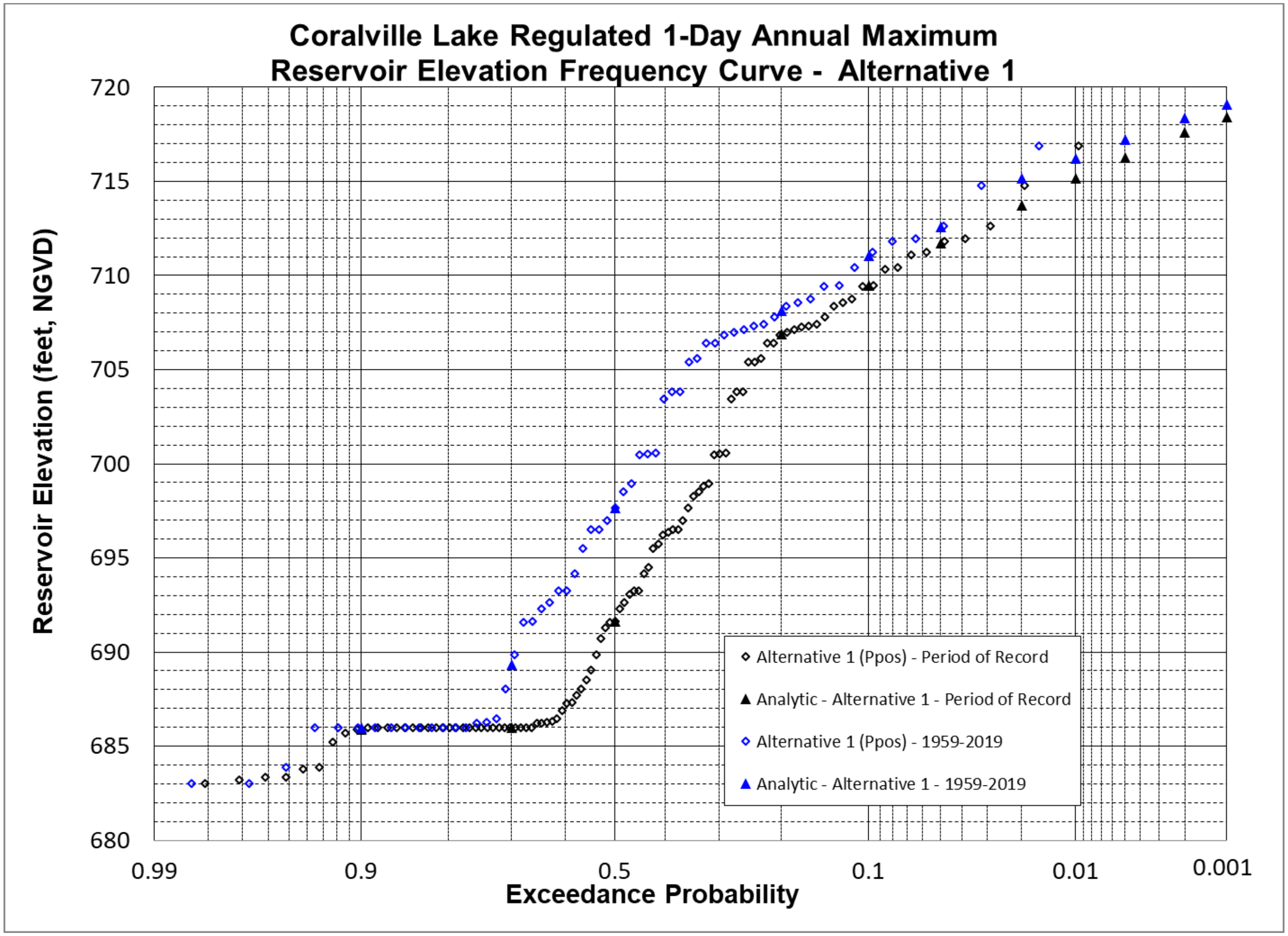


Figure B-87. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 1. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

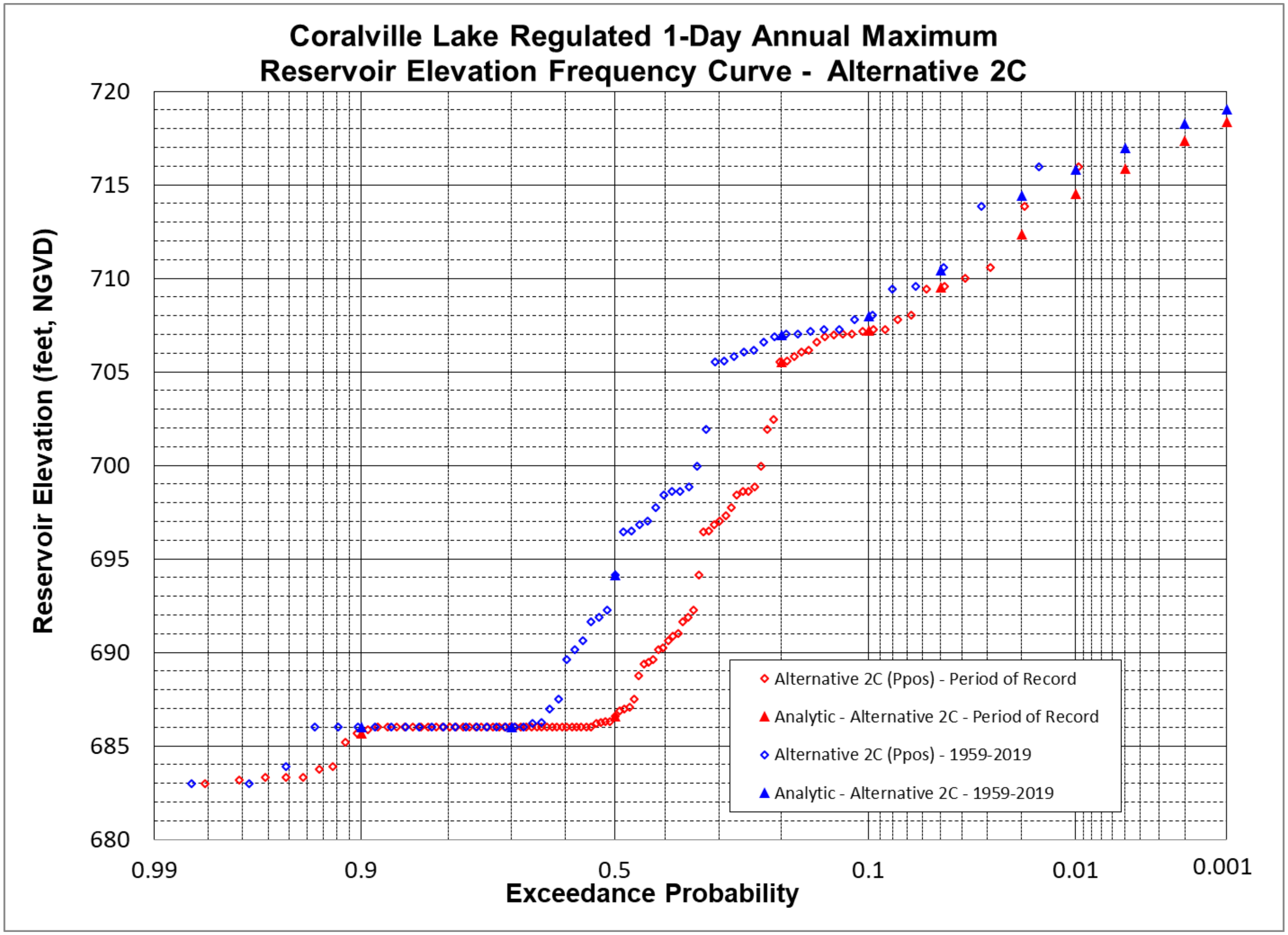


Figure B-88. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 2C. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

