TULE CANAL WETLAND CORRIDOR ENHANCEMENT FEASIBILITY STUDY

PHASE 1 REPORT

Prepared for
Reclamation District 108

Prepared by
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Conaway Ranch
ICF International

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GLOSSARY OF ACRONYMS

Acronym	Meaning
1D	One-Dimensional
2D	Two-Dimensional
AFP	Adult Fish Passage
BNP	Big Notch Project
Canal	Tule Canal
CDFW	California Department of Fish and Wildlife
cfs	Cubic Feet Per Second
CPG	Conaway Preservation Group
CVFED	Central Valley Floodplain Evaluation and Delineation
DEM	Digital Elevation Models
DWR	California Department of Water Resources
KLRC	Knights Landing Ridge Cut
LEBLS	Lower Elkhorn Basin Levee Setback
LiDAR	Light Detection and Ranging
Ranch	Conaway Ranch
WUA	Weighted Usable Area
WYT	Water Year Types
YBCS	Yolo Basin Cache Slough
YBSHRFPP	Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
YBWA	Yolo Bypass Wildlife Area

EXECUTIVE SUMMARY

This report examines the feasibility of modifying a four-mile section of the Tule Canal within Conaway Ranch to enhance salmon rearing habitat and other environmental values. This Phase 1 report evaluates three initial concepts reflecting various levels of landscape modification. All three concepts include reducing the capacity of the Tule Canal and degrading adjacent lands to create a more active floodplain. The concepts differ in terms of the future alignment of the Canal and the amount of agricultural land that would be converted to permanent habitat.

Feasibility study findings indicate that:

- It is feasible to increase floodplain activation and enhance salmon rearing habitat along the Tule Canal while protecting flood conveyance in the Yolo Bypass. The concepts evaluated need further refinement to reduce roughness and minimize upstream effects.
- Initial concept designs were effective at increasing floodplain activation while at the same time increasing agricultural productivity. The unintended consequence was reduced salmon rearing habitat outside the project area. Further design modifications may eliminate this issue, however, they may result in lower agricultural productivity.
- Realigning the Tule Canal to create a more natural water course is costly due to extensive earth work and does not produce significant environmental benefits compared to other options considered.
- The estimated cost to construct the project ranges from $29 million to $44 million, depending on the project size and design. Mitigation costs could add up to another $6.4 million.
- Estimates for long-term operation and maintenance costs range from $90,000 to $211,000 per year.
- Concept C, which has the largest area of permanent wetland habitat conversion, offers the greatest environmental benefits, and is the lowest cost alternative on a cost/acre basis.

Results from the initial phase of the feasibility study show benefits and costs vary by concept, with further refinement needed to identify a preferred approach. The next phase of the study (Phase 2) will examine a hybrid design that includes considerations from all three preliminary concepts, with further optimization to address each of the Project goals.

1 INTRODUCTION

1.1 BACKGROUND

This feasibility study (Study) focuses on a 4.3-mile reach of the Tule Canal (Canal) south of County Road 22 within the Yolo Bypass (Bypass) (Figure 1). The land encompassing the project area is owned by the Conaway Preservation Group (CPG) and is within Conaway Ranch (Ranch). The Ranch is an approximately 17,000-acre property and includes lands both inside and outside to the west of the Bypass, mostly within Reclamation District 2035. The Ranch produces primarily rice in addition to tomatoes, alfalfa, and other crops like safflower. The Ranch has a long history of environmental stewardship and contains habitat easements for giant garter snake, Swainson's hawk, and Tricolored blackbirds. A 4,000-acre agricultural easement on the east side of the Ranch exists to maintain current habitat-friendly agricultural practices and croplands. The proposed wetland and riparian project discussed in this report is within the agricultural easement.

The Canal was originally created as a borrow area for the construction of the east levee for the Bypass. It exists today as a drainage structure for agricultural lands on the Ranch and elsewhere in the Bypass, and water supply conveyance for lands to the south of the Ranch. These functions would continue following the implementation of a project. The current geometry of the Canal is designed to promote drainage, however, the Canal generally contains some water year-round as long as significant agricultural operations are active in the region. Flow in the Canal will be increased due to planned operations of the of the California Department of Water Resources (DWR) and US Bureau of Reclamation (USBR) Yolo Bypass Salmonid Habitat Restoration and Fish Passage (Big Notch) Project (BNP). Habitat in the Canal consists of channelized wetland, shallow aquatic habitat, invasive aquatic weeds, as well as riparian habitat.

Salmonids and other fish species access the Canal from the Bay Delta and the Sacramento River via Prospect Slough and continue up the Toe Drain which becomes the Canal (Figure 1). There is no permanent connection to the Sacramento River at Fremont Weir, however there are seasonal connections when 1) the Fremont Weir overtops sending excess floodwaters down the Bypass, 2) the Fremont Weir Adult Fish Passage Modification Project (AFP; construction completed summer 2018) is operated after an overtopping event, and 3) the BNP (gate construction completed summer 2024; operations planned beginning winter 2025/2026) is operated between November 1 and March 15 (with limited operations post March 15) to provide more frequent juvenile salmon access to inundated lands and adult passage through the Bypass.

The purpose of the Tule Canal Wetland Corridor Enhancement Project (Project) is to provide between 450 to 1000 acres of restored permanent and seasonal wetland habitat along on the Canal. The restored habitat is intended to regain a portion of the vast loss of similar habitats in the Sacramento Valley and help recover endangered and threatened species that rely on permanent and seasonal wetland habitats associated with the Sacramento River ecosystem. Suitable habitat is known to be a limiting factor for salmonids and endangered and threatened species such as the Giant Garter Snake and the Western Pond Turtle. The proposed Project location is connected to current riverine corridor systems leading to the Delta and would complement other restoration activities such as those being pursued in the Lower Elkhorn Basin Levee Setback (LEBLS) Project, which shares the eastern boundary with the project area.

1.2 PROJECT GOALS AND OBJECTIVES

The goal of the Project is to promote a more vibrant and diverse wetland and riparian habitat corridor by expanding the functional footprint of the Canal, while maintaining or improving the flood functions of the Bypass, agricultural production on adjacent lands, existing water supply (and drainage) functions in the Canal, water quality, fish passage, and recreational opportunities on adjacent agricultural lands. The Project is intended to benefit aquatic, terrestrial, and amphibian species, including threatened and endangered species such as Central Valley Chinook Salmon (*Oncorhynchus sp.)* and Steelhead, (*Oncorhynchus mykiss)*, Giant Garter Snake, Western Pond Turtle, Yellow Billed Cuckoo, Swainson's Hawk, and Tricolored Blackbird. All would benefit from expanded wetland and riparian habitats providing nesting and foraging habitat for bird species, seasonal salmon floodplain rearing habitat for salmonids, and permanent refugia for Giant Garter Snake and other amphibians.

Visioning for this Project has developed over time, much of which originated during a Tule Canal Charrette held in 2021, led by Yolo County and involving a variety of interested parties. Through the charrette process, the stakeholders imagined a transformed Canal as an integrated and multi-benefit corridor that engages people, sustains farmers, protects property, and provides diverse wildlife habitats. The Project goals and objectives were developed in alignment with the Yolo Bypass Cache Slough Partnership (Partnership) Pillars (ybcspartnership.org) to include flood conveyance, agriculture, habitat, water supply, water quality, and recreation, which helped guide development of the proposed concepts A financial goal was also added to check the financial viability of any proposed concept. To understand if the proposed concepts meet the objectives defined for the project, the performance of the concepts were assessed using evaluation criteria adapted from those developed through Floodplains Reimagined (RD 108, 2024).

The Project is also intended to complement ecosystem functions provided by nearby projects such as BNP, LEBLS, and downstream projects such as Prospect Island, Liberty Island Conservation Bank, North Delta Fish Conservation Bank, Yolo Flyway Farms Tidal Restoration Project, and Lower Yolo Ranch Tidal Restoration Project (Figure 1).

Project goals and objectives are discussed in more detail in Appendix A. This appendix also includes the modeling approach, evaluation criteria, and metrics detailing how concept plans are evaluated against the Project goals and objectives (Appendix A, Table 1).

1.3 OUTREACH SUMMARY

To communicate and disseminate information regarding the Project to interested parties, a website was built to house relevant background and project information (www.tcenhancement.com). A virtual informational meeting was initially held in May 2023 to kickoff the feasibility study. More information on this meeting and other outreach completed, including information dissemination to neighboring landowners, stakeholders and interested parties, for this Project is summarized in Appendix B. The Project team also engaged with the Partnership to provide periodic updates and solicit feedback on the feasibility study in March 2024 and May 2025.

2 EXISTING CONDITIONS

2.1 SETTING

The Bypass is part of the Sacramento River Flood Control Project (SRFCP), which includes levees, weirs, and Bypass infrastructure that help manage the historic flooding in the Sacramento Valley (DWR, 2010). The Yolo Bypass covers approximately 59,000-acres and can convey a design flow of 343,000 cubic feet per second (cfs) over Fremont Weir, which is about 80 percent of the floodwaters in this region (DWR, 2010). Flows enter the Yolo Bypass through Fremont Weir, which is on the Sacramento River just upstream of the confluence with the Feather River, and an additional 112,000 cfs enter over the Sacramento Weir, which is on the Sacramento River just upstream of the confluence with the American River (Figure 1). The water that enters the Yolo Bypass helps protect the cities of Sacramento and West Sacramento from flood flows on the Sacramento River system. Water flows through the Yolo Bypass and into the Cache Slough complex, then joins the Sacramento River just north of Rio Vista. (DWR, 2019)

2.2 LAND USES IN THE YOLO BYPASS

Land use in the Yolo Bypass (between Fremont Weir and the Liberty Island Stair Step [Figure 1]) is approximately 51% agriculture, 24% managed wetlands, and 6% tidally inundated, with the balance consisting of open water and naturalized areas consisting of seasonal wetland and riparian woodland/scrub habitats. Agriculture mostly consists of rice but also includes key crops like alfalfa, corn, sunflowers, and tomatoes. Managed wetlands are predominately managed under various conservation easements to maintain inundation during the winter to support more suitable habitat conditions for waterfowl and associated habitats which supports recreational hunting. A large proportion of the lands in the downstream end of the Yolo Bypass are subject to tidal activity due to restoration projects at Yolo Flyway Farms (constructed 2018) and Lower Yolo Ranch (constructed 2020) and breaching of Liberty Island in 1997 and Little Holland Tract in 1983. Additionally, about 30% of the Yolo Bypass area is open for waterfowl, dove, pheasant, turkey, and deer hunting. Waterfowl hunting composes the majority of hunting opportunities, mostly on private winter flooded rice and public/private managed wetlands.

