ENVIRONMENTAL FLOWS SUMMARY

IOWA RIVER SUSTAINABLE RIVERS PROJECT

USACE Photo

February 2023

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ENVIRONMENTAL FLOWS SUMMARY
IOWA RIVER SUSTAINABLE RIVERS PROJECT

I. INTRODUCTION

This Iowa River Sustainable Rivers Project (SRP) environmental flows (e-flows) report closely follows the SRP e-flows report completed for the Des Moines River SRP project (Nature Conservancy, 2017). This report's purpose is to explore whether Coralville Dam management changes related to flow could improve the long-term ecological health of the Iowa River and Coralville Lake. A partnership between the Nature Conservancy in Iowa (TNC) and the U.S. Army Corps of Engineers (Corps), Rock Island District (District), supports this collaborative effort. The E-Flows Team (Team) comprised of TNC, District, Iowa Department of Natural Resources (DNR), and Johnson County Conservation personnel is the group assisting with the e-flows analysis.

The Coralville Lake flood risk management mission activities have a higher priority than fish and wildlife management activities. That said, Congress authorized the fish and wildlife management mission at Coralville Lake and Dam and any proposed SRP activity will be given the highest priority possible.

The District used the Hydrologic Engineering Center's Regime Prescription Tool (HEC-RPT) to help capture the Team's environmental flow recommendations (Appendix D). The Team considered potential management impacts (positive and negative) on the following resources:

1. Fish & Mussels
2. Water Quality & other considerations (reservoir focused: shorebirds, waterfowl, pool levels), and,
3. Floodplain habitat, riverine waterfowl and wildlife.

This report defines flow goals designed to enhance ecosystem health on the river and attempts to identify ecosystem flow opportunities as possible given the existing constraints. The defining flow goals are to:

1. Clarify hypotheses for each focus reach regarding flow-related issues and potential flow changes or enhancements that could be made, i.e., identify where flow prescriptions may conflict or where there is the greatest opportunity to enhance benefits via pool-level or flow manipulations.
2. Develop environmental flow hypotheses based on specific e-flow components(low flows, flood pulses, small floods and large floods), with an understanding of the existing flow prescriptions, and how existing flows could be modified.
3. Identify significant knowledge and information gaps and potential monitoring needs.

The Team considered four distinct geographic reaches on the Iowa River for flow management measures (Figure 1):

1. Coralville Lake: from Coralville Dam upstream to Amana at the 220th Trail Bridge
2. Coralville Lake Tailwater downstream to the Lone Tree/Tri-County Bridge
3. Lone Tree/Tri-County Bridge to Wapello
4. Wapello to the confluence with the Mississippi River

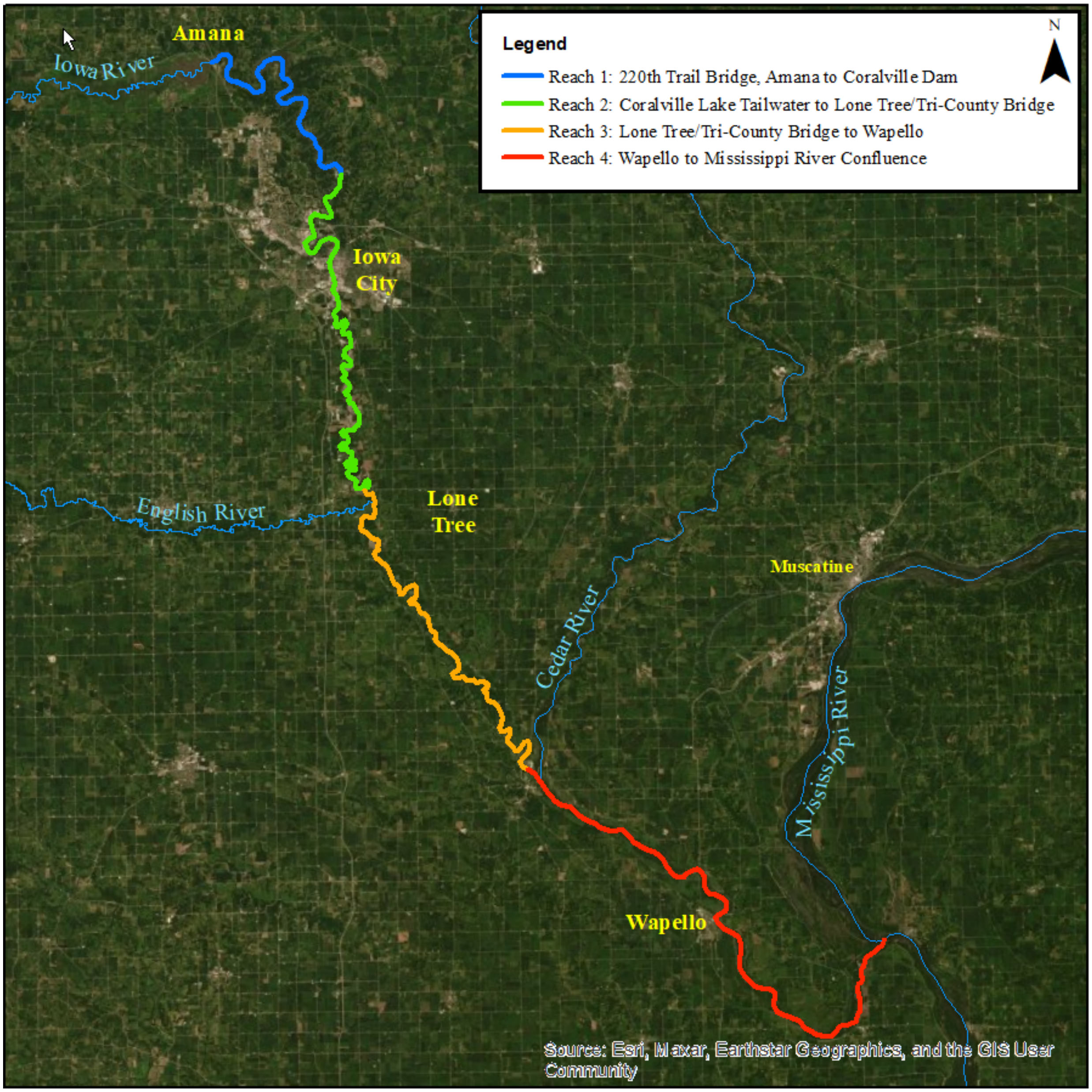

Figure 1. Iowa River Geographic Reaches

The Team (Appendix A, *E-Flow Team Members*) compiled many initial questions, hypotheses, and recommendations for ways to improve environmental flows.

The Team defined environmental flow needs in terms of their ecological function in the context of high and low flow regimes. The Team defined baseflows and flood events in terms of magnitude, timing, duration, and frequency of flows, as well as rates of change between different flow conditions. The Team considered “contingencies” and “uncertainties”, or knowledge gaps. Table 1 shows an example of ecological functions performed by specific environmental flow components.

Table 1. Ecological Functions Performed by Different River Flow Levels and Flow Component Ecological Roles

Base Flows and Seasonal Flows
• Provide migration and spawning cues for fish • Provide migration and spawning cues for fish • Provide adequate habitat space for aquatic organisms including reptiles, amphibians, and invertebrates • Ensure overwintering habitat for turtles and other herptiles • Maintain suitable water temperatures, dissolved oxygen, and water chemistry • Maintain water table levels in floodplain, soil moisture for plants • Provide drinking water for terrestrial animals • Keep fish and amphibian eggs suspended • Enable fish to move to feeding and spawning areas • Support hyporheic organisms (living in saturated sediments)
Low Flows (drought)
• Provide migration and spawning cues for fish • Provide migration and spawning cues for fish • Enable recruitment of certain floodplain plants • Purge invasive, introduced species from aquatic and riparian communities • Concentrate certain prey into limited areas to benefit predators
High Pulse Flows
• Provide migration and spawning cues for fish • Provide migration and spawning cues for fish • Shape physical character of river channel including pools, riffles and runs (channel forming flows) • Promotes movement and redistribution of stream bed substrates (sand, gravel, cobble) • Bankfull discharges • Prevent riparian vegetation from encroaching into channel • Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants • Aerate eggs in spawning gravels, prevents siltation
Floods
• Provide migration and spawning cues for fish • Trigger new phase in life cycle (e.g., insects) • Enable fish to spawn on floodplain, provide nursery area for juvenile fish • Manage flood pulses to reduce impacts on sand bar nesting turtles • Provide new feeding opportunities for fish, waterfowl • Recharge floodplain water table • Maintain diversity in floodplain forest types through prolonged inundation (i.e., different plant species have different tolerances) • Control distribution and abundance of plants on floodplain • Deposit nutrients on floodplain • Maintain balance of species in aquatic and riparian communities • Create sites for recruitment of colonizing plants • Shape physical habitats of floodplain • Deposit gravel and cobbles in spawning areas • Flush organic materials (food) and woody debris (habitat structures) into channel • Purge invasive, introduced species from aquatic and riparian communities • Disburse seeds and fruits of riparian plants • Drive lateral movement of river channel, forming new habitats (secondary channels, oxbow lakes) • Provide plant seedlings with prolonged access to soil moisture *(based on Richter et al., 2006)*

The environmental flow component recommendations included:

- Low flows (seasonal, annual and extreme low flows);
- High flow pulses (up to bank full discharge);
- Small Floods (overbank flows, approximately 2- to 10-year return period);
- Large Floods (floodplain maintenance flows, > approximately 10-year return period).

The Team considered the significance of environmental flow components in relation to the following:

- Hydrogeomorphic processes – including channel formation, sediment dynamics and gravel movement.
- Floodplain processes and functions – including functions such as vegetation establishment, seed dispersal, riparian community structure and function, seasonal access for fish, habitat for species such as amphibians and birds, etc.
- Water quality – including temperature, dissolved oxygen (DO) and nutrients.
- Key indicator species – including a range of species with different life histories, with flow requirements identified for specific life-history stages.
- Implications for population dynamics of non-native species and their interactions with native species and communities.
- Environmental pulse flows should not be conducted when there is high flow on the Cedar River that will lead to increased flooding of wildlife areas on the Wapello to Mississippi Reach. Pulse flows should be timed to avoid creating conditions that will exceed 21 feet on the Wapello gage when combined with flows of the Cedar River.[1]

The Team considered the following questions when defining environmental flowcomponents:

- How have dam operations changed river hydrology, morphology, and habitat?
- How do present and pre-dam channel morphology in the Iowa River compare to the upper limits of Coralville Lake?
- What opportunities exist in the Iowa River to develop structure or off-channel habitat for aquatic and bird life (e.g., reconnection of old oxbows)?
- When considering birds, herps, mussels and fish species of greatest conservation need, are there flow management strategies that would benefit all?

The Team integrated the flow recommendations into a single unified set of environmental flow definitions for each reach.

Flow Requirements and Expert Findings for the Iowa River

The Team found flows from Coralville Lake were not substantially different than current operations because outflows under current operations resemble natural inflows except when

[1] The District is acceptable to this condition as long as it is an “environmental flows” release and not a Flood Risk Management release. The FRM release is 25 feet at the Wapello gage.

flows are ratcheted back during downstream tributary flooding. Implications of hypothesized pool level modifications on river flows will need to be further explored in reservoir simulation models.

II. CORALVILLE LAKE PROJECT BACKGROUND

Coralville Lake, built and maintained by the U.S. Army Corps of Engineers, Rock Island District, is operated as a multi-purpose reservoir. The primary purpose for areas below the lake is flood risk management (FRM), authorized by Congress (PL 75-761). Other congressionally-authorized purposes include low flow augmentation, fish and wildlife management (PL 85-624), and recreation (PL 78-534). Coralville Lake maintains a permanent conservation pool to augment low flows during drought and implements a fall pool raise to benefit migrating bird species. While recreation is an important and highly visible activity at Coralville Lake, it is a supplemental benefit of its operations.

Access for recreational purposes is provided and maintained, however water levels are not managed for this purpose. Flood risk management remains the number one priority for the reservoir, and gate settings for the dam, which controls outflow, are determined by Rock Island District hydrologists.

Coralville Lake is regulated to conform to a strict water control plan (WCP) that is coordinated by the Corps of Engineers with local, state and Federal agencies having water resources responsibilities. The WCP includes regulation of releases during flood and drought periods. Table 2 summarizes the WCP for Coralville Lake.

Table 2. Coralville Lake Dam Water Control Plan Information

Dam Information
Construction: began 1949, completed 1958 Watershed: 3,084 square miles Type: Earth-filled embankment Length: 1,400 feet Height: 100 feet Top Width: 22 feet Top of Dam Elevation: 743 feet NGVD29
Normal/Conservation Pool
Length: 23 miles Area: 5,430 acres Storage: 23,770 acre-feet Water Surface Elevation: 683 feet NGVD29 Spring Conservation Pool: 679 feet NGVD29
Flood Risk Management Pool
Length: 41.5 miles Area: 24,800 acres Storage: 371,630 acre-feet Water Surface Elevation: 712 feet NGVD29 (top of spillway)
History
Highest Recorded Inflow: 57,000 cfs (2008); 39,000 cfs (1993) Highest Recorded Outflow (Spillway + Conduit): 39,500 cfs (2008); 25,800 (1993)
Record High Pool Elevations
717.02 feet (2008) 716.75 feet (1993) 711.85 feet (1969) 711.05 feet (2018)

Figure 2 displays the Coralville Lake Water Control Plan.

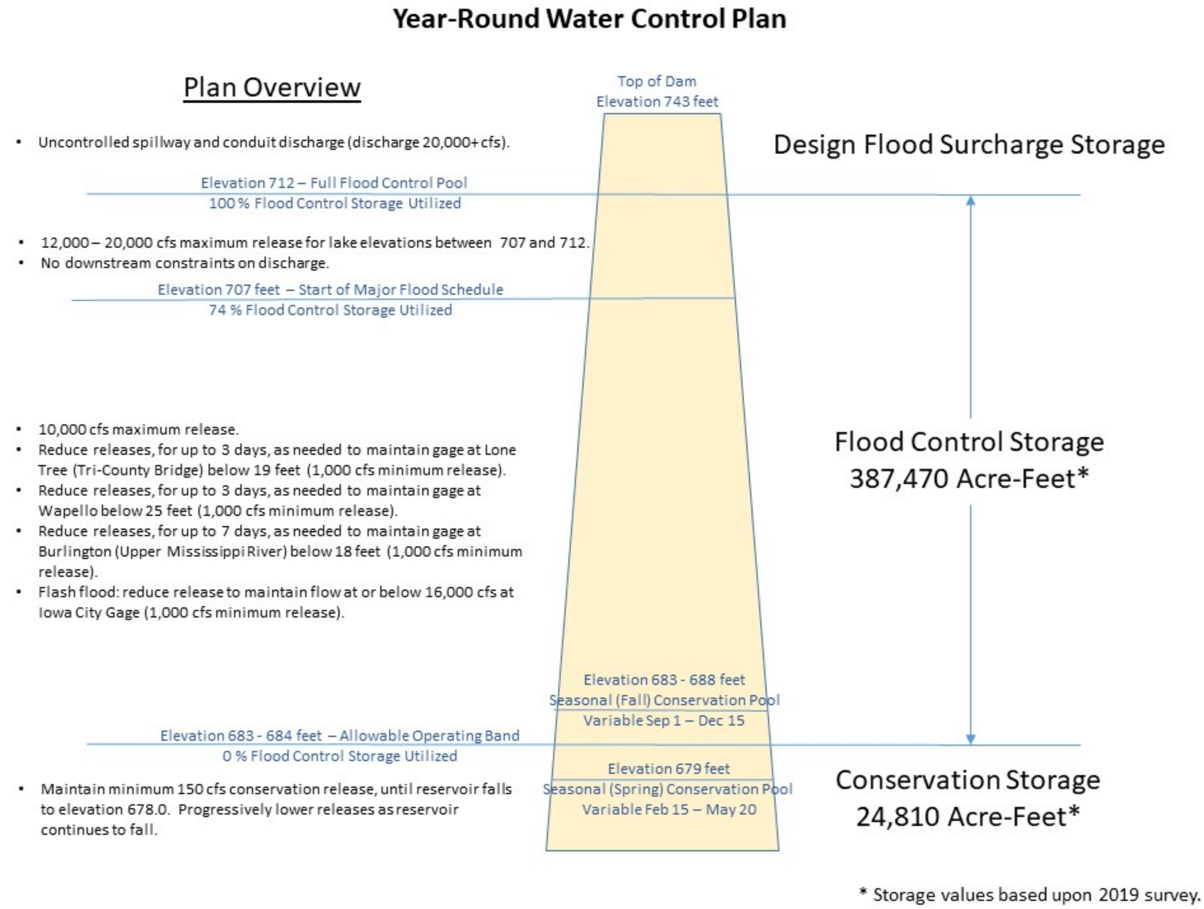

Figure 2. Coralville Water Control Plan

Constraints. Based on the WCP, the District must operate Coralville Dam as outlined in Figure 2. Figure 3 explains these operating limits over a calendar year. The lowest FRM operating level is in the Spring (mid-February to Mid-May). This level is an option and not required every year. Similarly, the fall raise for natural resource management is optional and dependent on sufficient rainfall to raise the pool level.