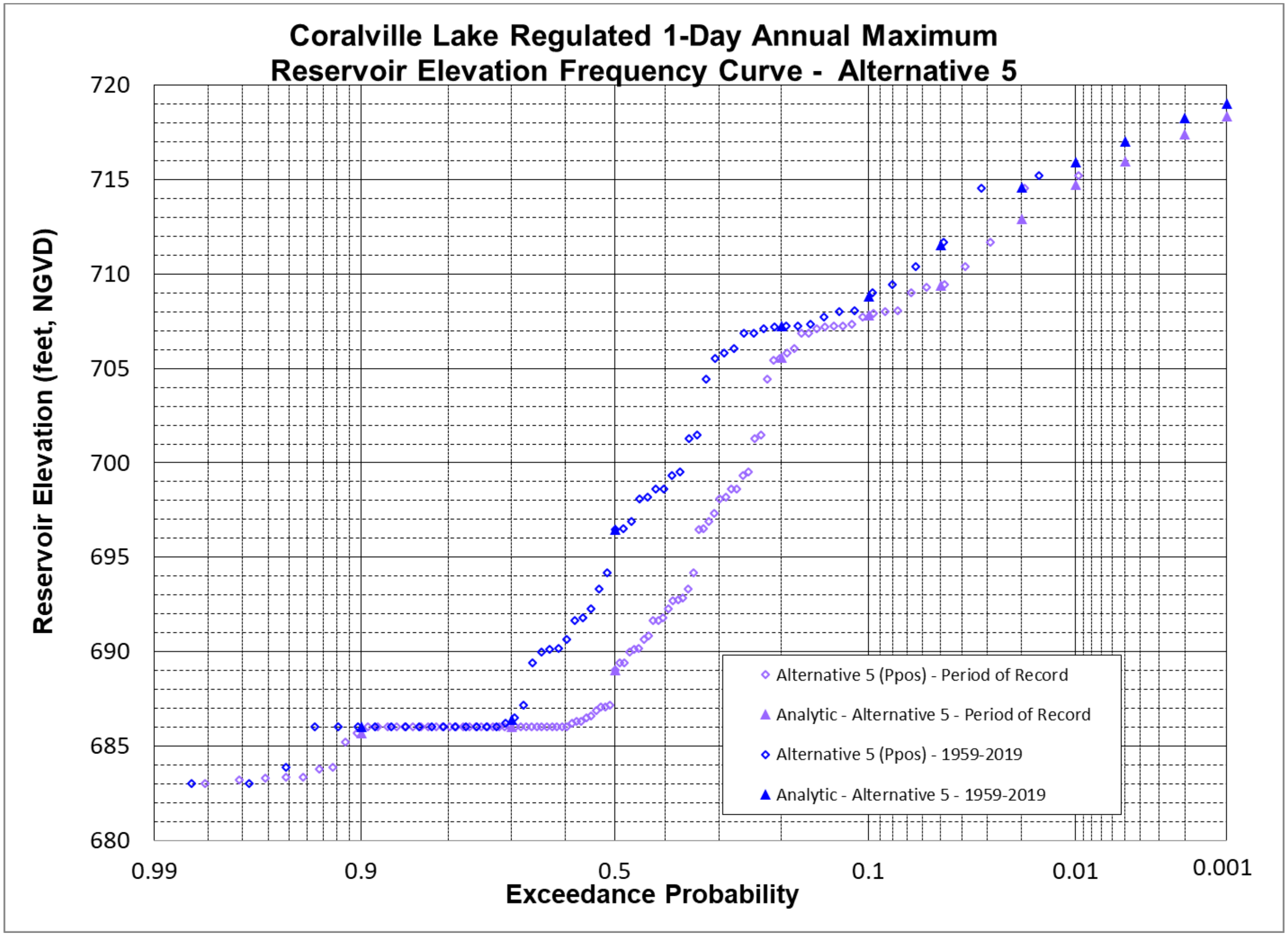


Figure B-89. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 5. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

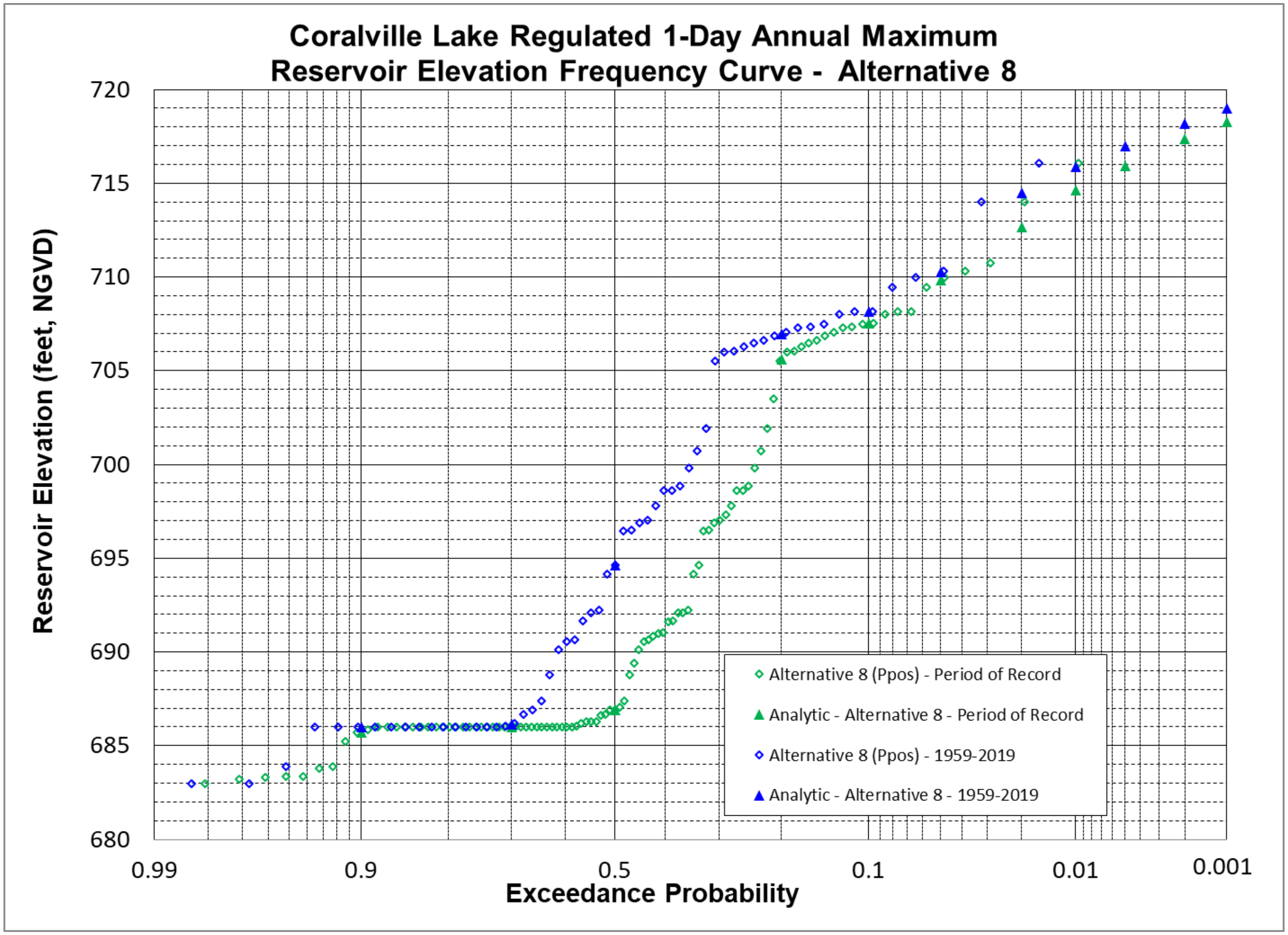


Figure B-90. Coralville Lake Annual Maximum Pool Elevation Exceedance Frequencies – Alternatives 8. Comparison of Period of Record (1917-2019) and 1959-2019 Curves. AEPs for simulated events estimated using Weibell plotting position (Ppos).