In this feasibility study, land use throughout the Bypass was categorized from a variety of sources including farm plans of Conaway Ranch (Figure 2 and Figure 3), Conservation Easements owned and operated either privately or publicly by California Department of Fish and Wildlife (CDFW) or the United States Fish and Wildlife Service (USFWS), among others, crop mapping data (DWR), YBWA land use and management data provided by DWR and CDFW. The frequency of field unit utilization between 2013-2023 was also analyzed (Figure 2), which subsequently informed the concept footprints. Higher resolution vegetation data, collected by ICF (Section 2.7.1) was used to fill in the remainder from the Vegetation Classification and Mapping Program and was combined with available high resolution satellite data (CDFW, 2018) (Figure

4). Additionally, a field's potential to be open to waterfowl hunting was determined based on landowner feedback as well as the presence of duck blinds in aerial imagery.

2.3 FARMING OPERATIONS AT CONAWAY RANCH

Conaway Ranch is a 17,000 acre commercial farm, with approximately 6,800 acres in the Yolo Bypass that are cultivated primarily in rice. Farming operations on the Ranch are primarily conducted under lease arrangements to over 40 farmers. The mission of CPG which owns and operates the Ranch is to preserve and operate Conaway Ranch for commercial agriculture, water asset management, and wildlife habitat in an economically sustainable and socially responsible manner.

Water supply and drainage are critical supporting the agricultural use of the Ranch as well as wildlife and hunting. The Tule Canal is a critical drainage component for farming operations. Flows in the Tule Canal, and the associated water surface elevations (WSE) have a significant impact on flooding, particularly for farm fields adjacent to the Tule Canal. If the WSE of the Tule Canal is high, water backs up into the drainage canals on the Ranch and inundates farm fields, which impacts the ability of farmers to access the fields and prepare them for planting,

Farming operations typically begin in March and April with field preparations. When fields are sufficiently dry enough to allow machinery on the field, the field is "opened up" with a plow which helps speed up the drying process. If fields are dry enough to begin seedbed preparation (plowing, disking, leveling, fertilizer applications), planting can begin in late April and early May. A dry spring can make these operations proceed faster while rain or flooding events in March and April can significantly delay or preclude planting. Typically, if fields are not dry enough to access with equipment by April 15, they are fallowed for the season.

Farm fields in the Project area may be fallowed either due to late season flooding, water curtailments, or for rotational purposes. The Ranch maintains farm insurance to mitigate for losses due to natural flooding.

2.3.1 ECONOMIC CONSIDERATIONS

Any existing farm fields that are converted to permanent habitat would represent a loss of farming related revenue. The economic value of such losses would depend on a host of factors including the cost of cultivation, the commodity price of rice and other crops typically grown in the Project area and the frequency of planting under current conditions.

Fields permanently removed from agricultural production could require mitigation under Yolo County's Agricultural Conversion and Mitigation Ordinance (Sec 8-2.404). Under the ordinance, converted agricultural lands need to be replaced at a 1:1 ratio. Because the project is larger than 20 acres, it is not eligible for the County's In-Lieu Agricultural Mitigation Fee payment.

In addition to fields converted to habitat, adjacent fields may be impacted, either by more frequent flooding, which would further reduce economic returns, or by improved drainage which could result in increased production and higher returns. In addition to agriculture, lands at Conaway Ranch are used for private waterfowl hunting generating annual fee payments to CPG. CPG owns numerous waterfowl blinds on the Ranch used for these hunting activities.

2.3.2 LONG-TERM OPERATIONS AND MAINTENANCE

If existing agricultural lands are converted to permanent habitat, there would be other operational and cost considerations, primarily in terms of long-term operations and maintenance. Operations and maintenance activities would be required to manage and maintain any habitat lands at Conaway Ranch. Activities would likely include mowing, clearing ditches and drainage structures and maintaining the Tule Canal itself to provide for adequate drainage and prevent any potential obstructions to upstream fish passage. Management of invasive species (terrestrial and aquatic) would also likely be needed as a part of ongoing operations.

2.3.3 GAS INFRASTRUCTURE

There are five idle dry-gas wells on the Ranch along with 50 plugged wells. California Resource Production Corporation operates all five idle wells. Two of these idle wells (API 0411321180 and 0411321126) are located within the planning area and grading within a 100 ft buffer should be avoided to minimize exposure to costly California Geologic Energy Management Division (CalGEM) re-abandonment standards (Figure 3).

2.4 TOPOGRAPHY

In 2008, DWR collected LiDAR throughout the California central valley as part of the Central Valley Floodplain Evaluation and Delineation (CVFED) program. This is the base topography used for the majority of the analysis, but only some portions of the Project area. Some regions of this surface, including the densely vegetated riparian corridor along portions of Tule Canal in the Project extent, are not well represented because of thick vegetation or surface water resulting in poor LiDAR returns. To correct for this, additional topographic surveys were conducted by cbec within the riparian corridor of the Tule Canal in the Project extent to accurately document existing topography.

In 2010, single beam bathymetric surveys were performed by cbec to capture the bathymetry of the Canal. As part of this study, supplemental multibeam and single beam surveys were performed by cbec in January and November 2023 to provide updated Canal bathymetry in and near the Project area between County Road 22 and Interstate 80.

The final topographic surface, or digital elevation model (DEM), was a compilation of these data sources prioritizing the more recent cbec surveys. Further information on the surveys and surface can be found in Appendix C and Appendix D.

2.5 HYDROLOGY AND HYDRAULICS

To inform the hydraulic performance of the concepts, three hydraulic modeling tools were used. These included 1) reach-scale low flow modeling in the vicinity of Conaway Ranch via a one-dimensional (1D) HEC-RAS model, 2) system-wide flood flow modeling via the Yolo Bypass Cache Slough Master Plan combined 1D/2D HEC-RAS model, and 3) long-term Yolo Bypass-wide modeling via a combined 1D/2D TUFLOW model.

2.5.1 REACH SCALE LOW FLOW MODELING

To perform low flow conveyance calculations specifically catered towards the Conaway Ranch reach of the Tule Canal, a 1D HEC-RAS model was used (Appendix E). This model was used to prescreen preliminary concept designs and to identify channel geometries that met the projects conveyance needs.

2.5.2 SYSTEM WIDE FLOOD FLOW MODELING

Additionally, a large model developed to support the Yolo Bypass Cache Slough Master Plan (Master Plan) was used to determine hydraulic impacts of the concepts during larger floods. This model encompasses parts of Butte County on the north end, and extents south to the border of San Joaquin County and is aimed to guide project planning and implementation in the region. Several scenarios were simulated in this model for the 100-year flood event. The Baseline used in the Master Plan model included Sacramento Weir Widening but not LEBLS, the Fremont Weir BNP or AFP projects. The Master Plan model also includes "Master Plan Scenario 1", which included a culmination of regional potential future projects like LEBLS, Fremont Weir BNP and AFP, Little Egbert Tract, Upper Elkhorn Basin Expansion, and Fremont Weir Expansion, among others. More information on the development of this model can be found in Appendix F.

2.5.3 YOLO BYPASS LONG-TERM CONDITION MODELING

For long-term simulations, the recently updated 1D/2D TUFLOW model of the Yolo Bypass was used, which simulates the Yolo Bypass from Nelson Weir in the lower Sutter Bypass, down to Rio Vista, from October 2 to June 30 of water years 1997 to 2017, on a varying 55 to 220 ft cell grid (DWR, 2017a 2017b and 2021). The simulated water years span a wide range of hydrologic conditions in the Bypass, including six wet years (with 1997 representative of a 100-year flood) and three critically dry years, based on the Sacramento Valley Water Year Index (DWR, 2024). Prior to the current feasibility study being performed, the Baseline scenario (Existing Conditions) of this TUFLOW model was updated to include some features that were not constructed in the Bypass yet but planned to be built in the future. These include LEBLS, Sacramento Weir Widening, and the Fremont Weir AFP project. For this feasibility study the BNP was added to the Baseline scenario to reflect near-term changes in the hydrologic regime of the Yolo Bypass, which can allow up to an additional 6,000 cfs into the Tule Canal from the Sacramento River between November 1 to March 15 of each year. BNP implementation includes operable gates in Fremont Weir and associated transport channels (constructed 2024), alterations to Agricultural Crossing #1 (not yet constructed as of the date of this study), and improvements to the Tule Canal upstream of Agricultural Crossing #1 near Tule Pond (not yet constructed as of the date of this study).

The TUFLOW model topography was updated in this study to include the January 2023 bathymetric data of Tule Canal in the vicinity of Conaway Ranch. Due to this, the model calibration was replicated with the same calibration events as the most recent DWR study (DWR, 2021). This included a low flow event from 2010, a medium flow event from 2011, and wet extent comparisons to imagery from April 2011. To align water surface elevations with gage data and previous modeling efforts, the Manning's n roughness values in the Tule Canal were increased from 0.042 to 0.05 from Ag Crossing #1 to Country Road 22, and from 0.035 to 0.045 from Country Road 22 to Highway I-80.

2.6 GEOLOGY AND SOILS

Planning-level geotechnical recommendations for this Project provided by Blackburn Consulting, are included in Appendix G. Based on the review of available reports, maps, and two site visits, this memorandum includes information on existing geological and soil conditions, and design and construction considerations including ground preparation, fill and compaction, cut/fill slopes, cut-to-fill volumes changes, settlement, soil moisture, and groundwater impacts.

The soils found within the project are Holocene Basin Deposits heavy in clay and silt (Table 1 in Appendix G). Vegetation removal and stripping up to two feet will likely be needed prior to site grading. Improvements to the existing canal will require over excavation to remove soft, unstable soil and vegetation. It is recommended that cut/fill slopes up to 10-ft tall should not exceed 3:1 within the Project. When soil is excavated and compacted for fill, the volume of cut soil to be used as fill will decrease and the amount of decrease can be estimated based on soil types and assumed in-situ densities. Volumes changes of cut-to-fill were generally estimated to decrease between 25-50% in the Canal and 5-10% in the wetlands, with an additional 5-10% decrease throughout.