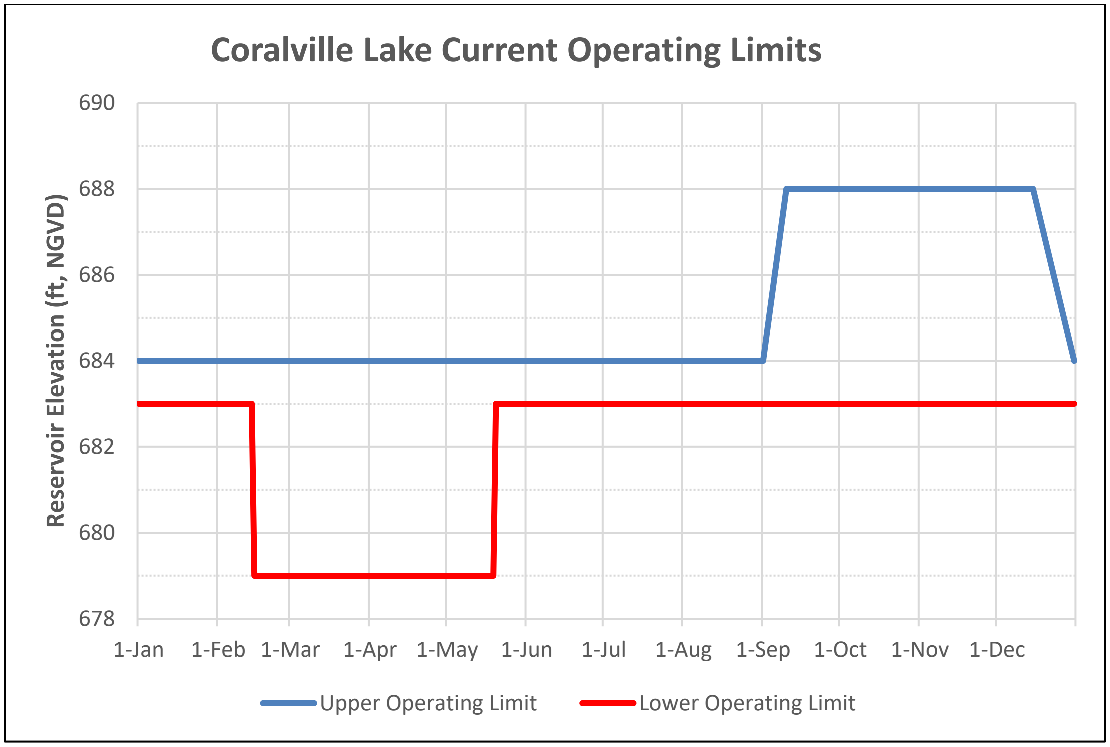

Figure 3. Coralville Lake Current Operating Limits

III. SUMMARY OF LITERATURE REVIEW AND PRELIMINARY FLOW HYPOTHESES

The natural flow regime provides a range of specific parameters (timing and magnitude of high and low flows, pulses and floods, duration of high and low flow pulses, and rate of rise and fall) that can be used to design managed flow regimes intended to mimic natural flows (Richter et al., 1996, 1997; The Nature Conservancy, 2005). A key concept in riverine ecology is that to maintain the ecological integrity of floodplain ecosystems, connectivity to the mainstem river environment is critical to the point that this idea is considered an overarching theme in river restoration water management (Sparks, 1995). The central concept in the River Pulse Floodplain model and similar models (Junk et al. 1989) is that flow events connect floodplain and mainstem systems on regular (usually annual) intervals and promote connectivity between the floodplain and the river, thus increasing the exchange between the two systems of nutrients, sediments, lateral connectivity and fish that directly affects community composition.

When connectivity between these systems is lost, changes in floodplain depth, surface area, and shape have been found to lead to additional alterations to a suite of abiotic and biotic characteristics that directly and indirectly affect fish communities. Direct effects include loss of habitat via increased sedimentation, resulting in unsuitable spawning habitat for many fish species, and loss of woody structure providing attachment sites for many macroinvertebrate species. As floodplain systems become more isolated, they often become shallower, leading to increased temperatures and susceptibility to hypoxic conditions during warm weather conditions, allowing for the dominance of species with higher tolerances for poor water quality.

In the Iowa River Basin, native fish, aquatic communities, and species historically depended on a mosaic of riverine habitats and fluvial processes to complete their life cycles. To define the flows needed to support this complex ecosystem, the Team organized species into groups based on sensitivity to one or more aspects of the flow regime. Biological and ecological traits are commonly used to describe groups of species with similar life histories, physiological and morphological requirements, and adaptations, thereby providing a mechanistic link to understanding or predicting responses to varying hydrologic conditions (Poff et al. 2006, Merritt et al. 2010, Mims and Olden 2012; Parks 2013).

Quantitative and qualitative information about how species respond in other river systems can help set expectations about the potential mechanisms and taxa response of species with similar functional traits. Table 3 summarizes the link between flow-dependent taxa and physical and chemical processes within the basin. For each taxa group, the Team summarized flow needs and key hydro-ecological relationships. For species within each group, the Team attempted to synthesize known information on critical life history stages and timing for species within each group, as well as to associate groups with habitat types. By overlaying key life history requirements for each group on representative hydrographs for each habitat type, the Team highlighted relationships among species groups and seasonal and interannual streamflow patterns. Table 3 represents a typical guild of species. The species listed represent a host of other species.

Figure 4 displays the flow components and ecological needs over a calendar year.

Table 3. Examples of Taxa Response to Key Hydro-Ecological Relationships

Group	Life History
Aquatic-lotic species Smooth softshell, spiny softshell turtles, map turtles, mudpuppy (lungless salamanders)	• some depend on specific hydraulic conditions, depth, velocity, width • use specialized stream-dependent feeding habits • sensitive to changes in water quality • require aquatic connectivity
Semi-aquatic lotic species Blanding's turtle, northern water snake, northern leopard frog	• rely on flowing waters within the active channel or groundwater dependent backwaters for one or more life stages, typically hibernation • depend on access to and quality of floodplain and riparian habitats for migration, feeding, and reproduction • Wood turtles nest on sand bars and need flow of river during summer months to prevent nest from drowning • Blanding's turtles need a variety of off-channel habitats of varying water depths for feeding, mating, and overwintering.
Riparian and floodplain-terrestrial and vernal habitat species bog turtle, northern cricket frog, blue spotted salamander, common musk turtle	• Amphibian mating, egg, and larval development may occur in vernal pools within the floodplain or in intermittent streambeds • terrestrial connectivity within riparian and floodplain habitats • Overwintering and nesting habitat for Common musk turtles. Common musk turtles nest in sandy areas in June/July and nests hatch in August/September • Common musk turtles (state listed) require slow flowing water (or backwaters) in addition to sandy uplands for nesting. They tend to overwinter buried in wet mud and must need some sort of flow to ensure there is oxygen in the water over the mud. Summer flooding could be an issue for CMT nesting. *Possible research?*
Floodplain spawners such as northern pike and gar spp.	• Spawn in flooded grass • Larval fish use flooded grass as cover

Group	Life History
Large River Species (wide ranging) Shovelnose Sturgeon, Lake Sturgeon, blue sucker, freshwater drum, Paddlefish, Longnose Gar, Skipjack Herring, Channel Catfish, Flathead Catfish, sucker sp. Hiodontidae spp.	• occur in tributaries and large rivers • spring spawners with migration typically cued by temperature and rising water levels • require connectivity to floodplain and backwater habitats as well as to upstream tributaries • long-lived, large-bodied, pelagic feeders requiring maintenance of deep, open waters
Migratory Residents Lamprey, Sauger, Walleye, American Eel	• spring spawners requiring connectivity between tributary and small river habitats during spawning migrations • medium body size requiring moderately deep habitats esp. during overwinter period
Backwater Dependent/ Specialist Species Golden Shiner, Longnose Gar, Tadpole Madtom, Brook Silverside, Red Shiner, Mississippi Silvery Minnow, Blackchin and Blacknose Shiner, Weed Shiner	• species utilizing or depend upon backwater habitats preferentially for at least part of their life cycle
Fluvial Specialists Black Redhorse, Blacknose Dace, Longnose Dace, Common Shiner, Hornyhead Chub, Northern Hogsucker, most Darters	• almost always found only in lotic systems, i.e., streams and rivers; described as needing flowing water habitats throughout their life cycle
Fluvial Dependent White Sucker, Golden and Shorthead Redhorse, Paddlefish, Mud Darter, Tadpole Madtom	• found in a variety of habitats but require access or use of stream habitats or flowing waters at some point in their life cycle, such as for tributary spawning; may have significant lake or reservoir populations that use tributary streams for some life requirement

Flow Components and Needs: Iowa River

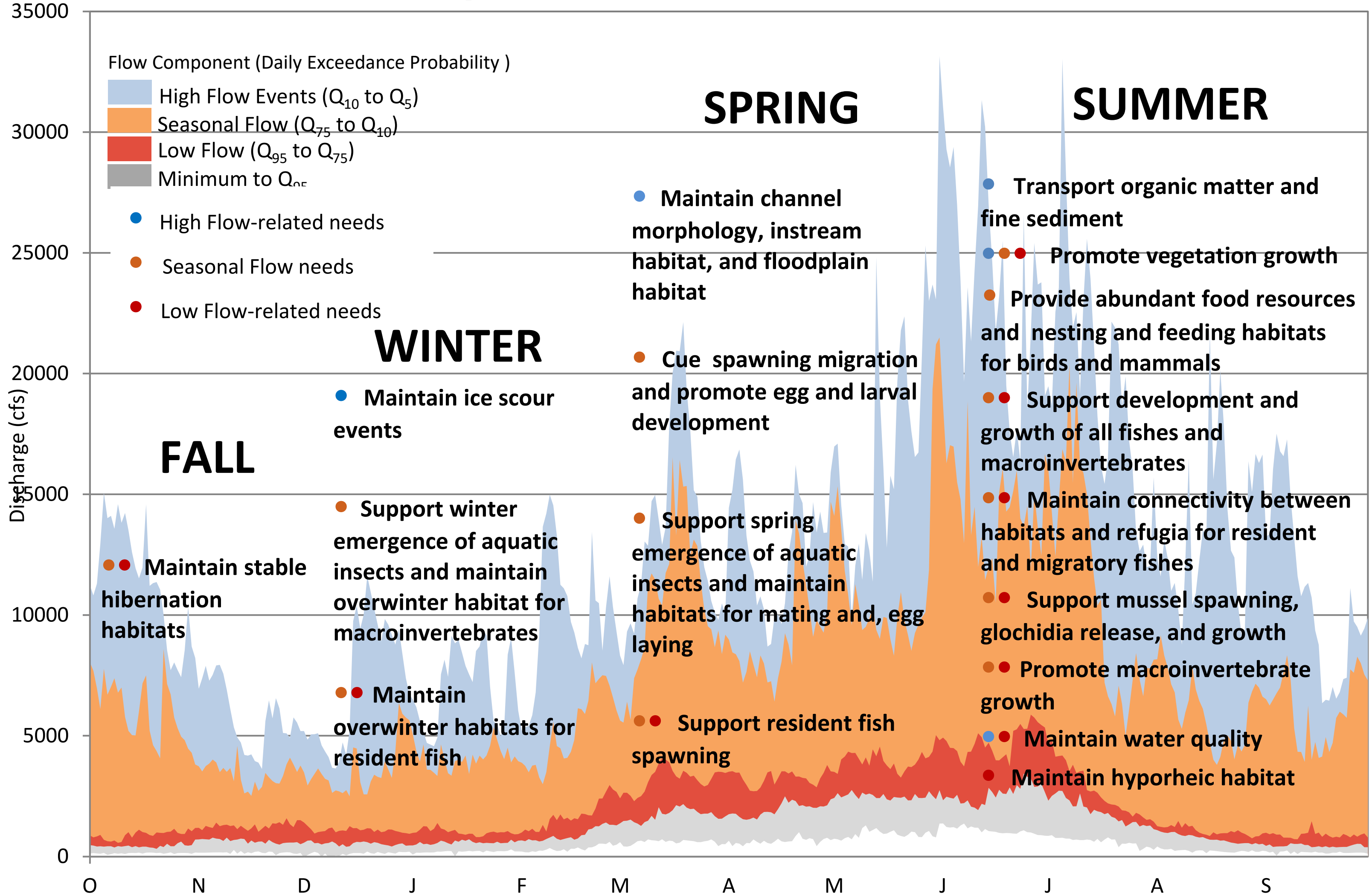

Figure 4. Preliminary Hypotheses of Flow Components and Needs for the Iowa River Downstream of Coralville Dam Over a Calendar Year

The most dramatic changes to hydrology in the Iowa River Basin occurred due to the extensive conversion of tallgrass prairie to annual row crops, shallow-rooted pasture/lawn grasses, and impervious surfaces. combined with extensive drainage modifications and significantly increased rainfall in the second half of the 20th century. These changes dramatically altered the magnitude, timing, and frequency of a range of environmental flow components. Therefore, understanding the impacts of Coralville Lake FRM project requires recognizing both changes due to the dam as well as these larger scale changes in basin hydrology. Although the historical flow record is extensive, many changes to the Iowa landscape were already significant by the time gages were installed in 1918. The Team assumed complete restoration of presettlement natural hydrology is not feasible at this point, and the goals of this project are to understand ecological flow needs and move towards restoring a more ecologically beneficial hydrology within the constraints of the modern context. Therefore, for the purposes of this report, hydrograph changes were explored in relation to flows after 1970. Analyses of hydrologic changes in HEC-RPT were based on comparing historical flow time series (water years 1992-2021) for the regulated versus unregulated flows (simulated flows without either of the projects) generated by the District (Landwehr, pers. communication).[2]

IV. SUMMARY OF CORALVILLE WATER LEVEL MANAGEMENT EFFECTS ON ENVIRONMENTAL FLOW COMPONENTS

Wet Years. The literature review comparing daily flow statistics for the 10th percentile, median, and 90th percentile flows, showed significant differences in the frequency distributions of daily and seasonalflows (TNC 2016). However, using HEC-RPT to compare wet, average, and dry year flows by water year allowed the Team viewed how the projects have impacted flows across individual water years.

