Sustainable Rivers Program

Oxbow Restoration Planning Report
Des Moines River below Saylorville Lake
Rock Island District

January 2020

Compiled by Rock Island District, U.S. Army Corps of Engineers

1500 Rock Island Drive, Rock Island, IL 61201

Prepared for U.S. Army Corps of Engineers

and other cooperating organizations

1. Introduction

The Saylorville Lake Project (Rock Island District) includes 3100 acres of floodplain and remnant oxbow cutoff channels immediately downstream of the dam outlet and within U.S. Army Corps of Engineers (USACE) fee title lands. This important natural resource area is officially recognized as the Ding Darling Greenbelt and a key component to the newly established USFWS Urban Wildlife Refuge on the Northeast side of Des Moines. Collectively, the partnerships and management of this unique area include USACE, U.S. Fish and Wildlife Service (USFWS), Iowa Department of Natural Resources (IADNR), Polk County Conservation, City of Des Moines and the Des Moines Area Metropolitan Planning Organization. This area is the most extensive and contiguous floodplain in public ownership along the Des Moines River.

The floodplain habitat and associated oxbows in this reach are physically and hydraulically disconnected from the river, except during high flow events. Additionally, the Saylorville Dam impacts the hydrology of the system through regulated outflows. This combination of stressors on the system impacts the functioning of the floodplain and oxbow habitat by altering the amount, timing, and duration of floodplain flooding. Consequently, habitat (i.e., fish, waterfowl, reptiles and amphibians), flood storage, sedimentation, and water quality (i.e., nutrient cycling) has diminished in quality over time.

Funding through the Sustainable Rivers Program (partnership between the USACE and The Nature Conservancy) brought together key stakeholders, partners, and resource agencies (USACE, USFWS, IADNR, Polk County Conservation, City of Des Moines and the Des Moines Area Metropolitan Planning Organization) to assess and explore solutions to increase the quantity and quality of floodplain habitat through improved oxbow structure and function. The two-day workshop included an orientation to the project site and site visit, along with breakout group discussion to identify and document habitat problems, opportunities for restoration, constraints to implementation, features and alternatives for restoration design, benefits resulting from implementation, and consensus around the preferred restoration design. The following information summarizes the results of the workshop, identifies future data and analysis needs, and presents rough order of magnitude design details.

Preliminary conceptual design and associated scope of work was developed through a planning workshop and follow-up technical analysis to assess the existing habitat, identify habitat problems and opportunities, develop alternative restoration plans and document ecosystem benefits to plant and wildlife species, increased water storage, nutrient reductions, and urban recreational opportunities.

2. Existing Conditions

Habitat: The oxbow system below Saylorville Lake is somewhat similar in structure and physical characteristics to the pre-dam 1930's condition. However, altered flows as a result of dam construction and operation, urbanization and local land use, and disruptions in sediment transport has altered the Des Moines River (actively incising, sediment starved system) and river-floodplain connection. Together these stressors limits the amount and timing of water flowing into, out of, and within the oxbow system. The lack of diversity in water inundation, duration, and timing reduces the functional capacity of the system.

Fish: Fish benefits are limited. Depths in the oxbows are not sufficient to support overwintering. Limited inflow, inappropriately timed inflow events, and inadequate connection to groundwater reduces opportunities for fish to gain access to and reside in the oxbow system.

Waterfowl: Oxbows which hold water longer provide limited opportunities for waterfowl loafing, feeding and reproduction. However, the size (acreage) of available habitat is a small portion of the overall area and is dictated by the timing of the high flow event. In general, waterfowl habitat is limited to extreme events (low flow dry periods and high flow wet periods).

Forest: Historically the area supported scattered trees with an abundance of savannah and prairie habitat types. Over time the lack of disturbance led to conversion of the area to forest with little canopy openings for prairie and savannah production.

Hydraulics & Hydrology: The State of Iowa collected Light Detection and Ranging (LiDAR) land surface elevation data for Polk County in April 2008. Elevation – volume curves were approximated for each oxbow (Figures 1-3). These curves can be used to estimate storage potential at various elevations for each oxbow (assuming sufficient loading and containment of water). Curves were delineated for individual oxbows, rather than the entire corridor.

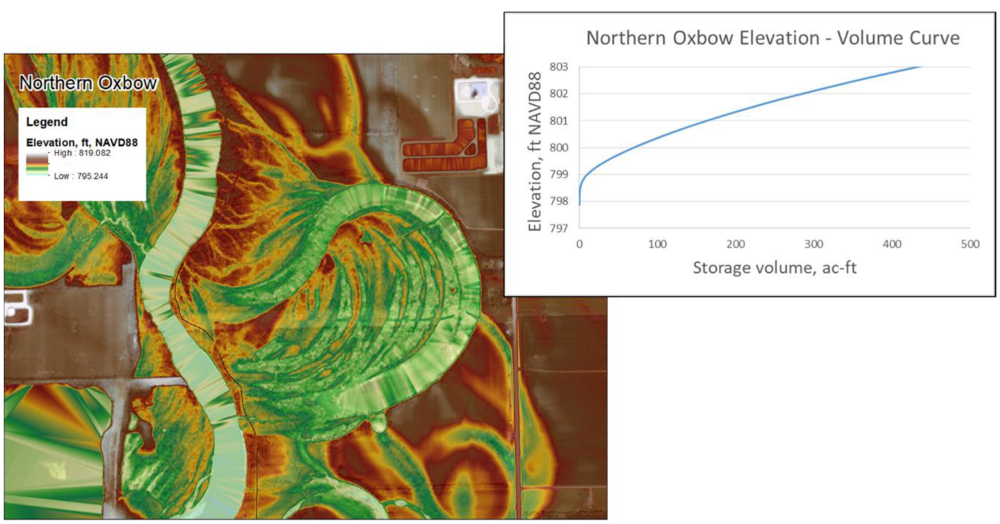

Figure 1: LiDAR data and elevation - volume curve for northern oxbow.

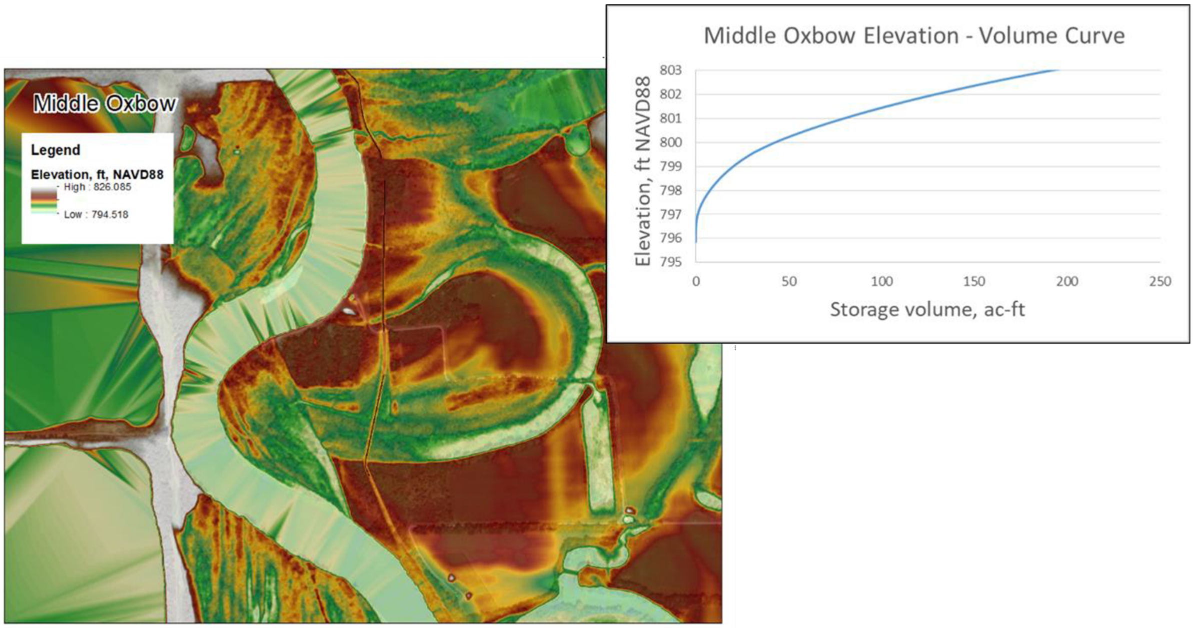

Figure 2: LiDAR data and elevation - volume curve for middle oxbow.

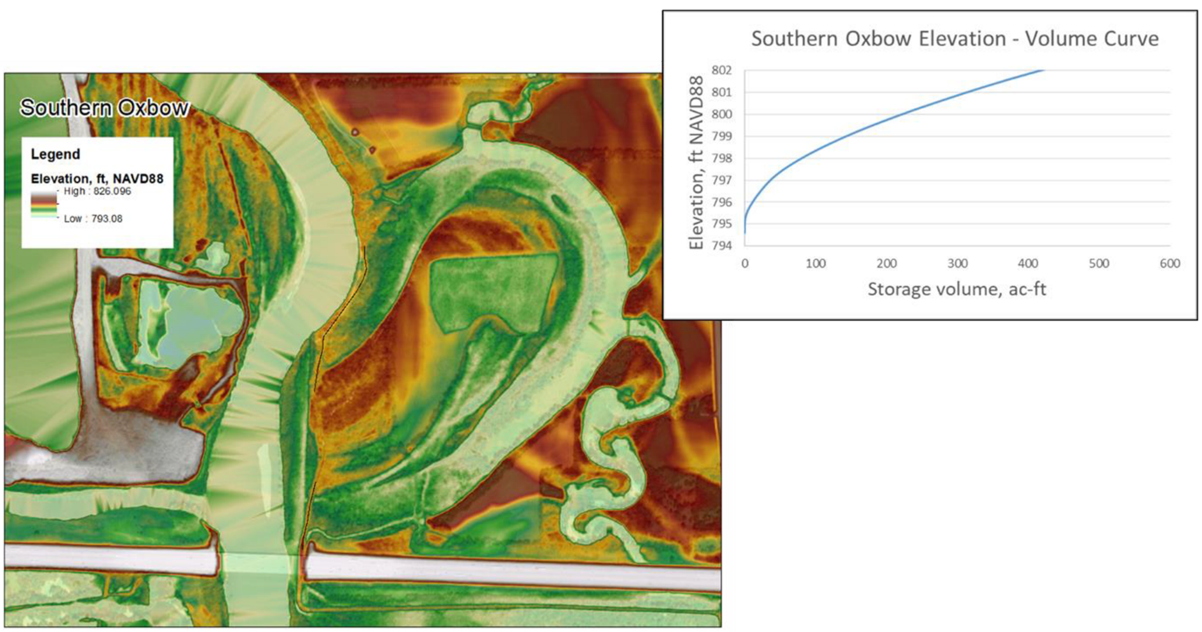

Figure 3: LiDAR data and elevation – volume curve for southern oxbow.

<u>Saylorville Lake Tail Water Gage:</u> The Saylorville Lake tail water gage is located on the Des Moines River at NW 66th Avenue, immediately upstream of the project area. It is approximately 2.4 miles from the gage to Interstate 80, the downstream boundary of the project area (Figure 4). Water surface elevation and flow data is available at this gage (Figure 5).

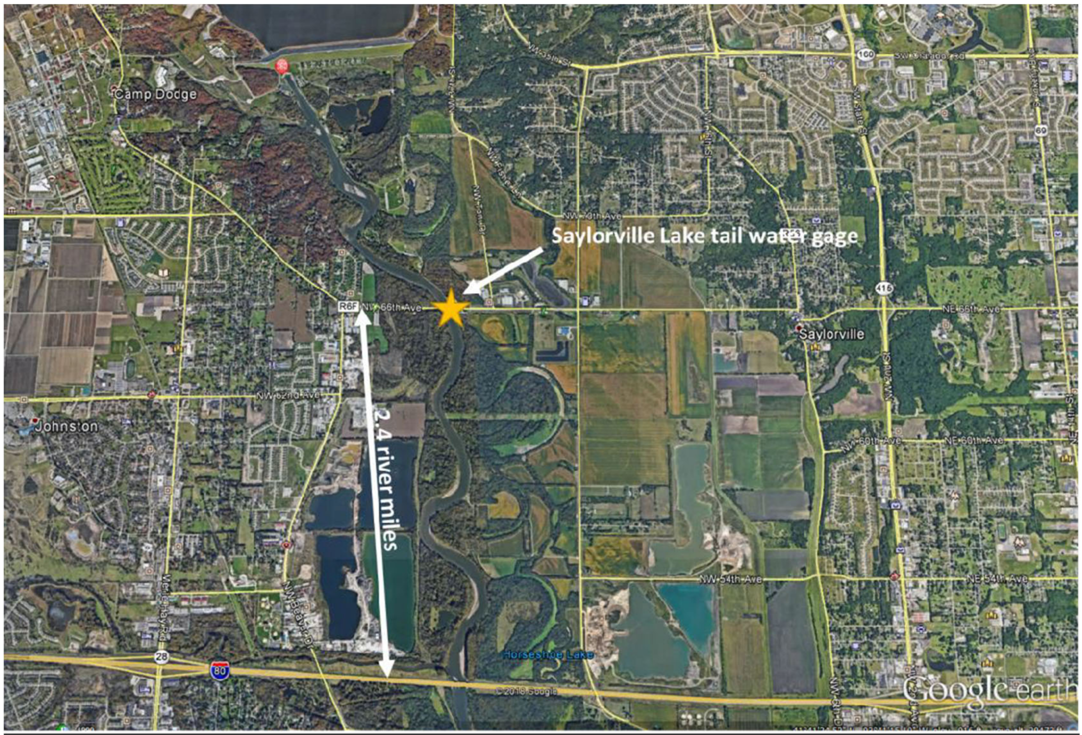

Figure 4: Location of Saylorville Lake tail water gage in relation to oxbows.

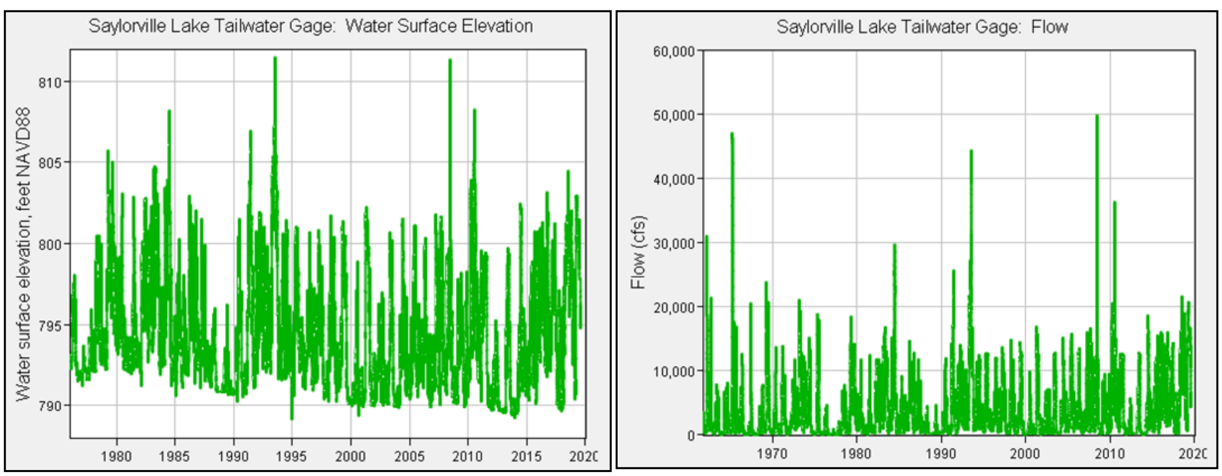

Figure 5: Period of record water surface elevation (left) and flow (right) at Saylorville Lake tail water gage.<u>*FEMA Flood Insurance Study Profile:*</u> *The regulatory 1% annual chance exceedance water surface profile for the Des Moines River in the project area is available in FEMA Flood Insurance Study #19153CV002A for Polk County, Iowa (effective February 2019).*

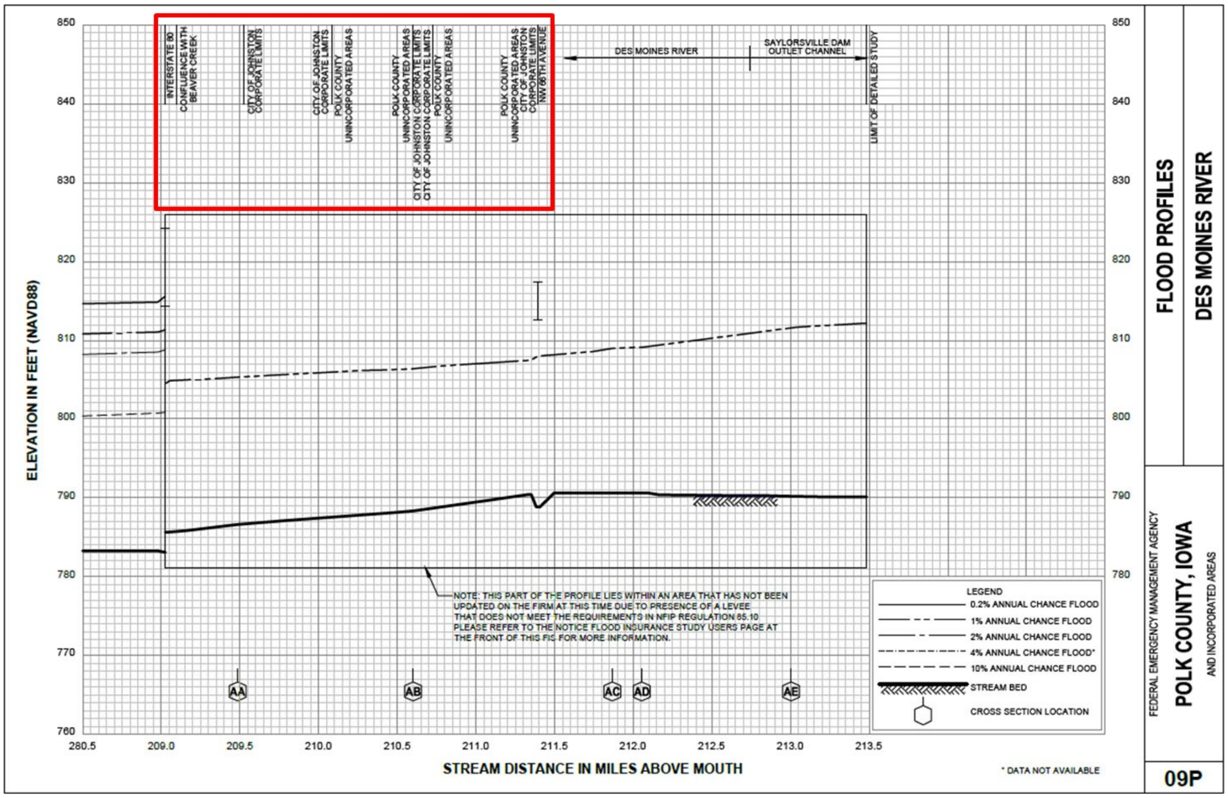

Figure 6: 1% annual chance exceedance water surface profile for Des Moines River. Project area highlighted by red box. (FEMA FIS #19153CV002A, effective February 2019)

<u>Des Moines River Basin Master Regulation Manual Update:</u> The Des Moines River Basin Master Regulation Manual update was effective February 2019 (https://www.mvr.usace.army.mil/About/Offices/Programs-and-Project-Management/Des-Moines-River-Water-Control-Plan-Update/). At Saylorville, operations will be similar to those enacted through temporary deviations authorized and implemented 2016 – 2019. Compared to the period of record, larger flow releases may occur sooner and for a longer period of time. The impact of the regulation update on annual flow frequencies was investigated during the feasibility study. A decrease in peak flows is expected for less frequent events (Figures 6-7).