2.7 BIOLOGICAL RESOURCES

2.7.1 VEGETATION AND WETLANDS

Twelve land cover types were identified in the project area based on the desktop evaluation. Some of the land cover types were identified in accordance with the *Manual of California Vegetation*, online edition (California Native Plant Society 2023). An overview of the land cover types can be seen in Figure 5 and a description of each land cover type can be found in Appendix H. The land cover types include the following types and estimated acreages (Table 1). Additional information on land cover types in the project area is provided in Appendix H.

There are an estimated 58.39 acres of wetlands and waters in the project area (Table 1). The open water land cover type (26.68 acres) consists of the Tule Canal. The Ludwigia land cover type (18.60 acres) is found on the edges of the Tule Canal and is characterized by aquatic, rhizomatous herbaceous hydrophytes. Floating primrose-willow (*Ludwigia peploides*) creates dense mats through its rhizomes and is primarily a monoculture in the Tule Canal's aquatic areas. Water fern (*Azolla filiculoides*) is co-dominant. No site visits were conducted as part of the desktop evaluation; thus wetlands are categorized broadly and may include ephemeral and intermittent drainages, seasonal wetlands, and vernal pools.

There are an estimated 81.94 acres of riparian land cover types in the project area (Table 1). Riparian land cover types are presumed to include Fremont cottonwood woodland, willow-dominated riparian habitat, and willow scrub. Most of the riparian land cover types are located on the west bank of Tule Canal. The Fremont cottonwood woodland landcover type in the project area is composed of a pronounced tree layer with an infrequently developed shrub stratum. The dominant trees likely include Fremont cottonwood (*Populus fremontii*), red willow (*Salix laevigata*), and Oregon ash (*Fraxinus latifolia*). The riparian land cover type is located along the Tule Canal and has a semi-open to continuous canopy. The dominant tree layer likely includes red willow (*Salix laevigata*), Gooding's willow (*Salix gooddingii*), and sparse individuals of California sycamore (*Platanus racemosa*) and box elder (*Acer negundo*). The willow scrub community found in the project area is like the riparian land cover type but differs by not having tree canopies and is in an intermediate stage between small trees and mature trees.

Table 1. Land Cover Types in the Project Footprint

<table>
<tr><th>Category</th><th>Land Cover Type</th><th>Acreage</th><th>Acreage by Category</th></tr>
<tr><td rowspan="5">Wetlands and waters</td><td>Ditch</td><td>0.22</td><td rowspan="5">58.39</td></tr>
<tr><td>Emergent vegetation</td><td>1.12</td></tr>
<tr><td>Ludwigia (Water Primrose Wetlands Herbaceous Semi-Natural Alliance)</td><td>18.60</td></tr>
<tr><td>Open Water</td><td>26.68</td></tr>
<tr><td>Wetland</td><td>11.77</td></tr>
<tr><td rowspan="3">Riparian</td><td>Fremont cottonwood woodland (Fremont Cottonwood Forest and Woodland Alliance)</td><td>45.63</td><td rowspan="3">81.94</td></tr>
<tr><td>Riparian (Goodding's Willow - Red Willow Riparian Woodland and Forest)</td><td>29.72</td></tr>
<tr><td>Willow Scrub</td><td>6.59</td></tr>
<tr><td>Agricultural land</td><td>Agricultural land</td><td>114.45</td><td>114.45</td></tr>
<tr><td rowspan="3">Upland</td><td>Annual grassland (Wild Oats and Annual Brome Grasslands Alliance)</td><td>19.51</td><td rowspan="3">56.24</td></tr>
<tr><td>Herbaceous vegetation (Upland Mustards Herbaceous Semi-Natural Alliance)</td><td>0.98</td></tr>
<tr><td>Ruderal</td><td>35.75</td></tr>
<tr><td>Developed</td><td>Developed</td><td>0.97</td><td>0.97</td></tr>
</table>

There are an estimated 56.24 acres of upland land cover types in the project area (Table 1, Figure 5). Upland land cover types are presumed to include annual grassland, herbaceous vegetation and ruderal. The annual grasslands likely consist of both annual and perennial grass species and are often seen as a secondary layer under Fremont Cottonwood Woodland and Riparian land cover types. The majority of the annual grasslands on-site are likely dominated by opportunistic non-native grasses such as wild oats (*Avena* spp.), rip gut brome (*Bromus diandrus*), and soft chess brome (*Bromus hordeaceus*). Select forbs are also like to be present. Separate from annual grassland, herbaceous vegetation can be found along disturbed roadsides and less commonly underneath trees and woodland canopies. Herbaceous vegetation differs from annual grassland by having a larger percentage of its relative cover being herbs or forbs. The ruderal landcover type is an intermediate between disturbed and herbaceous vegetation. The ruderal areas can be found adjacent to the Tule Canal largely along the Yolo Bypass east levee slope and the very southern portion of the project area.

There are approximately 114.45 acres of agricultural lands in the project area (Table 1, Figure 5). These fields are designated as tenant organic rice and fallow fields. The agricultural lands are located on the west side of Tule Canal adjacent to other agricultural lands that make up the Conaway Ranch property.

The developed land cover type is only found in the northernmost portion of the project area and includes the footprint under the I-5 causeway(Figure 5 in Appendix H). The I-5 causeway is devoid of vegetation; however, the area under the causeway is likely composed of annual grassland west of the Tule Canal and riparian habitat east of the Tule Canal.

2.7.2 FISH

Aquatic habitats in the Yolo Bypass include stream and slough channels for fish migration and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al., 2001a; CALFED Bay-Delta Program, 2000a and 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al., 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al., 2001a and 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al., 2001b). Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento splittail. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al., 2003).

In addition to providing important fish habitat, winter and spring inundation of the Yolo Bypass is a significant source of phytoplankton, zooplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al., 2004; Lehman et al., 2008).

Tule Canal in the project area is a low velocity waterway surrounded by agricultural fields with associated drainage ditches that connect with Tule Canal. Vegetation along the canal is primarily ruderal grasslands with riparian vegetation consisting of Fremont cottonwood woodland. In the Project area, Fremont cottonwood woodland is the dominant natural land cover type, especially along the west bank of Tule

Canal, while ruderal grassland is the second most dominant cover type and is found primarily along the east bank of Tule Canal. Riparian vegetation is important in controlling stream bank erosion, contributing to instream structural diversity, maintaining undercut banks in the absence of rock revetment, and providing canopy cover and shade.

Eleven special-status fish species were determined to have the potential to occur in Tule Canal or adjacent to the project area based on a review of the literature; the CNDDB search results; the NMFS and USFWS lists of endangered, threatened, and proposed species that could occur in the project area; and data collected on the toe drain and Tule Canal by DWR from 1998–2020 (Table A-2 in Appendix H). The life history for each of the 11 species with potential to occur in the project area are discussed in Appendix H. The potential for occurrence information for each of the 11 species with potential to occur in the Project area are discussed below.

Green sturgeon are anadromous, making extensive oceanic migrations and coming into freshwater rivers only to spawn. In the Sacramento River watershed, green sturgeon spawn in the Sacramento River and possibly the Feather and Yuba rivers. Green sturgeon is present in the Yolo Bypass when flows are high in the spring and winter during flooding events (U.S. Bureau of Reclamation, 2018). They can occur in the Yolo Bypass and Tule Canal during their upstream (adult) and downstream (adult, juvenile) migrations; therefore, there is a high potential for green sturgeon to occur in the project area. They have not been captured in the DWR surveys of the Toe Drain and Tule Canal (Interagency Ecological Program, 2022); however, there are CNDDB records of occurrences for the Toe Drain and Tule Canal (California Department of Fish and Wildlife, 2023).

The Central Valley population of white sturgeon spawns mainly in the Sacramento and Feather Rivers, with occasional spawning in the San Joaquin River (Moyle, 2002; Heublein et al., 2017). White sturgeon use the Toe Drain and Tule Canal for migration when the Sacramento River is not flooding (National Marine Fisheries Service, 2009) and also when the Yolo Bypass is flooded. A total of 1,044 white sturgeon have been captured during DWR surveys. White sturgeon have been captured in the DWR studies from January through May, while one was captured in August and one in December. Most white sturgeon were captured in February through April (Interagency Ecological Program, 2022). There is a high potential for white sturgeon to occur in the project area.

Steelhead occur in many Central Valley streams and rivers below impassable barriers that support well-oxygenated, cool, riverine habitat year-round. Steelhead use the Tule Canal for migration when there is no flooding from the Sacramento River (Harrell and Sommer, 2003; Sommer et al., 2014) and are known to enter the Yolo Bypass when flooding occurs. A total of 119 steelhead have been captured during DWR surveys of the Toe Drain/Tule Canal. They have been captured during the DWR surveys from October through June, with highest numbers in March (Interagency Ecological Program, 2022); therefore, there is a high potential for steelhead to occur in the project area.

Central Valley spring-run Chinook salmon occur in the Sacramento River and its tributaries, including Antelope, Battle, Big Chico, Butte, Clear, Cottonwood, Deer, and Mill Creeks, and the Yuba River (National Marine Fisheries Service, 2016). Adult spring-run Chinook salmon can stray into the Toe Drain/Tule Canal during their upstream migration from March to early October, even when there is no flooding from the Sacramento River (National Marine Fisheries Service, 2009 and 2019:83). Juvenile spring-run Chinook salmon have access to floodplain habitat in the Yolo Bypass only during mid- to high water years when the Fremont Weir is spilling and could be present in the Yolo Bypass and Tule Canal through May, based on rotary screw trap sampling in the Sacramento River at Knights Landing upstream of the Fremont Weir (National Marine Fisheries Service, 2019:83). There is a high potential for spring-run Chinook salmon to occur in the project area.

Sacramento River winter-run Chinook salmon occurs in the mainstem of the upper Sacramento River below Keswick Reservoir, and in Battle Creek where they have been recently re-introduced. Like adult spring-run Chinook salmon, adult winter-run Chinook salmon can stray into the Toe Drain/Tule Canal during their upstream migration from November through July when there is no flooding from the Sacramento River (National Marine Fisheries Service, 2009, 2019:67 and 2021). Juvenile winter-run Chinook salmon have access to floodplain habitat in the Yolo Bypass only during mid- to high water years when the Fremont Weir is spilling and could be present in the Yolo Bypass and Tule Canal through March, based on rotary screw trap sampling in the Sacramento River at Knights Landing upstream of the Fremont Weir (National Marine Fisheries Service, 2019:67). There is a high potential for winter-run Chinook salmon to occur in the project area.