The wet year management's main effect i reducing the frequency and the number of years during which flows exceed 10,000-20,000 cfs, thus reducing overbank flows and floodplain inundation, and prolong and extend the intermediate flow releases of 6-10,000 cfs. However, in the very wettest years, high flows still do occur. This should reduce bank erosion.

Average Years. Relative to the "unregulated" flows, Coralville Reservoir operations have increased seasonal (median) daily flows significantly in December when the conservation pool is being restored tothe lower level after the fall pool raise. Median flows are especially elevated relative to the unregulatedflow regime from May through September. Only October flows are lower under the regulated scenario.

Although 1994 was an "average" year, a high flow pulse in October 1993 was captured and stored, leading to higher releases for much of October and November than would have occurred without the dam. In 1995, Coralville Lake captured and stored several peak flow events in the spring, prolonging the 6,000 cfs flow release well into August. In many of the dry year scenarios such as 2001, the main impact of dam operations was to reduce the low flows in October and November down to the 150 cfs minimum flow in order to accomplish the fall pool raise.

[2] For the literature review, daily flow statistics were summarized for regulated and unregulated flows over the entire period of record (1918-2015) at each location provided (i.e., below Coralville). The literature review also included two-period comparisons (pre- and post- project) using the Indicators of Hydrologic Alteration software (TNC, 2007), flow time series were analyzed.

Dry Years. In general, Coralville Dam operations do not appear to substantially impact flows in dry years. However, unregulated low flows are typically higher in the fall when inflows are being stored to accomplish the fall raise, and the pattern is reversed in mid to late December for the fall pool drop.

Flows between 400-2000 cfs in December are significantly more frequent post-dam. Extreme low flows have been completely eliminated by the 150 cfs minimum flow requirement, and in general, low flows are more consistent across years than prior to the project. Dam operations do not seem to significantly impact low flows for the City of Coralville.

Using the literature review, the Team developed preliminary hypotheses for environmental flow needs by reach (Table 4).

Figures 5, 6, and 7 show examples for wet, average, and dry year flows from Coralville Dam. The project generally operates according to the seasonal pattern of inflows but tend to capture and store the highest flows and then release higher flows later in the season. Regulated flows are typically lower and flatter than unregulated flows would be from April to July, but higher and flatter from August through December.

Figure 5. HEC-RPT Time Series for Example Water Years [2008 (Fig 5a), 2013 (Fig 5b). and 2019 (Fig 5c)] for the Reach Below Coralville Dam, Comparing Unregulated Flows (purple), Regulated Dam Releases (turquoise), and Regulated Flows at Iowa City (blue). The grey dashed line (16,000 cfs) indicates the outflow for flash flood operations at Iowa City.

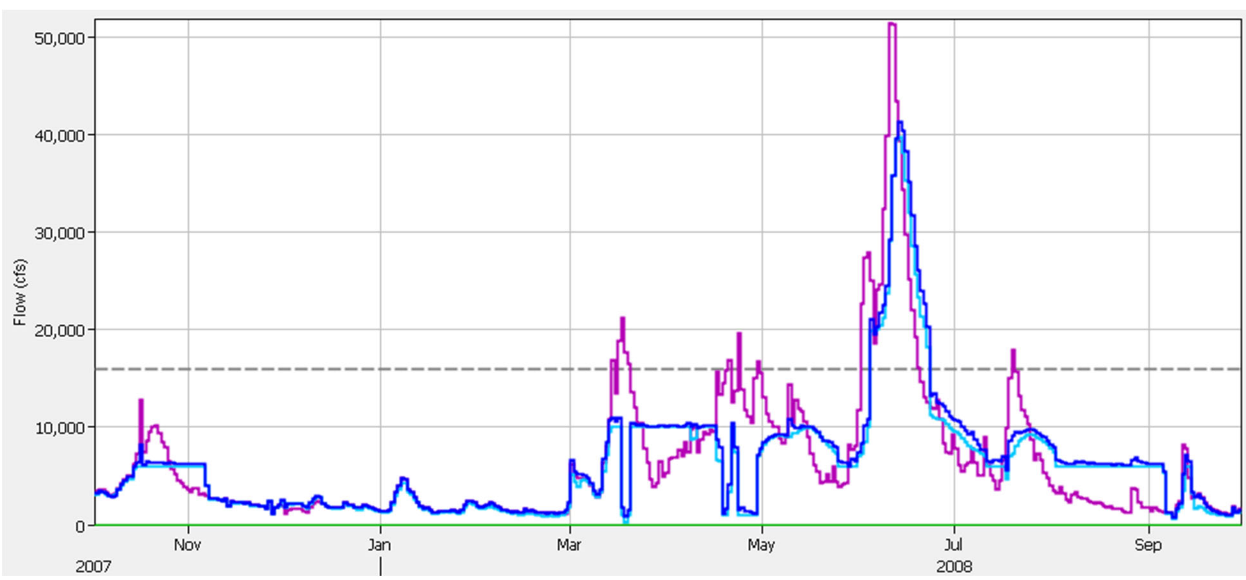

Figure 5a. 2008

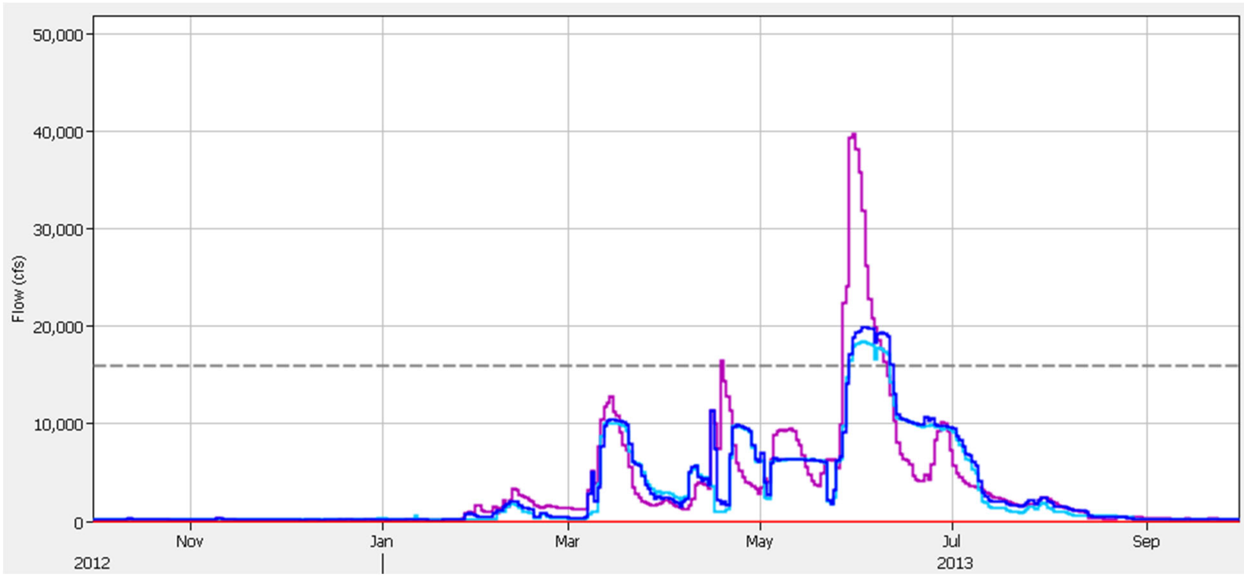

Figure 5b. 2013

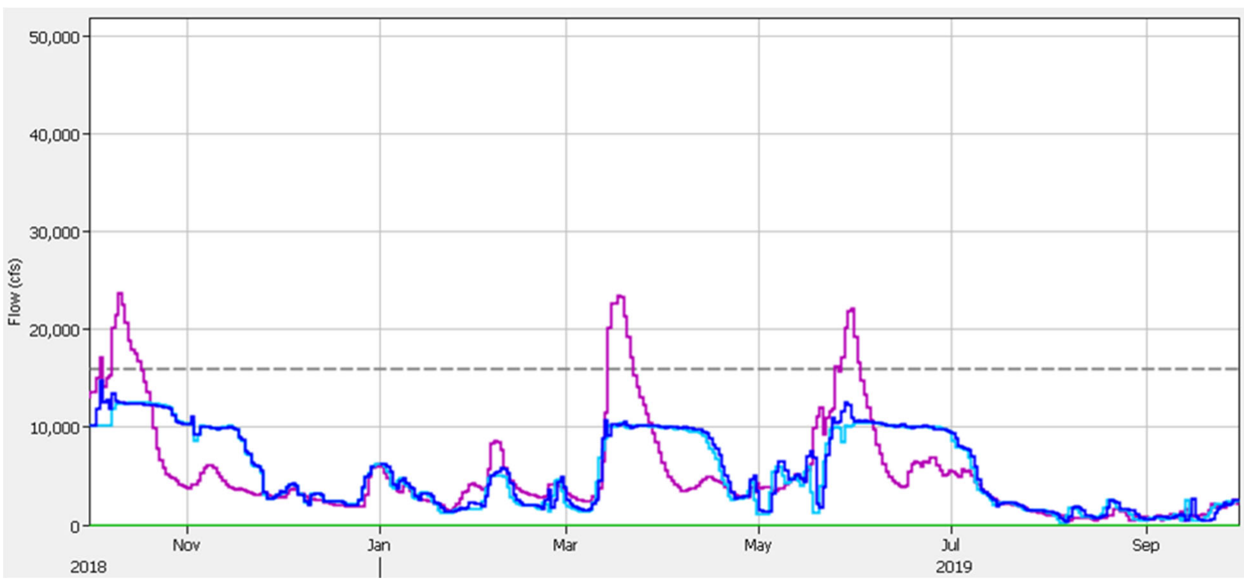

Figure 5c. 2019

Figure 6. HEC-RPT Time Series for Example Water Years for the Reach Below Coralville Dam, Comparing Unregulated Flows (purple), Regulated Dam Releases (turquoise), and Regulated Flows at Iowa City (blue), Using "Average" [1994 (Fig 6a), 1995 (Fig 6b)] and "Dry" [2012 (Fig 6c)] Year Examples

Figure 6a. 1994

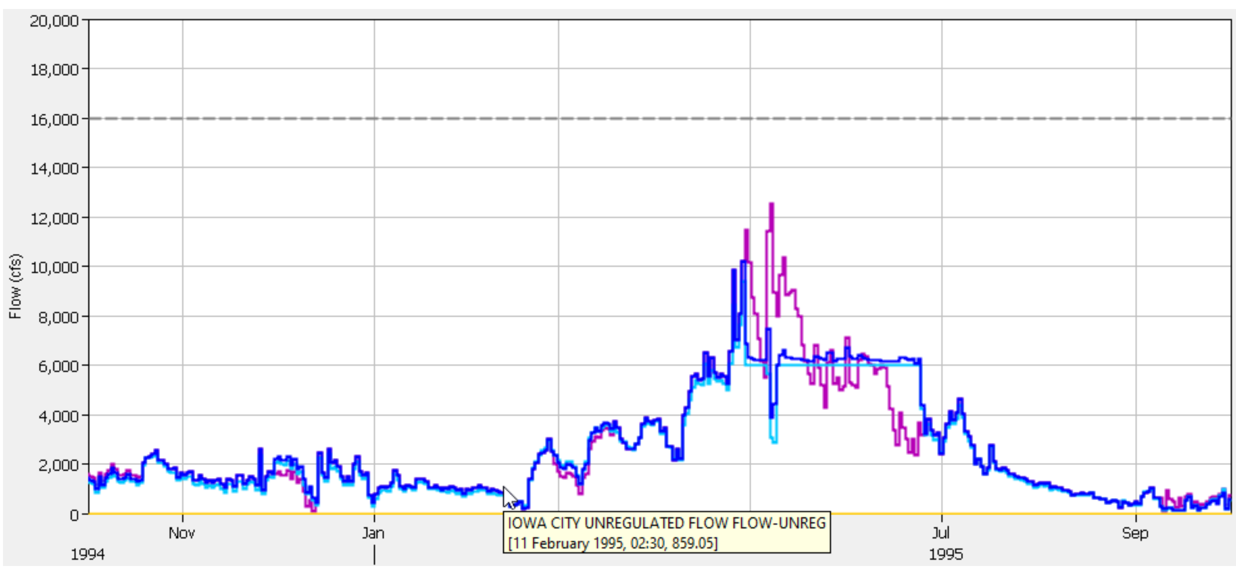

Figure 6b. 1995

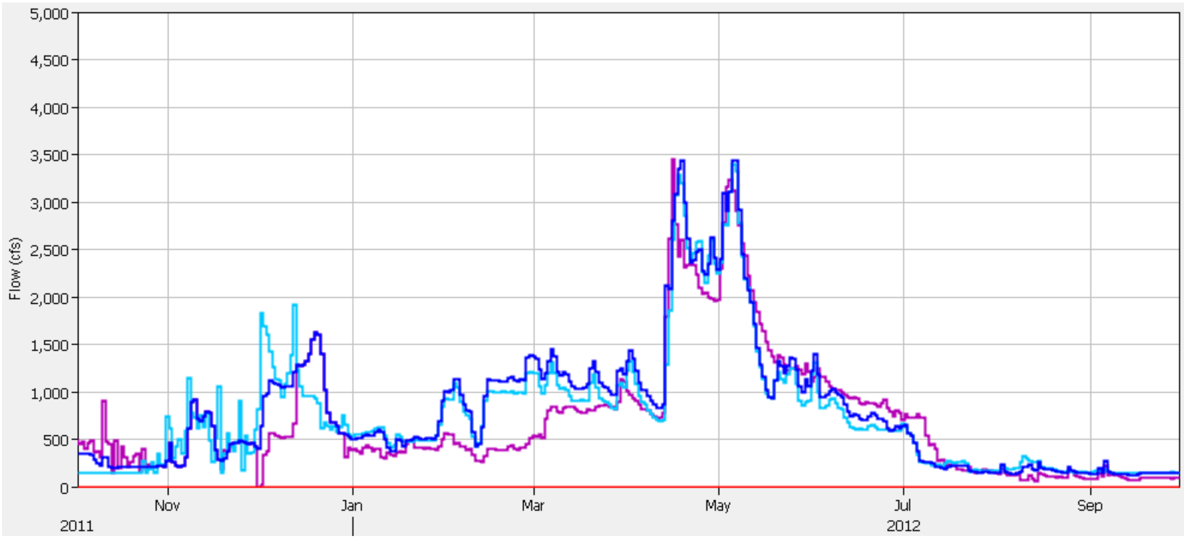

Figure 6c. 2012

Figures 7. HEC-RPT Time Series for Multiple Years [1991-2001 (Fig 7a), 2001-2011(Fig 7b), and 2011-2021(Fig 7c)] for the Reach Below Coralville Dam, Comparing Unregulated Flows (purple), Regulated Dam Releases (turquoise), and Regulated Flows at Iowa City (blue)