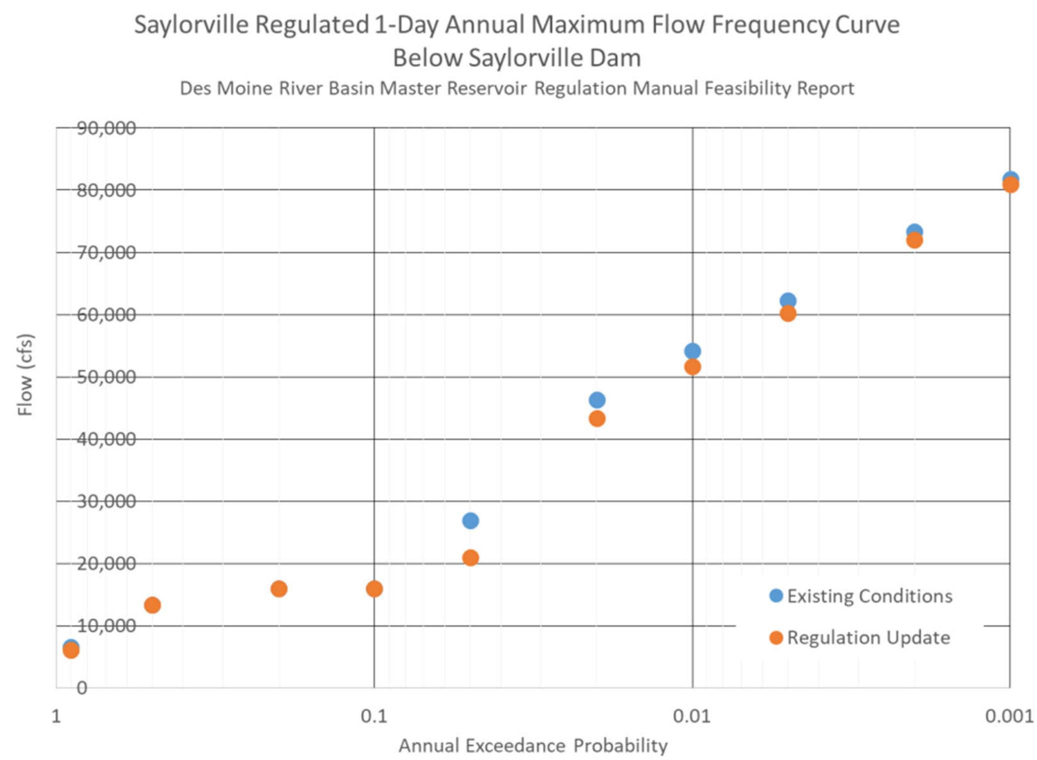

Figure 7: Annual flow frequencies computed for before ("existing conditions") and after ("regulation update") Des Moines River Basin Master Regulation Manual Update (2019).

Culverts: There are several culverts within the oxbow corridor. One culvert at the downstream end of the northern oxbow and two culverts at the downstream end of the southern oxbow (Figure 8) provide the primary connection between the Des Moines River and the oxbow corridor. Table 1 compares culvert invert elevations to the 90% and 50% annual chance exceedance water surface elevations computed in the Des Moines Basin Master Regulation Manual Update discussed above (accepted plan).

Table 1: Culvert invert elevations compared to 90% and 50% annual chance exceedance water surface elevations computed in the Des Moines River Basin Master Regulation Manual Update (accepted plan).

Elevation (ft, NAVD88)	Location	
	Culvert at downstream end of northern oxbow	Lower culvert at downstream end of southern oxbow
Des Moines River 90% ACE event	794.3	793.2
Culvert invert	796.8	795.7
Des Moines River 50% ACE event	798.3	797.2

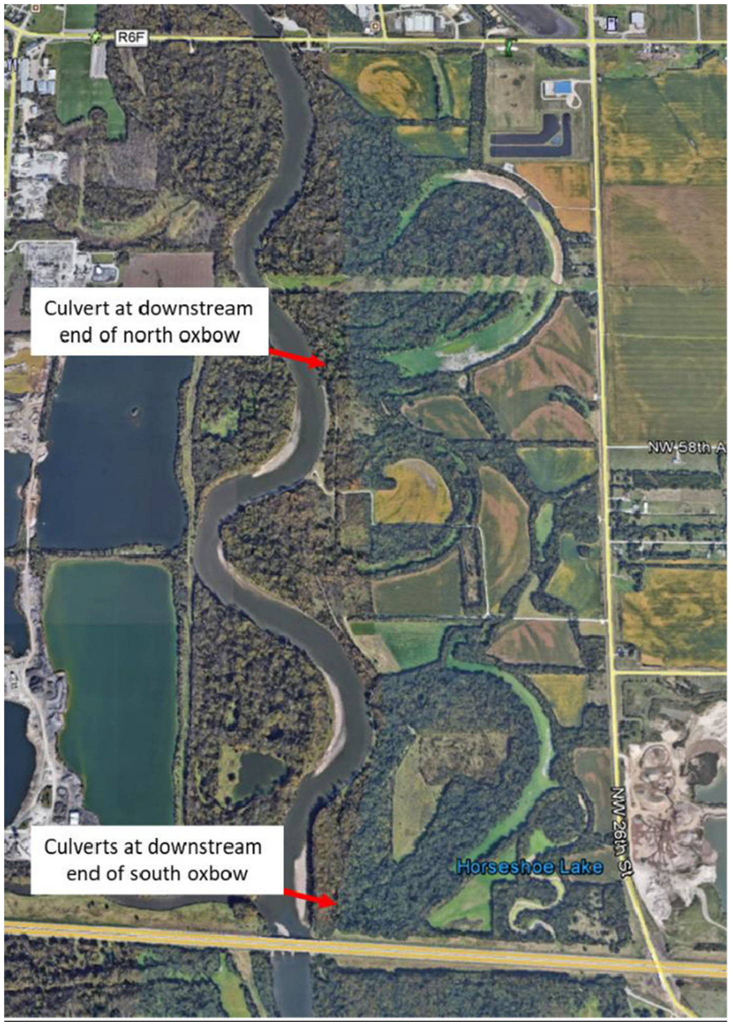

Figure 8: One culvert at the downstream end of the northern oxbow and two culverts at the downstream end of the southern oxbow provide the primary connection between the Des Moines River and the oxbow corridor.

Groundwater levels: As a condition of the use of federal land for drinking water collector wells, Des Moines Water Works monitored groundwater levels in the oxbow corridor from 2010 to 2015. Locations of monitoring wells are shown (Figure 9). Because sites MW4a and MW3b are directly adjacent to pumping activity, sites MW1 and MW2 are most appropriate for observing ambient groundwater levels. At these locations, groundwater elevations were generally found to exceed 791 feet (datum not provided) between October 2014 and October 2015 (Figure 10). Overall, from 2010 to 2015, groundwater levels were found to be strongly impacted by the operation of Saylorville Lake and the water surface elevation of the Des Moines River ("Saylorville Habitat Moinitoring Program", 2014 – 2015).

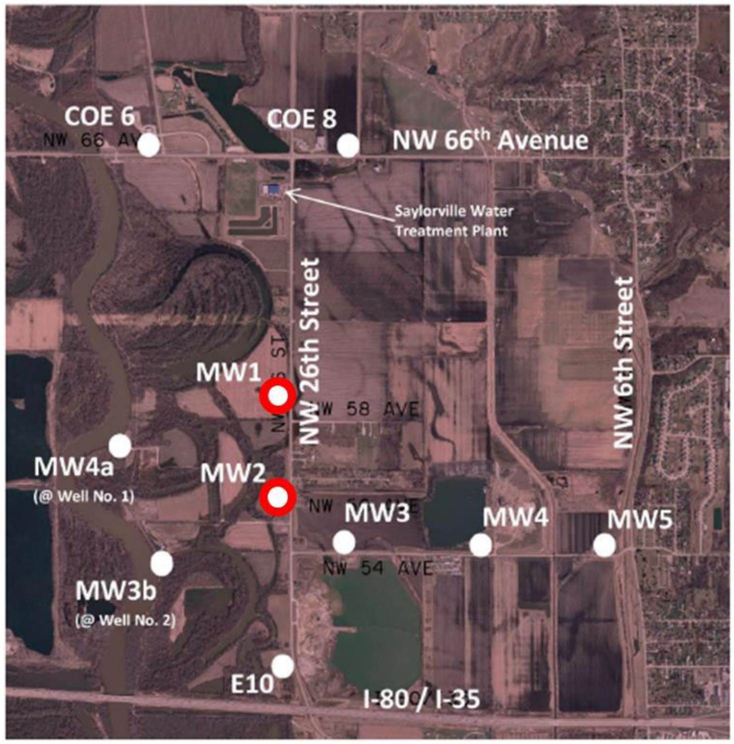

Figure 9: Locations of Des Moines Water Works groundwater monitoring wells ("Saylorville Habitat Monitoring Program", 2014 – 2015).

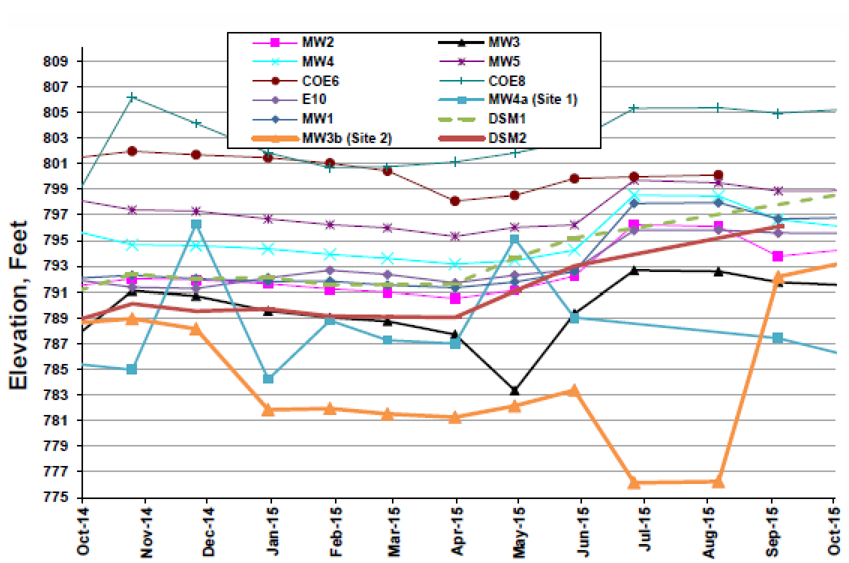

Figure 10: Observed groundwater elevations between October 2014 and October 2015 for locations shown in Figure 9. Sites MW1 and MW2 are most appropriate for observing ambient groundwater levels ("Saylorville Habitat Monitoring Program", 2014 – 2015).

Surface water levels: Des Moines Water Works also monitored surface water levels in the oxbow corridor from 2010 to 2015. Monitoring locations are shown (Figure 11). At these locations, water levels above the surface and in the first 24 inches below the surface are shown (Figure 12). Overall, from 2010 to 2015, surface water levels were found to be strongly impacted by the operation of Saylorville Lake and the water surface elevation of the Des Moines River ("Saylorville Habitat Moinitoring Program", 2014 – 2015).

Figure 11: Locations of Des Moines Water Works surface water monitoring sites ("Saylorville Habitat Monitoring Program", 2014 – 2015).

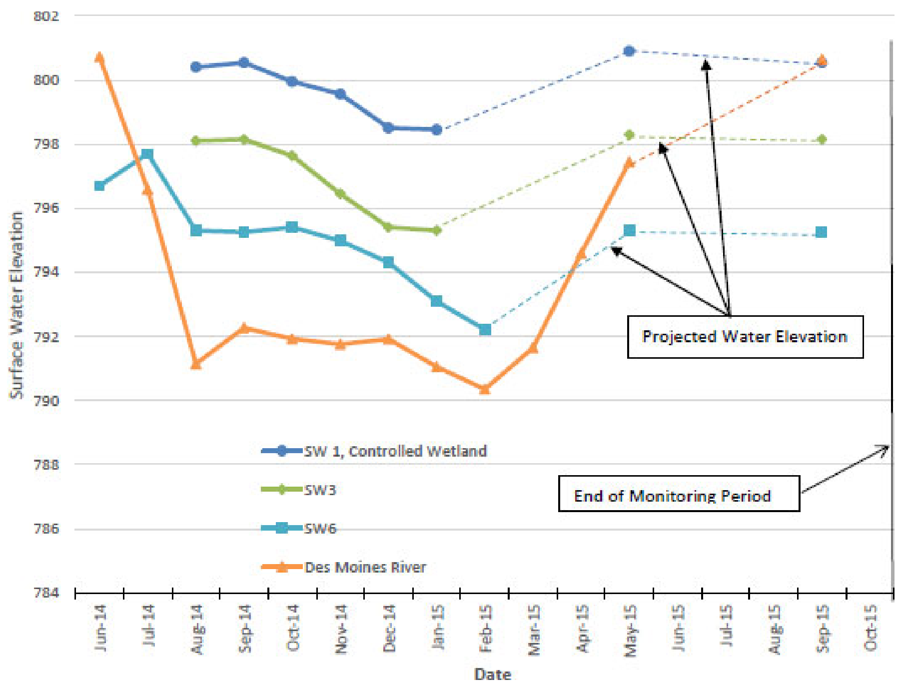

Figure 12: Observed surface water elevations (above ground and less than 24 inches below ground) between October 2014 and October 2015 for locations shown in Figure 11. Water was not present for dates not shown in plot. Dotted line represents period where monitoring conducted, but water is assumed to have been present. No data is shown for sites where water level was greater than 24 inches below ground ("Saylorville Habitat Monitoring Program", 2014 – 2015).

3. Problems, Opportunities, Constraints

The following lists the common **problems** which the group focused on for developing solutions:

- Hydraulic connectivity (enter and exit) of oxbows
  - Mainstem and within oxbow system
- Lack of ability to manipulate timing, duration, and inundation
  - No groundwater connection
  - No ability to provide year-round water
  - Water storage and retention
- Lack of disturbance
- Lack of a management plan
  - Habitat priorities
  - Focus species
  - Management criteria
- Public perception
- Aspects of climate change

The following lists the **opportunities** for restoration identified by the group:

- Hydraulically connect the oxbows to the river. Make sure water can both enter and exit the oxbow.
- Connect oxbows to each other where possible.
- Increase recreational use (kayaking, fishing, etc.).
- Water operations – conservation band offers ability to release water strategically into oxbows
- Dredging oxbows possible to improve fish and other habitats and increase water storage. Dig to GW to naturally improve water quality.
- Des Moines waterworks can be utilized to supply water to create specified water-based habitats for waterfowl, etc.
- Actively manage the flows for habitat and water storage
- Urban refuge designation offers opportunity to develop partnerships to for example develop interpretive/educational programs (e.g., through collaboration with USFWS)
- Engineering with Nature Features –
    - Keep the soil in the system. Use soils removed to connect oxbows to shore up higher elevation areas.
    - Leaky dams. Use downed trees to construct pseudo-stoplog features at selected culverts to manipulate water levels in oxbows and residence time.

The following lists the **objectives** for restoration:

- Restore oxbow habitat for fish (e.g., crappie and northern pike), waterfowl, and other related species (herptiles and wetland plants)
- Reconnect river to the floodplain and oxbows for flood storage; utilizing and modifying two existing culverts; use nature's energy (gravity) to make the connection; culverts should be modified to allow for regulating elevation and water flow
- Reconnect the oxbows to improve habitat, increase permanent water habitat (does not freeze over in winter), and increase water storage; design connectivity to slowly release water back into the river so as to maintain water storage for future rain events (modify existing culverts); basically create a permanent connection to the river and between the oxbows, allowing water to meander downstream via gravity through the oxbows (increasing residence time); this should also yield an increase in water quality
- Sequester nutrients; improve water quality
- Manage for waterfowl habitat; this is a main focus now along with deer hunting
- Store flood water
- Manage and retain storm water
- Improve recreation access for hunters and fishermen

The following lists the **constraints** of the site which may limit implementation:

- Neal Smith Trail
- Des Moines Waterworks – infrastructure, facilities, pump houses
- Saylorville outflows are dictated by a regulation manual
- Real estate
- Agriculture leases

- Utility Corridor

4. Preferred Restoration Design

The preferred design agreed on by the group consists of the following features, which are described in more detail later.