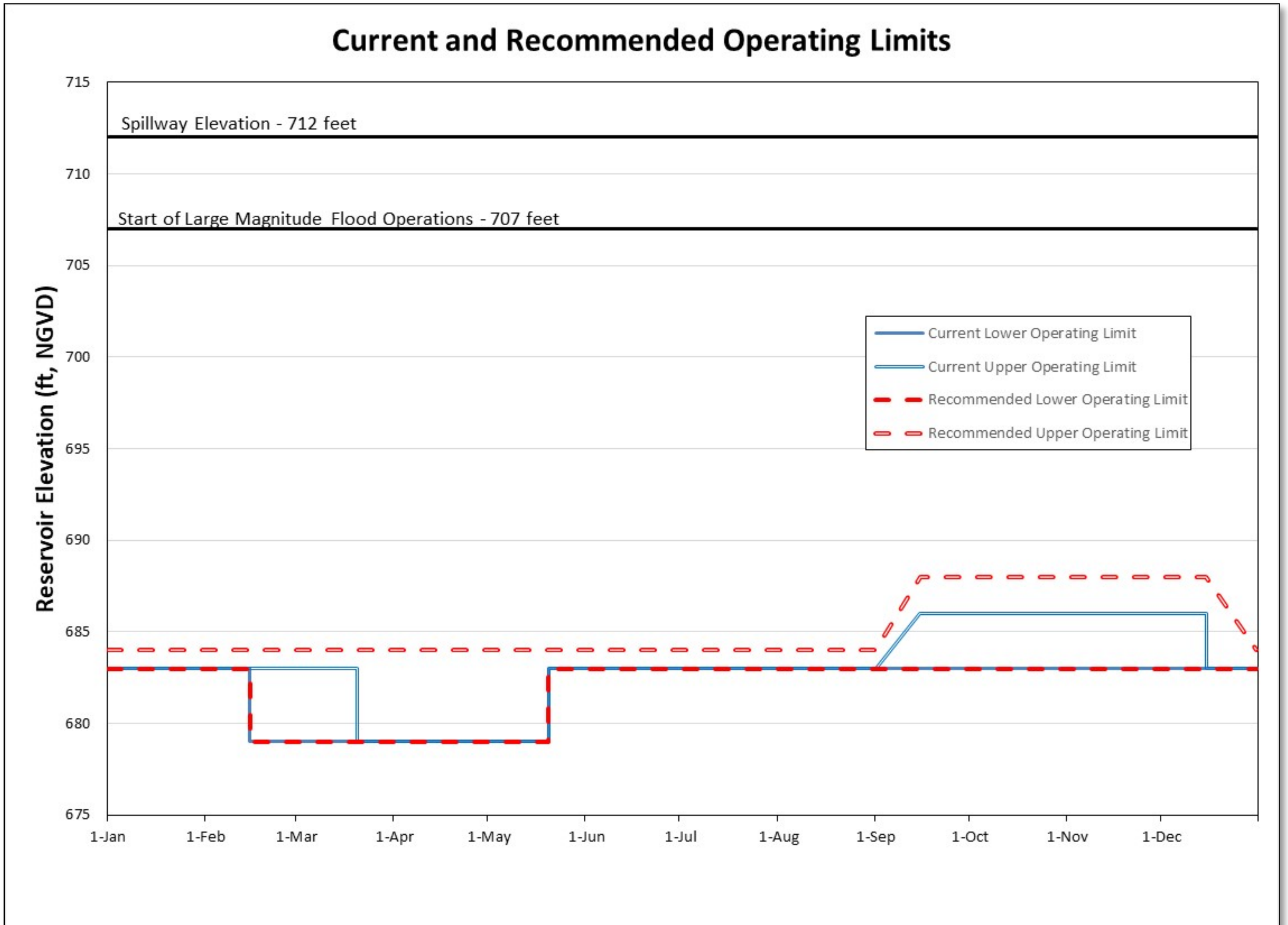


Figure B-91. Current and Recommended Operating Limits

CORALVILLE LAKE
WATER CONTROL UPDATE REPORT
WITH INTEGRATED ENVIRONMENTAL ASSESSMENT

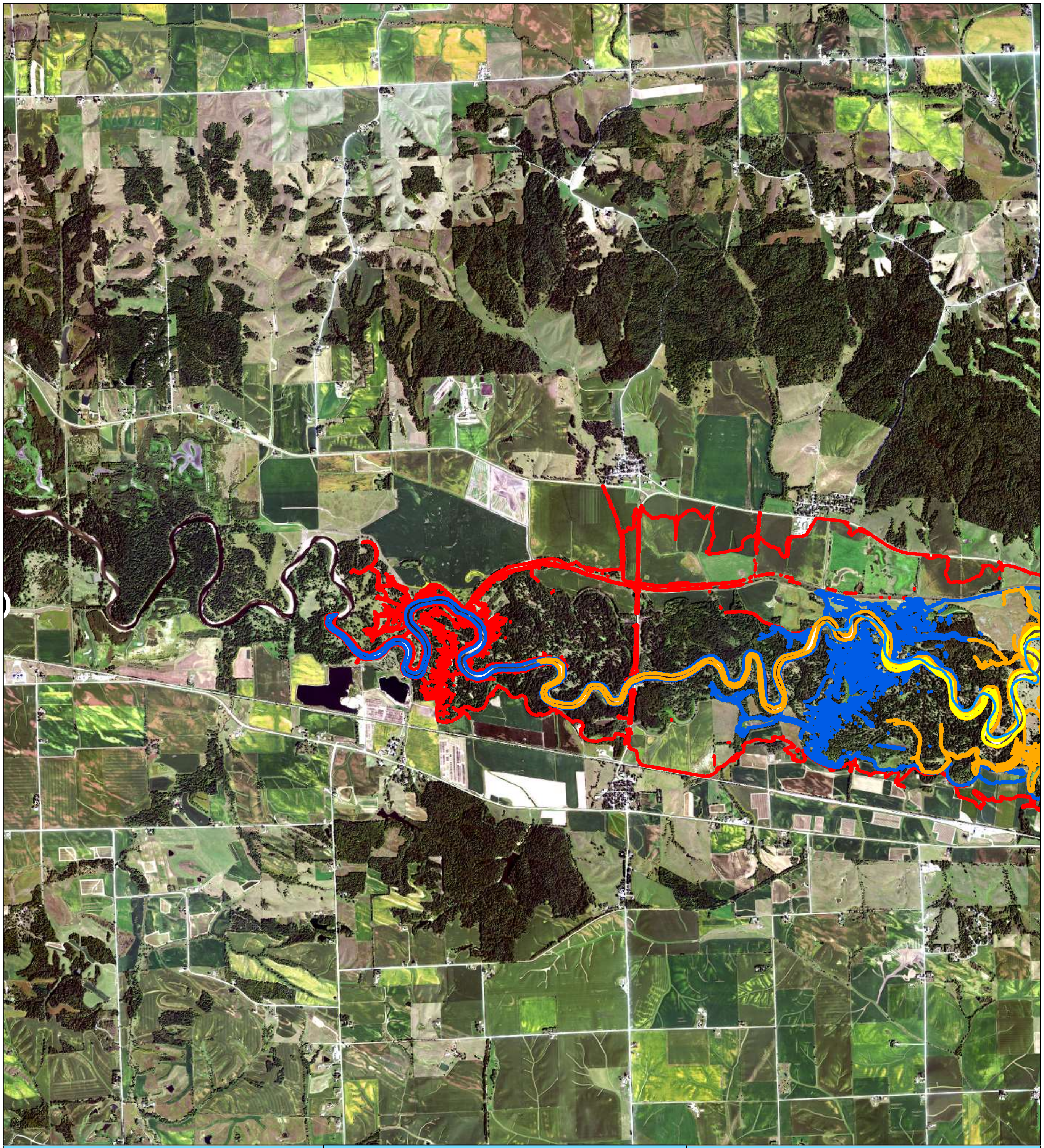
CORALVILLE LAKE
IOWA CITY, IOWA

APPENDIX B

HYDROLOGY AND HYDRAULICS

INUNDATION MAPS

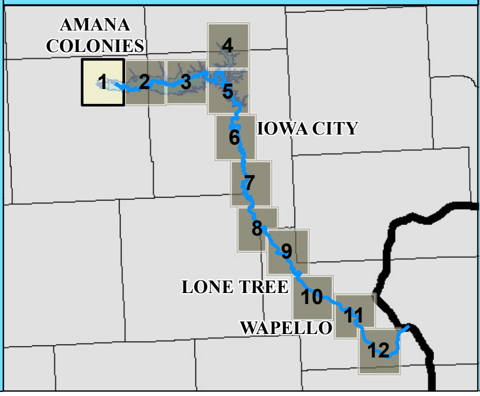
Iowa River Flood Inundation Map



Legend

- River Centerline
- El. 707 feet
- El. 712 feet
- El. 717 feet
- El. 725 feet

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

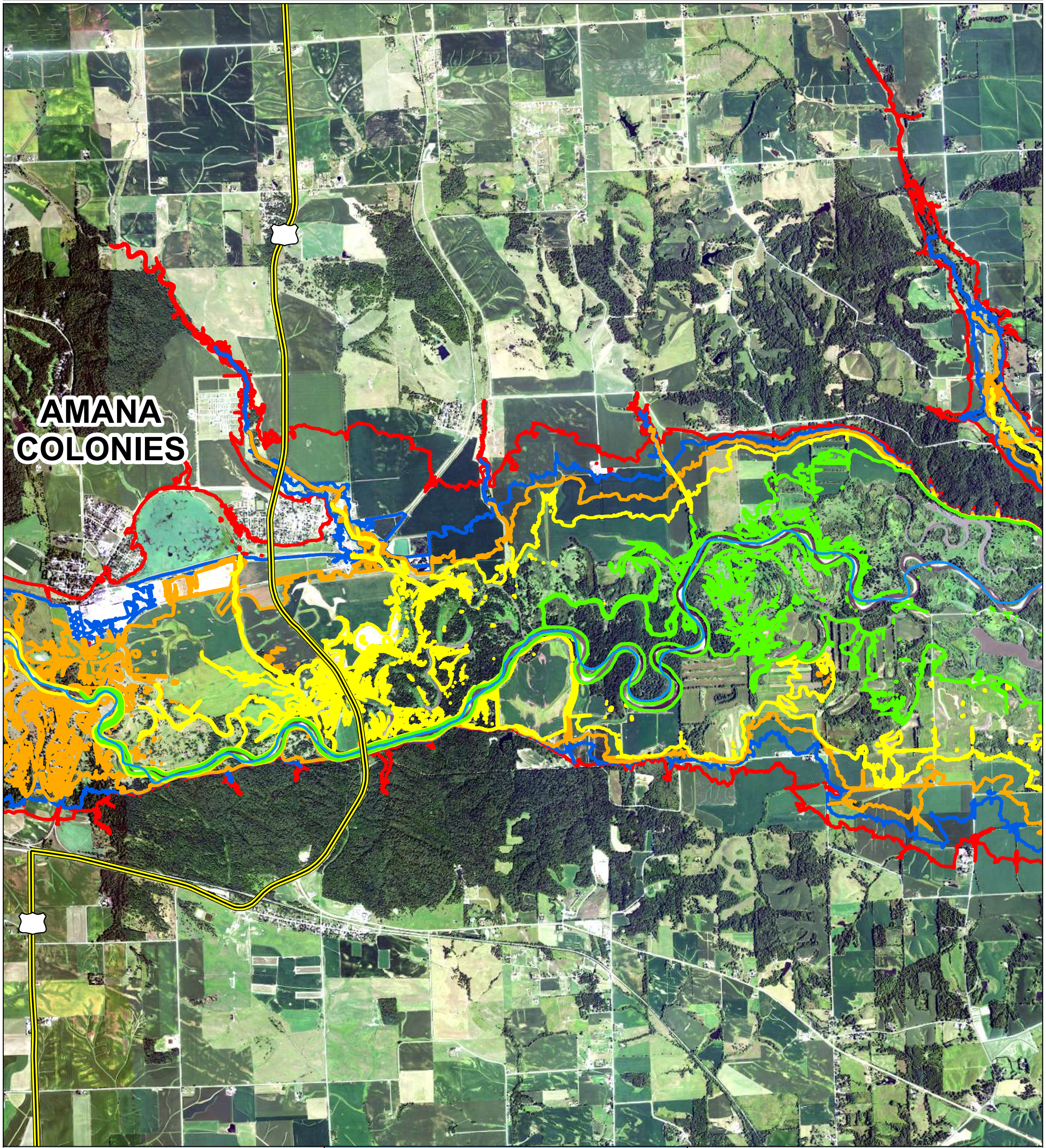
1 inch equals 1 miles

US Army Corps of Engineers® Rock Island District

PLATE 1

N W E S

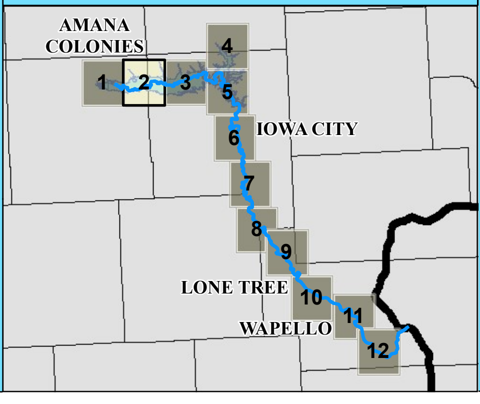
Iowa River Flood Inundation Map



Legend

- River Centerline
- El. 700 feet
- El. 707 feet
- El. 712 feet
- El. 717 feet
- El. 725 feet