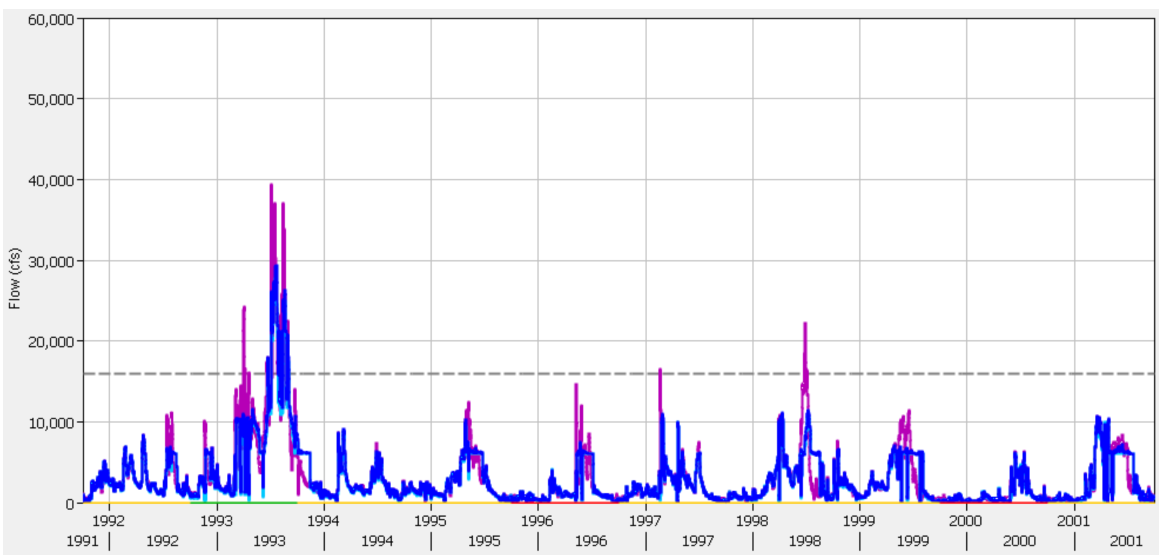

Figure 7a. 1991-2001

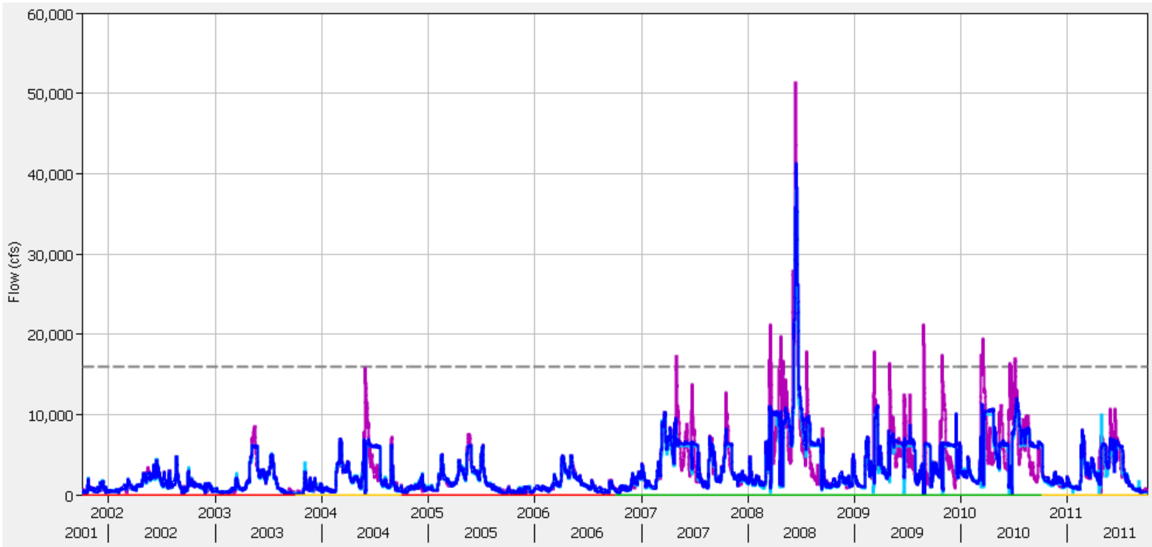

Figure 7b. 2001-2011

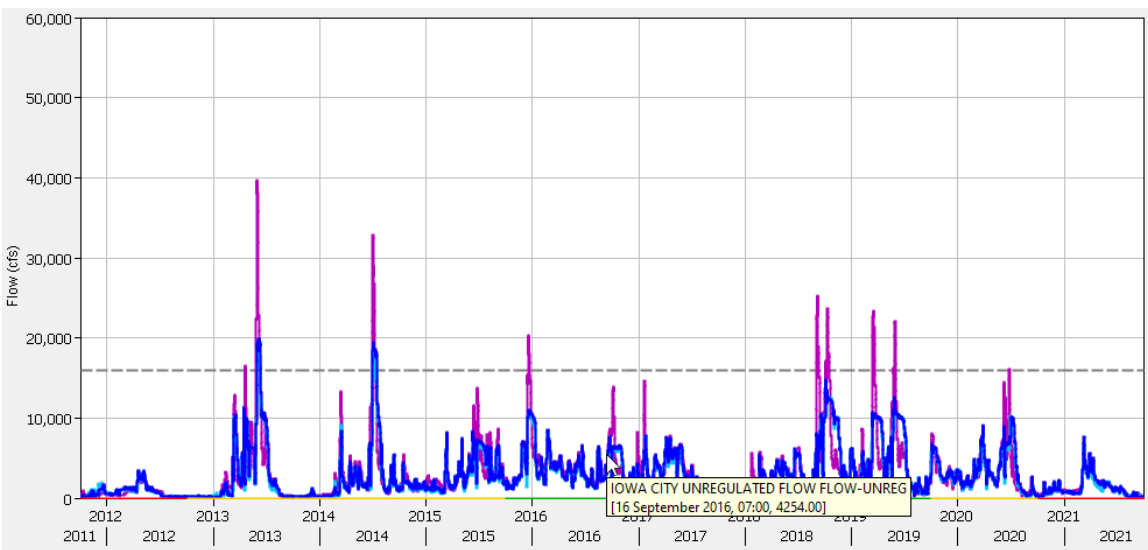

Figure 7c. 2011-2021

In Figures 7a, b, and c, “wet” years are indicated along the horizontal axis in green, “average” years in yellow, and “dry” years in red. Regulated and unregulated flows are similar in general except during high flows. High flows of15-40,000 cfs are captured and stored by the project, with prolonged releases of 12-15,000. Flows exceeding 45- 50,000 cfs (such as occurred in 2008 and 2010) are not fully captured and stored and result in flood releases.

Table 4. Preliminary Flow Hypotheses for Environmental Flow Needs by Reach (from the Literature Review)

220th Trail Bridge to Coralville Lake Dam	Coralville Lake Tailwater to Lone Tree/Tri-County Bridge	Lone Tree/Tri-County Bridge Gauge to Wapello
Explore whether pool elevations can better mimic natural seasonal inflows to improve fish, herp, & bird habitat	Coordinate Coralville Dam releases with recreational use, boating & fishing initiatives for the cities of Coralville and Iowa City	Bolster low flow releases during heat waves to moderate instream temperatures and reduce downstream fish and mussel mortality
Explore implications of manipulating reservoir time for denitrification	Explore implications of manipulating reservoir time for denitrification	More gradual rise and fall rates; reduce rapid fall storage drawdown and winter releases
Implications of sedimentation for waterfowl/shorebird habitat	Explore whether pool elevations can better mimic natural seasonal inflows to improve fish, herp, & bird habitat	Short-term low flow releases to benefit downstream recreation (as long as rise rate is not too rapid)
	Implications of excess sedimentation for habitat	Restore more natural seasonal pattern of low flows (higher & more variable)

Note: The SRP Flow Prescription Analysis does not include environmental flow needs from Wapello, IA, to the confluence with the Mississippi River due to the limited influence of the dam on the river in this reach. At Wapello, only 25% of the contributing watershed is located above Coralville Dam. Additionally, much of the agricultural land in the Wapello reach has been converted from agricultural production to natural habitat/conservation land with several tracts using Federal funds such as the Conservation Reserve Program and the Wetland Reserve Program making these areas much more important today for Species of Greatest Conservation Need. Pulse flows should not be conducted in conjunction with high flows on the Cedar River that will lead to increased flooding of wildlife areas on the Wapello to Mississippi Reach for e-flows. Pulse flows should be timed to avoid creating conditions that will exceed 21 feet on the Wapello gage when combined with the flow of the Cedar River for e-flow purposes. Flood releases may be higher.

V. DETAILED DISCUSSIONS AND ENVIRONMENTAL FLOW DEFINITIONS[3]

A. Fish and Mussels

The Team discussed factors contributing to fish and mussel mortality on the Iowa River and identified whether flow changes could be made to reduce the incidence of these mortality events. For fish, the literature survey revealed potentially chronic drivers of fish mortality.

The Team discussed the relationship of temperature and channel morphology changes on the lower Iowa River. The Team hypothesized that excessive water temperatures in some reaches of the lower Iowa River may be exacerbated, especially at low flow, by channel widening and simplification that has occurred in response to the dams and other changes in the river's flow regime, i.e., a "fluvial geomorphology problem". There was significant uncertainty about whether anything could be done on the flow management side that would affect or restore channel morphology given that land use, levees, and other changes may now constrain the function of channel-forming flood flows to significantly re- shape the river channel. Legacy channel changes were discussed in terms of how "reference flows" might need to be adjusted to achieve the same ecological benefit, i.e., for any given magnitude of flow, the amount of habitat created are likely to be different now than they were prior to the construction of the Coralville project. For example, the currently authorized 150 cfs minimum flow may not provide the benefits it once did in terms of instream wetted habitat.

Understanding how the channel has changed and the implications for habitat at different flow magnitudes was identified as a significant knowledge gap. Flow increases may provide benefits closer to the dam at Coralville but may not be maintained or extended very far downstream. There is simply not a lot of deep pool habitat between the confluence with the Cedar River and Mississippi River. Ultimately, the Team hypothesized the recent historical climate conditions and the current minimum flow of 150 cfs may be overly conservative and could potentially be increased without significantly impairing authorized purposes of the dam at Coralville. Increases in the minimum flow release could be coordinated with climate conditions as a buffer against excessive temperatures downstream. However, there was uncertainty about this recommendation which could be useful to model in order to predict what the implications would be both in terms of downstream benefits and impacts on the conservation pool.

With respect to environmental flow components, the connectivity to the floodplain during critical fish and mussel spawning and nursery periods for fish is an important factor. Critical timing for fish passage for spawning fish is April-May-June; however, high flow pulses in late summer and early fall may also benefit fish by moderating temperatures and creating greater connectivity between patches of more suitable habitat. Shovelnose sturgeon typically spawn in April or May; experts cited recent research from Missouri suggesting they may be protracted or opportunistic spawners that can spawn throughout the year whenever conditions are appropriate. Furthermore, some of the sturgeon mortality due to high water temperatures in the Des Moines River in 2012 were observed to be carrying eggs, and recently hatched sturgeon have been found as late as October. Previous studies suggested spawning is triggered by a combination of rising flows, daylight length, and water temperature, so it is possible sturgeon can take advantage of combinations of environmental conditions whenever they occur.

[3] Section V is derived from the Des Moines River Flows Prescription Workshop held in 2016. The Iowa River SRP Team assumes the ecosystem needs are similar between the two rivers.

Ecologically, flood pulses need to be predictable within the operational windows. Most fish species in Iowa spawn during spring and early summer high flows. Based on review of the historical flow records experts observed in the HEC-RPT, there is a role for a bimodal flood pulse, with one peak that primarily benefits early season spawners (March-April) and a second one supporting May-July spawning fish, as well as providing juveniles and backwater species access to shallow, productive nursery habitats in early summer. The Team also discussed the need for a fall rise to allow juvenile fish to access habitats on the margins for forage.

The natural flow regime tends to be associated with a fall "raise" as the growing season ends, evapotranspiration by terrestrial vegetation shuts down, and stored water in the system becomes more available. Although the Team recognized that dam operations, ongoing and legacy climate, land use, and drainage changes do represent constraints in terms of the feasibility of returning the system to a "natural" hydrograph, attempting to "mimic" the natural hydrograph is a guiding paradigm for identifying environmental flows. The goal is to design releases that yield the greatest ecological benefit. There was some question from a water management standpoint of how certain defined environmental flows would impact the reservoir water storage. In general, the Team felt that matching outflows to inflows represented the best way to "mimic" the natural flow regime; however, some planning would be needed to avoid excessive rate of change in either flows or pool levels when transitioning from wet to dry condition operating rules and vice versa, as well as in conducting pool raises and drawdowns.

The Team developed flow needs throughout the year for fish during wet, dry, and average conditions and attempted to define specific environmental flow needs. They discussed whether the environmental flow recommendations they developed for fish were appropriate, necessary, and sufficient for mussels as well. Much discussion centered on the implications of timing and rate of change of "unnatural" flow releases for mussel mortality and other potential negative impacts to aquatic and aquatic-dependent biota, particularly during winter. The Team modified the current approach, transitioning away from fall to winter pool levels by evacuating massive amounts of water in December depending on the IA DNR's requests, and typically averages 3" per day. The Team's desire is to restore the winter pool elevation much more gradually and limit the daily rate of change to no more than 6,000 cfs per day in two 3,000 cfs changes.

Overall, there appeared to be consensus that modifications need to focus on restoring a more natural rate of change as opposed to identifying specific flow or pool elevation targets. Analysis of pre- and post-project flow regimes suggest the most altered hydrologic indicators are rise rate and the fall rate. For example, both the literature review summary and the HEC-RPT hydrograph analysis identified differences between the regulated and unregulated flows in late December, specifically an apparent spike in daily 10th percentile low flows under the regulated flow regime.

Historically, once the period for the fall pool raise ends (~Dec 15-20), operations at Coralville Lake have moved to restore normal pool elevation by immediately releasing large amounts of water through the dam. This results in a pattern of rapidly increased flows in late December that is highly unseasonal (or unnatural), which could well be highly disruptive to aquatic and aquatic-dependent wildlife, especially mussels and herps. Ecologically, radical changes in flows and pool elevations were identified as very detrimental to mussel populations, particularly when entering cold periods, as well as likely detrimental to certain herps (especially turtles and frogs). There was a question of whether the fall pool raise should be maintained throughout the winter since mussels and other taxa are most vulnerable to exposure mid-December through February, and rapid drawdowns in pool elevation and/or river levels during the winter should be avoided if at all possible. At the same time, slowly lowering the lake pool during the winter could result in a continuum of sheet ice along the shore and raised the question of impacts to hibernating herps during the winter. Therefore, the Team decided to hold the pool at the fall rise elevation well into late winter/early spring. However, this conflicts with the authorized purposes of the dam in terms of ensuring adequate spring flood storage. The Team discussed whether spring flood storage could still be achieved by restoring the winter pool elevation much more gradually, and when to begin restoring the normal conservation pool elevation. In terms of reservoir elevations, the expert finding was to extend/prolong the releases from Coralville Dam to a drop of the pool no more than 3” a day in the winter, and no more than 6” a day in the fall. However, even 3-6”/day may have negative ecological impacts at certain times of year.

The Team used the HEC-RPT volume tracking feature to assess whether flows in average and dry water years would be sufficient to sustain environmental flows developed for wet year conditions. The volume tracking indicated there should be sufficient flow in most years to accommodate the environmental flow needs. For dry years, however, there might be insufficient flow to achieve the bimodal flood pulse, and it might be necessary to allow spring flood pulses only in conjunction with natural inflows. The Team discussed whether management should exploit the capacity of the reservoir to store water to ensure predictable timing of spring flood pulses during the periods identified for early- or late-season spawning. They also discussed whether to allow timing to be determined naturally based on storms and to ensure natural variability in timing that may benefit different species in different years. The Team’s preference is for natural climate variability, i.e., coordinating the flood pulse releases with natural storm events and inflow magnitudes, especially during dry years. There was uncertainty about the ecological value and function of dry year flood pulses that do not exceed bankfull.

Recognizing there might not be sufficient flow in some dry years to meet flood pulse environmental flows, the Team discussed whether flood pulses should include using some of the conservation pool storage to artificially create or enhance flood pulses during prolonged drought periods (e.g., 3+ years of dry conditions). For example, even during dry years, a spring pulse could be achieved if the fall pool raise were held through the winter, especially if the fall pool raise were increased (> 4 feet). This would likely create conflict with recreational uses or regulated purposes if it substantially reduced the elevation of the conservation pool. However, when the regulation manual for Coralville Lake was revised in 2020, the pool was not authorized to remain raised through the winter which would cause some difficulty storing enough water for a spring pulse during drier years.