Fall-run Chinook salmon occur in Central Valley streams and rivers below impassable barriers that support well-oxygenated, cool, riverine habitat. Late fall–run Chinook salmon currently spawn almost exclusively in the upper Sacramento River from Keswick Dam to the Anderson-Cottonwood Irrigation District Dam. Fall and late fall-run Chinook salmon use the Toe Drain/Tule Canal for migration when there is no flooding from the Sacramento River (National Marine Fisheries Service, 2009) and also when the Yolo Bypass is flooded. Based on rotary screw trap sampling in the Sacramento River at Knights Landing upstream of the Fremont Weir, fall-run and late fall–run Chinook salmon could be present in the Yolo Bypass and Tule Canal from January through April and from April to June/September through January, respectively (National Marine Fisheries Service, 2019:67). There is a high potential for fall- and late fall–run Chinook salmon to occur in the project area.

Pacific lamprey occur in the rivers of the Central Valley below impassable dams (Moyle et al., 2015). A total of 501 Pacific lamprey have been captured during DWR surveys. Pacific lamprey use the Toe Drain and Tule Canal for migration and were captured from December to April, with most lamprey caught in January and February (Interagency Ecological Program, 2022). Pacific lamprey is most likely to use the Yolo Bypass when flows are high and flooding. There is a high potential for Pacific lamprey to occur in the project area.

Western river lamprey occur in tributaries of the Sacramento and San Joaquin rivers (Moyle et al., 2015). A total of 126 river lamprey have been captured during DWR surveys. They use the Toe Drain and Tule Canal for migration and were captured from December to April, with most lamprey caught in January and February (Interagency Ecological Program, 2022). Like Pacific lamprey, western river lamprey is likely to use the Yolo Bypass when flows are high and flooding. There is a high potential for western river lamprey to occur in the project area.

Sacramento splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al., 1997 and 2008), and typically migrate upstream from brackish areas and spawn in fresh water, particularly on inundated floodplains when they are available, in March and April (Sommer et al., 1997; Moyle et al., 2004; Sommer et al., 2008). A total of 73,083 Sacramento splittail have been captured during DWR surveys. Sacramento splittail occur in the Toe Drain and Tule Canal during all months of the year—regardless of flooding—with the highest numbers present from January to June, with May having the highest numbers (Interagency Ecological Program, 2022). Lowest numbers (less than 30) occur from August to November. They use the Yolo Bypass for spawning and rearing. There is high potential for Sacramento splittail to occur in the project area.

Hardhead are a large cyprinid (minnow) and are widely distributed in low- to mid-elevation streams (to an elevation of approximately 5,000 feet) in the Sacramento-San Joaquin drainage from the Kern River in the south to the Pit River in the north. A total of 28 hardhead have been captured during DWR surveys. Small numbers (maximum of 6 for entire IEP study) of hardhead occur in the Toe Drain and Tule Canal during most months of the year except for March, July and August. They use the Yolo Bypass for rearing. There is a high potential for hardhead to occur in the project area.

Sacramento hitch have scattered populations throughout the Central Valley from the Tulare Lake basin in the south to Shasta Reservoir in the north (Moyle 2002). They occur in warm, low-elevation lakes, sloughs, and slow-moving stretches of rivers and in clear, low-gradient streams. They have the highest temperature tolerance among fishes native to the Central Valley, which allows them to survive in low numbers in channelized streams with silty bottoms and turbid water (Moyle 2002). A total of 445 hitch have been captured during DWR surveys. Sacramento hitch were captured during all months of the year with the highest numbers in June and July (Interagency Ecological Program 2022). This indicates they are using the Toe Drain and Tule Canal during all times of the year and when the bypass is not flooded.

2.7.3 WILDLIFE

Nineteen special-status wildlife species were identified from review of the California Natural Diversity Database (CNDDB) record search and U.S. Fish and Wildlife Service (USFWS) species list (Table A-2 in Appendix H). Twelve of the 19 species were determined to have the potential to occur in the Project area based on the review of existing information. Two species, white-tailed kite and western red bat, were not identified during the review but have the potential to occur in the project area due to the presence of Fremont cottonwood forest and riparian habitat. If a species was determined to have a low or no potential to occur in the Project area it was excluded from further analysis. The life history for each of the 14 species with potential to occur in the project area are discussed in Appendix H. The potential for occurrence information for each of the 14 species with potential to occur in the project area are discussed below.

Vernal pool fairy shrimp (*Branchinecta lynchi*) and vernal pool tadpole shrimp (*Lepidurus packardi*) have a low to moderate potential to occur in the project area. Annual grasslands in the project area may contain seasonal wetlands that provide suitable habitat for these species.

Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is found only in association with its host plant, elderberry (*Sambucus* spp.), which is commonly present in riparian forests and adjacent grasslands in the Central Valley (Barr, 1991:4–5). Elderberry shrubs can also be present in non-riparian valley oak (*Quercus lobata*) and blue oak (*Quercus douglasii*) woodland habitats (U.S. Fish and Wildlife Service, 2017). There is moderate to high potential for valley elderberry longhorn beetle to occur in the project area. Suitable habitat (elderberry shrubs) may be present in the project area. There are two CNDDB records for occurrences of valley elderberry longhorn beetle within approximately 1 mile of the project area (California Department of Fish and Wildlife, 2023).

Migratory and breeding habitat for monarch butterfly (*Danaus plexippus*) habitat contains milkweeds (*Asclepia*s spp.), nectar sources, and roosting structures. The potential for monarch butterfly to occur in the project area is low to moderate. Milkweed plants may be present in the project area and butterflies could migrate through or forage in the project area. There are no CNDDB records for occurrences of monarch butterfly within 5 miles of the project area (California Department of Fish and Wildlife 2023).

Aquatic habitats used by northwestern pond turtle (*Actinemys marmorata*) include ponds, lakes, marshes, rivers, streams, and irrigation ditches with a muddy or rocky bottom in grassland, woodland, and open forest areas (Stebbins, 2003:250). Northwestern pond turtle has a high potential to occur in the project area. Tule Canal provides suitable aquatic habitat and adjacent annual grassland and ruderal areas may provide suitable upland habitat. There is one CNDDB record for a northwestern pond turtle occurrence within 500 feet of the project area.

Giant garter snake (*Thamnophis gigas*) inhabits marshes, ponds, sloughs, small lakes, low-gradient streams and other waterways, and agricultural wetlands, including irrigation and drainage canals, rice fields, and the adjacent uplands (U.S. Fish and Wildlife Service, 2006:3). Suitable giant garter snake aquatic habitat consists of slow-moving or static water that is present from March through November with a mud substrate and the presence of prey (amphibians or fish) (U.S. Fish and Wildlife Service, 2017.I-3). Emergent and bankside vegetation that provides cover from predators and for thermoregulation are also required. There is high potential for giant garter snake to occur in the project area. Tule Canal provides suitable aquatic habitat in the project area. There is one CNDDB record for a giant garter snake occurrence in the project area and numerous additional records for occurrences surrounding the project area.

Swainson’s hawks (*Buteo swainsoni*) arrive in the Central Valley in March or April to establish nesting territories and breed (California Department of Fish and Wildlife, 2016:5). They usually nest in large, mature trees. Most nest sites (87%) in the Central Valley are found in riparian habitats (Estep, 1989:35), primarily because trees are more available there. Swainson’s hawk also nests in mature roadside trees and in isolated trees in agricultural fields or pastures. Swainson’s hawk have a high potential to occur in the project area. The Fremont cottonwood forest and riparian habitat in the project area provide suitable nesting habitat for Swainson’s hawk. The annual grassland, ruderal, and disturbed areas in the project area provide potential foraging habitat for this species. The are three CNDDB records for nest sites in the project area and numerous additional records for Swainson’s hawk nests in the vicinity of the project area (California Department of Fish and Wildlife, 2023).

White-tailed kite nests in trees or shrubs in open grassland, agricultural, wetland, oak woodland, and savanna habitats (Dunk, 2020). Habitat elements that influence nest site selection and nesting distribution include habitat structure (usually trees with a dense canopy) and prey abundance and availability (primarily the association with California vole, Microtus californicus), while the association with specific vegetation types (e.g., riparian, oak woodland, etc.) appears less important (Erichsen et al., 1996:165, 173; Dunk, 2020). White-tailed kite have a high potential to occur in the project area. The Fremont cottonwood forest and riparian habitat in the project area provide suitable nesting habitat for white-tailed kite. The annual grassland, ruderal, and disturbed areas in the project area provide potential foraging habitat for this species. There are no CNDDB records for occurrences of white-tailed kite nests within 5 miles of the project area (California Department of Fish and Wildlife, 2023).

Mountain plover (*Charadrius montanus*) nests outside of California in dry grasslands and shrub-steppe tablelands (Andres and Stone, 2009:10). Nonbreeding, winter habitat for mountain plover consists of grasslands, agricultural pastures and fields, and open sagebrush areas (California Department of Fish and Game, 2008; Andres and Stone, 2009:12). In the Central Valley, the species is found on short grasslands and plowed fields. The potential for mountain plover to occur in the project area is low to moderate. Mountain plovers could forage in the open areas of the project area. There is one CNDDB record for a mountain plover occurrence within 5 miles of the project area, but the occurrence is possibly extirpated (California Department of Fish and Wildlife, 2023).

Western burrowing owl (*Athene cunicularia hypogea*) occurs primarily in grassland habitats but may also occur in landscapes that are highly altered by human activity. Suitable habitat must contain burrows and relatively short vegetation with minimal amounts of shrubs or taller vegetation. Western burrowing owl may also occur in agricultural areas along roads, canals, ditches, and drains. There is a low to moderate potential for western burrowing owl to occur in the project area. Annual grassland, ruderal, and disturbed areas may provide suitable habitat in the project area. There are two CNDDB records for occurrences of western burrowing owl approximately 4 miles southwest of the project area (California Department of Fish and Wildlife, 2023).

Suitable tricolored blackbird (*Agelaius tricolor*) breeding colony sites have open, accessible water; a protected nesting substrate, including either flooded, thorny, or spiny vegetation; and a suitable foraging space providing adequate insect prey within a few miles of the nesting colony. Tricolored blackbird breeding colonies occur in freshwater marshes dominated by tules and cattails, in Himalayan blackberry (*Rubus armeniacus*), and in silage and grain fields (Beedy and Hamilton, 1997:3–4). Tricolored blackbird has a moderate potential to occur in the project area. Suitable nesting habitat may be present in the project area and tricolored blackbirds could forage in the grassland, ruderal, and disturbed areas in the project area. There are four CNDDB records for occurrences of tricolored blackbirds within 4 to 5 miles of the project area (California Department of Fish and Wildlife, 2023).