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

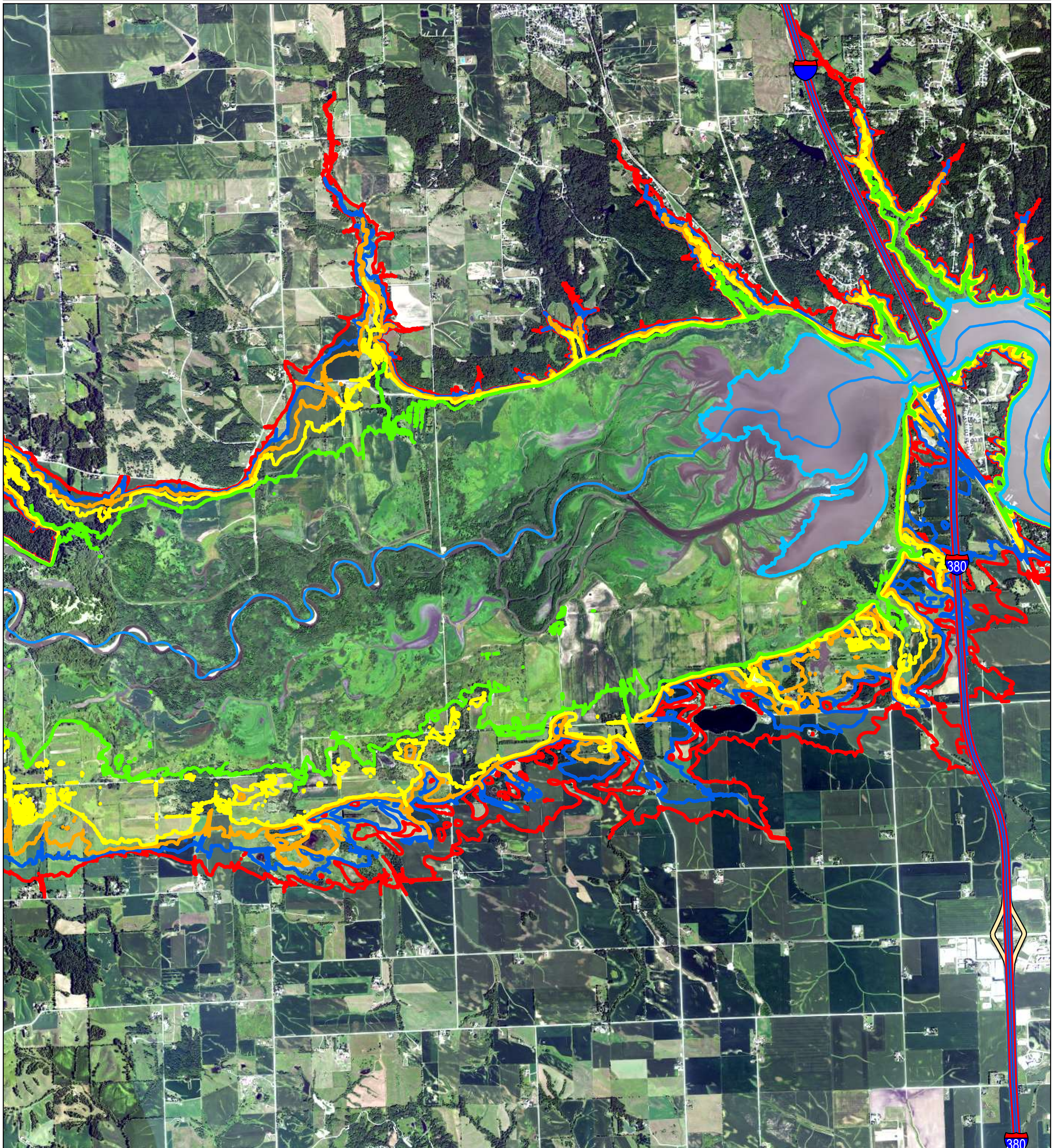
US Army Corps of Engineers ®
Rock Island District

PLATE 2

N W E S

DISCLAIMER - While the United States Army Corps of Engineers, (Herinafter referred to as USACE) has made a reasonable effort to ensure the accuracy of the maps and associated data, it should be explicitly noted that USACE makes no warranties, representation or guaranty, either express or implied, as to the contents, sequence, accuracy, timeliness or completeness of any of the data provided herein. The USACE, its officers, agents, employees or servants shall assume no liability of any nature for any errors, omissions, or innacuracies in the information provided regardless of how caused, The USACE, its officers, agents, employees or servants shall assume no liability for any decisions made or actions taken or not taken by the user of the maps and associated data in reliance upon any information or data furnished here. By using these maps and associated data the user does so entirely at their own risk and explicitly acknowledges that he/she is aware of and agrees to be bound by this disclaimer and agrees not to resent any claim or demand of any nature against the USACE, its officers, agents, employees or servants in any forum whatsoever for any damages of any nature whatsoever tha tmay result from or may be caused in any way by the user of the maps and associated data.

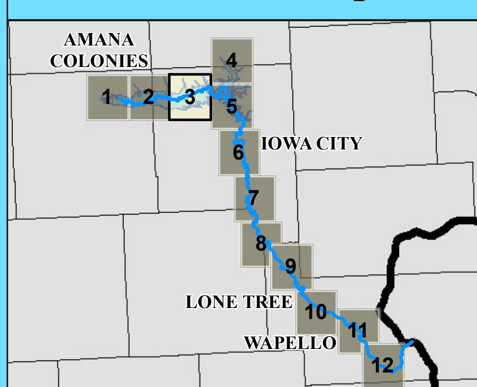
Iowa River Flood Inundation Map



Legend

- River Centerline
- El. 683 feet
- El. 700 feet
- El. 707 feet
- El. 712 feet
- El. 717 feet
- El. 725 feet

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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Rock Island District

PLATE 3

N W E S

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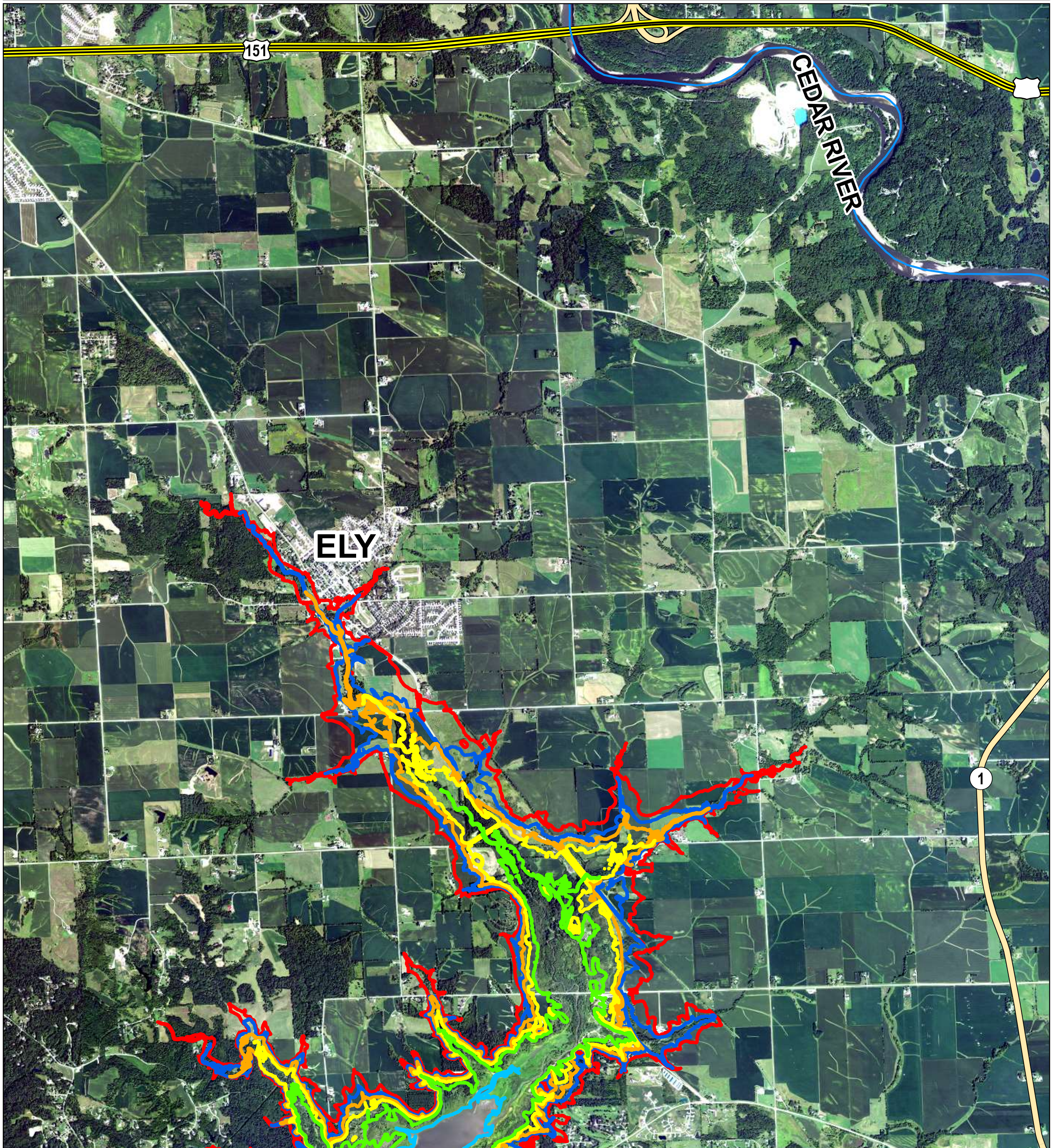
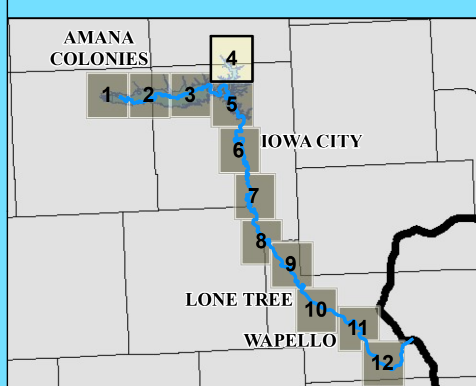
Iowa River Flood Inundation Map