Coralville Lake Tailwater to Lone Tree/Tri-County Bridge Gauge. There are ecologically significant mussel populations upstream and downstream of the Iowa City metropolitan area. About 54 species of native mussels were once found in Iowa. Now, there are about 42. Nine of these are endangered, another six are threatened, and several more species are very hard to find in Iowa (IA DNR, 2018). This area of the Iowa River contains one of the most diverse mussel communities from inland rivers in Iowa. There are approximately 27 mussel species in the Iowa River. It is home to the state-listed Pistolgrip (*Tritogonia verrucosa*) and the Federally-listed Higgins eye pearly mussel (*Lampsilis higginsii*).

Based on the water quality, and native mussel community below Coralville Dam, the District, the IA DNR, and the USFWS released inoculated fish with Higgins eye glochidia just below the dam in 2006. In 2011, the first adult mussels of that release were found. Additional free-release fish efforts are showing additional year classes of Higgins eye. To date, no survey has collected naturally-reproducing Higgins eye although the Team malacologists assume naturally-occurring reproduction is taking place since mussel surveys have found gravid females.

Notable sport fisheries in the river include walleye, smallmouth bass, and catfish. Because of the extent of urban infrastructure, the Team initially assumed there would be limited opportunity to restore floodplain inundation dynamics in this reach. However, there are more public green space and conservation holdings within the Iowa City metro area and opportunities to continue to create areas along the river corridor for recreational, green space, and wildlife benefits. The connectivity and management of these areas could possibly be improved in the future.

In comparing the regulated and unregulated flow series, the Coralville Dam passes natural inflows, with the regulated flows being very similar to the predicted unregulated flow series, except when flows exceed 16,000 cfs or when the Cedar River is forecast to have flooding issues. Below the confluence with the Cedar River, flow in to the Iowa River shows a very strong signature from the Cedar River contributions. This is because outflows from Coralville Dam are typically cut back rapidly when very high flows are forecast for the Cedar River. The rate of change is currently limited to 6,000 cfs per day (limited to two, 3,000 cfs changes), driven primarily by concerns about bank stability in-reservoir as well as downstream safety. However, even 3,000 cfs per day is a significantly greater rate of change than under the natural flow regime (comparing the regulated versus unregulated rise and fall rate). Although it is unknown as to what extent this rate of change results in detrimental effects in the reach between Coralville Dam and the Cedar River, it is certainly plausible that detrimental effects are occurring.

Summarizing uncertainties, the Team identified a need to further evaluate whether 3,000 cfs per day is a sufficiently protective restriction on the rate of change below Coralville Dam, as well as whether 150 cfs minimum flow is still adequate.

The Team considered the Iowa Power Dam (Coralville, IA) (Photograph 1) and Burlington Street Dam (Iowa City) (Photograph 2) influence on river safety and recreational and ecological impacts. The Team considered how the downstream dams would impact or benefit from the Iowa River e-flow prescriptions. These dams have implications for fish passage (and mussel presence), habitat connectivity, and District operations. The Burlington Street Dam complements the City's 26-acre park along the river to the south. The park includes wetlands to absorb flood waters.

Photograph 1. Iowa Power Dam, Coralville, IA (USACE photo).

Photograph 2. Burlington Street Dam, Iowa City, IA (USACE photo).

Coralville Reservoir. The Team considered how current management of conservation pool and elevation changes affects existing fisheries and mussel populations. Although the reservoir is manmade, the ecological communities it supports would be best adapted to a water level regime following the natural pattern of water level dynamics in regional lakes, wetlands, and floodplains. As an example of a key fishery resource, Crappie initially spawn starting at the end of May through the second or third week of June. Therefore, it would be best to avoid falling water surface elevations during that period.

The Team proposed a 6-inch increase to the conservation pool elevation starting 01 July (683-684 ft), that would be slowly lowered (1"/week) for 8-12 weeks. The purpose of this water level manipulation is to create exposed mudflat habitat for shorebirds (see additional discussion on mudflats in Section V.B.)

The uncertainties identified whether the rate of fish "loss" through the dam (downstream passage) is affected by the elevation of the gates. Larger releases can suck sediment laden waters into the lake more quickly and create turbid water conditions downstream (creating a water quality issue). High inflows to the lake cause large inputs of sediment largely settling out in the upper reaches of the reservoir. Releases from the dam are sediment deprived and promote less turbid waters but may contribute more to downstream bank erosion as those waters pick up sediment, especially at high outflows.

Experts observed species diversity among mussels in the reservoir itself is typically lower than in the riverine environment, as most Iowa River species prefer moving waters. The species known from Coralville Lake typically prefer littoral areas. For this reason, and because mussels have limited mobility, rapid changes in lake elevation, e.g., when the lake is "dumping" water to achieve a pool elevation target, are detrimental to mussels. Slow drawdowns are therefore preferred. The Team proposed a preliminary initial limit of no more than 3" of change per day. It was unknown what level of flow release a 3-inch elevation change corresponds to at different pool elevations.

The exception is at times of very high flow, usually during spring or summer, when areas have been rapidly inundated and there is a need to get water off inundated areas in the floodplain to manage them. At these times, rapid drawdown is unlikely to impact mussels because the rise was also rapid, and they will not have moved into those areas anyway.

Overall, the Team concurred the restriction on the daily rate of change proposed to benefit the river downstream of Coralville Dam would also benefit Coralville Lake by restricting the rate of change in reservoir elevations.

B. Water Quality and Reservoir Considerations

The Team investigated how flow and pool level management in the reservoir affects residence time, denitrification, and waterfowl versus shorebird habitat (both vegetated and mudflats), and the interaction among these various dynamics.

The Team considered reservoir management uncertainty concerning how to maintain bird migration/water depth dynamics over time, given gradual shifts in spatial habitat availability caused by sedimentation of the reservoir. Water levels will likely need adjusted over time to realize the same benefits. The Team also considered the value of mudflats for denitrification (likely greater per unit area than the denitrification occurring in bottom sediments or in the water column). The Team discussed the feasibility of managing variability in water levels explicitly to enhance denitrification and recognized that there might be benefits as well as costs associated with trying to optimize any one variable. For example, optimizing denitrification by manipulating residence time may negatively affect in-lake water quality, flood storage benefits, and/or downstream ecological flow benefits.

To restore a more “natural” hydrologic regime, the Team proposed greater variability in target pool elevations. For the purposes of waterfowl, a slow and relatively steady drawdown of water levels throughout the growing season is best for managing smartweed and other waterfowl forage. A drawdown by mid-July allows for vegetative establishment prior to the fall rise, or the period after October (ideally, mid-October) when these marginal areas are inundated to benefit fall migratory waterfowl. Exposed mudflats in late July, August and September benefit migratory shorebirds.

Framed in terms of current operational targets, elevating the current “normal” pool target by ~6” during early summer (starting from elevation 683-684 NGVD by July 1) could allow for a gradual drawdown starting in mid-July (July 15). Gradual drawdown (1-2”/week) to slightly below normal pool of 683 NGVD by September 1 would gradually expose mudflats. This level would be held until the end of the September, allowing plants to become established serving as forage for waterfowl when inundated by the fall rise. Current operations have created exposed mudflat areas that are gradually migrating longitudinally as areas previously 1-2” deep are raised by sedimentation. Again, pool level targets may need to be adjusted gradually over time in response to ongoing sedimentation.

The Team had concerns about bank sloughing in the immediate area of the reservoir, primarily in response to rapid changes in reservoir elevations and the implications for sedimentation, turbidity, and water quality. The Team recommended the District explore the implications of further restrictions on the rate of change in downstream releases. The Team explored upstream sediment contributions, i.e., tributary channels immediately upstream of Coralville Lake, and the degree to which the District has the authority to work on tributaries on private land, e.g., working with private landowners to conduct instream grade and/or bank stabilization work on channelized tributaries upstream. The Team proposed investigating the potential for water quality credit trading as a mechanism to reduce sediment inputs. Promoting riparian, emergent and submerged aquatic vegetation for the purposes of wildlife, waterfowl and fish habitat could also benefit lake water quality by holding sediment and increasing water clarity/reducing turbidity.

The Team identified the need for greater flexibility and variability in pool level management and elevation targets than under the current operating rules, which tend to focus on static pool elevation targets. To ensure changes in water level targets do not interfere with authorized purposes of flood control or recreation, improved forecasting is needed to allow for more proactive and real-time adaptive management. Restrictions on the maximum daily change in outflow for Coralville Dam is offset at a maximum of 1.3 feet/day.

The Team adapted the HEC-RPT to define alternative pool management for the environment. The tool can display pool elevations rather than flows (Figure 8).

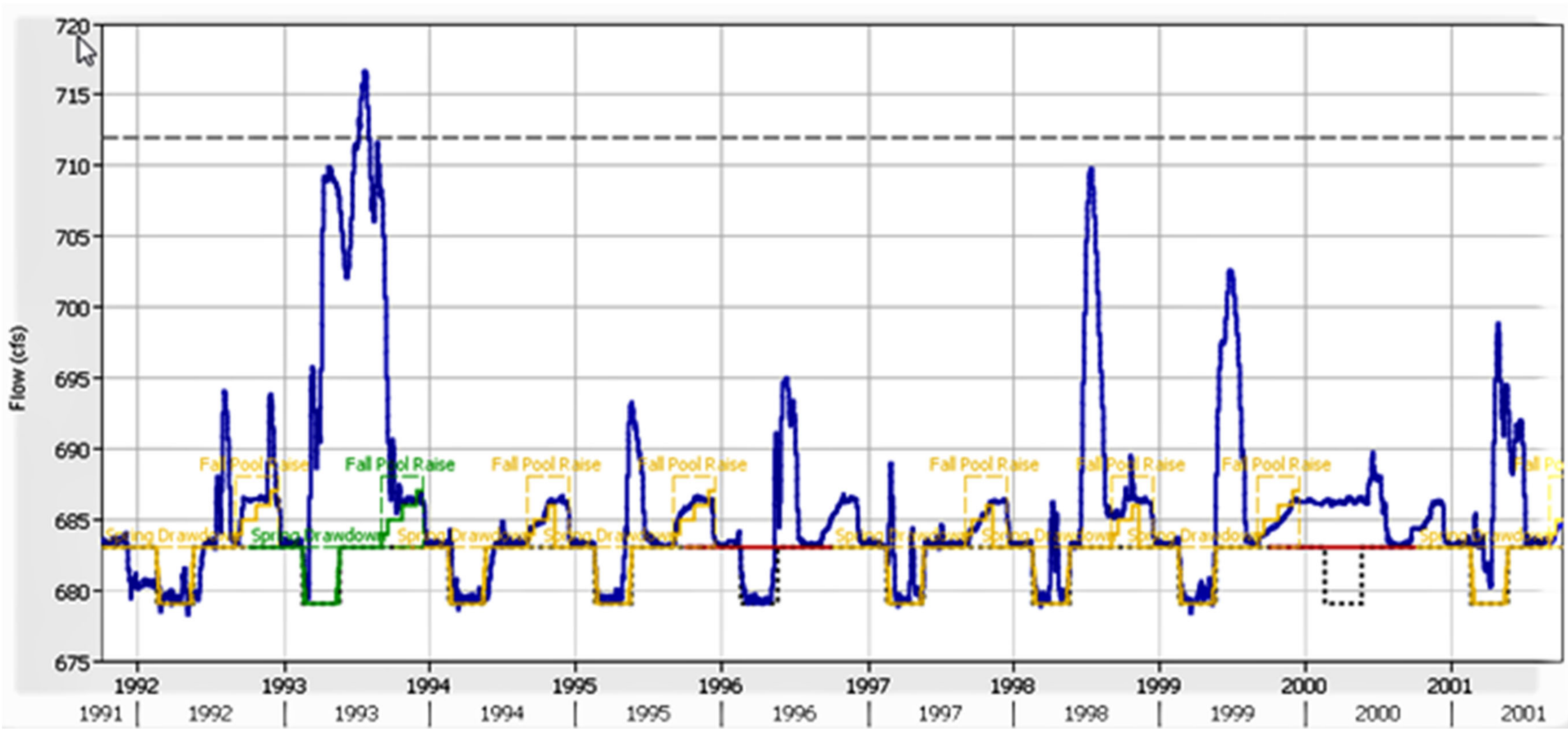

Figure 8. Example of Output for Discussion of Pool Elevation Environmental Definitions for Various Environmental Inputs and Goals

The blue line indicates the elevation of Coralville Lake's water surface. The dotted black line shows the bottom elevation of the authorized conservation pool. Boxes in green and yellow show the authorized spring drawdown and fall pool raise bands for wet and average years. Note that these do not exist for dry years, shown in red.

C. Floodplains

The floodplains are important to overbank flooding to ensure maintenance and connection of oxbows as well as the seasonally appropriate “charging” of floodplain ecosystems during timeframes important for multiple wildlife species. Above Coralville Dam, the hydrograph analysis showed the managed flow regime does not differ significantly from the unregulated flow series. The only change from the original flow regime in this reach is water can be retained over longer periods of time, which in general serves to benefit water quality by enhancing denitrification in the river.

The greatest influence on floodplain benefits is from Coralville Dam to immediately downstream of Coralville Dam to Hills, IA, and the floodplain between Hills and the confluence with the Cedar River.

D. Wildlife

The Team discussed wildlife needs across a broad range of taxa including waterfowl, songbirds, shorebirds insects, amphibians, and reptiles. The timing of shorebird use in the Coralville Lake mud flat area in the summer differs from the timing of the fall pool raise designed to benefit migratory waterfowl. However, management geared towards restoring a more natural flow regime would benefit almost all species and taxa of interest. The Team discussed e-flow impacts to plant species to include timeframes least damaging to desired species. In addition, the Team created and managed a chart through the HEC-RPT for "pulse" flooding to best meet habitat goals. High flows are needed to create oxbows and ephemeral wetlands in backwaters to support wildlife ranging from wood ducks to Blanding’s turtles. However, these wetlands need to be spatially diverse and have a range of hydroperiods; at least some of them need to be fishless in order to minimize predation on eggs and juveniles (for invertebrates, and amphibians). High flows are also needed to scour channels and create new depositional habitats such as sandbar habitat for turtles and other herps. The Team discussed habitat requirements for floodplain birds, (e.g., wood ducks, migrating songbirds) and mammals, (e.g., beaver, mink, muskrat, river otter) but these were considered subsumed within the natural hydrograph.

Legacy implications of past alterations of river dynamics and the challenge of restoring floodplain geomorphology and dynamics has implications for wildlife (Table 5). Soil types and deposits are factors influencing plant species growth and habitat suitability for wildlife at key stages of life history. For example, herps and shorebirds both require certain sediment deposition dynamics to create or maintain nesting, foraging, basking, and overwintering habitats. To attempt to “mimic” or manually restore these habitat mosaics by specifying where and how sediments are deposited is a daunting task but one which is likely to have a high impact on what species can survive where.

Table 5. Changes to the Iowa River Floodplain Since Construction of Coralville Dam

Pre-dam	Post-dam
Closed canopy	deforested
Narrow channels	widened channel
Sediment load	sediment starved
Tree buffers	lost riparian buffer
Open connected	disconnected

Permanently altered natural communities and species composition are influencing feasible restoration trajectories. The Iowa River, like many other highly developed rivers and streams, is incised, or entrenched, from increased scour from basin-wide hydrologic alteration as well as dam operations. Land clearing, ditching and draining, subsurface tiling, and climate change in the 20th century (increased rainfall) have all contributed to increased erosive flow from watersheds. Bank full conditions from controlled reservoir releases maintains stream power scouring riverbeds and banks leading to greater entrenchment and can ultimately result in significant disconnection of the river or riparian area from the floodplain and alluvial groundwater.