Major Components

1. Oxbow excavation
    a. Deepen oxbows to provide habitat for overwintering fish; permanent water source for waterfowl, reptiles, and amphibians; create opportunities for flood water storage and retention; and increase nutrient cycling.
    b. Fish habitat structures within the excavated oxbows to increase fish habitat diversity for a multitude of fish species.
    c. Strategic topographic excavation between oxbows will increase efficiency and effectiveness of within-oxbow water movement
    d. Dredged material placement used for beneficial use in and around the project site for purposes of floodplain forest restoration (topographic diversity) and flow management.
2. Culvert modifications
    a. lower and right-size select culverts to maximize river-floodplain connectivity
3. Water control structures
    a. Structures primarily for inflow shall be modified to include flap gates or stop log structures to allow manipulation of water entry and exit.
    b. Structures purely for outflow shall be actively managed using natural and nature-based features

Minor Components

1. Timber stand improvement – actions include canopy open creation, mast tree plantings, new forest stand creation
2. Prairie restoration – prairie plantings in the form of buffer strips planted around agricultural lands and oxbow to create habitat diversity and restore historic habitat conditions

The following information provides more detailed locations, quantities, and costs for each of the features included in the preferred restoration design.

Oxbow Excavation:

A desired goal of the project is to increase connectivity of the oxbows. This can be further achieved through excavation in the natural path of the oxbows or historic channel path. By maintaining and improving this historic path, the oxbows are greater able to utilize gravity as a means of transporting water within the oxbows. Recognizing demands on management staff and increasing the operability of the system by minimizing structures where possible and utilizing features that require little day-to-day maintenance was a factor considered by the team. Figure 13 indicates key areas identified in the workshop as potential excavation areas.

Figure 13: Identified oxbow locations for excavation to create deeper lake-like conditions for purposes of water storage, overwintering fish habitat, and greater habitat diversity.

The excavation depth investigated for the north oxbow was approximately 13 FT. It was identified from Des Moines Water Works groundwater data that the groundwater table is at approximately 789.5 feet. In order to ensure overwintering habitat of 6 FT (depth to groundwater plus an additional 6 FT below the groundwater table), an excavation depth of 13 FT was determined. Excavation depth is dependent on typical water level elevations, present low-flow winter regulations, desired maintained water depth and projected sedimentation. A closer look at sedimentation over the project life and in depth geotechnical analysis of the material being excavated is necessary to finalize depth and side slopes of the cut. Side slopes average around 4:1 but range from vertical to 6:1 slopes on USACE HREP projects where dredging occurs. (https://www.mvr.usace.army.mil/Portals/48/docs/Environmental/EMP/HREP/EMP_Documents/2012%20UMRR%20EMP%20Environmental%20Design%20Handbook%20-%20FINAL.pdf)

USACE staff has the ability to manipulate water levels through their partnership with Des Moines Water Works in the center oxbow, allowing for the management of duck habitat. By connecting north and center oxbow there may be further opportunities for USACE to manipulate water elevations. Cut 3 identified in Figure 13 initiates this connection. The design alternative explored for excavation in these areas includes a shelf at the diversion from the north oxbow to prevent water from draining out of the north oxbow at low flow times and ensuring enough depth remains in the north oxbow to provide overwintering habitat. This option serves as a spillway for the north oxbow into the center oxbow.

Spillways provide a defined location in which overtopping will occur and it's often necessary to armor and protect against erosion if velocities are high. An overtopping analysis should be conducted to ensure the elevation differences between the higher elevation bank along the oxbow and the lower shelf elevation adequately meet objectives for the project.

Excavation within the center and south oxbow do not target fish habitat but were set at varying elevations to provide a wide range of habitat and allow for some additional water storage during high flow periods. See Table 2 for elevation data.

Table 2: Table displaying oxbow excavation cuts, depth of excavation, required slopes, bottom elevation (existing condition), bottom elevation (with-project), approximate elevation of the groundwater, and benefits of the cut represented in increase in water storage (acre-feet).

	Depth of Cut	Slope	Bottom Elevation (Existing Conditions)	Bottom Elevation (After Cut)	GW Elevation	Increase in Storage (ac-ft)
C1	13	3	796	783	789.5	178.7
C2	13	2	795	782	789.5	15.3
C3	4	3	799.8	795.8	788	7.5
C4	5	3	793	788	789	5.3
C5	5	3	793	788	789	5.4
C6	10	3	794	784	789	74.7
C7	10	3	794	784	789	44.1

The total volume of material identified as excavation areas is 534.5 ac-ft. The increase in storage from existing conditions is approximately 331 ac-ft. This additional storage volume has the potential to mitigate flooding impacts downstream. Sections of the oxbow not indicated as excavation areas provide a varied elevation to allow for more shallow water habitat.

Placement of excavated dredged material should be used for beneficial use in and around the project site for purposes of floodplain forest restoration (topographic diversity) and flow management. Keeping material near the excavation area will lower excavation cost and time and provide topographic diversity along the bank of the oxbows.

Approximate cost to excavate on site material is $20 per cubic yard of material excavated. Incidental costs included in this unit price are removal of material and placement of excavated material. Opportunities to decrease unit cost are to utilize placement sites close in proximity to the removal area. Additionally work performed in house or through partners of the project would generally generate a lower rate than work performed by a contractor. See Table 3 for approximate costs of excavation at the various locations identified in Figure 13.

Table 3: Table displaying the oxbow excavation cuts, approximate cubic yards (CY) of material required to be excavated, estimated unit cost ($/CY), and total cost per cut.

	CY of Excavated Material	**Unit Cost**	**Total Cost**
C1	288,302	$20	$5,766,040
C2	24,684	$20	$493,680
C3	12,100	$20	$242,000
C4	8,551	$20	$171,020
C5	8,712	$20	$174,240
C6	120,516	$20	$2,410,320
C7	71,148	$20	$1,422,960
Total			$10,680,260

Fish Habitat Improvement Structures:

Several options are available to provide species specific fish habitat in the north oxbow. One option would be pallet structures (Figure 14). These can be cubes or other shaped structures to attract panfish and largemouth bass. One factor to keep in mind with structures such as these is the necessity of proper anchors. These structures can also present boating hazards and may need to be in secluded areas or sections of the oxbow that wouldn't receive boat traffic or public access. Simpler alternatives for fish habitat could include anchored felled trees or rock (Figure 15). These features are often little to no cost to the stakeholder as materials such as pallets can be obtained for free and trees that fall naturally can be found on site. The north oxbow excavation areas provide several opportunities for fish habitat.

Figure 14: Fish Habitat Pallet Structures (USACE photo).

Figure 15: Anchored Felled Tree at Beaver Island HREP (USACE photos).

Culvert Modifications and Water Control Structures:

Several locations were identified in which water control structures could provide increased benefits to the project site.

The culvert that connects the north oxbow to the Des Moines River currently sits at approximate EL 796.75. Based on survey data and available lidar this culvert can be lowered approximately 2 FT to EL 794 and the diameter increased from 3.5 to 6 FT to allow the oxbow to receive flows on a yearly basis and maintain a minimum of 1.5 FT water depth in the culvert during the 1-year event for fish passage. Although some fish will not enter dark tunnels or enclosed space, the length of the culvert (approximately 25 FT) is relatively short and does not present major concerns for fish passage due to light limitations. If desired grates could be put in place to allow light to enter. However, impacts to the Neal Smith Trail would need to be considered. Another aspect of culvert design that allows for fish passage is the velocities within the culvert and directly before and after the culvert. A more detailed analysis of the velocities in this section of the oxbow and surrounding the culvert and identification of burst speeds for target fish would be necessary to determine the final culvert design to ensure fish passage. As well as the adjustments to the culvert, it is recommended that a water control structure be put in place at this location to allow stakeholders to better manage the water levels within the oxbow. A stoplog structure would allow managers to prior to high water events and close to avoid water draining from the oxbow.

Stoplogs are a versatile option for water control that require relatively low maintenance and are relatively inexpensive. Several disadvantages to consider:

- Removal of stoplogs may require more than one person
- When head over the stoplog is high, removal can become nearly impossible
- Stoplogs with eyes at top are difficult to remove and are often hard to hook, which can also cause problems with sealing properly

Gatewells are another option that may allow better management flexibility and water retention.

Another water control structure location that was investigated is over an existing culvert at the south of the oxbows in the channel that drains through the three culverts under I-80. This avenue appears to be one of the areas water drains out quickly and causes the southern oxbow to dry out. A consideration with the inclusion of this structure would be a closer analysis on whether the road that goes over this culvert would need to be raised. Figure 16 shows the potential locations where culvert modifications were analyzed.

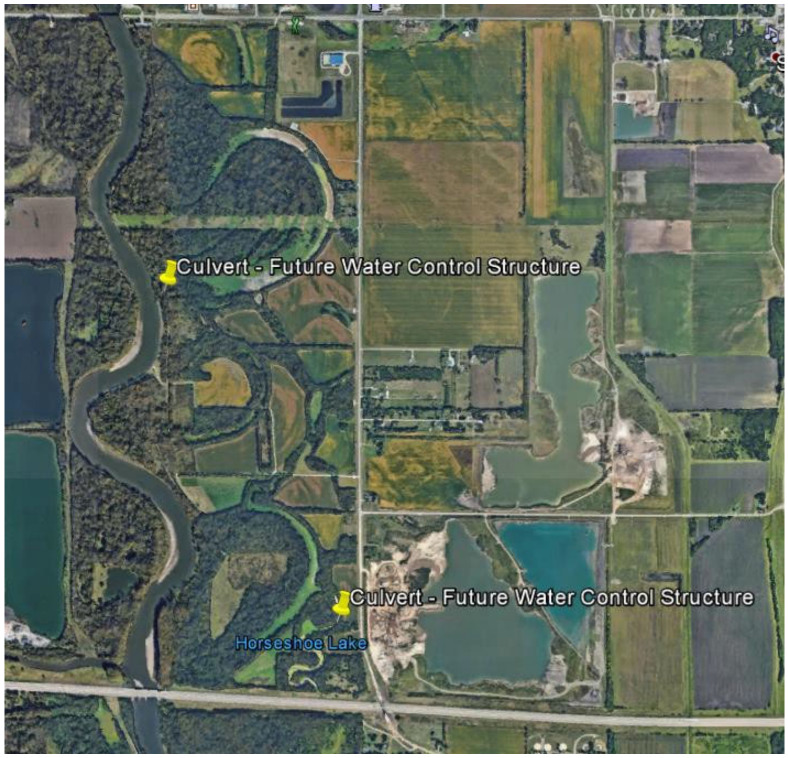

Figure 16: Identified existing culverts as candidates for modifications via stoplogs, leaky dams, or gate-type structures meant to allow for more manipulation and management of water levels across the oxbow complex.

Stoplogs are generally either aluminum or wood. However, prefab PVC stoplogs have been implemented at other Corps projects and proved successful. (https://www.agridrain.com/shop/c128/stoplogs-for-inlet-structures/p1133/pvc-stoplogs-for-inlet-structures/)

These typically only range in size up to 24" and would therefore only be an option for the southern water control feature. The larger water control structure to the north would require much more significant alterations to the existing culvert. These include lowering two feet and increasing the culvert's diameter which would require temporary closure of the Neal Smith Trail.

Soil borings are recommended at this location if this alternative is further considered. These borings would evaluate if the soils are suitable for the structure foundation. Additionally further investigation into the channel velocities directly upstream and downstream of the culvert would be required to determine if fish passage is likely and ensure the bank surrounding the culvert is protected to prevent erosion.

Cost estimates were based off of Corp HREP projects (Figure 17) and scaled to current dollars. (https://www.mvr.usace.army.mil/Portals/48/docs/Environmental/EMP/HREP/EMP_Documents/2012%20UMRR%20EMP%20Environmental%20Design%20Handbook%20-%20FINAL.pdf) Soil borings were not factored into the estimate. Another factor to consider in the construction of the north oxbow water control structure that is not captured in the estimate below would be additional excavation of the channel immediately upstream and downstream of the culvert. Water control structures vary significantly from project to project. Therefore, for preliminary estimates three projects were identified that had stoplog and culvert structures aimed at retaining water and managing water levels within the system. These culverts range in size from 5 FT to two 4.5 FT box culverts. Approximate costs for the prefab stoplog structure include furnishing and installing the 24" diameter water control structure. Approximate costs for the 6' concrete culvert and stoplog structure include all costs associated with furnishing and installing the reinforced concrete, handrails, and stoplogs. A 15% contingency was included in the estimate and project feature costs were escalated to current dollars using EM 1110-2-1304 (Table 4).

Table 4: Table displaying culvert modification structure type and approximate cost.

	2019 Escalated Costs +15% Contingency
24" Prefab Stoplog Structure	$37,000
6' Concrete Culvert and Stoplog Structure	$270,000

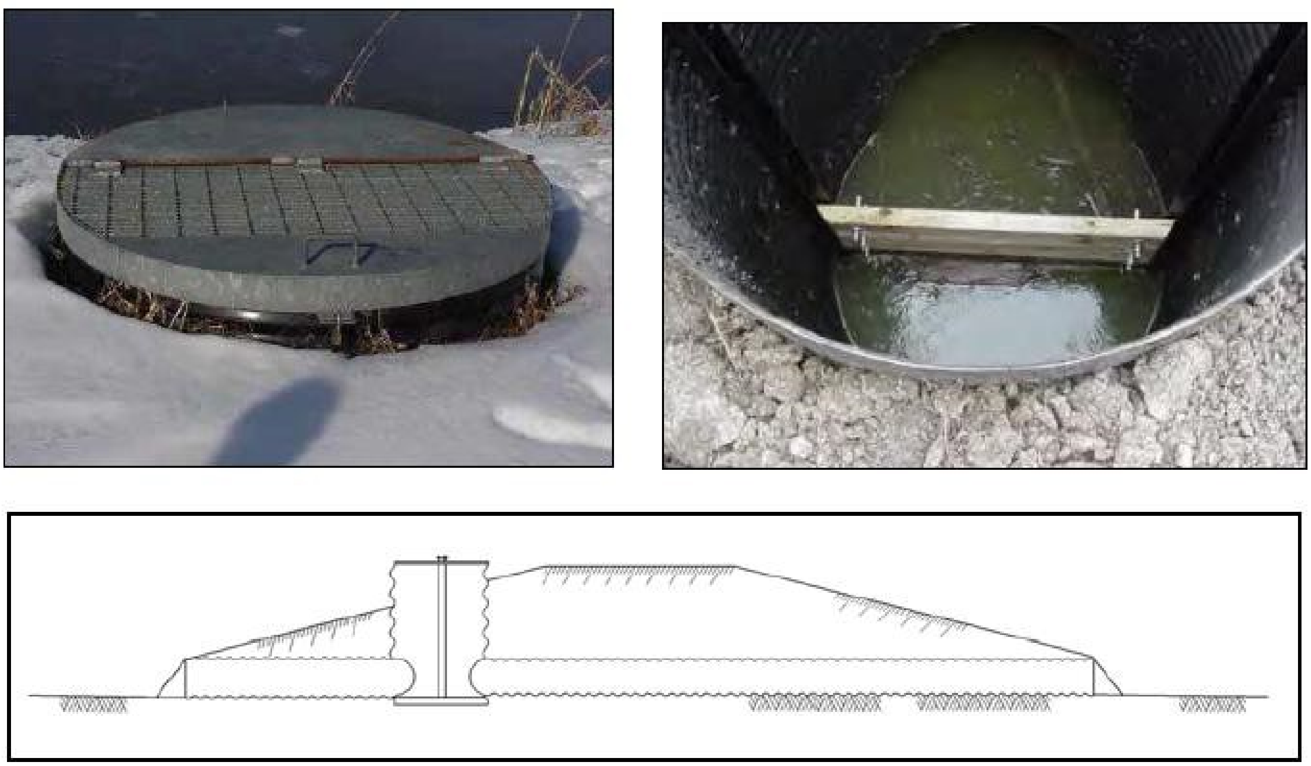

Figure 17: Culvert with Stoplog Structure at Banner Marsh HREP. https://www.mvr.usace.army.mil/Portals/48/docs/Environmental/EMP/HREP/EMP_Documents/Design%20Handbook%202012/05_Waterlevel_Management.pdf (USACE photos).

Timber Stand Improvement:

Operations Division at Saylorville Lake has already undertaken tree plantings and timber stand improvement projects near the oxbows in some locations. However, opportunities still exist to increase the quality of the habitat available in the area and convert current forested areas to more natural oak savannahs. Figure 18 shows several key areas that were identified as possible locations for timber stand improvements during the workshop.

Figure 18: Suitable locations identified as timber stand improvement (TSI 1–11) areas and used as the basis for quantities and cost estimates for restoration.

Cost of timber stand improvements were estimated at $1,500 per acre. This is rounded slightly up from Operations Division's current rate of $1,185 to account for any variability in acreage measurements and potential cost escalation in future years. See Table 5 below.

Table 5: Table displaying timber stand improvement areas (TSI 1-11), approximate acreage of each area, unit cost ($/acre), and total cost for restoration.