Legend

- El. 683 feet
- El. 700 feet
- El. 707 feet
- El. 712 feet
- El. 717 feet
- El. 725 feet

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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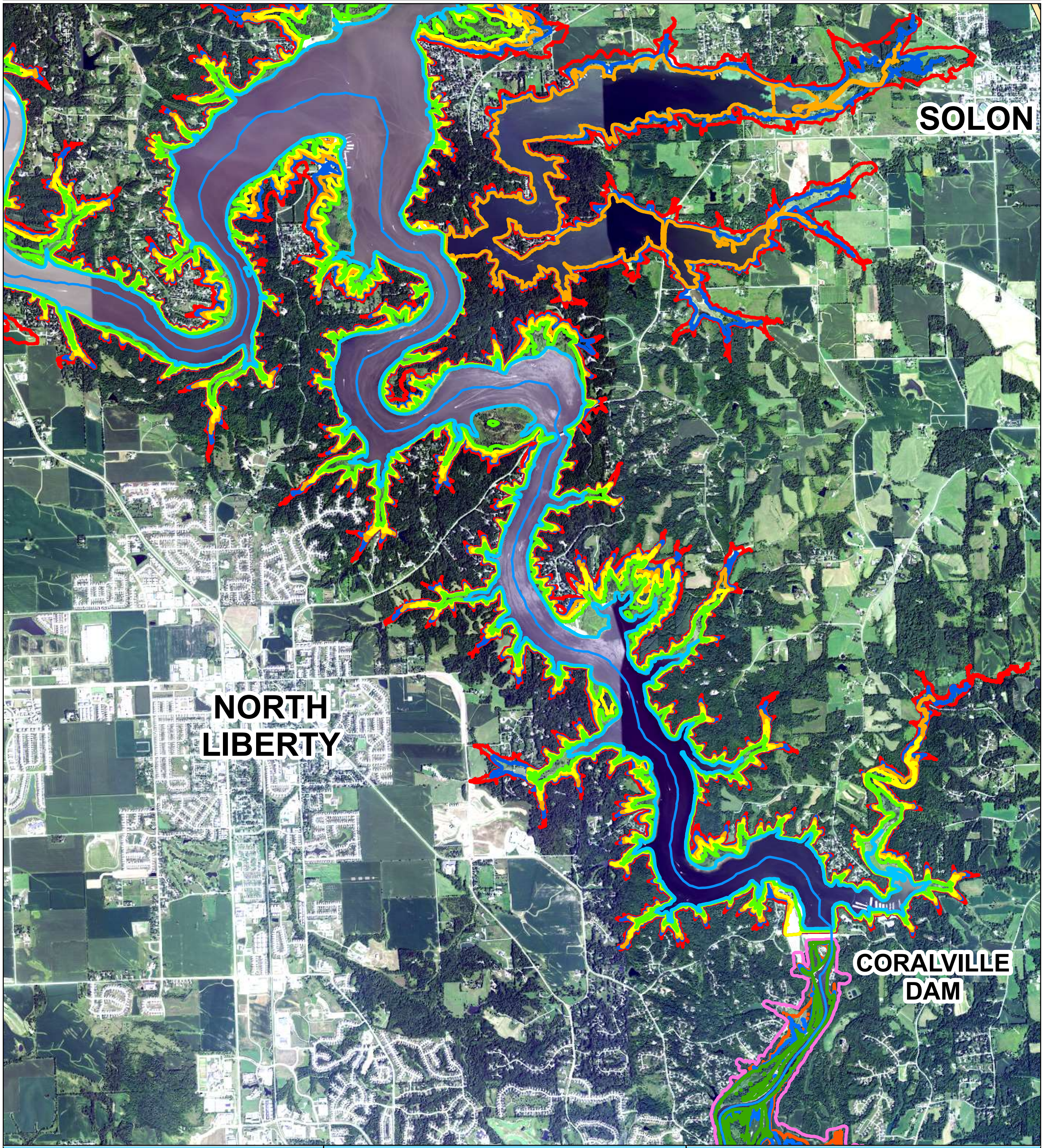
Rock Island District

PLATE 4

N W E S

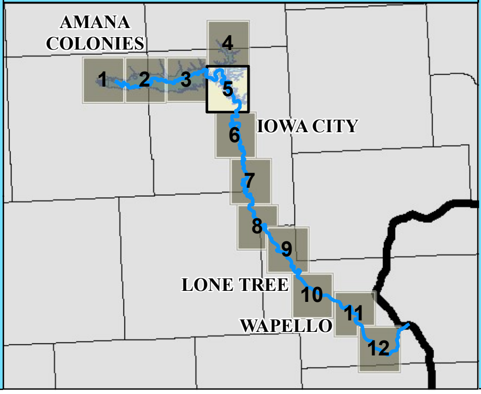
Iowa River Flood Inundation Map



Legend

- River Centerline
- El. 683 feet
- El. 700 feet
- El. 707 feet
- El. 712 feet
- El. 717 feet
- El. 725 feet
- 10K Release
- 16K Release
- 21K Release
- 51.5K Release

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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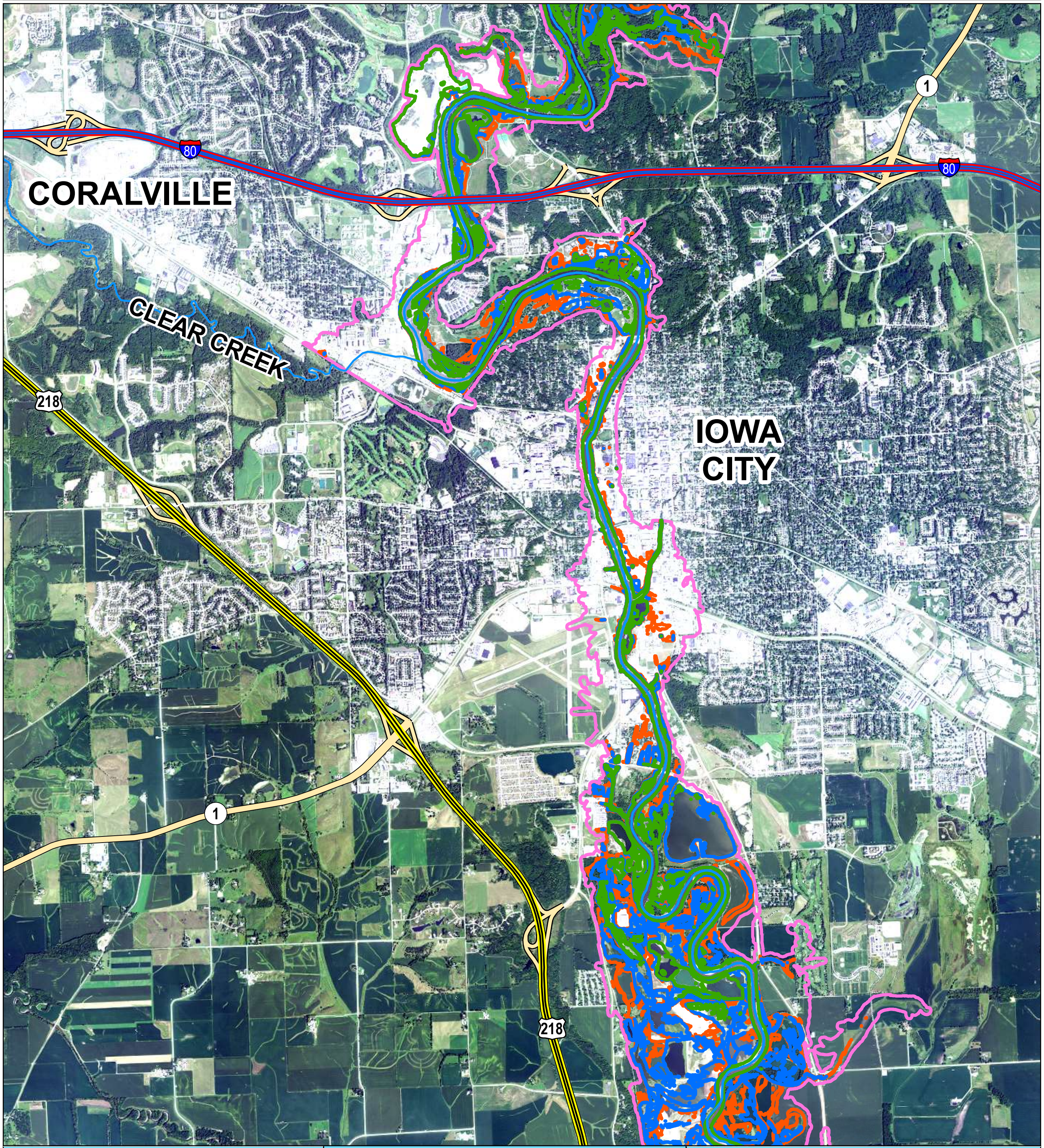
Rock Island District