Song sparrow (*Melospiza melodia*) is associated with freshwater marsh that is dominated by tules and cattails, as well as riparian willow thickets. The species may also nest in valley oak riparian forests with blackberry understory, along vegetated irrigation canals and levees, and in recently planted oak restoration sites. There is a moderate potential for song sparrow to occur in the project area. Suitable nesting and foraging habitat are likely present in the project area. There is one CNDDB record for an occurrence of song sparrow approximately 5 miles north of the project area (California Department of Fish and Wildlife, 2023).

Hoary bats (*Lasiurus cinereus*) occur throughout California but are thought to have a patchy distribution in the southeastern deserts (Zeiner et al., 1990a:62). They occur primarily in forested habitats, including riparian forests. Woodlands with medium to large trees with dense foliage provide suitable maternity roost sites (Zeiner et al. 1990b:62). Hoary bat have a moderate to high potential to occur in the project area. Trees in the project area likely provide suitable roosting habitat and the canal and adjacent open areas provide suitable foraging habitat. There is one CNDDB record for a hoary bat occurrence approximately 5 miles southeast of the project area (California Department of Fish and Wildlife, 2023).

Western red bat is found throughout much of California at lower elevations, primarily in riparian and wooded habitats but also occurs seasonally in urban areas (Brown and Pierson, 1996). Western red bats roost in the foliage of trees that are often located on the edge of habitats adjacent to streams, fields, or urban areas. This species appears to be associated with intact riparian habitat (particularly willows, cottonwoods, and sycamores [*Platanus* spp.]) (Pierson et al., 2006:14; Western Bat Working Group, 2017). Western red bat have a moderate to high potential to occur in the project area. Trees in the project area likely provide suitable roosting habitat and the canal and adjacent open areas provide suitable foraging habitat. There are no CNDDB records for occurrences of western red bat within 5 miles of the project area (California Department of Fish and Wildlife, 2023).

The Fremont cottonwood woodland, riparian, annual grassland, willow scrub, wetland, emergent vegetation, herbaceous vegetation, ruderal, and disturbed land cover types in the project area provide suitable nesting habitat for migratory birds. Migratory birds could nest in ground vegetation, shrubs, or trees in these land cover types. Riparian forest provides nesting habitat for numerous migratory birds. Raptors, herons, and egrets nest in the upper forest canopy. A variety of songbirds use the shrub canopy, and cavity-nesting birds, such as Nuttall's woodpecker (Picoides nuttalcii), and oak titmouse (Baeolophus inornatus), occupy dying trees and snags (Zeiner et al., 1990b:388, 472).

2.8 CULTURAL RESOURCES

A records search at the Northwest Information Center of the California Historical Resources Information System at Sonoma State University, Sonoma, California was conducted, along with review of additional sources of information, including historical maps from the U.S. Geological Survey and General Land Office. The search and reviews were conducted to identify areas within or immediately adjacent to the study area that have a high potential for the presence of historic and prehistoric sites.

The records search indicated that eight cultural resources studies have been conducted within 0.25 mile of the project area, and those reports were reviewed to determine what resources they identified. Additional coordination with DWR identified another study that intersected the northern end of the project area.

The studies identified eight previously recorded historic-era built-environment resources within 0.25 miles of the project area. Of the eight resources identified, three resources consisting of Tule Canal, a levee, and an irrigation canal, are within the project area. The records search results did not indicate the presence of any previously recorded archaeological resources. However, archaeological resources could be identified during future archaeological surveys and/or tribal consultation.

Regarding Tule Canal, based on additional background research done for the Swanston Ranch Irrigation and Fish Passage Improvement Project (ICF 2023), which is immediately south of the Tule Canal Enhancement Project, this project would have a low potential concern with regard to the proposed changes to Tule Canal affecting its ability to convey significance to a potentially eligible cultural resources district (the Sacramento River Flood Control Project district). The proposed project features, once the designs are more fully developed, would need to be formally analyzed for potential effects for this Project, but the potential seems low.

Additionally, a Native American Heritage Commission search of its sacred lands database did not indicate the presence of Native American cultural resources in the project area. NAHC also provided the contact information of 19 local Native American representatives. Once the regulatory process begins, these representatives will be contacted in coordination with the lead federal agency to solicit input on the project and any areas of concern to the tribes. Reference Appendix I for further details.

3 CONCEPT FORMULATION AND EVALUATION

The concepts presented in this feasibility study were configured to enhance the existing Tule Canal corridor through Conaway Ranch as informed by the regional vision for the Tule Canal (Yolo County, 2021) and study specific outreach to the local landowners, general public, permitting and trustee agencies, environmental interests, local and state governments, and interagency groups. With the knowledge and site understanding gained from baseline studies and modeling (Section 2.5), three concepts were formulated in conjunction with the Project team. Concepts were then modeled and assessed based on the evaluation criteria and metrics formulated for the study (Section 3.2).

3.1 CONCEPT FORMULATION

3.1.1 HYDRAULIC MODELING

Each of the three modeling tools identified in Section 2.5 were used to support concept formulation and evaluation (i.e., reach scale low flows, system wide flood flows, and Yolo Bypass long-term conditions).

3.1.1.1 REACH SCALE LOW FLOW MODELING

The low flow 1D HEC-RAS model was used to determine water levels and channel conveyance capacity at various flows to inform elevations and sizing of concept features (Appendix E). Specifically, this was used in setting the inlet elevation and to optimize the cross-sectional dimensions of the concept swales and the cross-sectional dimensions of the constricted Tule Canal to limit its conveyance to 1,000 cfs where appropriate.

3.1.1.2 SYSTEM WIDE FLOOD FLOW MODELING

The Master Plan 1D/2D HEC-RAS model was used to determine the system wide impacts the concepts could have when combined with potential future concepts. Initial iterations of the Conaway Ranch concepts were developed that represented the minimum and maximum grading extents and incorporated into the Master Plan Scenario 1 to represent potential future conditions with numerous implemented projects (Appendix F). The results of this modeling lead to a decrease in concept roughness on any land that was converted on the floodplain, from an unmanaged wetland/riparian roughness (n = 0.065 for Medium and n = 0.1 for Dense) in the initial concepts to a medium density seasonal wetland roughness (n = 0.045) in the final concepts, due to the increased initial roughness causing stage increases at the 100-yr flood in excess of 0.1 ft at the Yolo Bypass at Knight's Landing Ridge Cut (KLRC) index location described in Appendix F. As discussed in Section 2.5, this model's Baseline did not include LEBLS or the Fremont Weir BNP or AFP. So, comparisons between Master Plan scenarios were used to generally guide concept formulation as opposed to providing threshold numerical results that would dictate exactly what the concept should have.

3.1.1.3 YOLO BYPASS LONG-TERM CONDITION MODELING

After the reach-scale low flow and system-wide flood flow modeling, the concepts were integrated into the more detailed 1D/2D TUFLOW model. Concept features including floodplain grading, swales, berms, and drainage canals were further iterated upon to verify that the intended drainage and feature activation flows and target water levels were being met.

The DEM for each concept was built and imported to the long-term TUFLOW model including concept swales, habitat mounds, Canal modifications, and any other necessary grading. Existing model drains were adjusted to account for the concepts (Figure 6) by removing any existing ditches within the concept footprints in Baseline, and replacing them with a long drainage ditch along the concept berm outside the concept. A flapped culvert was implemented at the main drain at the southern end of the Ranch connecting the fields west of the concepts to the Tule Canal to replace the existing unflapped culvert.

Each concept converts the relevant floodplain area from agricultural and/or naturalized areas into a seasonal wetland/swale complex, which changes concept Manning's n roughness from 0.031 and/or 0.041 to 0.045, respectively. Within the Tule Canal corridor where wetland/riparian habitat replaces Baseline land use types, roughness is increased from 0.031 to 0.065.

3.1.2 CONCEPT ELEMENTS

The overall intent of the concepts is to create a more natural form of seasonal wetland/swale complex with associated riparian/scrub habitat, which would naturally inundate more frequently during low flows in the winter and spring and provide rearing habitat for out-migrating juvenile salmon and associated habitats for aquatic, terrestrial, and amphibian species, while meeting the broader suite of goals and objectives identified for the Project. To meet the goals and objectives of the Project, all concepts were designed to activate the floodplain more frequently. Concepts were also developed to minimize flood impacts throughout the Bypass and improve agriculture and wetland drainage within Conaway Ranch and surrounding properties. Proposed concepts aim to increase fish and bird habitat, while also meeting the agricultural, financial, and recreational goals of the Ranch. These goals were targeted and achieved through a combination of the following Project elements:

- Tule Canal Modifications
- Tule Canal Realignment
- Land Use Modifications
- Dry Farmed Field Degrade
- Floodplain Recontouring
- Agricultural Berm Enhancements
- Drainage Enhancements, and
- Yolo Bypass East Levee Toe Modifications

Three concepts were developed that incorporate each of these project elements at different scales. Agricultural fields that would be affected in each concept are shown in Figure 3. Concept A is a minimal concept, with the smallest project footprint and smallest extent of floodplain grading. Concept B utilizes the same floodplain grading extent as Concept A but a slightly larger footprint of changes within the Tule Canal extending through the reach owned by the State. Concept B also realigns the Tule Canal throughout the Project extent. Concept C has the largest footprint, which also extends through the reach owned by the State, but extends east to provide greater connectivity with LEBLS. Project elements are described below, followed by more detailed descriptions of all concepts in Sections 3.1.3- 3.1.3.3.

3.1.2.1 TULE CANAL MODIFICATIONS

To raise WSEs within the Tule Canal, which would activate the floodplain more frequently at lower flows, the Tule Canal conveyance capacity was optimized to approximately 1000 cfs and included filling overly wide sections where the shallow shoals harbor invasive aquatic weeds. The conceptual 1000 cfs capacity channel geometry is 40 ft bottom width, 3:1 side slope, and 10 ft deep (Figure 7).

3.1.2.2 TULE CANAL REALIGNMENT

Realignment of the Canal through the adjacent floodplain was also considered to increase channel complexity and floodplain interaction. For consistency with other concepts, the location of the realigned canal coincided with the location of the main swale where the floodplain was recontoured (see “Floodplain Recontouring” in this section). The realigned channel was constructed to maintain a 1000 cfs capacity throughout the length of the concept footprint as outlined in the previous section. Other concepts leave the Tule canal in its current alignment.