Due to flood protection measures, urbanization, levees, and other changes, groundwater tables have been altered. In many places, the floodplain has been disconnected from the river both physically and hydraulically. The combined effect of flood control and entrenchment results in less frequent out-of- bank events. In response, oak trees (e.g., swamp white, bur, and pin) and other less flood tolerant tree species have been drawn in closer to the river. Although semi-tolerant of flooding (e.g., 1 in 10 years), these species are susceptible to prolonged saturation of their roots, especially later in the season. Oak mortality is being observed in recent years, possibly in response to frequent flooding and longevity of flooding events in recent decades. Based on these changes and previously completed flow frequency analyses, the Team examined how flood pulses could result in sufficient reconnection of the floodplain.

Active management approaches (i.e., going beyond environmental flow definitions) included but were not limited to:

- excavating pools in the floodplain to create connections to groundwater in winter;
- grazing and fire management to control invasive and favor native vegetation; and
- mechanical removal and herbicide control of invasive vegetation

Overall, with improved management, including flow controls, active management of vegetation, and restoration of fire geared toward species of greatest concern, the river system could be managed to restore portions of the floodplain to something approximating pre-project floodplain ecological systems and communities. Out-of-bank flood events mimicking the natural flood pulse should benefit downstream floodplain ecology in many ways. Habitat forming processes supporting wetlands and floodplain forest are highly visible responses. The District would work with other conservation agencies, organizations, and interested landowners to optimize overbank flows to enhance off channel habitats.

Animal migrations respond to seasonal habitat availability, with fish moving onto floodplains during floods. Sediment, nutrient, and microbial responses that sequester nutrients on floodplains are less visible but are critical for supporting services in an ecosystem services context.

Even without full restoration of hydrology, many species would benefit by increasing habitat availability and connectivity within the river corridor. It would also enhance denitrification and carbon sequestration in the floodplain. However, the altered river system will not be able to fully return to what it was in “native” species diversity. Going forward, “what we get” will depend very much on what we explicitly manage for in terms of desired future conditions, whether that is biodiversity, aesthetics, or the result of neglect.

The Team’s final environmental flow definitions for the high flow components are integrated with the fish and mussel flow criteria and summarized in Table 6. The definitions include regular flood pulses of 10K cfs or more and occasional flood flows resulting in overbank flows inundating all or a portion of the remaining floodplain (> 10K cfs, lasting 3-7 days). For oxbow formation, the flood duration needs to be of sufficient duration for fine material to settle. Additional work is needed to refine environmental flow recommendations to ensure maintenance and restoration of the floodplain trees and understory plant communities across the full spectrum of the natural flood disturbance regime and hydroperiods.

The current median low flows under the District's current operational flows are actually lower than they were historically, even though overall there is more water moving through the system now in terms of annual water yield. Currently, the 90th percentile low is much higher than 150 cfs. There were some occasional extreme low flow periods in the pre-project time series when flows went below 150 cfs. During these critical low flow periods, reservoirs are re-filling, but the system is producing more water than 150 cfs which could be passed. At the same time, changes in river channel morphology mean that 150 cfs today results in a very different habitat mosaic than many years ago. Overall, there is probably an opportunity to modify low flows to better mimic the natural low flow hydrology by simply passing inflows during these low flow periods. During the Water Control Manual[4] update, no recommendations or changes to the 150 cfs were made.

E. Uncertainties and Research Needs

The Team identified numerous research needs questions relating to management manipulations impacting water quality in the reservoir. Research results from this project should guide reevaluation and development of a future water monitoring plan to ensure monitoring is addressing the key information needs.

Questions concerning denitrification are:

- Where and how is the majority of denitrification occurring?
- Is there a tradeoff between floodplain and riparian denitrification in saturated riparian areas, both downstream of and around the margins of the reservoirs, versus retention time in the reservoirs?
- How is the rate of denitrification impacted by water level manipulations designed to meet environmental flow needs?

Future reservoir analysis should include aeration, circulation, and mixing. Additional investigations should include how phosphorus levels in the reservoirs compare to ambient lakes in the ecoregion.

The Team identified the turbidity relationship to nutrients; interrelationships among turbidity, nutrients and algae blooms, light penetration, fluctuating water levels; and implications for emergent and submergent aquatic vegetation as an area of future study.

Another area of uncertainty identified is the increasingly frequent problem of cyanobacteria blooms (toxic algae). More research is needed on what conditions trigger the blooms, what factors influence toxicity, and how these can be controlled or mitigated. Increasing residence time to enhance denitrification would potentially conflict with the goal of managing or

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[4] Coralville Lake Water Control Update Report with Integrated Environmental Assessment, Coralville Lake, Iowa City, IA), 1 October 2021

reducing the frequency of these blooms, which seem to be associated with retention. Additional study is needed to assess the algal bloom/retention time relationship at Coralville Lake.

The Team identified several research needs related to shorebird habitat and population response, in particular the need to evaluate shorebird response if proposed changes to water level management are made. Beach bacteria were also identified as a major concern, particularly as they impact recreational uses. Waterfowl and shorebird waste is likely a bacteria source. Is there a tradeoff between managing for high waterfowl and shorebird use and nutrient inputs to the lake? Could "artificial" solutions be designed to mitigate for high animal source inputs, e.g., aeration, etc.?

Additional understanding of water quality issues basin wide in terms of loads and solutions is needed. Finally, climate change was identified as a major unknown needing analysis in terms of implications for water quantity, including inflows and pool level targets, and water quality.

Table 6. HEC-RPT and Expert Defined Environmental Flows

Environmental Flow Component	Combined Findings& Remaining Questions
Pulse Flow Component	**Spring:** Does the optional spring drawdown have measurable positive or negative environmental impacts? Recruitment, maintenance and staging for the summer spawn/mussel drop. Maintenance-Growth Flows between the spring and summer rise – something that models the best guesstimate of the natural flow – smooth transition between the two peaks. Uncertainty about the magnitude of flow to maintain in between the two peaks: how low can you go to sustain optimal or minimal conditions for newly spawned fish and assist with the preparation of summer spawners? There is recent data from flood pulses on the Des Moines River to help answer this. Mussels need enough water for them to survive. Mussel glochidia drop off their host fish at different times for different species. The E Flow Team needs to look at mussel assemblage and what is living there and target specific groups. Can flows be used to inhibit invasive species such as reed canary grass, invasive carp species, and other species? Are there specific flows that promote invasive species growth and range expansion?
Fall Forage 9/1-9/15 7,500-10,000 # Peaks 1	Should engage oxbows, create connectivity to the river old channel scars that are on the landscape, connected under high flow conditions (historically 3–5-year event) Need to refine: how much floodplain will you engage if only go to 10,000 cfs? Are there particular areas good for spawning or are problem areas e.g., Are agricultural fields good for fish spawning? What flows does it take to engage those kinds of areas? Attempt to time early season releases with storm events to engage as much of the ecosystem as possible. If inflows occur prior to Early Season Spawning, might hold the water until it can be released during early season spawning. Early season spawning peak could be moved around based on storms and to accommodate different spawning species if you are going to only get one of the pulses for the year. In general, best to leave it to thestorm events to assist in when we are going to trigger that pulse. Dry years: based on historical inflows, dry years usually only have one or two pulses. Therefore, coordinate releases with storms. May need to draw into available conservationpool to get these pulses. Need to verify these dry year pulses – what benefit are we getting from this? Are we getting fisheries recruitment? Clarifying: these pulses are not getting out of bank for floodplain inundation every year; these pulses are for in-channel spawning conditions (walleye, shovelnose sturgeon, freshwater drum and others.). The IA DNR has data from recent Des Moines River studies that will help resolve this concern.

Table 6. HEC-RPT and Expert Defined Environmental Flows

Environmental Flow Component	Combined Findings& Remaining Questions
Wet Year Pulse Flows	Planning should focus on a flood tolerant oak flow prescription (e.g., Swamp white oaks, southern pin oaks, burr oaks) preferred 1 in 10 years. Habitat forming flood to create sandbars for nesting and basking for turtles. Infrequent extreme floods create habitat high on the floodplain. Common floods create habitat on the rest of the floodplain.
Average Years	Create ephemeral pools for amphibians and insects (important to feeding bats), habitat for migratory wood ducks, hooded mergansers, red shouldered hawks, night herons,prothonotary warblers, wading birds, and rare plants and associated insects and bats. Minnows and bullfrogs will overwinter in unfrozen waters. Amphibians, turtles and many other species require access to the floodplain to reproduce in stagnant water, or isolated pools. Ideally, an average year would occur every third year. Emphasize ponding after pulse.
Dry Years, Low Flows	Includes a minimum of 150 cfs. This low flow needs to be evaluated as to whether it is sufficient, given that it appears a larger low flow could be sustained based on recent climate trends. Evaluate whether enhancing low flows during heat waves could potentially moderate river temperatures and reduce thermal stress. In addition, low flow period benefits need to be weighed against augmenting low flows.

VI. CORALVILLE POOL ELEVATION TARGETS

The pool level targets for Coralville Lake should be driven primarily by wildlife habitat needs for species including waterfowl, shorebird, fish and turtles, as opposed to water quality considerations. This would result in large benefits to water quality in addition to wildlife, whereas management for water quality could be done with few benefits to wildlife. Restoring natural floodplain inundation and frequency downstream of the dam, as well as restoring seasonable variability pattern to pool elevation management would provide the best opportunity to enhance denitrification in marginal wetlands and saturated habitats. (Significant denitrification is likely to occur both upstream of the dam along the margins of the pool and mudflats, as well as downstream when elevated flows are in contact with the floodplain.) In years of late summer or Fall flooding, this would allow water to extend into vegetation at higher elevations, which would improve water quality and waterfowl food.

Attempting to manage pool elevations or artificially increase residence time in the reservoirs for the purposes of optimizing denitrification might conflict with other management goals, because the timing of ecologically based opportunities to store water does not necessarily coincide with the timing of peak nitrogen delivery to the reservoir. There is no conflict between water quality and creation of mudflats and managing for vegetation on behalf of waterfowl. Environmental river flow and pool level definitions are likely to result in some conflicts and will need refined once these conflicts and implications have been identified and explored in linked models.

Invasive Species. Because Coralville Reservoir is designed to reduce the frequency of overbank flows, invasive species are influenced by terrestrial succession dynamics and not significantly by flood disturbance. However, in recent years there have been several record floods and downstream releases have on several occasions exceeded the flood flows the reservoir was intended to contain and/or minimize. Within the reservoirs, elevated pool levels can help to kill invasive plants, but often kill or cause disturbance to native species as well and provide extensive areas of disturbed habitat that provide opportunity for invasives to re-establish. For this reason, active management is often required to facilitate restoration of native species. There was some discussion of the role of fire in the natural disturbance regime, and the prospects of restoration with and without fire, particularly in reference to restoring native vegetation.

VII. UNCERTAINTIES AND RESEARCH NEEDS

Environmental flow key uncertainties focus on interactions between climate and hydrology. How do past human-induced alterations and natural river sinuosity affect prospects for restoring “natural” hydrology particularly with respect to groundwater/surface water dynamics in the active river area? Drainage management in the floodplain and the tributaries upstream led to changes and disconnections in hydrology. This may affect floodplain dynamics, including wetland hydrology, cottonwood (and other floodplain/wetland vegetation) regeneration and establishment, denitrification, as well as how altered hydrology would ramify ecologically throughout the food web (from vegetation to invertebrates to fish and wildlife). Monitoring groundwater and surface water in the floodplain at two locations, downstream of Coralville Dam and at the upper end of the Coralville Lake are recommended. The Team needs to discuss what measurements are needed.

VIII. INTEGRATION OF EXPERT DEFINED ENVIRONMENTAL FLOWS

A. Coralville Lake Tailwater to Lone Tree/Tri-County Bridge Gauge.

Spring flood pulses for early season spawning fish were merged with the flood pulse definitions for sandbar habitat formation (for turtle nesting). This prompted additional discussion of appropriate magnitude, frequency and duration for each of the environmental flow components (high and low), given the need for a diversity of hydroperiods and inundation frequencies in the floodplain to ensure access to some habitats for fish as well as fishless habitats for herps and other species dependent on temporary wetlands.

The Team considered flood pulse magnitudes for fish in terms of implications for floodplain vegetation and forest regeneration and maintenance. Some species can tolerate significant inundation, i.e., 1-2 feet; however, timing, duration and frequency are important considerations which influence the outcome. The pulse magnitude required to trigger willow and cottonwood regeneration is fairly large and infrequent, perhaps 1 in 50 years. The magnitude of the late spring/early summer rise flow component raises concerns for the floodplain in terms of implications for oaks, which, although flood tolerant, are subject to limits on duration and frequency of inundation, particularly later in the season. In years where flooding occurs before May, or lasts only 6 to 8 days, oak mortality would be of less concern. For fish, the spring flood flow magnitude was a wet year flow recommendation, and therefore would occur in theory only in 1 of 3 years.

Ultimately, the Team altered the environmental flow definition by shortening the duration and allowing for multiple, shorter duration spikes. The final proposed environmental flow component involved flood pulses sustained for 4 to 7 days, receding back to near bankfull (between 8,000–10,000 cfs) for the remaining portion of the seasonal flood window. Given there would be significant spatial variability in depth and extent of inundation at any given flow level, the implications of any prescribed flow could be evaluated spatially with stage-discharge models to determine the exact spatial distribution of habitats of different flow durations and frequencies. Additional research/literature review is needed to determine the duration that would result in an excessive oak mortality risk.

The Team elaborated on low flow environmental recommendations, proposing low flows should mimic the natural flows through the system to the extent inflows and pool levels allow (while maintaining as much as possible a minimum flow of 150 cfs or more). The benefits and feasibility of bolstering low flows below Coralville Dam during critical heat periods should be further explored, especially given the potential flexibility provided by long-term increased water yield as well as the potential to mitigate impacts of downstream channel alteration.

Figure 9 summarizes the Team’s integrated environmental flow recommendations for the reach below Coralville Dam.