PLATE 5

N W E S

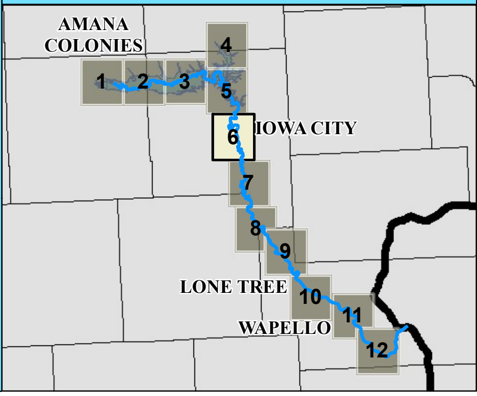
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 0.8K additional from Clear Creek (10.8K total)
- 16K Release, 1.5K additional from Clear Creek (17.5K total)
- 21K Release, 1.6K additional from Clear Creek (22.6K total)
- 51.5K Release, 0.7K additional from Clear Creek (52.2K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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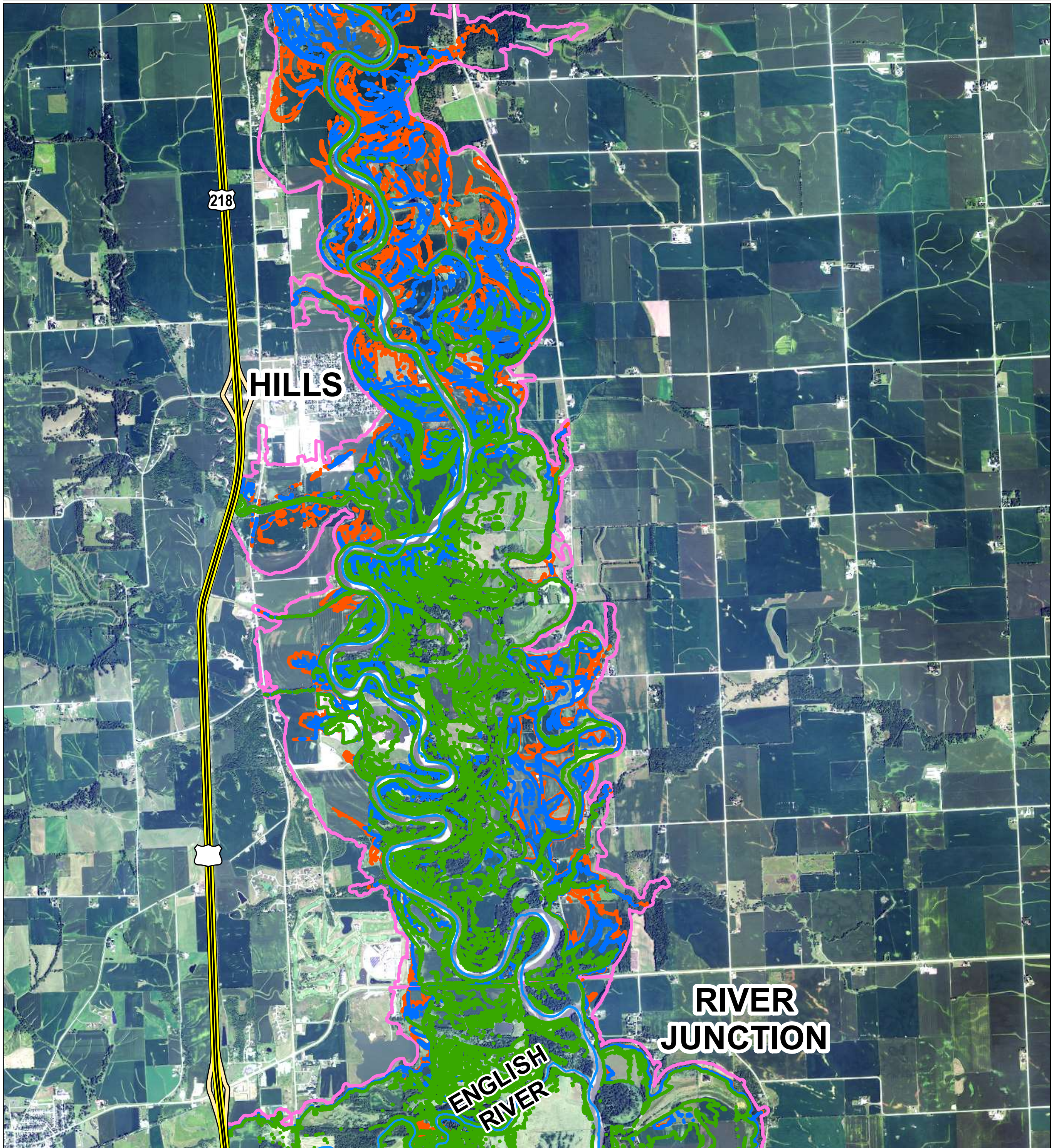
Rock Island District

PLATE 6

N E S W

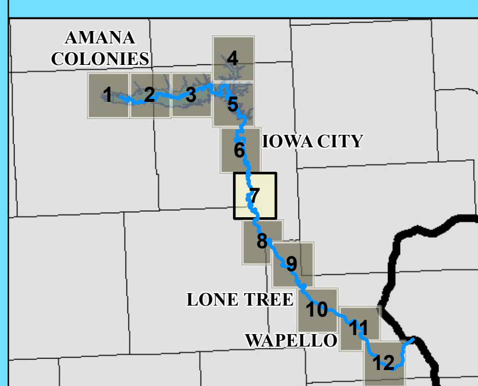
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 0.8K additional from Clear Creek (10.8K total)
- 16K Release, 1.5K additional from Clear Creek (17.5K total)
- 21K Release, 1.6K additional from Clear Creek (22.6K total)
- 51.5K Release, 0.7K additional from Clear Creek (52.2K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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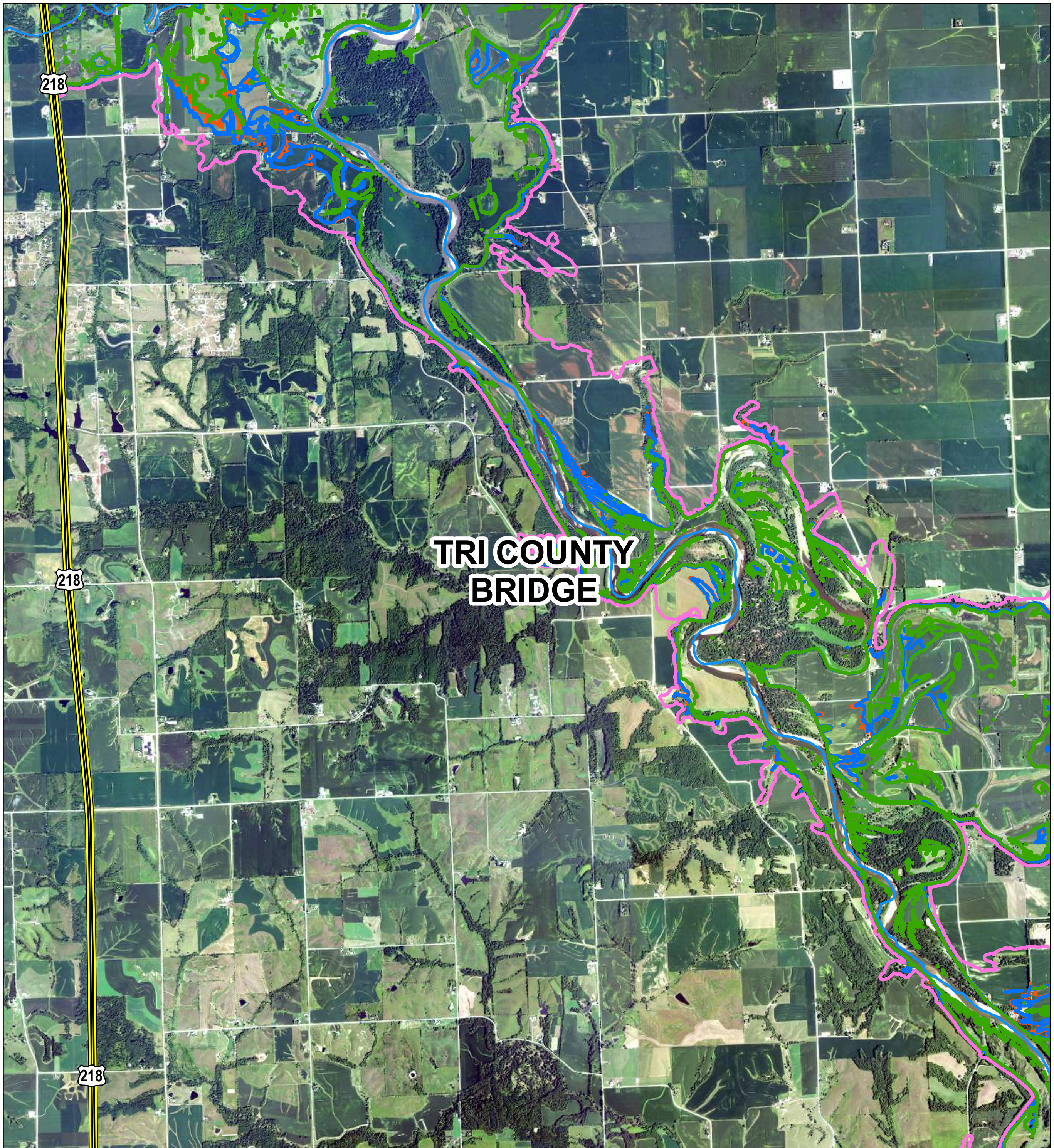
PLATE 7