3.1.2.3 LAND USE MODIFICATIONS

In existing conditions, the lands within the Project vicinity are predominantly agricultural (i.e., rice or dry farmed). Dry farmed fields were targeted for inclusion into the concepts because they are not considered unique or prime farmland. Other agricultural fields are infrequently farmed for assorted reasons (i.e., late season flooding, water curtailment, crop rotation), likely subject to more frequent inundation due to operations of the BNP and were also targeted for inclusion into the concepts even though they are classified as unique farmland. Some limited number of agricultural fields have naturalized over time and are no longer farmed (i.e., Fields 36-4, 33-3, and 10-2E) and were targeted for inclusion into the concepts. Existing wetland habitat and a narrow band of riparian habitat adjacent to the Tule Canal were also targeted for inclusion into the concepts.

Existing habitats targeted for inclusion into the concepts were intended to retain their existing land cover except where they are marginally impacted by grading activities associated with other concept features. The rice fields and naturalized fields targeted for inclusion into the concepts will be converted to a seasonal wetland/swale complex with some riparian woodland/scrub on higher elevations. Spoils generated from grading would be used to create low mounds among the seasonal wetlands/swales, adding to habitat complexity and providing a variation in surface elevations to accommodate a more diverse planting palette under a variety of flow conditions including some riparian woodland/scrub (these low elevation mounds will be referred to as habitat mounds). The seasonal wetlands and swales would be planted and seeded with low-growing seasonal herbaceous wetland species. Some of the mounds may be planted with riparian scrub species or may just be planted and seeded with herbaceous species. The dry farmed fields will predominately be riparian woodland/scrub with swales providing connectivity to the Tule Canal. This distribution of a more densely vegetated riparian corridor directly adjacent to the Canal with a seasonal wetland/swale complex to the west of the riparian corridor was informed by preliminary flood modeling to address flood risk (see Section 3.2.1, Section 2.5, and Appendix F). Some maintenance will be required to manage vegetative roughness to meet the flood functions of the Bypass. Final Landcover maps are shown in Figure 8.

3.1.2.4 DRY FARMED FIELD DEGRADE

Consistent across all concepts, the dry farmed fields (i.e., Fields 3-5, 10-3, 15-4, and 15-7) were degraded approximately 2.5 ft to 3.5 ft to enhance the frequency of inundation and activate at a flow of 1000 cfs. The narrow band of riparian habitat along the Canal is preserved except where it is marginally impacted by grading activities associated with other concept features to enhance connectivity between the Canal and the floodplain.

3.1.2.5 FLOODPLAIN RECONTOURING

Shallow-sloping swales were introduced on the floodplain west of the canal to promote seasonal wetland inundation, enhance connectivity through the riparian corridor, and generally enhance habitat conditions and volitional access throughout the concept areas. Proposed geometries include a swale bottom width of 30 ft, side slopes of 10:1, and swale depths of ±2 ft, which activate at a Tule Canal flow of 700 cfs. The swales were paired with shallow fills that are approximately 2 ft high above adjacent field grade to provide habitat complexity and diversity. The swales connect back to the Tule Canal at multiple locations to enhance volitional access and generally improve drainage through and within the concept areas. Figure 7 shows an example cross-section at the location of the white line(s) in Figure 9 demonstrates the floodplain recontouring.

3.1.2.6 AGRICULTURAL BERM ENHANCEMENTS

The purpose of the agricultural berm modifications is to enhance site access and minimize frequent inundation on adjacent agricultural fields outside the concepts. Within each concept, existing field berms were degraded and co-located drainage canals were filled. At the western extent of the concepts, existing or new agricultural berms were enhanced by raising to 5 ft above adjacent field grade.

3.1.2.7 DRAINAGE ENHANCEMENTS

Adjacent to the agricultural berm enhancements, new drainage canals were co-located at the berm toe outside the concepts to convey agricultural tailwater and receding floodwaters from the farm fields back towards the Tule Canal. To improve drainage, which was largely concentrated at the main drain under existing conditions, multiple new drainage connections (i.e., flapped culverts) through the agricultural berm enhancements were made to improve drain times from the farm fields as well as provide multiple egress points for juvenile salmon through the concepts back to the Tule Canal. The flapped culverts also preclude backwatering onto the farm fields upon initiation of floodplain activation, which means flood water can only get into the adjacent farm fields on the Ranch by overtopping the enhanced agricultural berms.

3.1.2.8 YOLO BYPASS EAST LEVEE TOE MODIFICATIONS

Modifications were considered to the remnant west toe of the east levee between the full height levee sections following the levee degrade activities associated with LEBLS. The full height levee sections, which are approximately 350 ft in length and spaced 0.5 miles apart, provide upland refugia during high water conditions, and were not modified. The purpose of further degrading the west levee toe was to enhance lateral connectivity between the Ranch and LEBLS. The remnant west toe varies in elevation along its length (i.e., ranges from 17 ft to 24 ft), includes three design notches as part of LEBLS, and was modified by lowering it to match adjacent field grade in LEBLS (i.e., 13 ft to 14 ft). The upstream notch, which serves as the inlet to LEBLS and was set to 17.5 ft as dictated by previous coordination between DWR and Conaway Ranch, was modified by lowering it to 15 ft to provide an equitable Tule Canal flow split between the Ranch and LEBLS.

3.1.3 FINAL CONCEPT CONFIGURATION

3.1.3.1 CONCEPT A

The footprint for Concept A (Figure 9) is the smallest of the concepts at 448 acres, and occurs only on Ranch lands. Project footprint area and cut/fill estimates are provided in Table 2. The following Project elements were included in Concept A:

- Tule Canal Modifications and Realignment
    - Canal is maintained in its original linear alignment.
    - Canal capacity is reduced to 1000 cfs within the 2.5-mile reach owned by the Ranch.
- Land Use Modifications
    - Naturalized fields (36-4, 33-3, and 10-2E) and dry farmed fields (3-5, 10-3, 15-4 and 15-7) (Figure 3) are converted into seasonal wetland/swale complex and riparian woodland/scrub habitats with additional elevation modifications described below.

- Dry Farmed Field Degrade
    - Relatively high elevations fields (3-5, 10-3, 15-4, and 15-7) are degraded up to 3.5 ft to activate at 1000 cfs, while maintaining the riparian buffer along the Canal.
- Floodplain Recontouring
    - Shallow swales and low elevation habitat mounds are proposed throughout the concept footprint.
- Agricultural Berm Enhancements
    - Between Fields 10-3 and 10-2E, the agricultural berm was degraded and rebuilt along the north, west, and south boundaries of Field 10-2E, exterior field berms were added to Fields 36-4 and 33-3, and existing field berms were increased in elevation.
- Drainage Canal Enhancements
    - Drainage was added along the exterior of the agricultural berms with drainage connections through the agricultural berms into the concept footprint connecting into the swale network.

3.1.3.2 CONCEPT B

For Concept B (Figure 9 and Figure 10), the project footprint is similar to Concept A except that it was expanded to include a small private inholding and the State-owned sections of the Tule Canal, while retaining the minimum extent of the floodplain footprint (479 acres). Project footprint area and cut/fill estimates are provided in Table 2. The following Project elements were included in Concept B:

- Tule Canal Modifications and Realignment
    - Tule Canal is realigned throughout the project footprint, which increases Tule Canal length from 4 miles to 4.6 miles.
    - The proposed channel was designed to meander through field 33-3 and downstream through the degraded floodplain in fields 3-5, 10-2E, 10-3, and 15-4 (Figure 3).
    - The existing Tule Canal alignment is backfilled to create additional habitat and a 1000 cfs capacity canal is constructed with the same alignment as the main swale in Concept A.
- Land Use Modifications
    - Naturalized fields (36-4, 33-3, and 10-2E) and dry farmed fields (3-5, 10-3, 15-4 and 15-7) (Figure 3) are converted into seasonal wetland/swale complex and riparian woodland/scrub habitats with additional elevation modifications described below.
- Dry Farmed Field Degrade
    - Relatively high elevations fields (3-5, 10-3, 15-4, and 15-7) are degraded to activate at 1000 cfs, while maintaining the riparian buffer along the canal.
- Floodplain Recontouring
    - Shallow swales and low elevation habitat mounds are proposed throughout the concept footprint.
    - This concept retains the swale alignment of Concept A while replacing the main swale with the realigned Canal, resulting in fewer swales than the other concepts.
- Agricultural Berm Enhancements
    - Between Fields 10-3 and 10-2E, the agricultural berm was degraded and rebuilt along the north, west, and south boundaries of Field 10-2E, exterior field berms were added to Fields 36-4 and 33-3, and existing field berms were increased in elevation.

- Drainage Canal Enhancements
  - Drainage was added along the exterior of the agricultural berms with drainage connections through the agricultural berms into the concept footprint connecting into the swale network.

3.1.3.3 CONCEPT C

Concept C (Figure 9 and Figure 10) expands the project footprint to the east to include the LEBLS west remnant levee toe degrade to 15 ft, and to the west to include more agricultural fields that are infrequently farmed representing the maximum floodplain footprint (1042 acres). Project footprint area and cut/fill estimates are provided in Table 2. The following Project elements were included in Concept B:

- Tule Canal Modifications and Realignment
  - Original linear alignment is maintained.
  - Reduced channel capacity of a 4-mile reach within the project footprint to 1000 cfs.
- Land Use Modifications
  - Naturalized fields (36-4, 33-3, and 10-2E), dry farmed fields (3-5, 10-3, 15-4 and 15-7) and rice fields (3-1W, 31-4E, 3-2, 3-3, 3-4, and 10-2W) (Figure 3) are converted into seasonal wetland/swale complex and riparian woodland/scrub habitats with additional elevation modifications described below.
- Dry Farmed Field Degrade
  - Relatively high elevations fields (3-5, 10-3, 15-4, and 15-7) are degraded to activate at 1000 cfs, while maintaining the riparian buffer along the canal.
- Floodplain Recontouring
  - Shallow swales and low elevation habitat mounds are proposed throughout the concept footprint.
  - The swale alignment for this concept builds on the alignment from Concept A, expanding further into the larger project footprint.
- Agricultural Berm Enhancements
  - Existing agriculture berms within the project footprint were removed and an existing berm along the western border was raised along with the addition of a new berm on the south side of Fields 10-2W and 10-2E.
- Drainage Canal Enhancements
  - Existing agriculture drains within the project footprint were removed.
  - Drainage was added along the exterior of the agricultural berms with drainage connections through the agricultural berms into the concept footprint connecting into the swale network.
- Yolo Bypass East Levee Toe Modifications
  - The west levee toe was further degraded to match adjacent field grade in LEBLS (i.e., 13 ft to 14 ft).
  - The upstream LEBLS notch was lowered to 15 ft to provide an equitable flow split between the Ranch and LEBLS.