	Acres	Unit Cost	Total Cost
TSI 1	58	$ 1,500.00	$ 86,900.00
TSI 2	32	$ 1,500.00	$ 47,700.00
TSI 3	33	$ 1,500.00	$ 49,400.00
TSI 4	15	$ 1,500.00	$ 23,100.00
TSI 5	19	$ 1,500.00	$ 28,700.00
TSI 6	43	$ 1,500.00	$ 63,800.00
TSI 7	18	$ 1,500.00	$ 26,300.00
TSI 8	3	$ 1,500.00	$ 4,900.00
TSI 9	5	$ 1,500.00	$ 7,100.00
TSI 10	7	$ 1,500.00	$ 9,900.00
TSI 11	7	$ 1,500.00	$ 10,400.00
Total	239	$ 1,500.00	$ 357,800.00

Prairie Planting:

Another key goal identified by the stakeholders is to increase the acreage of prairie within the USACE and Iowa DNR managed land directly surrounding the oxbows. Potential future prairie planting locations are show in Figure 19. These planting would require some adjacent leased farmland to be converted. This land use change offers many benefits such as a decrease in high nutrient run-off and an increase in natural habitat.

The areas identified in Figure 19 indicate the larger areas selected as possible prairie planting areas during the workshop. However, additional locations that could provide increased benefits would be between the oxbows and leased farmland. Small sections in these areas could serve as buffer strips for remaining farmland in the area. Buffer strips decrease nutrient, pathogen and sediment loads into the oxbows.

The Cottonwood Recreation area is currently managed by USACE Operations Division staff at Saylorville Lake and this area includes several areas of reestablished prairie. Implementing a similar approach and lessons learned at this site for future prairie plantings at the three oxbows south of the Cottonwood Recreation area would effectively utilize existing resources and staff knowledge.

Figure 19: Suitable locations identified as prairie habitat restoration areas (PP 1-5) and used as the basis for quantities and cost estimates for restoration (Table 6).

Cost associated with prairie plantings include site preparation, seeding costs, and management costs. Site preparation requires the elimination of all weeds and existing vegetation. Herbicides, mowing, and burning are all potential methods of site preparation. OD staff at Saylorville Lake have utilized burning, disking and seed drilling to establish prairie. Generally a burn line is mowed in to allow for future burning as a management practice. Woody areas will require more extensive preparation including tree clearing. Both burning and mowing can be employed to maintain the prairie and prevent reestablishment of invasive or undesired species.

Costs are based off of Operations Division current contract for prairie planting and management in that area (Table 6).

Table 6: Table displaying type of work required for successful prairie plantings, total area for restoration, unit cost ($/acre), total cost and notes.

Type of Work	Total Area	Unit Cost	Total Cost	Notes
Tree mulching/shearing/girdling and shrub removal	9.1	$1185	$ 10,780	only in areas with trees
Herbaceous Mowing	44.9	$165	$ 7,410	
Broadcast Herbicide Application - non-selective, burn down	44.9	$77	$ 3,460	
Field Disking	44.9	$113	$ 5,070	
Native Grass Drill Seeding	44.9	$113	$ 5,070	
Total Cost to Establish Prairie			$ 21,010	

Additional Features:

Several features were identified and discussed for inclusion in the preferred restoration design. These features would have significant added benefits to the habitat and would not overly inflate the overall cost or complexity of restoration.

One feature to be considered is the addition of floating wetlands (Figure 20) or aquatic habitat plantings. If natural habitat does not reestablish itself as desired, this could be implemented in any or all of the three oxbows. Maintenance of floating wetlands can be higher magnitude when compared to other wetland-type features.

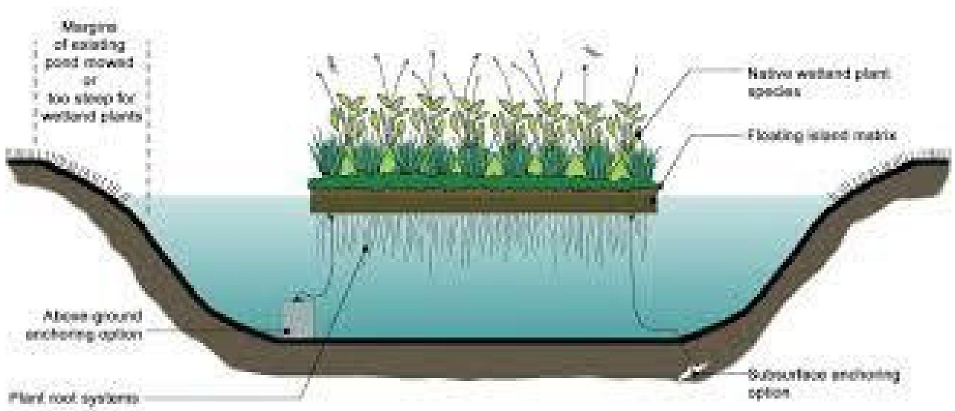

Figure 20: Example schematic for a floating island. Floating islands have the benefits of not requiring large quantities of fill material for construction, offer habitat diversity, and improve water quality (photo courtesy of Texas Community Watershed Partners, Texas A&M University).

Another feature to be considered is the addition of run-off attenuation structures (i.e., leaky dam; Figures 21-22). This feature uses engineering with nature principles such as minimal management requirements and natural construction materials (i.e. felled trees). This could be utilized in sections of the oxbow that are draining at an above desired rate. However, one considerations would be the potential to sediment in causing the dam to no longer leak and altering its design function. Leaky dams could be minimal to no cost if put in place by Operations staff.

Figures 21-22: Photo examples of run-off attenuation structures (i.e., leaky dams). These structures can have significant impacts on flood peaks in small to medium events. They also provide numerous ancillary benefits including water level manipulation, increased residence time of water within the system, sediment capture, and water quality improvements (USACE photos).

5. Benefits of the Preferred Design

Engineering With Nature (EwN) – Engineering With Nature is the intentional alignment of natural and engineering processes to efficiently and sustainably deliver economic, environmental, and social benefits through collaborative processes. The concepts discussed in this report (e.g., run-off attenuation structures [leaky dams], beneficial use of excavated material, and use of existing oxbow structure to maximize effectiveness and efficiency provides numerous benefits including flood risk reduction, habitat restoration, water quality improvements, water storage, and social/recreational opportunities. The preferred restoration design meets the intent of EwN and is a triple win outcome!

Water Storage – excavation of deep water areas within the backwaters creates an additional 331 acre-feet of water storage. Additionally, culvert modifications and changes in water flow within the complex increases water residence time and under small events potentially reduces flood risk downstream.

Social/Recreational – the management actions in the preferred design provides numerous additional recreational activities to users of the area. For one, additional habitat diversity provides an increase in the acreage available to recreational users. Secondarily, greater habitat value presents additional opportunities for plants and animals to develop, reproduce, and benefit from the area, thereby increasing the carrying capacity of the site and overall quality of the recreational experience.

Habitat - The Ecosystems Functions Model (HEC-EFM) analysis was used to illustrate potential habitat impacts from the hydraulic results. Three habitat types were assessed: dabbling ducks, fish spawning, and fish overwintering.

Dabbling ducks: Habitat value was assigned to each cell of the HEC-RAS model grid according to Figure 23 for each individual day during the Fall months (September 1st – November 30th). It is assumed that ideal habitat for dabbling ducks is 1-2 feet, but some value can be attained in the 0.5 – 3 foot range.

Figure 25 shows results of this analysis for both the existing condition and the selected plan. An increase in habitat value is shown in the northern portion of the south oxbow. A decrease in habitat value is shown in the middle and upper portions of the north and middle oxbows. This occurs because dredge cuts in these areas create depths too deep for dabbling ducks. However, this analysis was conducted for 2018, a fairly wet year. Analysis of a more typical or more dry year is likely to show a more positive change.

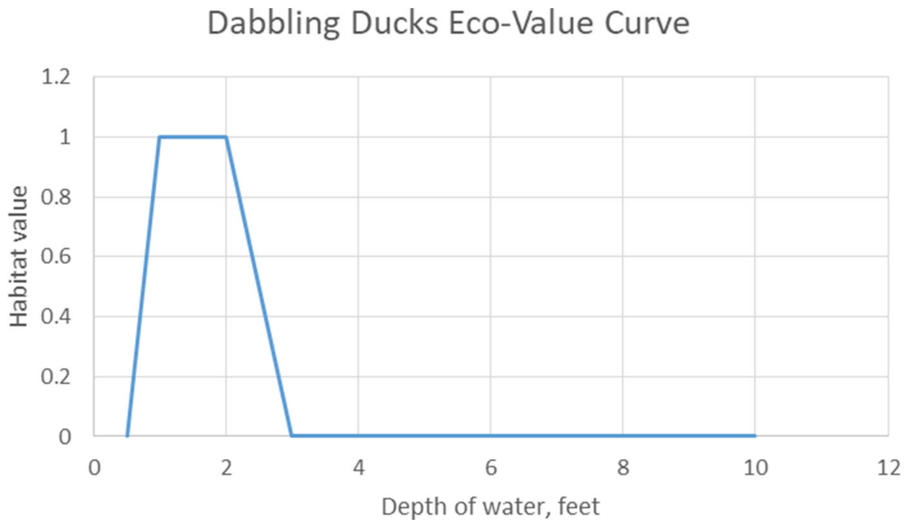

Figure 23: Ecological relationship used in the HEC-EFM analysis for dabbling ducks. Graph shows habitat value as depth of water changes.

Fish overwintering: Habitat value was assigned to each cell of the HEC-RAS model grid if the minimum elevation between November 1st and December 31st was 6 feet. It is assumed that 4 or more feet of water depth covered by 2 feet of ice is ideal for fish overwintering. Velocities in the oxbows are assumed to be fairly low during the winter months. Ideally, the time period November 1st to March 31st would be evaluated, but only CY2018 was simulated for this workshop.

Figure 26 shows results of this analysis for both the existing condition and the selected plan. For the existing condition, no habitat value is shown within the oxbow corridor. For the selected plan, large portions of each oxbow show habitat value. It should be noted that rainfall, runoff, evapotranspiration, and groundwater recharge / discharge were not included in this analysis – but would likely impact the viability of this habitat significantly.

Fish spawning: Habitat value was assigned to each cell of the HEC-RAS model grid according to Figure 24 for each 25 day duration during the Spring months (April 1st – June 30th). It is assumed that ideal habitat for spawning fish is 1 – 2 feet, but some value can be attained in the 0 – 6 foot range.

Figure 27 shows results of this analysis for both the existing condition and the selected plan. Some increase in habitat value is shown in the southern dredge cut of the south oxbow. A decrease in habitat value is shown throughout the oxbows, as water gathers in deep dredge cuts rather than spreading out into shallow areas.

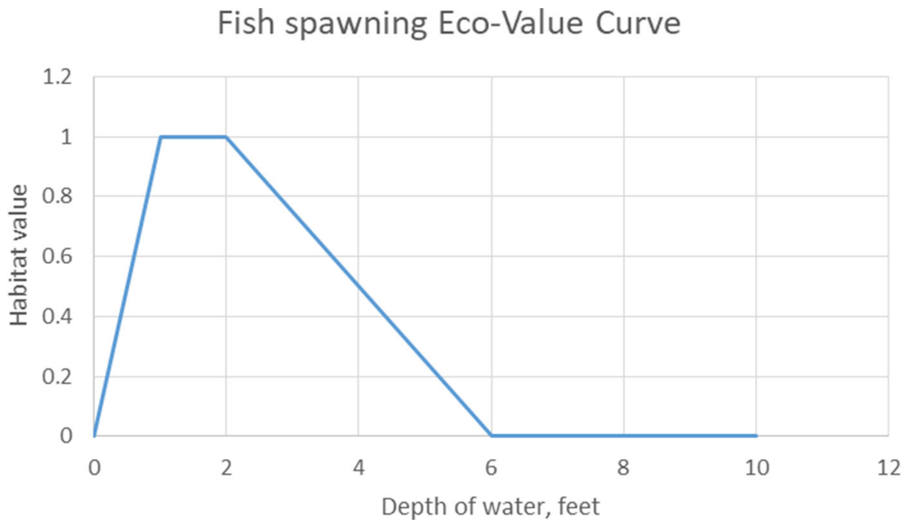

Figure 24: Ecological relationship used in the HEC-EFM analysis for fish spawning habitat. Graph shows habitat value as depth of water changes.

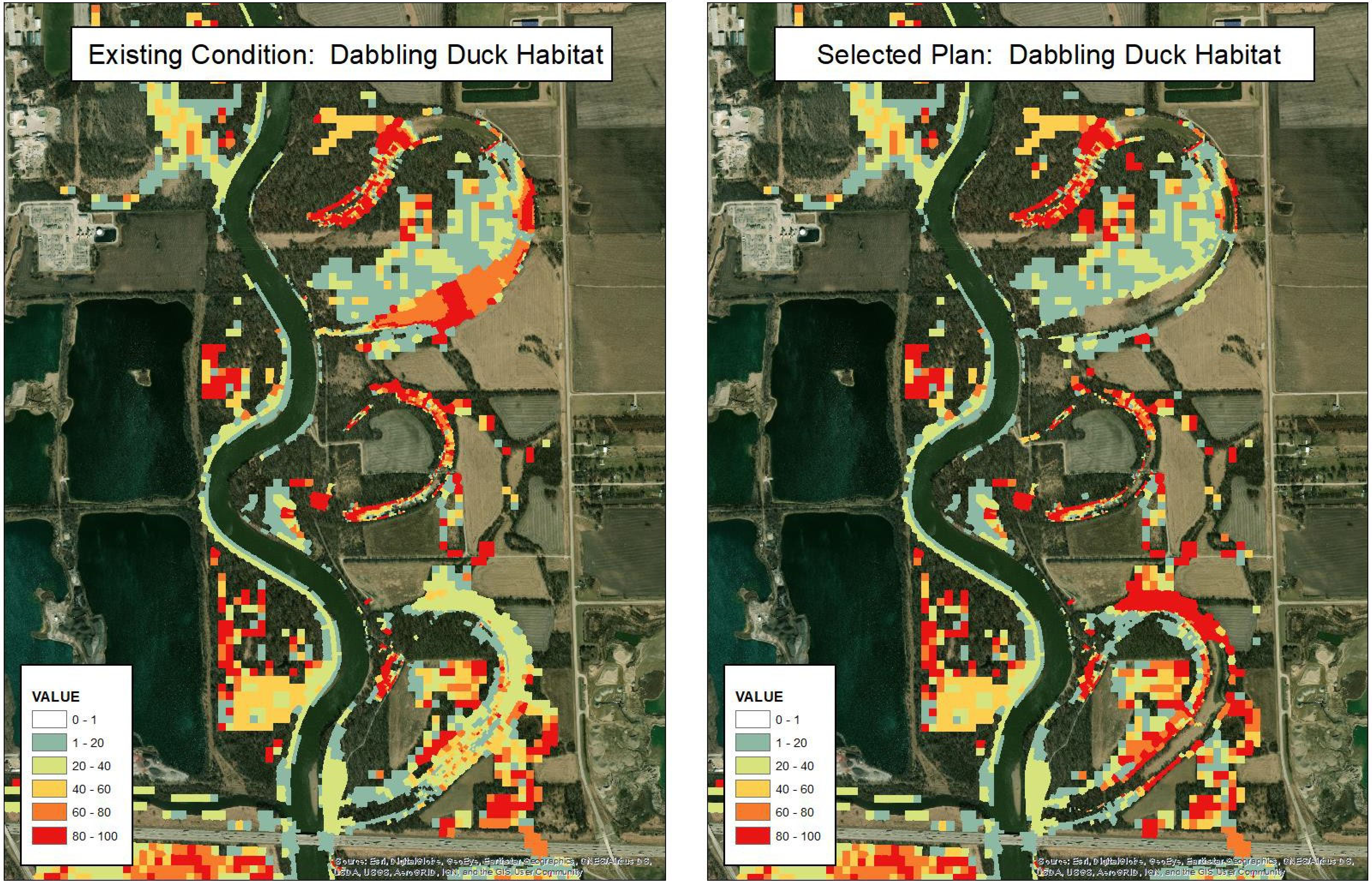

Figure 25: Dabbling duck habitat value computed for existing condition (left) and selected plan (right). Areas with more habitat value shown in red.

Figure 26: Fish overwintering habitat value computed for existing condition (left) and selected plan (right). Areas with more habitat value shown in red (note – habitat values between dabbling duck habitat and fish overwintering habitat cannot be compared).