N W E S

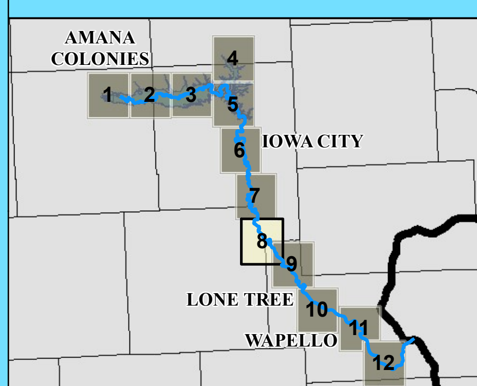
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 10.9K additional from Clear Creek and English River (20.9K total)
- 16K Release, 15.4K additional from Clear Creek and English River (31.4K total)
- 21K Release, 15.2K additional from Clear Creek and English River (36.2K total)
- 51.5K Release, 34.9 additional from Clear Creek and English River (86.4K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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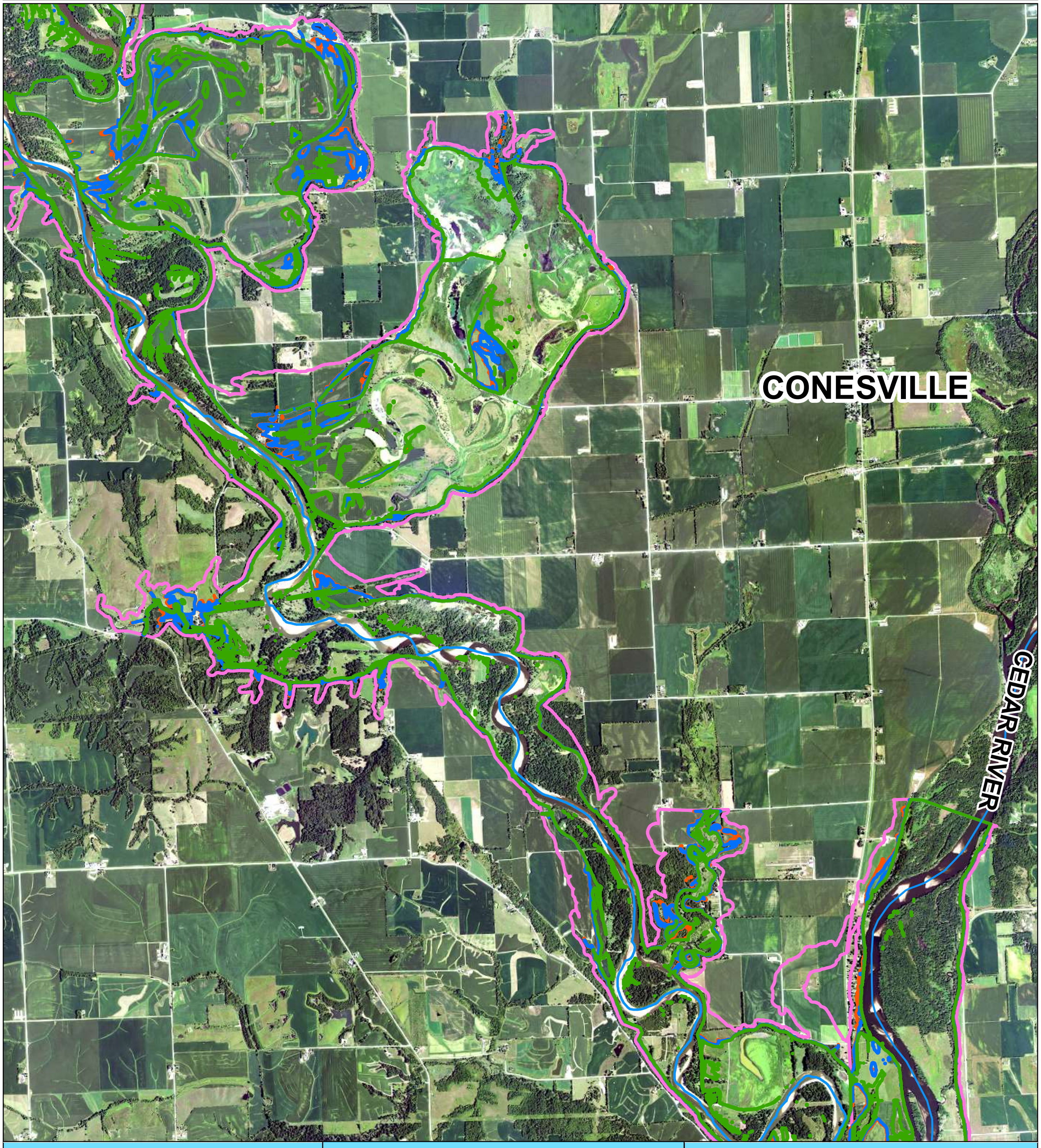
PLATE 8

N W E S

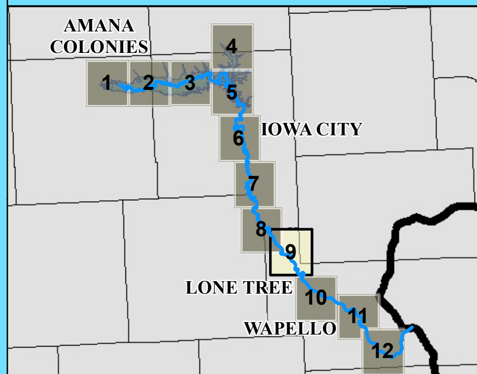
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 10.9K additional from Clear Creek and English River (20.9K total)
- 16K Release, 15.4K additional from Clear Creek and English River (31.4K total)
- 21K Release, 15.2K additional from Clear Creek and English River (36.2K total)
- 51.5K Release, 34.9 additional from Clear Creek and English River (86.4K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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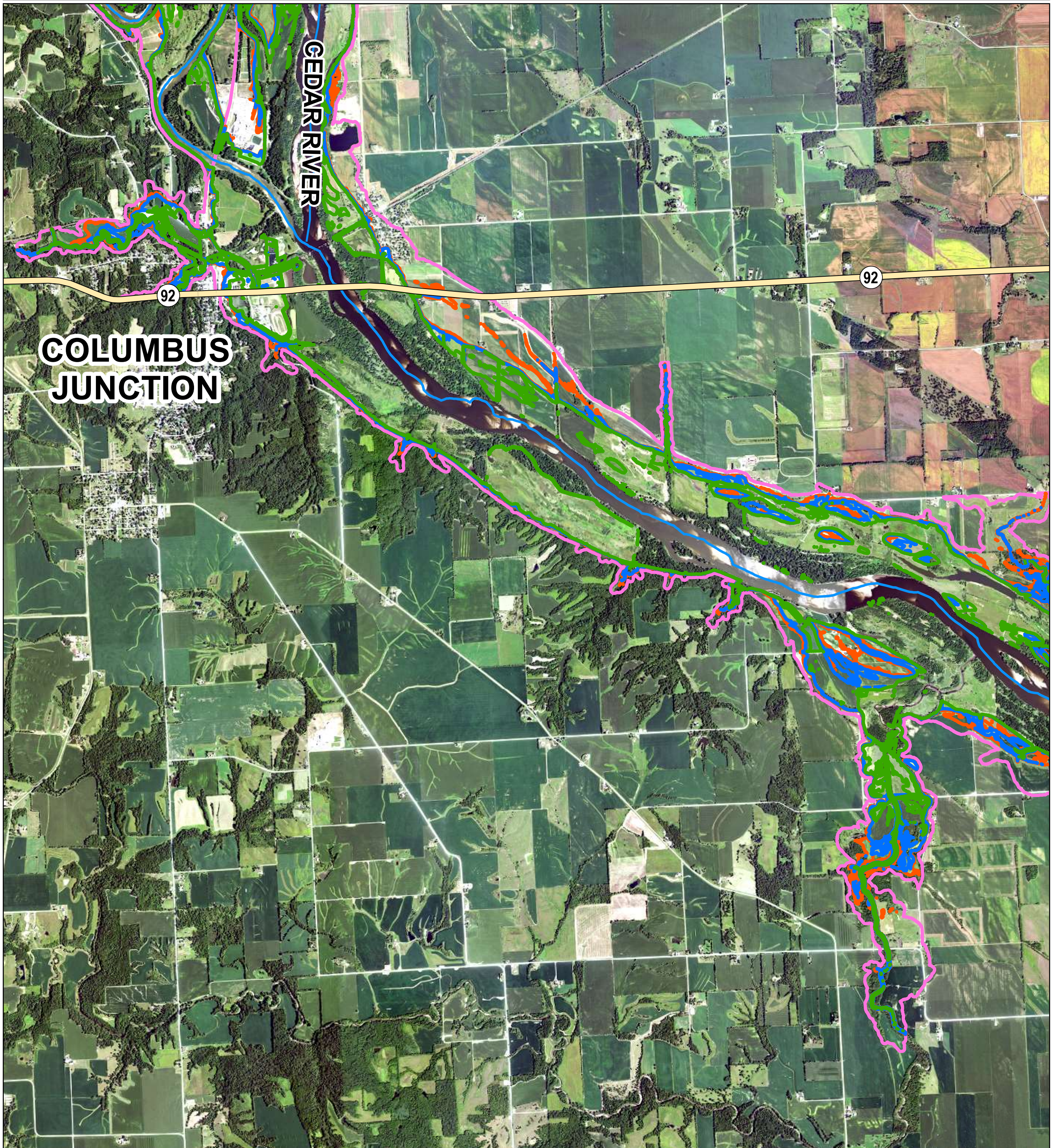
Rock Island District

PLATE 9

N W E S

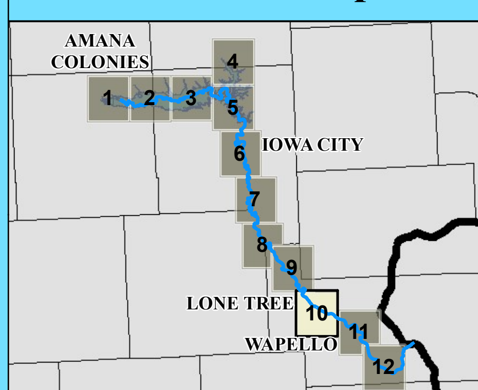
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 58.2K additional from Clear Creek, English and Cedar Rivers (68.2K total)
- 16K Release, 84.5K additional from Clear Creek, English and Cedar Rivers (100.5K total)
- 21K Release, 103.1K additional from Clear Creek, English and Cedar Rivers (124.1K total)
- 51.5K Release, 154.4K additional from Clear Creek, English and Cedar Rivers (205.9K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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PLATE 10