Table 2: Concept Summary

Concept	Tule Canal Alignment	Project area (acres)	Estimated Cut (CY)	Estimated Fill (CY)	Net Cut (CY)
A	Uses existing Canal alignment, but capacity modification updates were limited by the Conaway property boundaries.	448	805,449	389,192	416,257
B	Realign and modify capacity for the entire length of Canal throughout the project footprint.	479	1,259,413	921,208	338,205
C	Uses existing Canal alignment and capacity was modified along the whole project footprint.	1042	1,259,081	711,799	547,282

3.2 EVALUATION CRITERIA DEVELOPMENT AND APPROACH

Building on the goals and objectives set for the Project (see Section 1.2), evaluation criteria and associated metrics were developed to facilitate the comparison between Baseline and the concepts. The evaluation criteria and metrics define the compatibility of the concepts against the project objectives, see Appendix A, Table 1. The evaluation criteria rely on both quantitative approaches, such as hydrodynamic modeling, hydrospatial analysis, and numerical analyses, and qualitative approaches.

The evaluation criteria were largely informed by those developed through Floodplains Reimagined (RD108, 2024). This includes habitat suitability evaluation criteria for juvenile salmonids, waterfowl, shorebirds, and sandhill cranes, along with criteria to evaluate land use impacts to agriculture, waterfowl hunting, and wetland management. The habitat suitability parameters involved in the hydrospatial analyses used in this study, as largely adapted from Floodplains Reimagined, are outlined in Table 3. The evaluation criteria also includes quantitative metrics (e.g., acres of land use) or qualitative metrics. More information on the development and evaluation approach for each of the primary goals or pillars is outlined in the sections below.

Table 3: Hydrospatial Evaluation Criteria

Evaluation Criteria		Cover Type	Season		Depth (in)		Velocity (ft/s)		Connect-ivity to Channel	Optimal Duration (days)
			Start	End	Min	Max	Min	Max		
Habitat Suitability	Floodplain Juvenile Salmon	Riparian, Wetlands, Rice, Other Agriculture	1-Nov	30-Jun	7.2	None	None	1.5	Required	14
	Waterfowl	Wetlands, Rice, Other Agriculture	15-Aug	31-Mar	>0	≤12	None	None	None	None
	Shorebird	Wetlands, Rice, Other Agriculture	1-Jul	15-May	>0	≤4	None	None	None	None
	Sandhill Crane - Roosting	Wetlands, Rice, Other Agriculture	1-Oct	15-Mar	>0	≤8	None	None	None	None
Land Use Impacts	Agriculture Compatibility	All Agricultural Fields	15-Mar	1-Jul	30% Wet Area	None	None	None	None	None
	Waterfowl Hunting	All Managed Fields	4th Sat in Oct	3rd Sun in Feb	12	None	None	None	None	None
	Managed Wetland	All Managed Wetlands	3rd Sun in Feb	31-Mar	Berm Height	None	None	None	None	None

3.2.1 FLOOD

Each of the concepts were compared to Baseline to evaluate changes in the maximum water surface elevation to understand if the concepts have a neutral or positive effect on flood management. A general rule of thumb used by the Corps is that increases in water surface elevations due to a project of +0.10 ft or greater may be considered a significant hydraulic effect. The Master Plan model was used to initially screen flood impacts of the concepts throughout the Yolo Bypass and vicinity at key index points during a 100-year flood event. The TUFLOW model was used to spatially assess the flood impacts of the concepts on the water surface elevations within the Yolo Bypass during the peak of the 1997 flood event.

3.2.2 AGRICULTURE

For agricultural compatibility, late season inundation was used as the key metric to capture potential lost productivity. If inundation happens too late in the year, the ability to timely access and prepare fields for planting is diminished and crop yields will suffer.

Based on landowner feedback and previous analyses (DWR, 2017a and 2017b), agricultural fields were considered wet when 30% of the field area was inundated. Wet field days are then used to determine the first possible plant date for a given agricultural field. To plant a field, 34 consecutive dry days are needed after March 15, which consists of 6 days of field dry out and 28 days field preparation time (ERA, 2017). If these 34 consecutive dry days occur such that the field can be planted by June 1, the field is considered plantable, and if not, the ability to plant is lost due to flooding that year. This is considered a conservative analysis in that landowners may not plant a field for a variety of reasons including water curtailment during drought, crop rotation, and fallowing (Figure 2). To account for model uncertainty and the potential of landowners to manage nuisance inundation, one wet day is allowed within the 34 dry day period, such that the dry day count starts over only when two consecutive wet days occur.

Within each field to determine the change in number of plantable years, the number of plantable years per concept was summed and compared to Baseline. Maps of change in plantable years and tables of the number of plantable acres over different subregions are the main metrics to evaluate agricultural compatibility. Additionally, land use change that occurs as a result of concept implementation was analyzed to evaluate agricultural compatibility.

3.2.3 HABITAT

Habitat suitability was evaluated for juvenile Chinook Salmon rearing and three groups of bird species to cover the variety of habitat conditions this region supports. Species-specific calculations use land cover and hydraulic model results of depth and velocity to determine suitability. These are converted into a habitat suitability score of 0 to 1 for each component of the criteria, which are aggregated into a final habitat suitability score by calculating either the geometric or multiplicative mean of the components. Each component of the criteria was configured to keep suitability in three suitability scores as opposed to using a curve: 0 for unsuitable, 0.66 for sub-optimal, and 1 for optimal.

Habitat suitability was first calculated based on the hydraulic model results for each water year. The total *suitability sum* was then calculated in every cell of the model by summing the final suitability values on each day within a cell, across the applicable period for that habitat group type. The difference in suitability sum was calculated by subtracting each cell's Baseline value from a given concept's suitability sum. Finally, each concept's suitability sum was added over different subregions to obtain each concept's *Weighted Usable Area* (WUA) within different footprints. To represent habitat suitability for the different concepts, difference in suitability sum maps and difference in WUA are the reporting metrics.

3.2.3.1 FLOODPLAIN JUVENILE SALMON HABITAT

Floodplain Juvenile Salmon Habitat Suitability Criteria were evaluated through hydrospatial analyses, taking into account landcover, timing (seasonality and duration), depth, velocity, and/or connectivity (Table 3) (Whipple, 2024). Juvenile salmon experience sub-optimal depths when water depths are between 0.6 ft and 0.9 ft, and reach optimal depths when inundation is greater than 0.9 ft deep. When below 0.6 ft of depth, the inundation is unsuitable for salmon. By contrast for birds, (Section 3.2.3.2)) and all three evaluations of field impacts (Agriculture – Section 3.2.2, Managed Wetland – Section 3.2.3.3, Waterfowl Hunting – Section 3.2.7), increased inundation depths results in less usable habitat and/or more impacts. Additionally, depth is only considered when the velocity is below 1.5 ft/s. Juvenile Salmon rearing considers agricultural fields (including rice) as sub-optimal land cover, and wetlands, riparian, tidal areas, and any existing open water areas as optimal land cover. To capture the Fall, Winter, and Spring runs of salmon, the outmigration period evaluated encompasses November 1 to June 30.

Hydraulic connectivity to the main channel is required for juvenile salmon since minimizing fish stranding and providing passage are vital to population health. For managed fields, connectivity begins on these fields when perimeter berm overtopping of the field occurs as merely backwatering up a field outlet is not considered volitional ingress given the narrow ingress opportunity. During berm overtopping, connectivity is considered optimal. Then, once the field depth falls below berm overtopping and is draining through its outlet, connectivity is considered sub-optimal as juveniles have a narrow egress opportunity. Duration of inundation is also important to capture for salmon and is considered sub-optimal when an area is wet and connected for less than 14 days, but greater than 14 days it becomes optimal.

3.2.3.2 BIRD HABITAT

Bird Habitat Suitability Criteria were evaluated through hydrospatial analyses, taking into account landcover, timing (seasonality and duration), depth, velocity, and/or connectivity (Table 3) (Dybala, 2024). These criteria address waterfowl, shorebird, and Sandhill Crane (cranes), all three of which are similar in that they all use the same land cover suitability scores and are all based on a maximum suitable depth (must be inundated) with no restrictions on velocity (Table 3). This maximum depth for each type of bird is set to capture depths at which foraging and/or roosting can occur for each species. Applicable land cover types include rice, wetlands, and other agriculture, all of which receive an optimal score. For waterfowl, suitability is evaluated from August 15 to March 31 with a maximum depth of 12 inches. Shorebird suitability ends when the water is deeper than 4 inches and includes periods lasting from July 1 to May 15 of each year. Finally, cranes were evaluated for roosting suitability. Evaluation of foraging suitability was considered, but the Floodplains Reimagined criteria dictated that this was only evaluated within 5 km of known roost locations, and there are no known roost locations within that distance to the Yolo Bypass. Therefore, only roosting was evaluated, with a maximum depth of 8 inches and spanning October 1 to March 15. Since each of the starting dates for these bird types begins before the simulation, the calculated period for each type of bird begins on October 2 of each year which aligns with the simulation start date.

3.2.3.3 MANAGED WETLAND

The Managed Wetland Evaluation Criteria was developed to capture management impacts due to increased depth of inundation on managed wetlands (DU, 2024). Managed wetland impacts were evaluated from the end of the waterfowl hunting season (after the second special hunt weekend in February) until the end of the simulation period (June 30). The period during the waterfowl hunting season was evaluated for impacts using the Waterfowl Hunting Evaluation Criteria (Section 3.2.7).

Managed wetland impacts were determined similarly to waterfowl hunting impacts (DU, 2024). To evaluate this, each day within the simulation period was weighted by relative wetland manager importance (Date Impact) and was evaluated for the impact that the depth on the field has on the field’s post-hunting operations (Depth Impact). When the field depth was shallower than 12 inches (corresponding to the suitable depth range for waterfowl), the Depth Impact score was zero on the applicable field. However, when water on fields reaches the elevation of their surrounding berms, the ability to access the field is impacted, and thus Access Impacts are designated with a Depth Impact score of 2.5. Finally, when water on fields exceeds 6 inches above the field berm elevation, this is potentially damaging to the berms or infrastructure, and so Infrastructure Impacts are designated and assigned a Depth Impact score of 5 on that day and field. These Depth Impact categories capture the potential infrastructure damage and impairments to field access that managed wetland landowners could face due to excess inundation, where higher scores indicate greater impacts. The Date Impact score was held as 1 for all days in the evaluated period as in-season differences are not being considered.