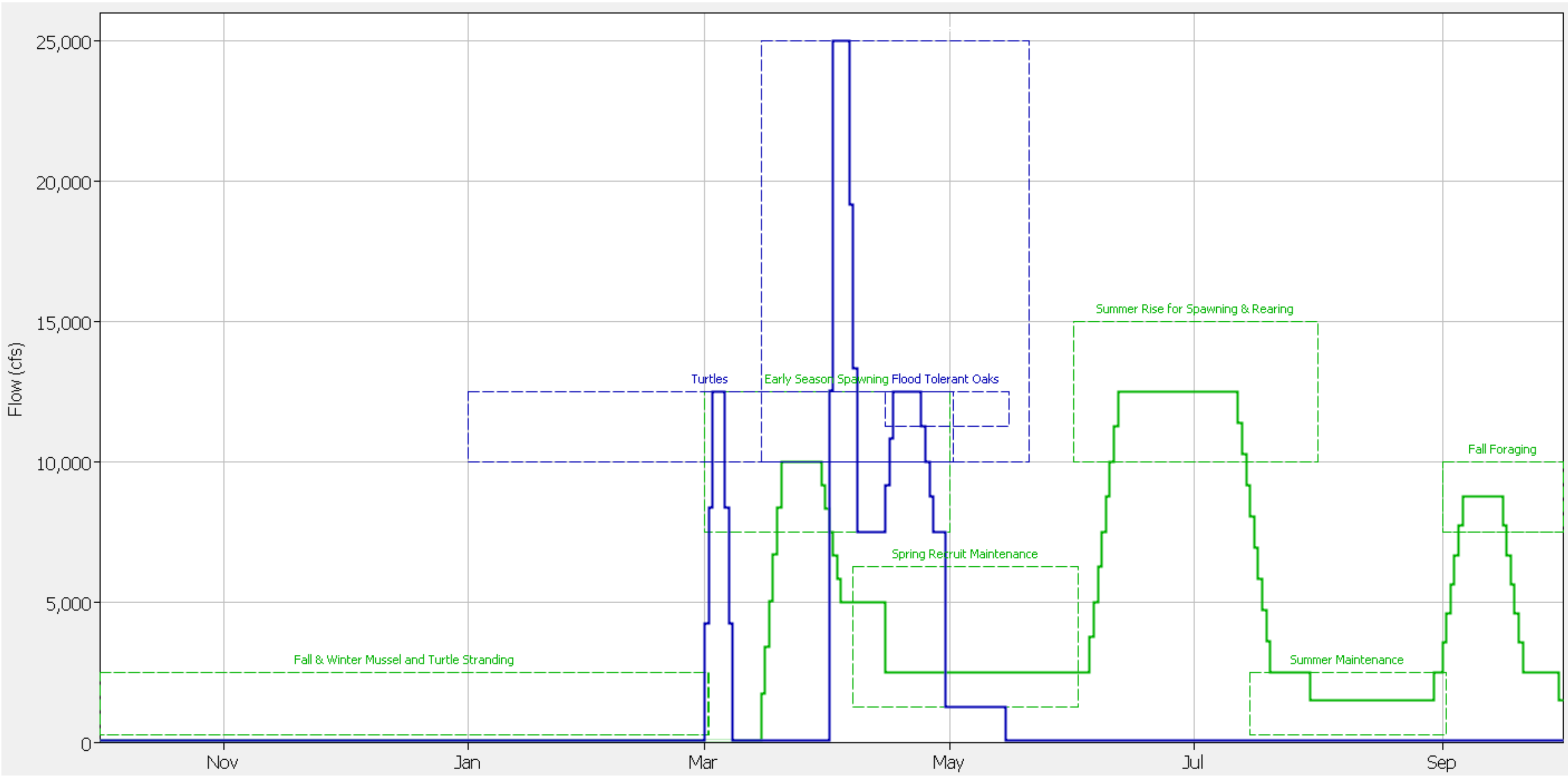

Figure 9. Final Integrated Environmental Flow Recommendations for the Reach Below Coralville Dam

The green line represents recommendations for Fish and Mussels.
The red line represents recommendations for Floodplain Connectivity.

B. Lone Tree/Tri-County Bridge Gauge to Wapello

The regulated hydrograph below the dam appears to be very similar to the unregulated, "natural" flow hydrograph except when Coralville Dam outflows are rapidly cut off in response to flooding on the Cedar River. It is uncertain whether there is substantial opportunity or benefit to be gained from significantly altering current operations beyond those resulting from implementing proposed pool elevation changes (Section VIII. C). Any proposed alterations to current operating rules would require monitoring and/or modeling to assess how changes might affect target pool elevations, water quality, metro area flood protection, and other authorized purposes. For this reason, the Team did not include a final HEC-RPT environmental flow graph for this reach.

The final environmental flow finding for the reach below Coralville Dam was to continue the current practice of allowing releases to correspond closely to inflows, as modified by the pool level changes for the reservoir, with one significant caveat: the need to explore whether the current 3,000 cfs per day restriction on daily rate of change is adequate to protect mussels, herps, and other riverine or riparian flora and fauna from washout or stranding. Depending on the timing of rate restrictions, a slower drop in pool levels could substantially impact the management of IA DNR-managed area above the dam. For example, late summer flooding past July 1 has different implications than earlier flooding where levels could be back to normal by end of June.

Workshop participants recognized that creating green space for recreation and wildlife along the river corridor would provide more flexibility in environmental flow management. This would allow floodplain physical and hydrologic connectivity throughout this reach. The Team expressed support for exploring and implementing proposals to remove obsolete, low-head dams and levees on the mainstem river for reasons ranging from improved safety and recreational opportunities to fish passage and mussel colonization.

C. Coralville Lake Pool Levels

Final integrated pool elevation findings are: (see Figure 10 and Table 7):

- greater flexibility in pool target elevations designed to mimic natural variability
- reducing the allowable daily rate of change when raising or lowering pool levels to achievetarget elevations or downstream flows
- a small spring rise—in addition to the fall rise—followed by a slow and gradual drawdown through the summer months, designed to promote establishment of vegetation and mudflats

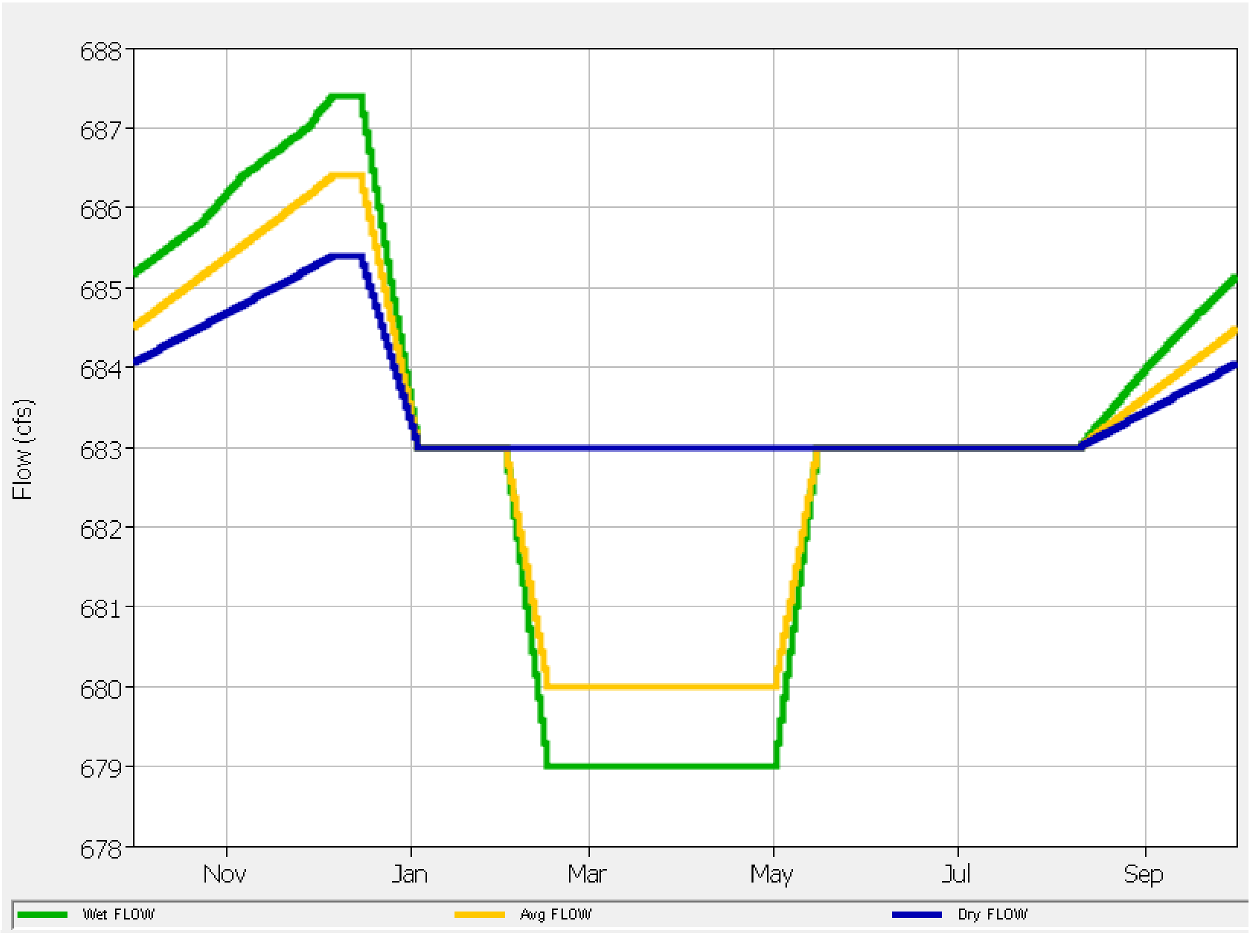

Figure 10. Integrated Pool Level Findings for Coralville Lake

Green line: full range of operation limits. Spring drawdown is an option, not a requirement
Yellow and red lines: potential scenarios during average (yellow) and dry year (red) operations

Table 7. Integrated Pool Level Findings for Coralville Lake

Date	Dry	Avg.	Wet	Description
01 Sep	683	684	685	Begin fall pool raise for waterfowl per IA DNR request. In late flood years, the DNR would likely request this elevation change starting at 1-2 feet higher (ending up at a max of 5 feet above normal pool). Elevations will bevariable based on vegetative conditions.
01 Oct	684.2	685.2	686.2	
01 Nov	685.4	686.4	687.4	
06 Dec	686.4	687.4	688	
15 Dec	683	683	683	Decrease the pool beginning 15 December at a maximum of a 2-inch drop per day, back to elevation 683 or until freeze-up and ice forms to protect overwintering herptiles
15 Feb	683	680	679	Earliest start date for the optional spring drawdown
20 May	683	683	683	Restore conservation pool for spring flows
				Maintain spring pool levels for late fish spawners.
01 Jun	683	683	683	Raise the pool to elevation 684 by 01 July. For the summer pool raise and drop, increasing quickly is fine, but thelevels should drop more slowly/incrementally. In wet years, hold the drop in flood pool levels to a maximum of 3” per day.
15 Jul	684	684	684	Drop 2" per week to 683 by end of August (6 weeks). Elevations will be variable based on vegetative conditions.

The Team discussed whether reservoir management findings, specifically slowing the rate of rises and drawdowns of pool elevations, are compatible with the environmental flow needs (Table 8). This would have to be explored prior to future workshops using linked models. For example, the fish and mussel recommendation for a fall foraging flow pulse downstream of Coralville Dam may have implications for whether the fall pool rise can be accomplished, particularly in dry years. Models linking flows to pool level elevations are needed to explore the probability and frequency of conflicts between potentially competing environmental flow and environmental pool management benefits.

IX. UNCERTAINTIES, KNOWLEDGE GAPS, AND RESEARCH NEEDS BY REACH

Each of the breakout groups identified significant uncertainties and knowledge gaps while formulating their flow requirements, many of which were common to multiple breakout groups. Table 9 is a synthesis of key knowledge gaps and research needs for each reach.

Table 8. Integrated Final Environmental Flow Needs Proposed for Coralville Lake Specific to Fish, Mussels, and Floodplain Resources

Turtle, Fish and Mussel Considerations		Flow Window				Example Flow[1]			
	Name	**Start Date**	**End Date**	**Min Flow (cfs)**	**Max Flow (cfs)**	**Date**	**Duration (Days)**	**Peak (cfs)**	**Duration of Peak (Days)**
	Early Season Spawning	01 Mar	30 Apr	7,500	12,500	15 Mar	20-Jan	10,000	10
	Fall Foraging	01 Sep	30 Sep	7,500	10,000	01 Sep	20-Jan	8750	10
	Fall/Winter Mussel and Turtle Stranding	01 Oct	01 Mar	250	2500				
	Spring Recruit Maintenance	07 Apr	01 Jun	1250	6250				
	Summer Maintenance	15 Jul	01 Sep	250	2500				
	Summer Rise for Spawning and Rearing	01 Jun	31 Jul	10,000	15,000	05 Jun	14-Feb	12,500	30

Floodplain Considerations		Flow Window				Example Flow			
	Name	**Start Date**	**End Date**	**Min Flow (cfs)**	**Max Flow (cfs)**	**Date**	**Duration Days)**	**Peak (cfs)**	**Duration of Peak (Days)**
	Amphibian and Insect Habitat Creation	01 Mar	15 Apr	10,000	15,000	01 Mar	7	15,000	3
	Cottonwood/Willow Trees	15 Mar	20 May	10,000	25000	01 Apr	7	25000	4
	Flood Tolerant Oaks	15 Apr	15 May	11,250	12,500	15 Apr	12	12,500	7
	Turtle Habitat Creation	01 Jan	01 May	10,000	12,500	15 Feb	7	12,500	3

[1] Hypothesized pool level modifications on river flows will need to be further explored in reservoir simulation models.

Table 9. Summary of Uncertainties, Knowledge Gaps, and Research Needs

Coralville Lake	Coralville Lake Tailwater to Lone Tree/Tri-County Bridge	Lone Tree/Tri-County Bridge Gauge to Wapello
Can retention time be manipulated to appreciably enhance denitrification without interfering with other authorized purposes?	How do different constraints on rate of outflow and/or pool level change (e.g., no more 1.3 feet/day) affect outflow operations?	Monitor/model whether low flow releases during heat waves can moderate instream temperatures and reduce downstream fish and mussel mortality
Monitor/model whether winter drawdown impacts Turtle species within the reservoir (but will probably get the same information from Red Rock??? So maybe not needed within the reservoir here?	Monitor/model how hydrological changes impact Blanding's turtles at Cone Marsh – both with upland nesting habitat and with overwintering (in water) habitats.	Monitor/model whether winter drawdown impacts Common Musk Turtles at Wapello and determine where these turtles nest (and whether there are hydrological threats to the nesting habitats with June – early Sept. water level changes).
Sediment budget and identify sources; bank sloughing in relation to the rate of pool level changes	Is the 1.3 feet/day rate of change limit on Coralville Dam releases sufficient to protect fish and mussels below Coralville Dam?	Cost/benefit of restoring out-of- bank flood flows (public and private; alternative strategies; e.g., habitat/wildlife/without benefits vs cost of floodplain acquisition, easements, damages
Relationship of water level management, vegetation dynamics, nutrient and sediment loading and in-reservoir turbidity	Can restoration of flood pulse flows and floodplain inundation also enhance denitrification?	Feasibility of flow and water level changes to restore and/or improve habitat by restoring sediment dynamics, given past changes
Mudflat and vegetation management role in denitrification	Can restoration of flood pulse flows and floodplain inundation aid in control of invasives/ restoration of floodplain plant communities?	Implications of channel change and legacy effects for restoration prospects; e.g., can flood pulses that remain within the channel positively affect fish and mussels while not causing flood damages?
Cyanobacteria and toxins: Source, what causes blooms, and does increasing residence time for denitrification cause an increase in harmful algal blooms?	Is the minimum 150 cfs from Coralville Dam adequate for environmental concerns?	Magnitude and duration of flows required to mimic the role of corresponding "natural" ecological flow components, especially for "prescribed" floods. How much of each type of habitat is created at each level of flow, e.g., at what flow are sandbars and/or backwater areas inundated?
Beach bacteria sources and management options	At what outflow does the area identified below Coralville Dam benefit floodplain inundation?	Are there (non-flow related) options to restore fish passage at Burlington Street Dam? (i.e., bypass fish passageway)

Table 9. Summary of Uncertainties, Knowledge Gaps, and Research Needs

Coralville Lake	Coralville Lake Tailwater to Lone Tree/Tri-County Bridge	Lone Tree/Tri-County Bridge Gauge to Wapello
Implications of reservoir sedimentation rates for when and how official target elevation for conservation pool(s) will be raised		Can restoration of flood pulse flows and floodplain inundation aid in control of invasives/restoration of floodplain plant communities? How do different constraints on rate of outflow and/or pool level change (e.g., no more than 1.3 feet/day) affect outflow operations?
Evaluate implications of recommended pool level changes for shorebird habitat and population response Feasibility of maintaining fall pool raise through the winter months.		
Can pool level manipulations designed to mimic natural seasonal hydrology aid in control of invasives? Investigate the recommendation to monitor ground water and surface water in the floodplain downstream of Coralville Dam and at the upper end of Coralville Lake.		