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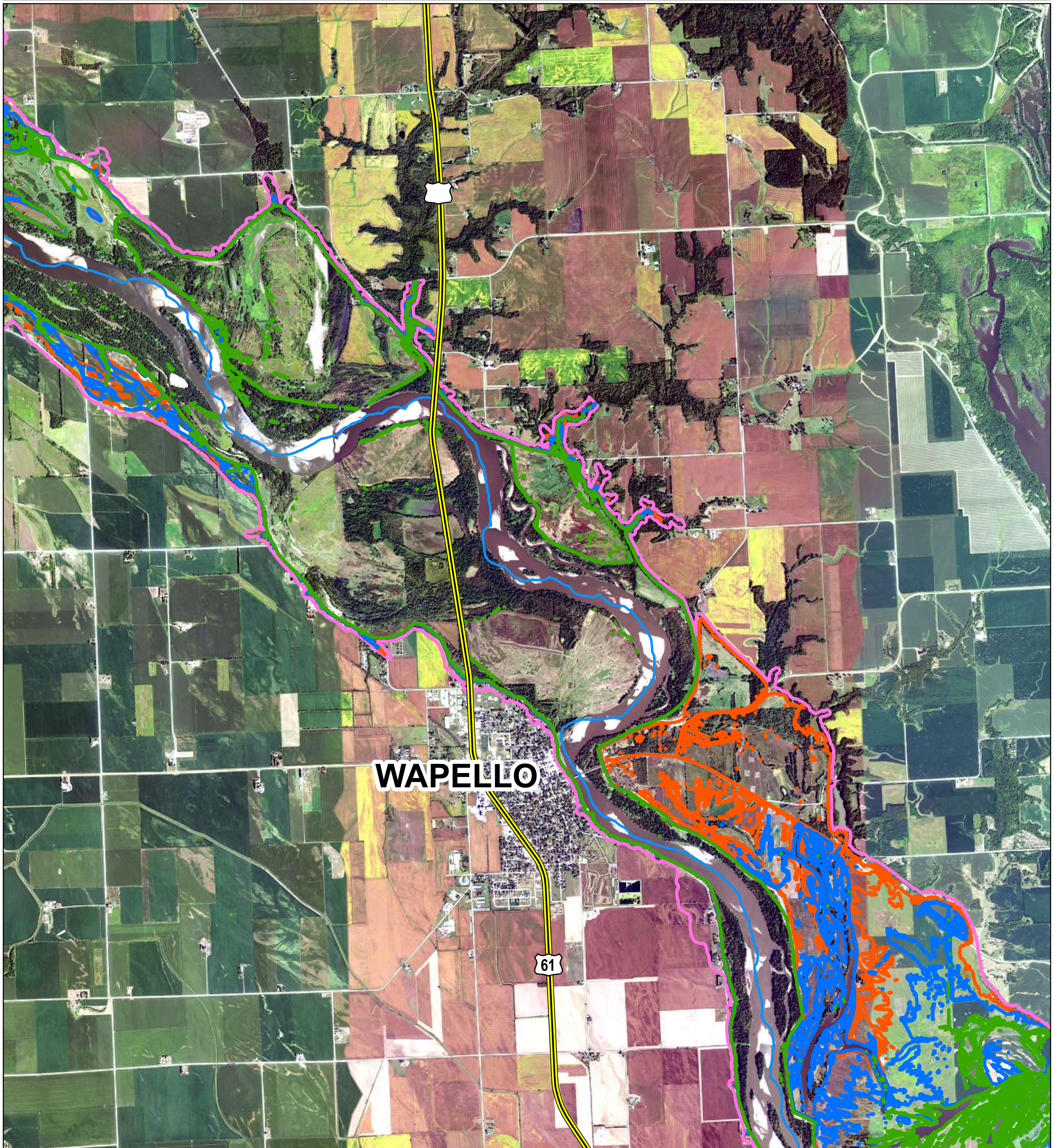
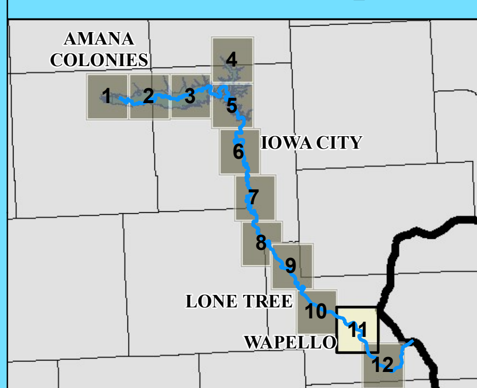
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 58.2K additional from Clear Creek, English and Cedar Rivers (68.2K total)
- 16K Release, 84.5K additional from Clear Creek, English and Cedar Rivers (100.5K total)
- 21K Release, 103.1K additional from Clear Creek, English and Cedar Rivers (124.1K total)
- 51.5K Release, 154.4K additional from Clear Creek, English and Cedar Rivers (205.9K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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PLATE 11

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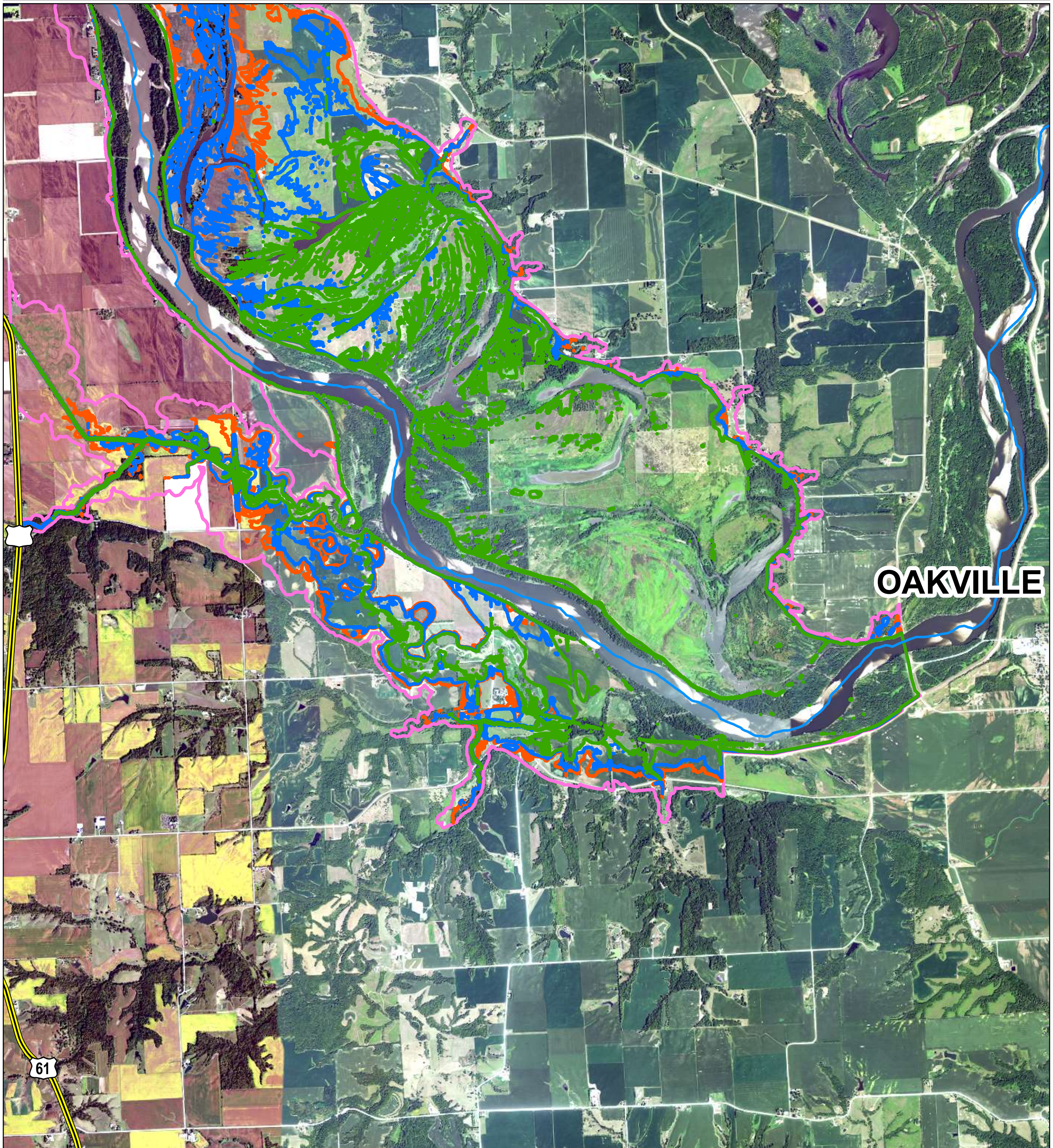
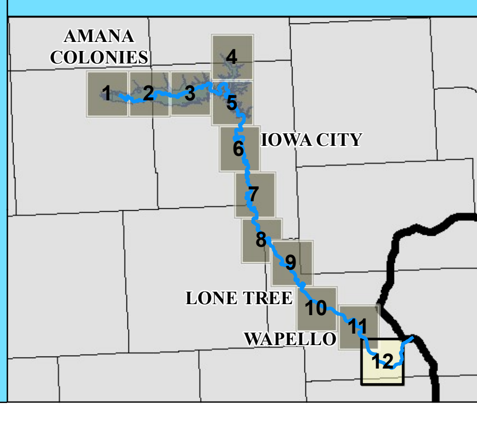
Iowa River Flood Inundation Map



Legend

- River Centerline
- 10K Release, 58.2K additional from Clear Creek, English and Cedar Rivers (68.2K total)
- 16K Release, 84.5K additional from Clear Creek, English and Cedar Rivers (100.5K total)
- 21K Release, 103.1K additional from Clear Creek, English and Cedar Rivers (124.1K total)
- 51.5K Release, 154.4K additional from Clear Creek, English and Cedar Rivers (205.9K total)

Location Map



USACE Floodplain Delineation reflects modeling of the mainstem reaches of the Iowa River (identified by the blue River Centerline feature on the maps).
Tributaries of the mainstem were not modeled.

0.4 0.2 0 0.4 0.8 1.2 1.6 Miles

1 inch equals 1 miles

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PLATE 12

N W E S