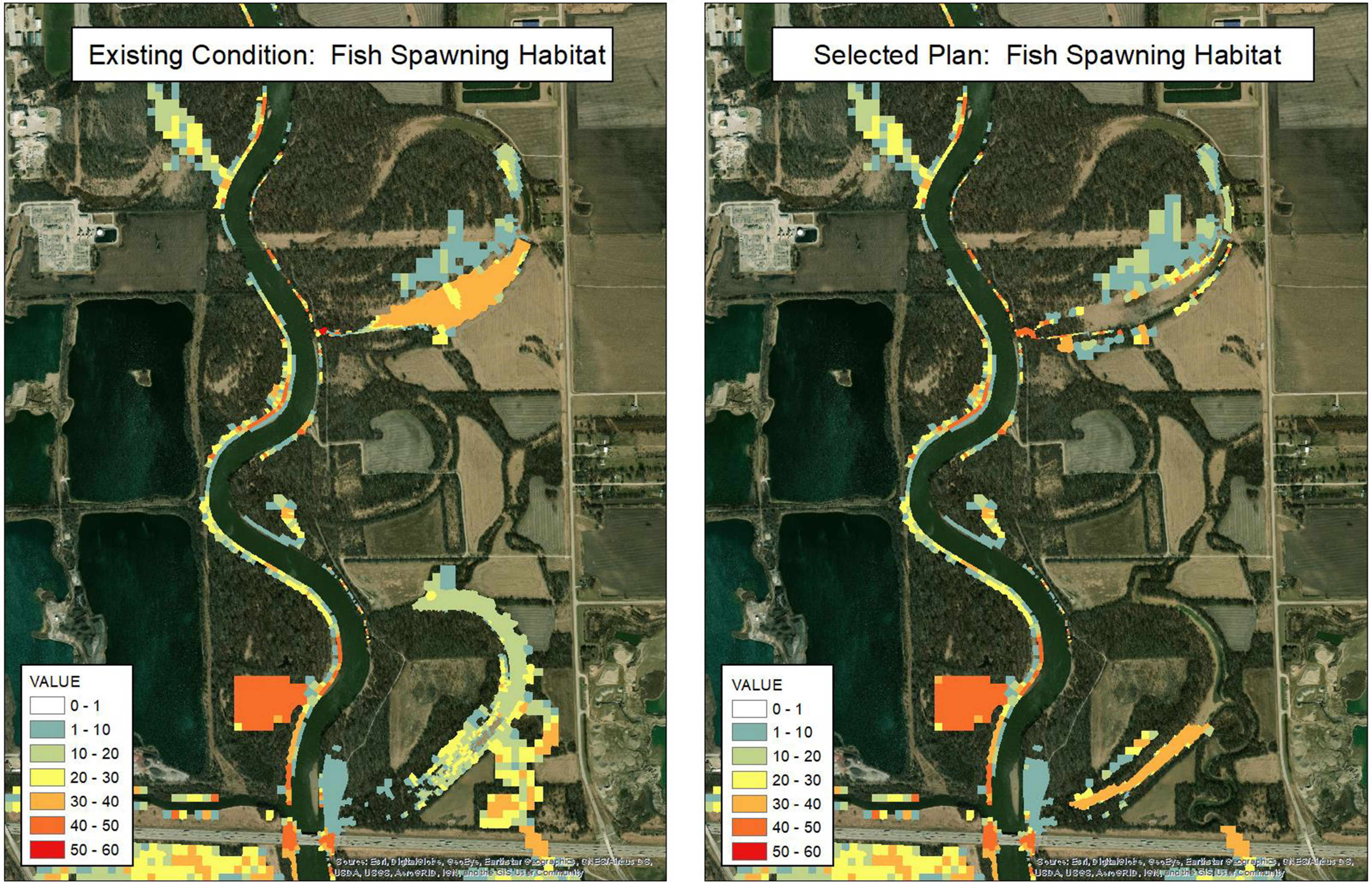

Figure 27: Fish spawning habitat value computed for existing condition (left) and selected plan (right). Areas with more habitat value shown in red (note – habitat values between dabbling duck habitat, fish overwintering habitat, and fish spawning habitat cannot be compared).

7. References

Des Moines Water Works, “Saylorville Habitat Monitoring Program”, October 2014 – October 2015.

FEMA, “Flood Insurance Study Number 19153CV002A”, Effective February 1, 2019, https://map1.msc.fema.gov/data/19/S/PDF/19153CV002A.pdf

USACE Rock Island District, “Des Moines River Basin Master Reservoir Regulation Manual Feasibility Report with Integrated Environmental Assessment”, January 2019, https://www.mvr.usace.army.mil/About/Offices/Programs-and-Project-Management/Des-Moines-River-Water-Control-Plan-Update/

Saylorville Lake Oxbow Restoration Planning – September 2019

Appendix: 2D Hydraulic Model

In support of Saylorville Lake Oxbow Restoration Planning, HEC-RAS version 5.0.7 (Brunner 2018) was used to approximately model the hydraulics of the Des Moines River and floodplain within the oxbow corridor. Two cases were simulated: (1) existing condition and (2) selected plan. Initial model development was conducted by Gary Brunner, HEC. Post-workshop refinement was conducted by Rock Island District. HEC-EFM 5.0 (Hickey 2016) was used to illustrate potential habitat impacts from the hydraulic results.

Please note: The objective of this model was to simulate water surface elevations and timing and duration of oxbow filling. This model should not be used for engineering design without further refinement. Additionally, all model terrain elevations were derived from LiDAR. Benchmarked survey data is needed to verify model geometry.

Hydraulic Model Development

Components required for the development of the unsteady, two-dimensional HEC-RAS model are detailed below.

Approximate survey of oxbow corridor: An approximate survey (laser level, not benchmarked) of the study area was conducted the week of August 19, 2019 by Saylorville Lake staff. The intent of this survey was estimate rough depths throughout the Oxbow corridor. Data collected includes:

- Location, length, diameter, and depth below top of road for 22 culverts within the modeled area
- Water depth measurements within the northern oxbow
- Elevations on a short portion of the Neal Smith trail altered in 2013, relative to a location likely unchanged since Iowa LiDAR was flown.

Model datum: Horizontal datum for this work was Albers Equal Area Conic, USGS version. Vertical datum for this work was NAVD 1988.

HEC-RAS geometry: Geometry of the 2D HEC-RAS model extended from NW 66th Avenue to approximately 10,000 feet downstream of I-80 (Figure A1). The standard mesh cell size was 100 ft. Breaklines were added to the model along the Des Moines mainstem (cell size 50 feet), along the centerline of each oxbow (cell size 25 feet), and along the Neal Smith trail (cell size 25 feet). "Near Spacing" and "Far Spacing" options were used in the mesh development to create a smoother transition between areas with different cell sizes

Terrain data was developed from IA LiDAR (raster cell size 10 feet). The Des Moines River channel (from 2015 CWMS modeling) and an assumed Beaver Creek channel were burned into the terrain. As needed, terrain elevations were lowered slightly such that the invert of each culvert was above ground elevation. Terrain elevations were also lowered in the northern culvert using best judgment and the approximate survey data detailed above.

A 2D area connection was used to represent the Neal Smith trail, which acts as a barrier between the Des Moines River mainstem and the oxbow corridor. Elevation data was derived from Iowa LiDAR and adjusted using the approximate survey data detailed above. Additional 2D area connections were added at road crossings containing culverts. Culvert data was then added to each 2D area connection (locations shown in Figure A1, green dots).

A Manning's n roughness layer was produced from the 2016 NLCD using default n values. Roughness in the Des Moines River channel was specified as 0.033.

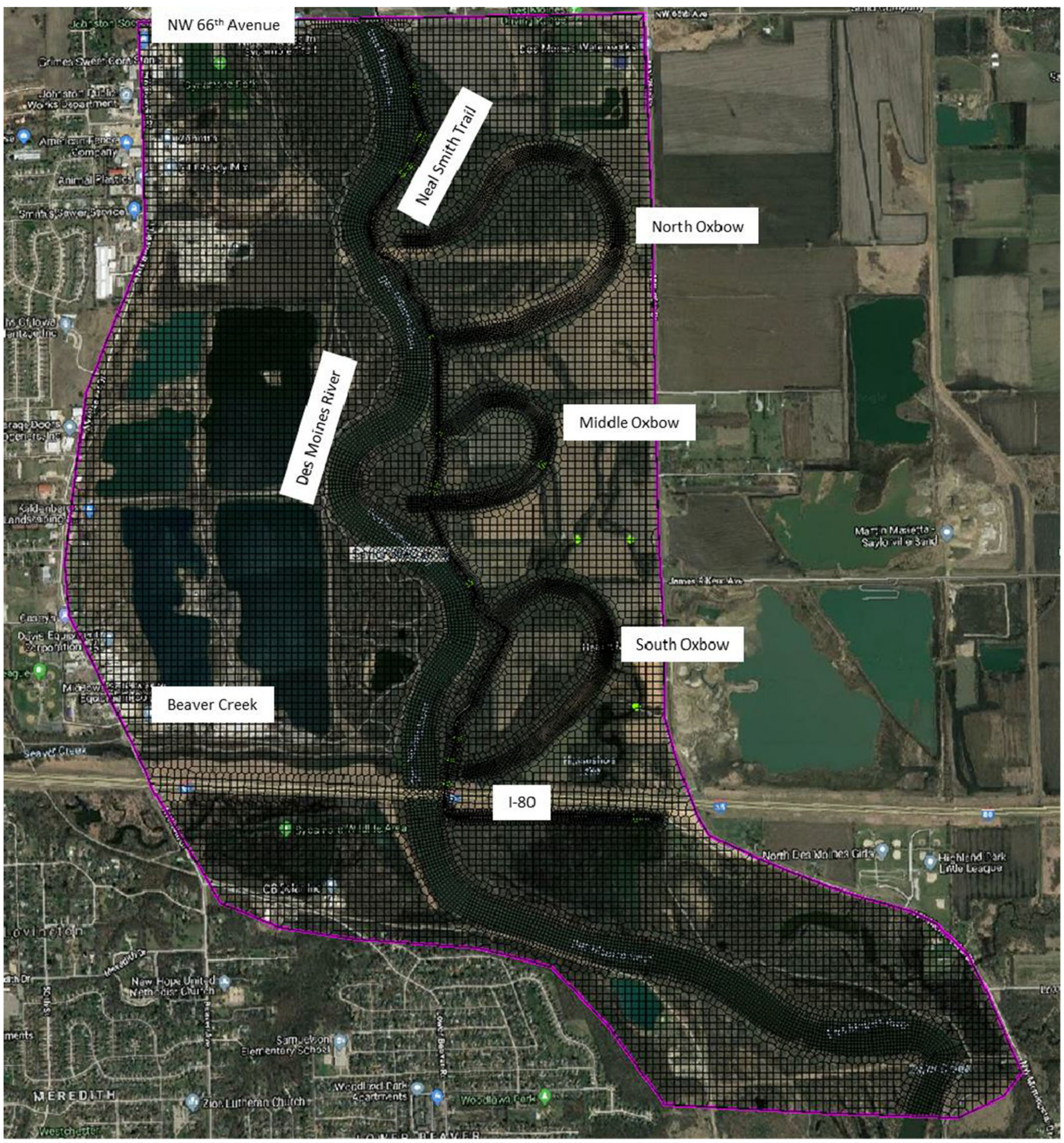

Figure A1: Saylorville Oxbows 2D HEC-RAS model extent. Model boundary shown in pink. Mesh cells drawn in black. Culvert locations shown by green dots.

HEC-RAS boundary conditions: Normal depth (slope = 0.0009) were specified as the downstream boundary condition for this model. Flow hydrographs were specified for Beaver Creek and the Des Moines River using data from Beaver Creek at Grimes, IA (Figure A2) and Des Moines River at Saylorville, IA (Figure A3) gages, respectively. In future modeling efforts in this area, it could be beneficial to extend the study area downstream approximately two models and use the Des Moines River 2nd Ave. gage water surface elevations as the downstream boundary condition.

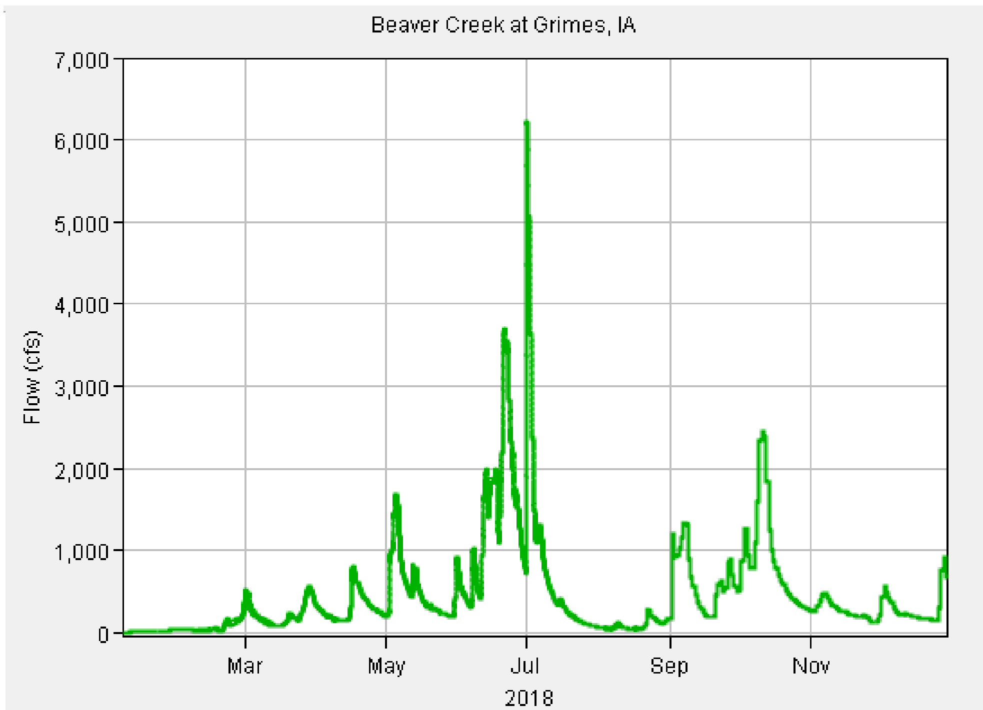

Figure A2: Flow hydrograph, Beaver Creek at Grimes, IA.

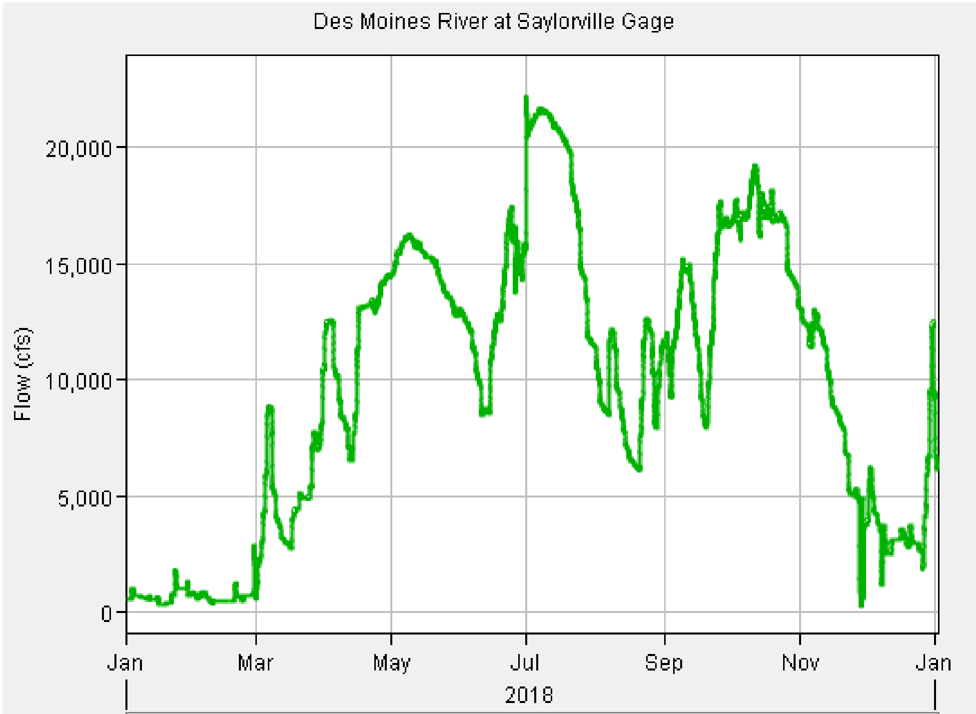

Figure A3: Flow hydrograph, Des Moines River at Saylorville, IA.

HEC-RAS computations: 2D hydraulic flows and water surface elevations were computed using the diffusion wave equation set. Time step was controlled by the courant condition.

HEC-RAS approximate verification: The existing conditions case was developed using the time period January 1, 2018 – December 31, 2018. This year was fairly wet and therefore considered appropriate for simulating movement of water through the oxbow corridor at a wide variety of flows. Historic water surface elevation data is not available within the oxbows; however, slight alterations to terrain were made such that the oxbows would be loaded according to local observations.

Figure A4 shows the existing case inundation map for April 28, 2018. Discharge at Saylorville tail water gage is approximately 14,500 cfs (34% annual chance exceedance*) and water is beginning to enter north and south oxbows via their downstream culverts. Figure A5 shows the existing case inundation map for July 1, 2018. Discharge at Saylorville tail water gage is approximately 22,000 cfs (5% annual chance exceedance*) and water is beginning to overtop a low spot on the Neal Smith trail.

*Annual chance exceedances from 2019 Des Moines River Regulation Study.