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ENVIRONMENTAL FLOWS SUMMARY

IOWA RIVER SUSTAINABLE RIVERS PROJECT

APPENDIX A
E-FLOW TEAM MEMBERS

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John Rathbun	Clear Creek Watershed Management Coalition
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Bryan Hellyer	IA DNR Wildlife
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Anthony Seeman	Iowa Soybean Association
Sean McMahon	Iowa Agriculture Water Alliance
Jim Jordahl	Iowa Agriculture Water Alliance
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Carl Gonder	Friends of Coralville Lake (NGO)
Sara Carmichael	Iowa Rivers Revival (NGO
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Josh Eash	US Fish & Wildlife Service
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ENVIRONMENTAL FLOWS SUMMARY

IOWA RIVER SUSTAINABLE RIVERS PROJECT

APPENDIX B
E-FLOW TEAM “CONSIDERATIONS

- Adjust pool stage to decrease thermal stability to decrease potential for cyanobacterial blooms.
- Increase water residency time to decrease nitrates below Coralville Dam. A mass balance model should be done to look at actual reduction in nitrates.
- Create more stability to benefit establishment of a permanent vegetation cover.
- 6” inundation of permanent floodplains for 14-36 days during May-June segments 2&3 is preferred.
- Nitrate Concentration, Nitrate Load, Ammonia Concentration, Cyanobacteria/toxins
- Loss of storage volume in drought conditions.
- Partnering on upland treatment to reduce sedimentation.
- Streambank stabilization- proper technical review (i.e., fluvial geomorphologists)
- Pursue options for placement of dredged sediment.
- Timing of pulses and impacts on adjacent agricultural lands.
- Pool manipulation to de-nitrify through residence time.
- Use of mud flats as a denitrifying wetland area.
- More sub-impoundments within the lake pool (e.g., 683-684) to improve water quality and maintain more stable water level regime for wildlife use.
- Re-connect old river/ stream channels and oxbows to spread water flow out in the reservoir basin
- Create smaller catchment “pond” wetlands in the heavily eroded gullies onto Federally managed property to catch water off adjacent private property.
- Collect and review Data on changes in residence time, nutrient processing rates, sedimentation deposition rates, gas efflux, and other ecological parameters.
- Build and utilize strong models to demonstrate how changes in reservoir height affect the ecological processes and parameters (e.g., how much longer is the residence time per foot of reservoir height)

- Goal: high spring flow followed by a drop to conservation pool by 15 July, which is then maintained through 1 October with periodic raises (1-2') to curtail vegetation. This would benefit many migratory birds including shorebirds and waterfowl.
- Sedimentation should be considered with respect to mudflat habitats.
- Willow encroachment is a serious problem that is getting worse.
- Late summer pulses are needed to reduce blue-green algae blooms.
- Rate of Changes. Slower changes to mimic natural fluctuation changes, winter flows, fish passage.
- Install natural non-structural landscape projects in watershed.
- High Pulse Duration and Duration of flood—increase this duration time for increased flood pulse during spring-summer. Major implications for Round body Sucker Growth and Production. Decrease annual rate of change throughout the year—helps with pulse duration and frequency.
- High water permits should be predictable in time. Low water periods should be predictable in time.
- Rate of change seems too dramatic, needs to be spread out over more days. Bi-modal spring/summer flood pulse needs mimic.
- Peak discharge happening later in summer when mussels are dropping fish hosts-Adjust for more natural regime.
- Geomorphic recovery for any impacts that alter the naturalized flow paradigm.
- Rejuvenate oxbows.
- Winter flows should be maintained for overwintering fish and mussels.
- Maintain spring pool levels for late fish spawners.
- Transitioning flow releases to minimize impact to aquatic life; that is to: 1) minimize nitrogen super saturation in Coralville Dam tailwater and 2) prevent stranding mussels on riverbed during draw downs.
- What are the December release impacts? (spike in flows)
- Do we need to explore management for more native riparian/floodplain vegetation (instead of Japanese millet)?
- Mitigation for drawdown as a separate issue.
- Rapid rise and fall rates have negative implications for herps too?
- Increased vegetation growth for food production for waterfowl habitats.
- Restricted recreation use during nesting season.

- Management to promote long term plant sustainability through flooding cycles.
- Intentional flooding of oxbows 2–3-year cycle to re-charge for herps.
- Flood/Raise annually (fall)
- General floodplain forest health-connectivity on a historical basin –flooding to appropriate levels on timeframes historically occurring.
- Restorations of oxbows/sloughs.
- Hold high water levels over winter for hibernating herps and mussels.
- In general, mimic historic phenology of natural flows.
- Consider inundation days as marker for perennial vegetation establishment.
- Manage actively for late-season minimum outflows including mini-pulses in late season.
- Spring flood pulse mimicked to greatest practical degree. More reliably emulate 1-2-year recurrence.
- Promote flow regime that maintains water in oxbows, sub impoundments, etc. for an amphibian reproduction (mid-March through June). This will also enhance state threatened red-shouldered hawk nesting conditions.

ENVIRONMENTAL FLOWS SUMMARY

IOWA RIVER SUSTAINABLE RIVERS PROJECT

APPENDIX C
STAKEHOLDER ISSUES

In stakeholder workshops conducted for the Iowa River in 2020 to identify the major concerns held by expert stakeholders and river users, eight issues were identified as primary issues of concern for flow regime management:

1. Nitrate Levels
2. Mussel Mortality
3. Sturgeon Mortality
4. Migrating Waterfowl and Shorebirds
5. Herptiles
6. Streambank Erosion and Sedimentation
7. River Recreation
8. Miscellaneous

These concerns are similar to those raised during the Des Moines River E-Flows workshops. In addition to articulating flow hypotheses, workshop participants were encouraged to identify opportunities for flow management with respect to these issues. Stakeholders cited the following opportunities for flow management.

1. Reduce Nitrate Levels

- Which water level management practices can maximize nitrate reductions within Coralville reservoir?

- Which flow management practices at Coralville Lake can maximize nitrate reductions for downstream customers and aquatic life? Quantify benefits on a graduated scale.

- Correlate nitrate reduction to economic benefit in water treatment for users on the Iowa River.

2. Reduce Mussel Mortality

- In general, identify the presence and status of mussel species from upper limits of Coralville Lake to the Mississippi River. What are the seasonal habitat preferences of mussels and what is their ability to move with changing flows and water levels? What are the lifecycle and reproductive needs of mussels and or impacts related to water flow, water depth, temperature, oxygen, host species, stability of substrate, nutrients, and sediment? Which mussels are reproducing fast enough in the lower Iowa to sustain healthy populations? Which mussels are in decline or no longer present?

3. **Reduce Sturgeon Mortality**

- How do sturgeon populations below Coralville Dam respond to temperature stimuli and low flows during hot periods and what measures (in-stream and riparian structural or flow management) can be utilized to help mitigate those adverse periods? How can flows be altered to reduce temperature induced mortality?

- What are the reproductive requirements and habits of sturgeon and how important is the lower Iowa River to the overall population of sturgeon in the Mississippi River for spawning?

- Identify time of the year sturgeon are in the Lower Iowa River and identify geographically their major areas of use

- Identify flow management strategies that would potentially benefit sturgeon.

4. **Improve Conditions for Migrating Waterfowl and Shorebirds.**

- The Iowa Audubon Society has designated the Coralville Reservoir/Hawkeye Wildlife Area/Lake McBride State Park an Important Bird Area, citing its values of rare or unique habitats, and significant species concentrations. What are the specific needs and optimal reservoir conditions for migrating birds at Coralville Lake? What reservoir water management practices would encourage germination of wild plants for waterfowl and to benefit migrating birds?

- The Coralville Regulation Manual currently allows the Iowa Department of Natural Resources to request a fall lake raise for the purpose of aiding waterfowl with an allowable fall pool level up to elevation 688.0. Iowa DNR Wildlife Bureau managers do not believe the allowable raise is adequate due to accumulated sediment and impact on hunting access via water. What are the ideal fall lake raise parameters for waterfowl hunting at Coralville Lake?

- Recommend flow management strategies that are most beneficial to migrating waterfowl and shorebirds.

5. **Improve Conditions for Herps**

- What are the seasonal habitat preferences of herps and what is their ability to move with changing flows and water levels in the Iowa River from the upper limits of Coralville Lake to the Mississippi? Are there riparian or riverine habitat restorations that could benefit reptiles and amphibians when subjected to changing flow regimes?

- Which herps are reproducing fast enough in the Iowa River to sustain healthy populations? Which herps are in decline or no longer present? In general, geographically identify presence of herps species from upper limits of Coralville Lake to the Mississippi.

- What flow management practices at Coralville Dam could aid herp life cycles? Specifically, creating/maintaining fish-free ephemeral wetlands for amphibians; overwintering habitats for turtles; dry, sandy areas near the river (but unflooded July-August) for turtle nesting.

6. Reduce Stream Bank Erosion

- Are there opportunities to reduce stream bank erosion with specific flow regime practices at Coralville Dam?
- Identify geographically the areas of most active bank erosion along the Iowa River from upper limits of Coralville Lake to the Mississippi.

7. Improve Conditions for River Recreation

- Identify events in the past five years (canoe/kayak/triathlon/etc.) that have been affected by stream flows in the Iowa River and determine what, if any, could have been improved with short term flow deviations from Coralville Dam.
- What are the ideal flows for specific stretches of the Iowa River for canoe/ kayak/boating?
- Recommend flow management strategies that would be most beneficial to Iowa River non-motorized boating.

Project Partner Input

Project partners were given the opportunity to comment on the draft Environmental Flows Summary Iowa River Sustainable Rivers Project in December 2022. The IA DNR provided several comments on the report. Many of these comments were editorial in nature and not addressed here. The more substantial comments are addressed here.

1. Andy Robbins, IA DNR, stated: “Pulse flows should not be conducted when there is high flow on the Cedar River that will lead to increased flooding of wildlife areas on the Wapello to Mississippi Reach. Pulse flows should be timed to avoid creating conditions that will exceed 21 feet at the Wapello gage when combined with flows of the Cedar River”.

The District is acceptable to this as long as it is a “environmental flows” release and not a Flood Risk Management (FRM) release. The FRM release is 25 feet at the Wapello gage.

2. Mr. Robbins stated, “The Coralville Lake WCP was recently updated and USACE began operating under the new plan this spring. Control points were raised significantly at Lone Tree and Wapello (which I didn’t concur with due to impacts to wildlife areas under my management on the Iowa River). This is a brand-new flow/flood prescription compared to what has been in effect on the Iowa River for decades. The SRP should keep this in mind when developing any proposals. We are currently in year one of the previous hydrology being altered and the effects of this change are yet to be determined”.

The District acknowledges the IA DNR’s position and will work with the IA DNR to achieve environmental flow benefits without significantly impacting the IA DNR’s management goals at Odessa.

3. Amy Foster and Sherri Proud, City of Coralville, stated, “The program would not have any effects any of our wetlands. The only connection we have is a groundwater-driven connection between the wetland behind the Hyatt (old Marriott) and the river. The water fluctuations in times of drought or flood have showcased that wetland’s ability to adapt. So, we are ok there. The drought times have reduced the blooms on our Rose Mallow in that wetland but the plants themselves have survived. Thank you for asking us”.

4. Greg Gelwicks, IA DNR stated "Anything that can be done to reduce prolonged bank full flows would be beneficial (Section IV. Wet Years.). Prolonged bank full flows cause excessive bank erosion which contributes excess sediment that reduces pool depths and embeds coarse substrates on riffles".

The report was reworded to clearly state the new water control plan an environmental flows would attempt to reduce bank full events, thereby reducing bank erosion.

5. Mr Gelwicks stated, "Low flow releases (Table 4) should be looked into, but it seems it would require substantial flow increases to affect temperatures downstream of the confluence with the Cedar River".

This subject may be a research opportunity within the SRP. The Team will add this opportunity to the Iowa River SRP Adaptive Management Plan.

6. Ryan Hupfeld, IA DNR suggested the Team should evaluate what flows would provide those temperature relief benefits and how far downstream it could influence based on the recent historical climate conditions and the current minimum flow of 150 cfs. The 150cfs outflow may be overly conservative and could potentially be increased without significantly impairing authorized purposes of the dam at Coralville.

The E-flow team will consider minimum flows while preparing the Iowa River SRP Adaptive Management Plan preparation. Any alteration to the 150 minimum flow will not take place if is outside the Iowa River Water Control Plan limits.

7. Mr. Gelwicks stated (reference Table 7, page 38), "Many fish in Iowa rivers seek out deep, low current areas to overwinter. Increasing flows during winter and early spring may cause increased flows in overwintering areas that have low current during winter low flow conditions. This may displace overwintering fish from these areas. This may also be a concern for the December drawdown which increases flows downstream in late December. Most fish are in overwintering areas by early November and remain there until at least early April."

Depending on certain years' e-flow and reservoir management goals, the Team will adaptively manage outflows to balance habitat benefits. This is described in the Iowa River SRP Adaptive Management Plan.

ENVIRONMENTAL FLOWS SUMMARY

IOWA RIVER SUSTAINABLE RIVERS PROJECT

APPENDIX D
HYDROLOGIC ENGINEERING CENTER'S REGIME PRESCRIPTION TOOL

Sustainable Rivers is an ongoing nationwide partnership between the Corps and the Nature Conservancy to improve the rivers by changing the operations of Corps dams, while maintaining or enhancing project benefits. The Hydrologic Engineering Center's Regime Prescription Tool (HEC-RPT) is a software program to help teams reach agreements on managing the flow regime of a river. The Hydrologic Engineering Center, the Portland District and The Nature Conservancy developed the HEC-RPT in support of the SRP. The HEC-RPT was designed to provide an easy way to capture and present evolving flow recommendations in a workshop context. The HEC-RPT meets these needs by facilitating entry, display and documentation of flow recommendations and justifications in real-time public settings, i.e., rapidly displaying, adjusting and documenting hydrographs and accessing and plotting historical hydrologic data to guide scientists and managers in developing flow recommendations. It is a visualization tool and not intended to perform the quantitative analyses already performed by other software packages. Instead, HEC-RPT seeks to complement those packages by making it easier to create flow times series that other software can import and use in analyses.

The Team used HEC-RPT to identify and capture suggestions for environmental flow improvements to sustain species and ecological processes on the four key Iowa River reaches. Three groups were formed to define the river flows or pool levels needed to keep specific aspects of the ecosystem healthy and functioning: 1) floodplain fish, wildlife, and habitats; 2) fish and mussels; and 3) water quality, reservoirs, and waterfowl.

Each group began by capturing hypotheses about flow needs, discussing life history of key species and taxa in relation to the "natural" (unregulated) versus regulated flow pattern. Connections between the species and flows were identified and incorporated into a set of environmental flow recommendations.

A strength of HEC-RPT is its ability to display and navigate hydrologic data sets. For the workshop, scientists imported data to HEC-RPT that showed how the river has been managed since construction of the dams, as well as how the river would have flowed if there were no reservoirs. During the workshop, HEC-RPT was used to build and display the flow recommendations, in real-time. Ideally, when a flow component was proposed, its magnitude, duration and timing were entered into text fields. Plots in HEC-RPT update automatically with new entries, which allowed the subgroups to review and revise their findings.

Recognizing the inherent variability of flows in response to climate, the HEC-RPT software is designed to allow for flow prescriptions to be tailored to wet, dry, and average years. Given that "natural" flows on the Iowa River have been altered by climate change and land use, HEC-RPT operators and workshop facilitators defined "reference flow conditions" for the purposes of the workshop project based on flow conditions between Water Years 1992-2022. The regulated and unregulated flow series water year data were used to divide the historical flow record into thirds: wet, average, and dry. This analysis was completed prior to the workshop in setting up the software "project" for full functionality during the workshop.

The final step in the workshop was to unify the environmental flow recommendations from each separate group. The merging feature in HEC-RPT allowed expert findings to be brought into the same project and plotted together.