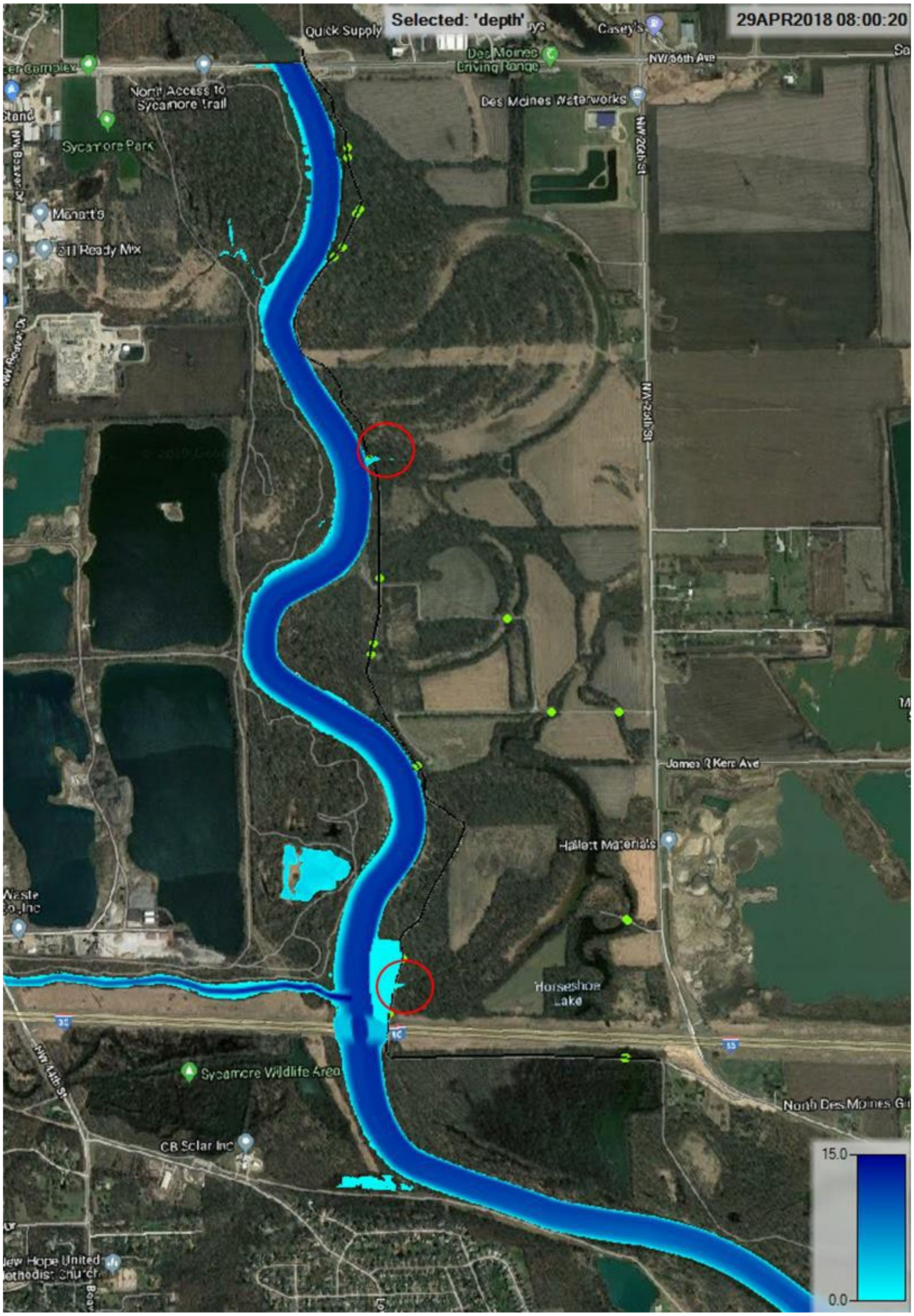

Figure A4: Approximate model verification - existing condition 2D HEC-RAS inundation map April 28, 2018. Discharge at Saylorville tail water gage is approximately 14,500 cfs and water is beginning to enter north and south oxbows via their downstream culverts. Depths are shown by the blue gradient in feet.

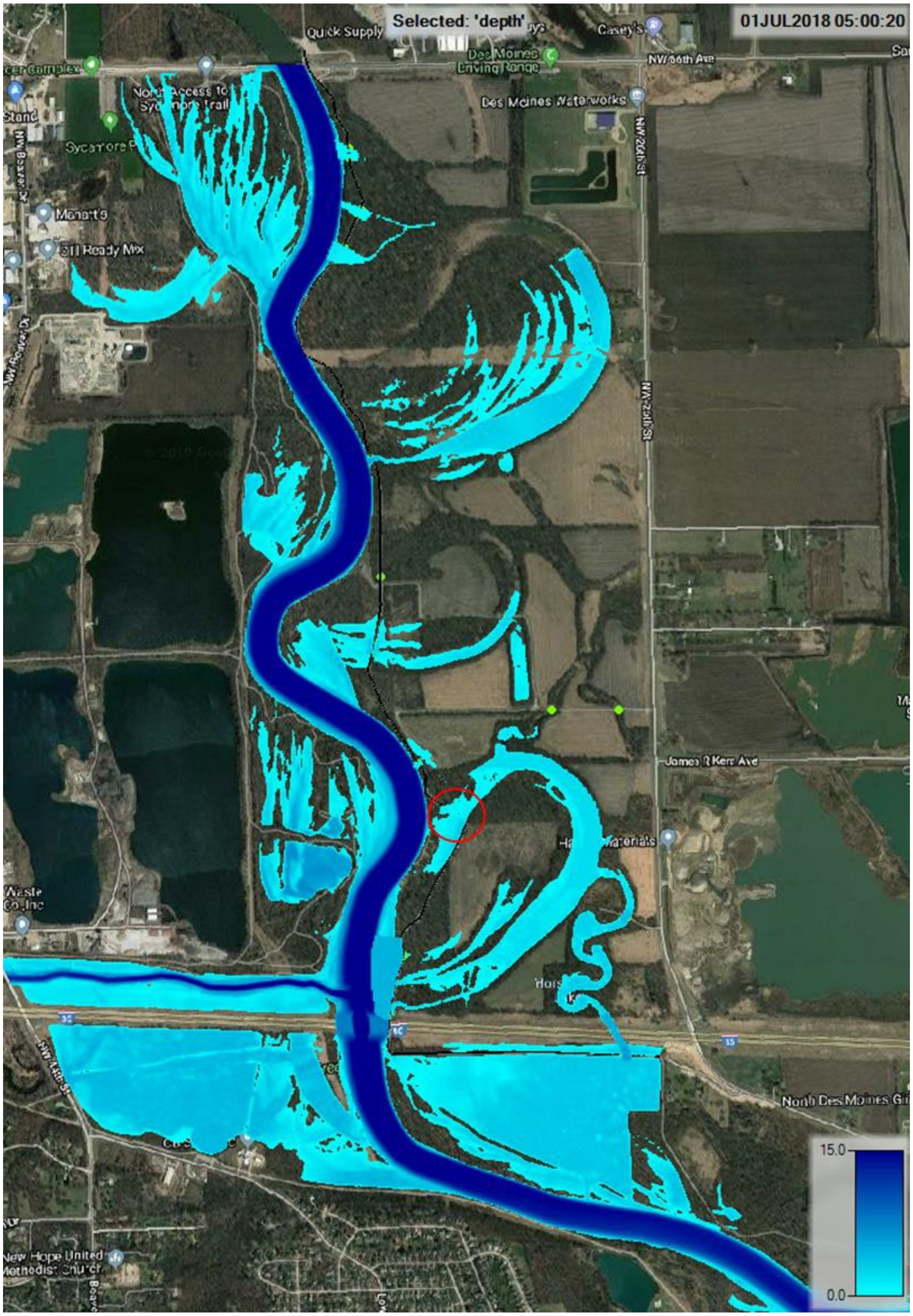

Figure A5: Approximate model verification - existing condition 2D HEC-RAS inundation map July 1, 2018. Discharge at Saylorville tail water gage is approximately 22,000 cfs and water is beginning to overtop a low spot on the Neal Smith trail. Depths are shown by the blue gradient in feet.

Hydraulic Modeling of Selected Plan

Changes to existing condition: The main report (see Section 4: Preferred Restoration Design) suggests a potential plan for restoration of the Oxbows. To model hydraulic impacts of the proposed design, boundary conditions and computational settings were not changed. However, the following changes were made to the existing conditions geometry (Figure A6):

- Dredge cuts (4 – 13 feet deep) were added to the model terrain (locations shown in red).
- The culvert at the downstream end of the north oxbow (circled in blue) was lowered from an invert elevation of 796.75 feet NAVD88 to 794 feet NAVD88. The diameter of this culvert was increased from 3.5 feet to 6 feet.
- The two culverts in the road crossing east of the south oxbow (circled in orange) were removed.

Figure A6: Selected plan – changes to existing condition 2D HEC-RAS model geometry. Red polygons show proposed dredge cuts added to model terrain. Blue circle shows culvert to be lowered and increased in diameter. Orange circle highlights two culverts to be removed.

Results: By comparing the existing condition and selected plan depth results, several states of interest were observed with regard to filling and emptying of the oxbows. The date and Des Moines River flow for each state of interest is listed for reference.

- State of interest 1 (occurred March 6, 2018 – 6,000 cfs): No water enters the oxbows for the existing condition. For the selected plan, water enters the downstream culvert adjacent to the north oxbow and begins to fill the lower portion of the north oxbow.
- State of interest 2 (April 29, 2018 – 14,500 cfs): For the existing condition, water enters the downstream culverts adjacent to the north and south oxbows. For the selected plan, water continues to accumulate in the north oxbow and begins to move down the dredged channel connecting the north and middle oxbows. Water enters the two downstream culverts adjacent to the south oxbow.
- State of interest 3 (May 9, 2018 – 16,000 cfs): In both cases, water is accumulating in the north and south oxbows. Depths are deeper for the selected plan; however, the existing condition case actually inundates a larger area of the south oxbow.
- State of interest 4 (June 24, 2018 – 17,500 cfs): Depths continue to be deeper for the selected plan case. Inundated area is fairly similar in the north oxbow. In the south oxbow, inundated area is still larger for the existing condition case.
- State of interest 5 (July 1, 2018 – 22,000 cfs): Depths continue to be deeper for the selected plan case. The existing case inundates more of the south oxbow (including part of the Neal Smith trail). The selected plan inundates more of the north and middle oxbows.

Figures A7 – A16 compare simulated 2018 inundation depths with the existing condition and selected plan geometries. Table A1 summarizes flows, flow frequencies, and inundation depths in each oxbow for each case.

Table A1: Flows, flow frequencies, and inundation depths at various states of interest observed with regard to filling and emptying of the oxbows.

Date	Flow (cfs)	ACE*	Water depth at deepest portion of north oxbow (feet)		Water depth at deepest portion of middle oxbow (feet)		Water depth at deepest portion of south oxbow (feet)	
			Existing condition	Selected plan	Existing condition	Selected plan	Existing condition	Selected plan
3/06/2018	6,000	91%	dry	0.2	dry	dry	dry	dry
4/29/2018	14,500	34%	dry	14.9	dry	dry	dry	dry
5/09/2018	16,000	10%	2.4	15.7	dry	dry	1.0	1.6
6/24/2018	17,500	8%	3.6	16.4	dry	dry	1.8	11.4
7/01/2018	22,000	5%	3.9	17.9	2.3	7.0	1.9	11.8

*Annual chance exceedances from 2019 Des Moines River Regulation Study.

State of Interest 1: Existing Condition, 6,000 cfs

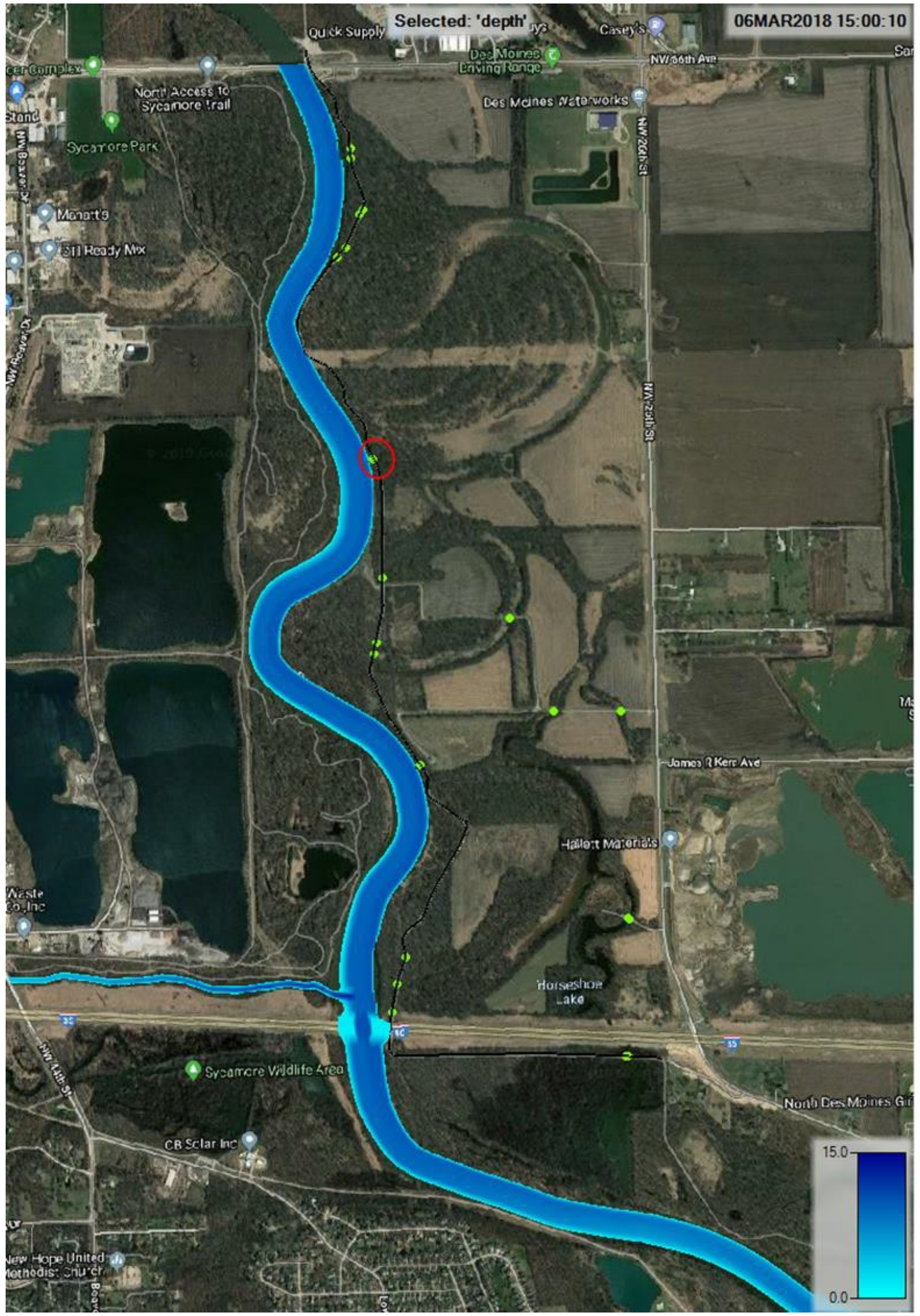

Figure A7: Existing condition 2D HEC-RAS inundation map March 6, 2018. Discharge at Saylorville tail water gage is approximately 6,000 cfs and water has not entered oxbow corridor. Depths are shown by the blue gradient in feet.

State of Interest 1: Selected Plan, 6,000 cfs

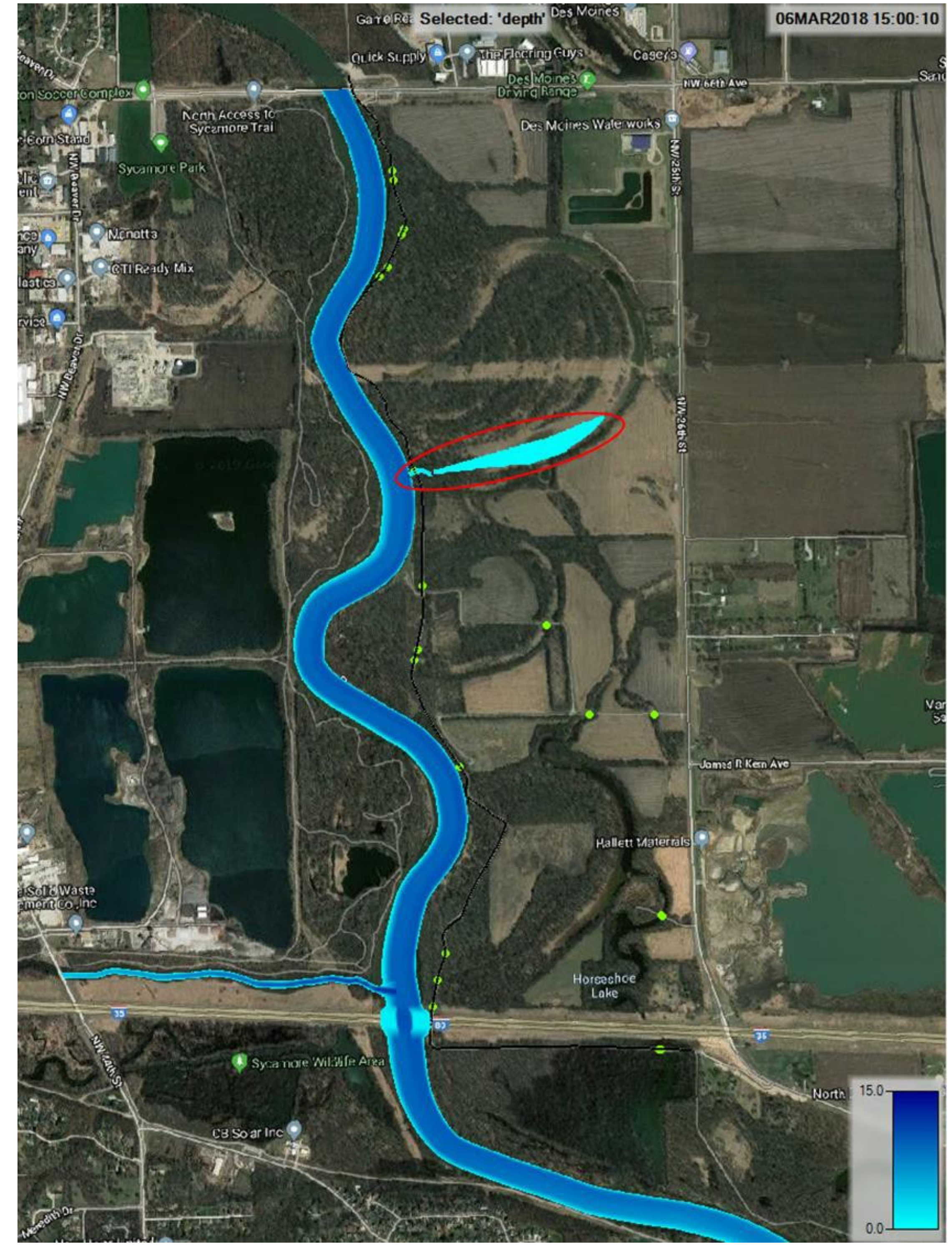

Figure A8: Selected plan 2D HEC-RAS inundation map March 6, 2018. Discharge at Saylorville tail water gage is approximately 6,000 cfs and water has entered north oxbow via its downstream culvert. Approximately 0.2 feet of water has accumulated in the deepest portion of the north oxbow. Depths are shown by the blue gradient in feet.

State of Interest 2: Existing Condition, 14,500 cfs

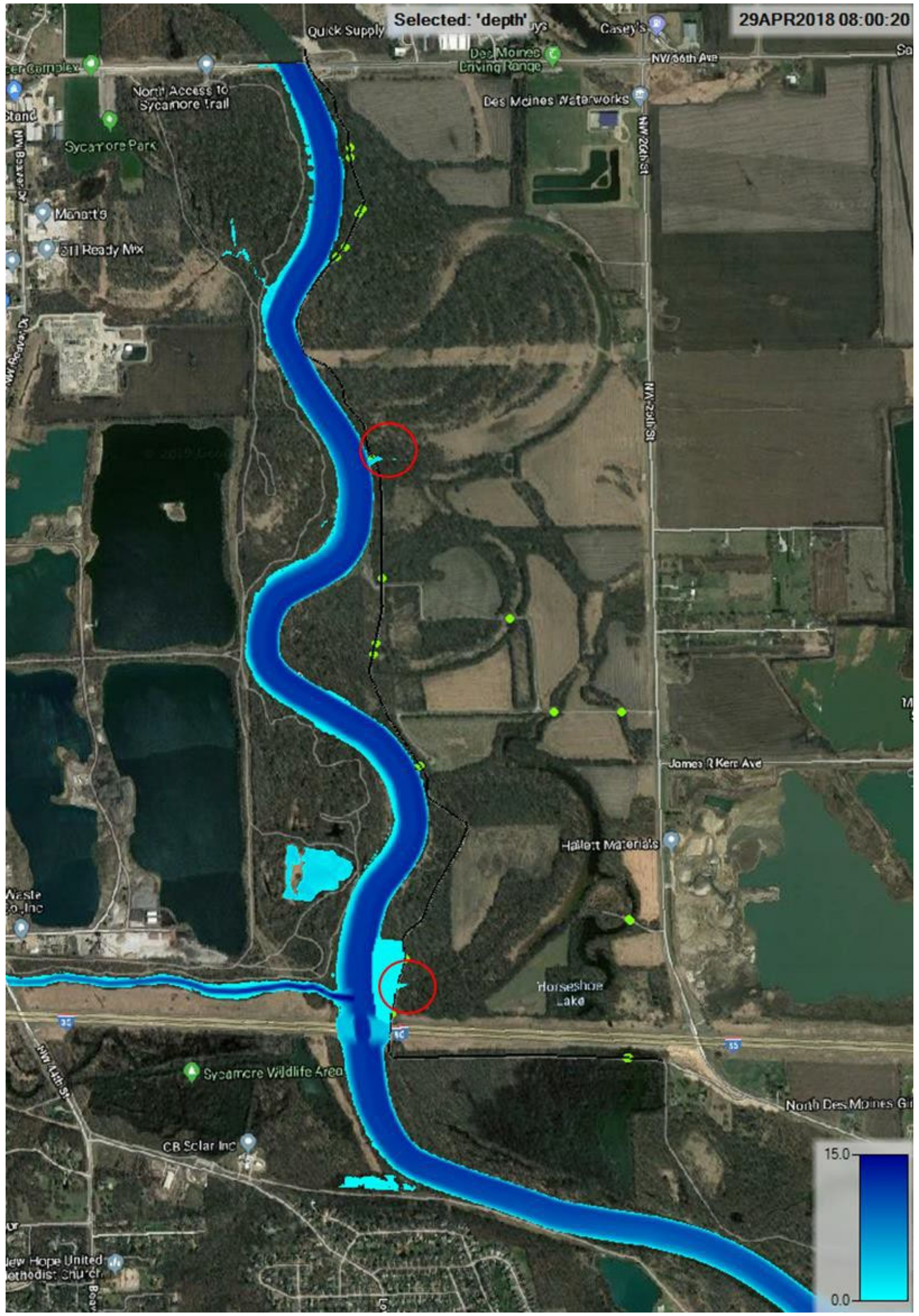

Figure A9: Existing condition 2D HEC-RAS inundation map April 29, 2018. Discharge at Saylorville tail water gage is approximately 14,500 cfs and water is beginning to enter north and south oxbows via their downstream culverts. Depths are shown by the blue gradient in feet.

State of Interest 2: Selected Plan, 14,500 cfs

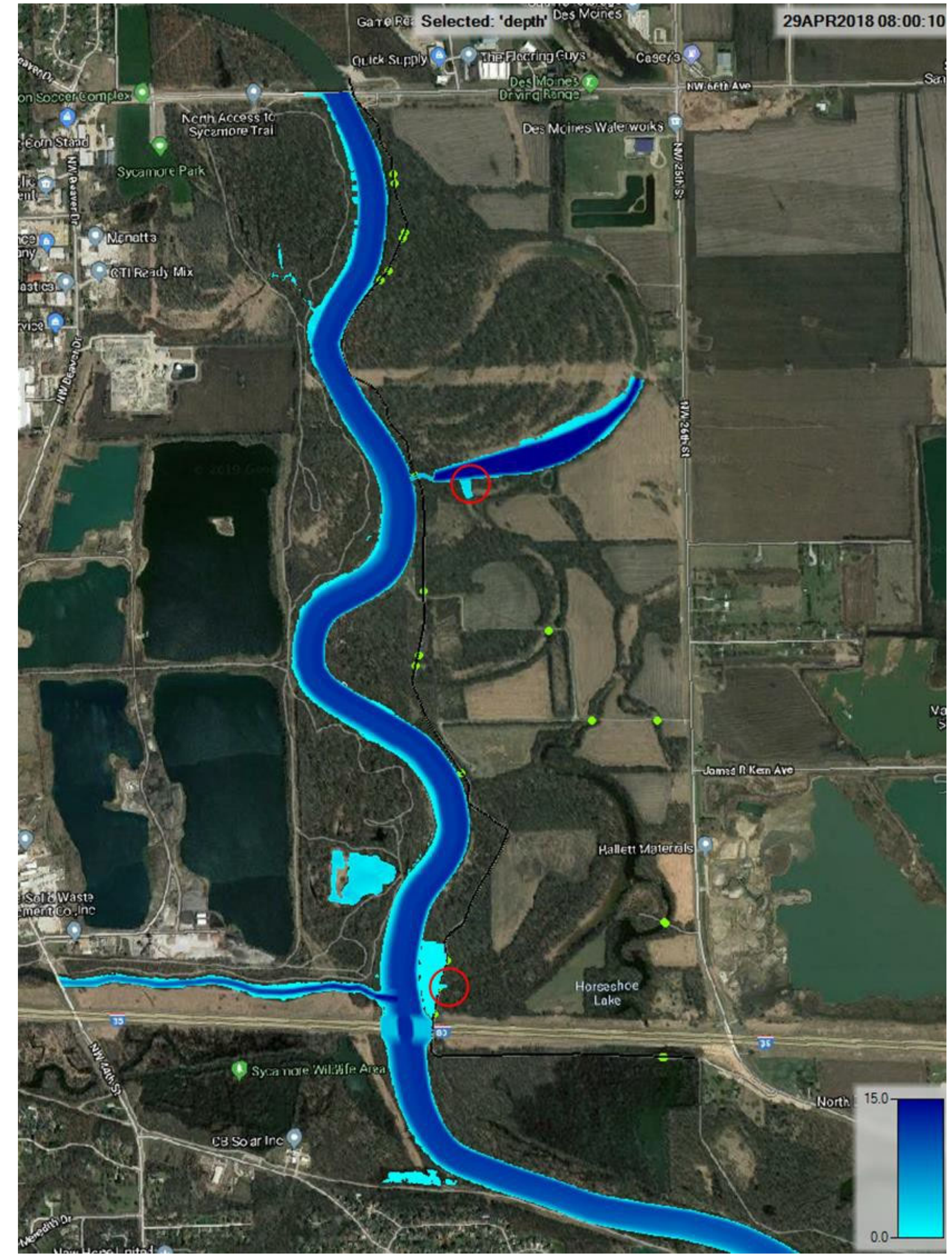

Figure A10: Selected plan 2D HEC-RAS inundation map April 29, 2018. Discharge at Saylorville tail water gage is approximately 14,500 cfs and water is beginning to enter south oxbows via their downstream culverts. Approximately 14.9 feet of water has accumulated in the deepest portion of the north oxbow and water is starting to move through the channel connecting the north and middle oxbows. Depths are shown by the blue gradient in feet.

State of Interest 3: Existing Condition, 16,000 cfs

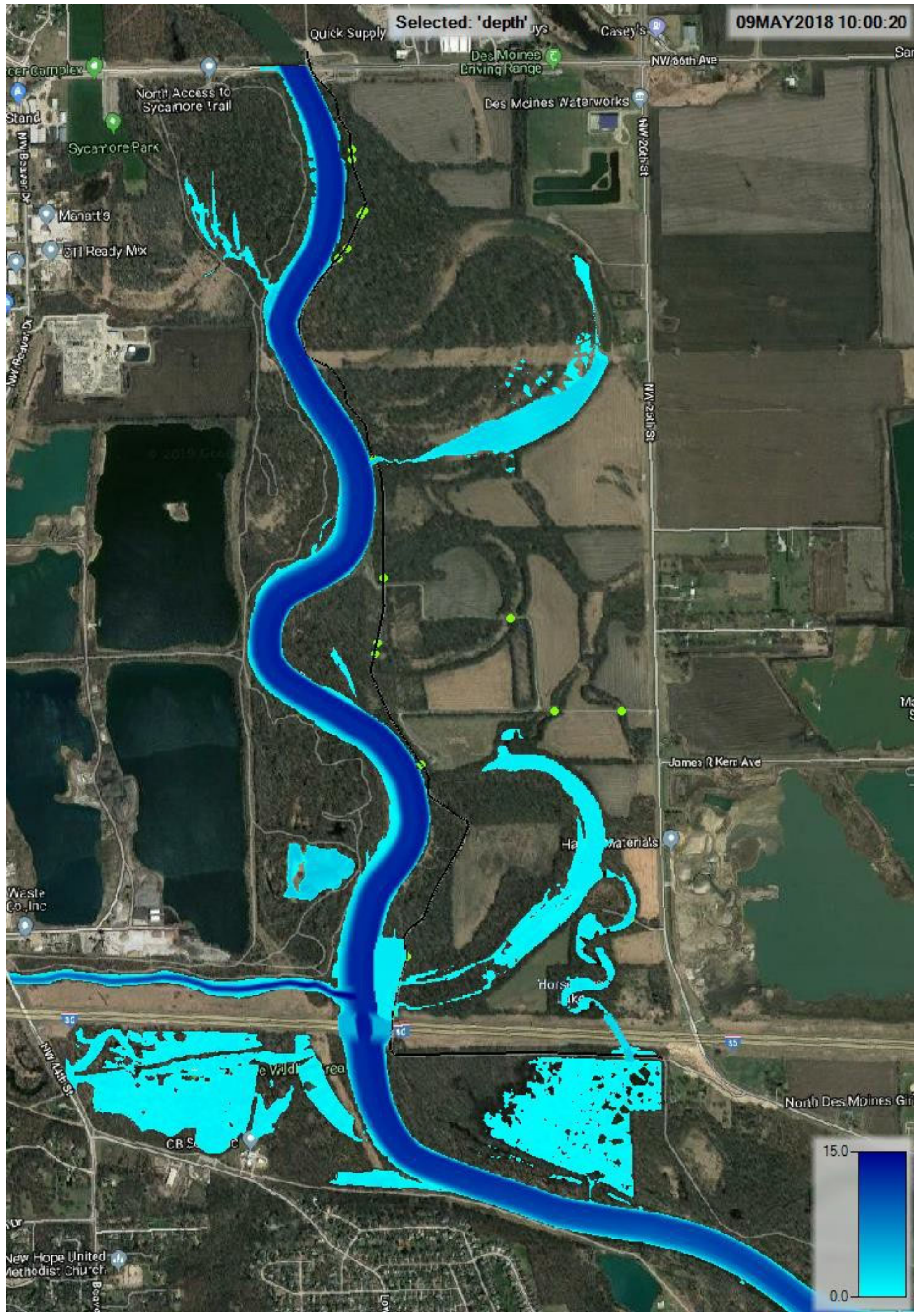

Figure A11: Existing condition 2D HEC-RAS inundation map May 9, 2018. Discharge at Saylorville tail water gage is approximately 16,000 cfs. Approximately 2.4 feet of water has accumulated in the deepest portion of the north oxbow and approximately 1 foot of water has accumulated in the deepest portion of the south oxbow. Depths are shown by the blue gradient in feet.

State of Interest 3: Selected Plan, 16,000 cfs

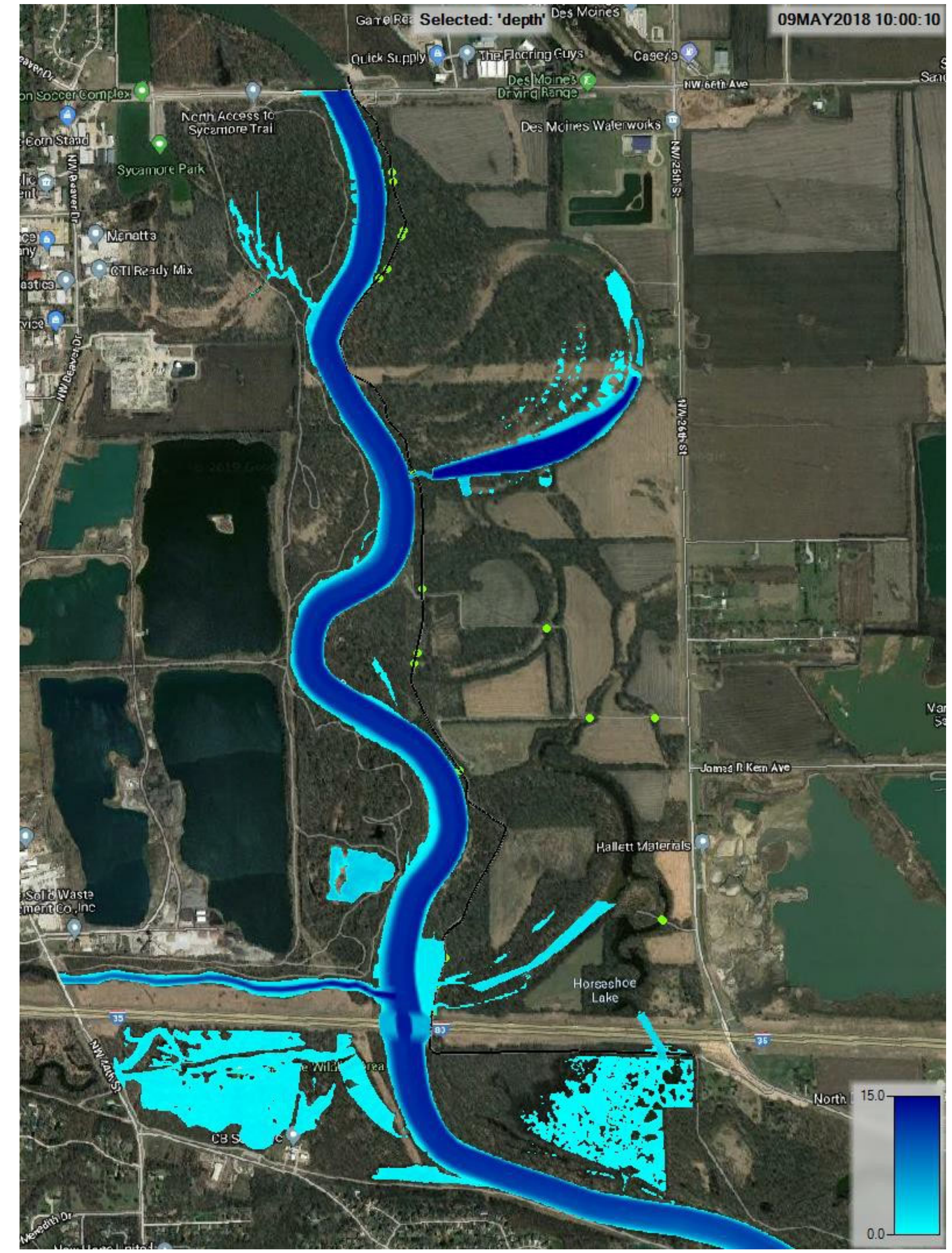

Figure A12:   Proposed plan 2D HEC-RAS inundation map May 9, 2018. Discharge at Saylorville tail water gage is approximately 16,000 cfs. Approximately 15.7 feet of water has accumulated in the deepest portion of the north oxbow and approximately 1.6 feet of water has accumulated in the deepest dredged portion of the south oxbow. Depths are shown by the blue gradient in feet.

State of Interest 4: Existing Condition, 17,500 cfs

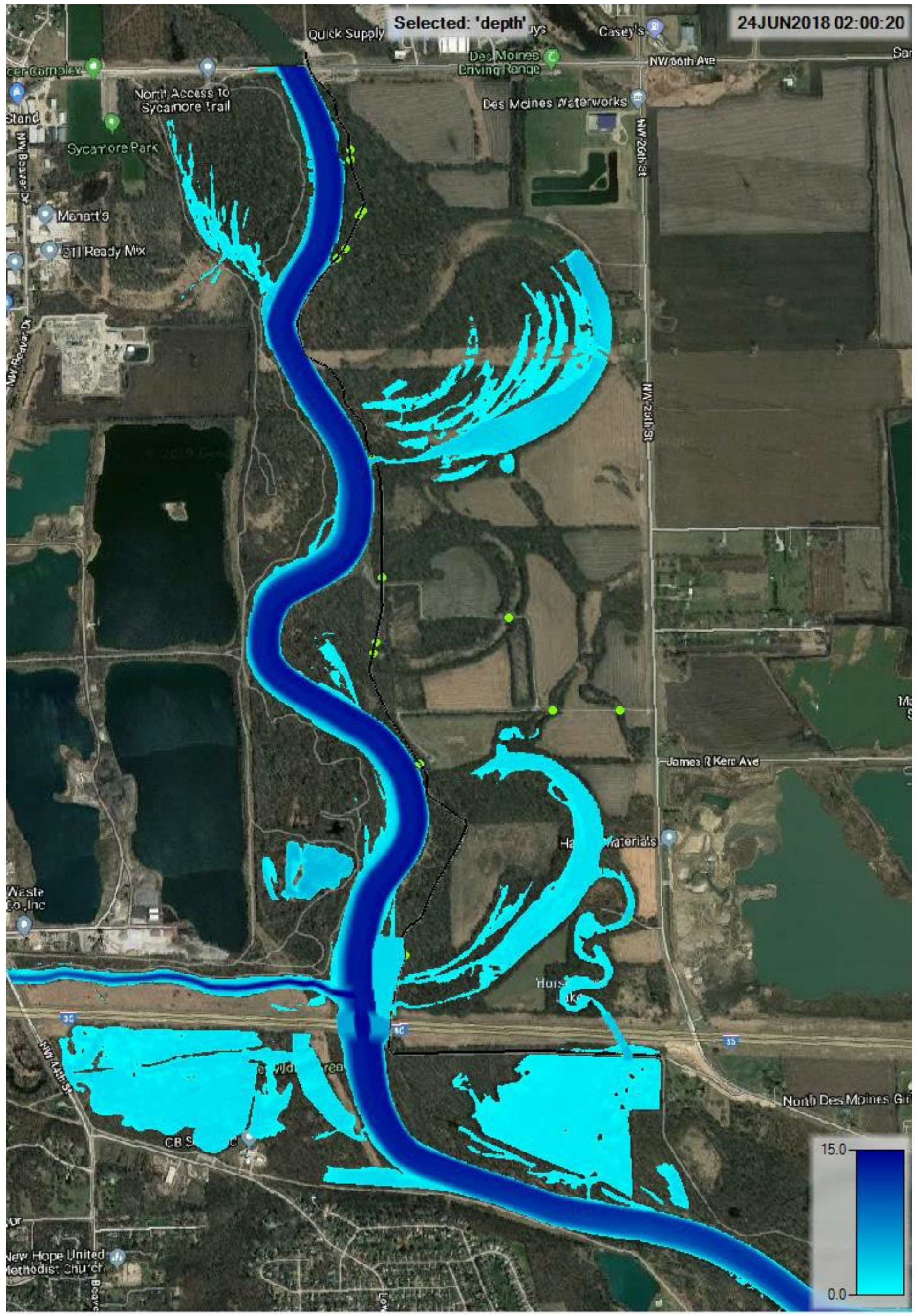

Figure A13: Existing condition 2D HEC-RAS inundation map June 24, 2018. Discharge at Saylorville tail water gage is approximately 17,500 cfs. Approximately 3.6 feet of water has accumulated in the deepest portion of the north oxbow and approximately 1.8 feet of water has accumulated in the deepest portion of the south oxbow. Depths are shown by the blue gradient in feet.

State of Interest 4: Selected Plan, 17,500 cfs

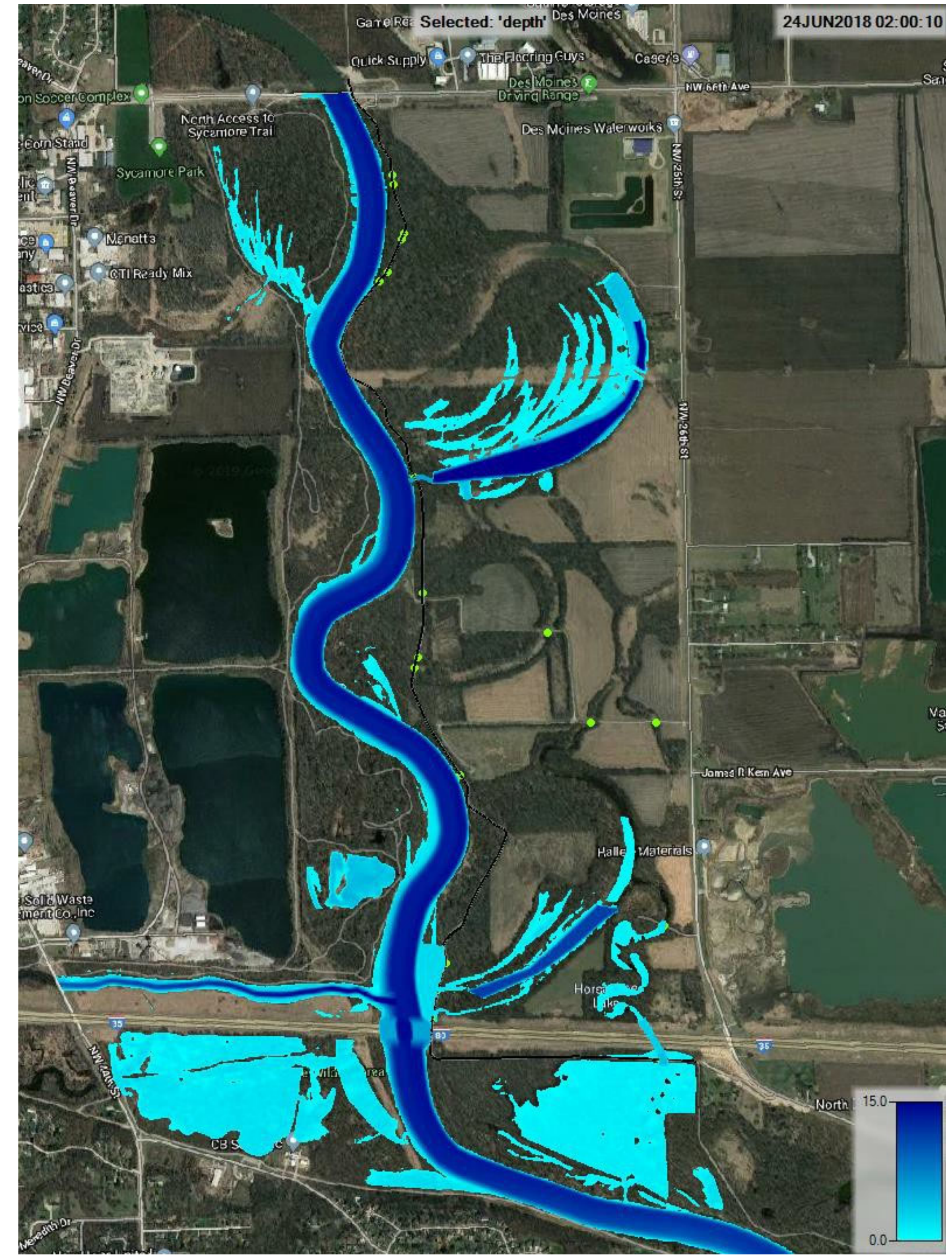

Figure A14: Selected plan 2D HEC-RAS inundation map June 24, 2018. Discharge at Saylorville tail water gage is approximately 17,500 cfs. Approximately 16.4 feet of water has accumulated in the deepest portion of the north oxbow and approximately 11.4 feet of water has accumulated in the deepest portion of the south oxbow. Depths are shown by the blue gradient in feet.

State of Interest 5: Existing Condition, 22,000 cfs

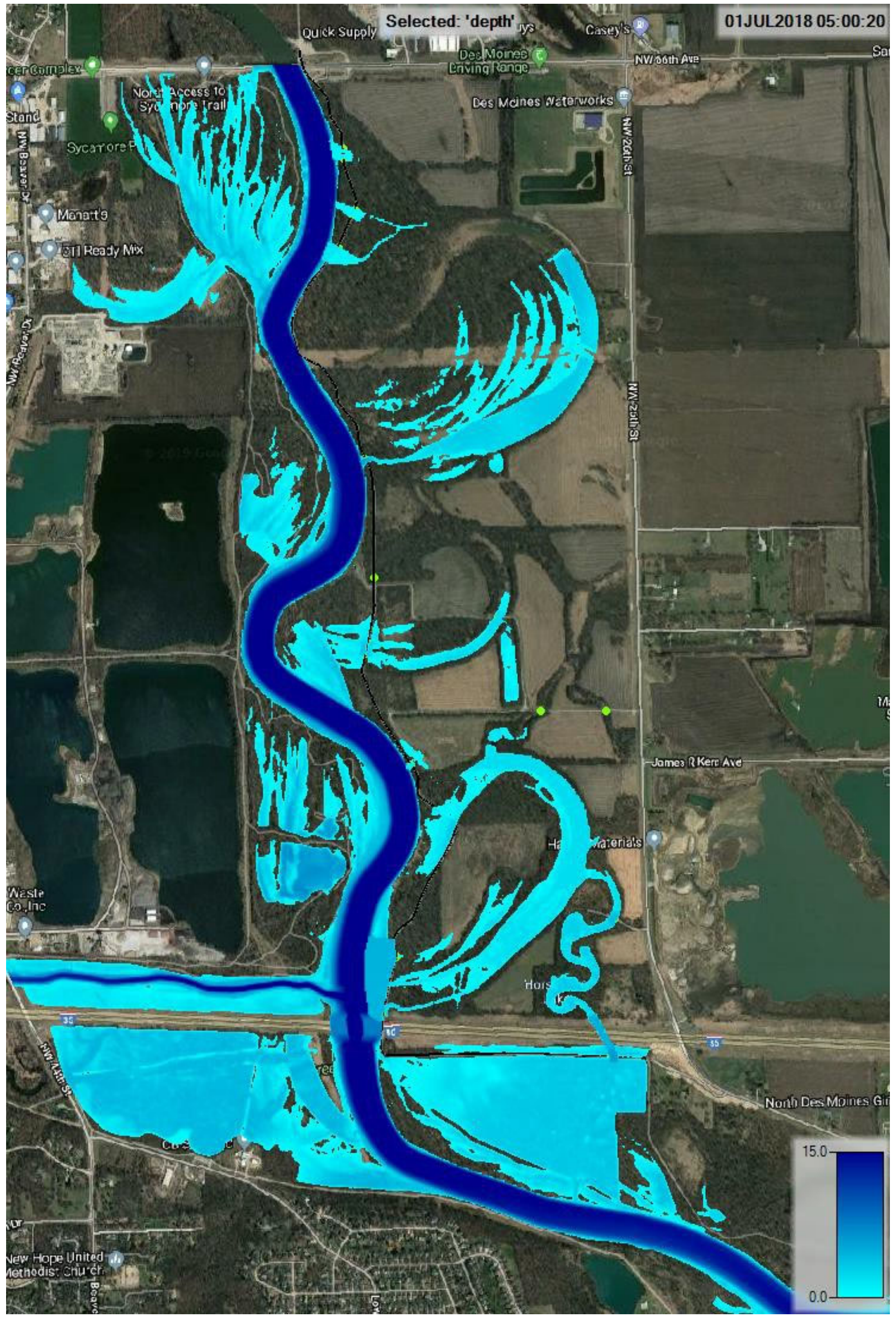

Figure A15: Existing condition 2D HEC-RAS inundation map July 1, 2018. Discharge at Saylorville tail water gage is approximately 22,000 cfs. Approximately 3.9 feet of water has accumulated in the deepest portion of the north oxbow and approximately 1.9 feet of water has accumulated in the deepest portion of the south oxbow. Depths are shown by the blue gradient in feet.

State of Interest 5: Selected Plan, 22,000 cfs

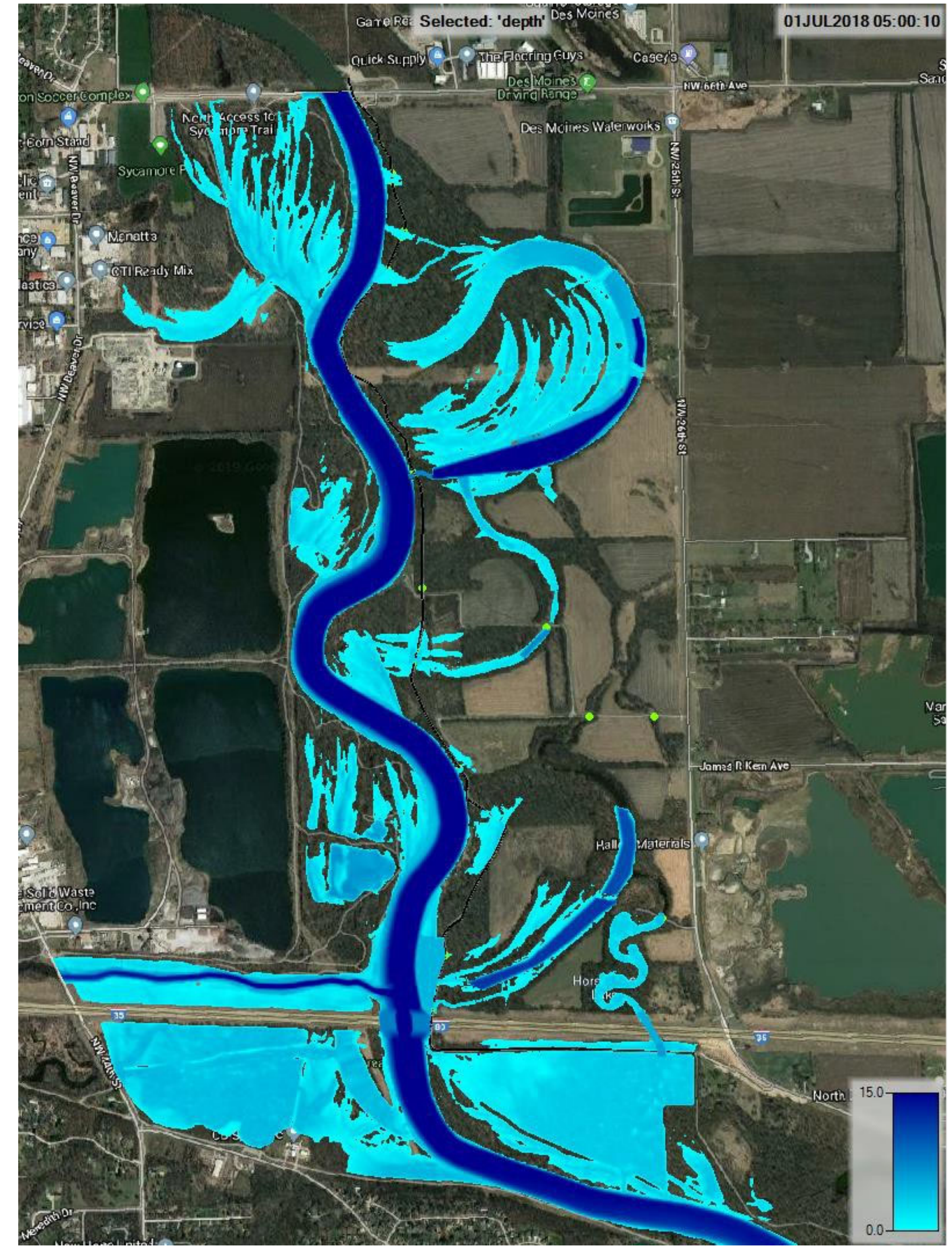

Figure A16: Selected plan 2D HEC-RAS inundation map July 1, 2018. Discharge at Saylorville tail water gage is approximately 22,000 cfs. Approximately 17.9 feet of water has accumulated in the deepest portion of the north oxbow and approximately 11.8 feet of water has accumulated in the deepest portion of the south oxbow. Depths are shown by the blue gradient in feet.

Hydraulic Modeling Next Steps

The hydraulic modeling discussed above is appropriate for planning purposes. The following is recommended to improve this work for the purpose of engineering design:

Complete land survey of the oxbow corridor: All elevations derived from LiDAR and approximate survey (as detailed above) should be verified with horizontally and vertically accurate land survey. Survey should include: top of road elevations for the Neal Smith trail, top and invert elevations for all culverts, top of road for culverts, centerlines for all three oxbows, a few cross sections of each oxbow, and a complete survey of the I-80 culvert just southeast of the south oxbow.

Other hydrologic processes: Rainfall, runoff, evapotranspiration, and groundwater recharge / discharge should all be investigated for their impacts on the oxbow corridor. Processes that are found to be significant should be incorporated into the 2D RAS model.

Computational refinement: The computational mesh and time step should both be tested for adequacy. The selected plan geometry runtime is fairly long and efforts could be made to improve this. Additionally, if 2D velocity output is required for design purposes, further refinement of the mesh will probably be required.

Comparison during a variety of flow records: Above, the existing condition and selected plan geometries were compared for 2018 flows. As this was a fairly wet year, it isn't very representative of the period of record. Years like 2011 or 2017 could be more appropriate for quantifying design benefits.

Separate modeling of features: Modeling dredge cuts and culvert alterations separately could improve understanding of the system and help justify each individual component.

Inclusion of stop log structures in selected plan case: Flap gates could be used to model holding back water once it enters the oxbows.

Conclusions

Overall, this 2D HEC-RAS and HEC-EFM modeling establishes a base understanding of how water tends to move through the Saylorville oxbow corridor and how altering the hydraulics would impact habitats of interest. Without a project, the north and south oxbows can be expected to fill at their downstream culverts at approximately 34% ACE. Lowering and increasing the diameter of the north oxbow's downstream culvert could increase frequency of loading to the north oxbow to approximately 91% ACE. Dredging throughout the corridor would increase inundation depths throughout, but may reduce total inundated area in the south oxbow. Further investigation of other hydrologic processes (rainfall, runoff, evapotranspiration, and groundwater) is needed to quantify long term retention of this water. Land survey and further model refinement would be needed to apply these results to engineering design.

References

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