Date Impact and Depth Impact were multiplied together to get a field's impact score on each day, then summed across all applicable days in a water year to calculate Managed Wetland Impact score across that year. The resulting score was multiplied by the field area to determine a total impact score over selected footprints. See Table 4 for potential single day score values for Managed Wetland impacts. Managed wetland compatibility is evaluated using change in impact score maps and impact area summations over various subregions.

Table 4: Impact Score Single Day Score Calculation for Managed Wetland Impacts

Impact Category	Depth Impact	Date Category	Date Impact	Single Day Score
Access	2.5	Post Waterfowl Hunting Season	1	2.50
Infrastructure/ Maintenance	5	Post Waterfowl Hunting Season	1	5.00

3.2.4 FINANCIAL

Implementation of a concept is financially viable when there is a return on investment or compensation for lost value. This requires that there is sufficient revenue or compensation to offset costs associated with project planning and design, construction or project implementation or construction, post-construction monitoring, and long-term operations and maintenance.

3.2.5 WATER SUPPLY

Maintaining or improving drainage, water supply, and groundwater conditions are important considerations as they affect agricultural operations and management of wetlands both onsite and offsite. Based on an understanding of upstream and downstream changes to stage and flow, impacts on the ability to drain (via gravity or pumping) and divert were assessed based on the hydrodynamic model results. Water control infrastructure changes were also characterized along with the potential changes and improvements to drainage. The impacts of these changes were evaluated qualitatively. Changes in groundwater recharge were quantified based on hydrodynamic model results.

3.2.6 WATER QUALITY

Potential water quality impacts could include changes to temperature, dissolved oxygen, methyl mercury and invasive weeds throughout the Bypass including the Tule Canal. Water quality modeling was not completed for this study, but each concept and the concept elements was assessed qualitatively for potential impacts to the water quality parameters noted above.

3.2.7 RECREATION

Potential recreation impacts could include changes in land use (e.g., conversion of winter flooded rice for waterfowl hunting) and changes in onsite and offsite waterfowl hunting conditions. Changes in land use will be quantified based on the change in acreage of managed waterfowl hunting fields. Changes in waterfowl hunting conditions will be quantified based on the Waterfowl Hunting Evaluation Criteria (DU, 2024).

The Waterfowl Hunting Evaluation Criteria were developed to capture impacts due to increased depth of inundation during the waterfowl hunting season. The main waterfowl hunting season starts on the fourth Saturday in October and lasts for 100 days, followed by two special hunt weekends in February where families and veterans are provided exclusive access. This analysis was done on all fields with winter managed inundation regardless of whether they are available to hunting since this can potentially be used to evaluate future hunting opportunities. To evaluate this, each day within the simulation period was weighted by relative hunter importance (Date Impact) and was evaluated for the impact that the depth on the field has on the field's hunting operations (Depth Impact).

Depth Impact was broken into four categories for every day of the simulation in all applicable fields – no impact, Bird Use impact, Access impact, and Infrastructure impact. Similar to the managed wetland impact analysis, periods when the field depth is less than 12 inches were assigned no impact, and days field depths reach berm overtopping and 6 inches above berm overtopping were assigned Access and Infrastructure impacts with Depth Impact scores of 2.5 and 5, respectively. However, since the ability of waterfowl to use these fields is critical for waterfowl hunting, when the field depth exceeds the maximum suitable depth for waterfowl of 12 inches (Table 3, Section 3.2.3), the additional impact category of Bird Use Impacts are designated at a Depth Impact score of 1.5.

Due to certain periods of the hunting season being more important to hunters, each day is assigned a varying Date Impact score throughout the applicable period. The main 100-day waterfowl hunting season is broken out into peak and non-peak periods. Peak periods are assigned a Date Impact score of 5 occurring on the first two weeks of the hunting season and the second week in December through the end of the 100-day portion of the waterfowl hunting season. Non-peak periods are assigned a Date Impact score of 2.5 and occur in the period between the two peak seasons, from early November to early December. Finally, the special hunt weekends in February are assigned a Date Impact score of 3.75.

Similar to the managed wetland analysis, Date Impact and Depth Impact scores were then multiplied together to get the single day impact score for each field. Table 5 shows the potential combinations of Depth and Date Impact and their resulting final score for a single day. The higher scores indicate more impact. This score was then summed over the waterfowl hunting season for each water year for all applicable fields, which was then multiplied by a field's area to get the impact score over different subregions. Maps of change in Waterfowl Hunting impact score from Baseline and tables of the impact area score for different subregions are the main metrics used to evaluate waterfowl hunting compatibility.

Table 5: Impact Score Single Day Score Calculation for Waterfowl Hunting Impacts

Impact Category	Depth Impact	Date Category	Date Impact	Single Day Score
Bird Use	1.5	Non-peak (Early Nov - early Dec)	2.5	3.75
Bird Use	1.5	Peak: Late Oct - Early Nov, early Dec - late Jan	5	7.50
Bird Use	1.5	Feb Special hunt Weekends	3.75	5.63
Access	2.5	Non-peak (Early Nov - early Dec)	2.5	6.25
Access	2.5	Peak: Late Oct - Early Nov, early Dec - late Jan	5	12.50
Access	2.5	Feb Special hunt Weekends	3.75	9.38
Infrastructure	5	Non-peak (Early Nov - early Dec)	2.5	12.50
Infrastructure	5	Peak: Late Oct - Early Nov, early Dec - late Jan	5	25.00
Infrastructure	5	Feb Special hunt Weekends	3.75	18.75

3.3 CONCEPT EVALUATION

3.3.1 HYDROSPATIAL ANALYSIS

The TUFLOW model results were extracted for post processing, specifically for depth, velocity, and water level. These were then processed into the appropriate metrics for each component of the Multi-Benefit Analysis (Section 3.3.2).

For habitat analysis, depth and velocity are converted into hydraulic habitat suitability using the depth and velocity criteria for each species (Section 3.3.2.3). Depth and water level were also used to determine connectivity to the Tule Canal for each location being evaluated, including when berm overtopping occurs to initiate connectivity. The results of the field mapping analysis (Section 2.2) was used to assign cover suitability throughout the Bypass, with updated cover maps for each of the concepts (Figure 4).

For wetland and agricultural compatibility evaluations, the results of the field mapping analysis (Section 2.2) were used to determine which fields should be evaluated in each analysis. Depth and water level were also used to analyze impacts in terms of depth on the fields for wetland compatibility analyses (Sections 3.3.2.3 and 3.3.2.7), and impacts in terms of wet field days for agricultural compatibility (Section 3.3.2.2).

3.3.2 MULTI-BENEFIT ANALYSIS

Using the hydraulic modeling results, the hydrospatial analysis approach, and qualitative discussion, each concept was analyzed for alignment with the goals and objectives per the evaluation criteria and metrics. Each concept was assessed for the degree that each concept met the criteria from “very compatible” to “less compatible”. The results for each of the goals are summarized below. Final rankings comparing results across all the goals are provided in Section 4.

3.3.2.1 FLOOD

An important goal of the Project is to maintain flood conveyance with the objective to have neutral or flood positive impacts within the region with each concept design. This was evaluated through hydrodynamic modeling of each concept. The Master Plan model and the TUFLOW model were used to evaluate flood impacts. The 1997 water year experienced the largest magnitude flows during our modeling period, ~100-year recurrence interval, and was therefore used for understanding the regional impacts of the alternatives on flood stages.

The Master Plan model was used to assess the flood impacts of the concepts, specifically Concept C, on the WSE throughout the Yolo Bypass and vicinity at key index points during a 100-year flood event (Appendix F).

The differences between Baseline conditions TUFLOW model and the Master Plan model are noteworthy. The Baseline conditions for this study include LEBLS, BNP, AFP, and Sacramento Weir Widening (Section 2.5). The Master Plan Baseline, however, only includes the Sacramento Weir Widening project. For concept modeling, the TUFLOW simulation only added the Conaway Ranch concepts to its Baseline. While in the Master Plan model, the concepts were added to Master Plan Scenario 1. This scenario includes LEBLS, which is consistent with the TUFLOW modeling, but it also includes many projects that were not included in the TUFLOW modeling such as the Fremont Weir Expansion/Extension, Yolo Flyway Farms Restoration Project, Conaway Ranch Levee Setback, and Nigiri-Knaggs Ranch Salmonid Project, among others (Appendix F). While both models have application to this study it is important to note that the Master Plan model did not provide a consistent comparison to the TUFLOW model results presented in this report.

However, the results from this study show that flood impacts fall within the Master Plan Model threshold of 0.1 ft at the KLRC Index point based on optimizing the vegetation cover within the concept footprint (i.e., dense riparian adjacent to the Tule Canal and seasonal wetlands for the balance of the footprint).

Additionally, the TUFLOW model was used to assess the flood impacts of the concepts on the water surface elevations within the Yolo Bypass. Figure 11 shows the difference between the modeled water surface elevations between each concept and Baseline at the peak water levels of the 1997 flood event. Concept A has the smallest flood impact, increasing the flood stage up to 0.15 ft directly upstream of the Project, just downstream of County Road 22. A smaller increase of up to 0.1 ft in the Bypass was observed up to 4.25 miles upstream, just upstream of KLRC.

Concept B increases flood stages up to 0.2 ft in a small area directly upstream of the Project, with smaller flood impacts extending slightly further upstream than Concept A.

Concept C has the largest flood impact increasing the flood stage up to 0.3 ft directly upstream with up to 0.1 ft flood increases at KLRC. Localized increases in flood stage greater than 0.1 ft can likely be mitigated by refining the landcover changes and limiting the type of vegetation opposite the inlet to LEBLS (Appendix F).

3.3.2.2 AGRICULTURE

Agriculture objectives seek no net impact on farming operations both onsite (i.e., Conaway Ranch) and offsite (i.e., neighboring lands) and ideally achieve improvements to onsite agricultural production. Each concept can 1) permanently impact agricultural production via conversion of farmable ground to habitat within the concept footprint, and 2) affect onsite and offsite agricultural production due to alteration of water movement and transient storage via concept features (i.e., agricultural berms and improved drainage canal system).

LOSS OF AGRICULTURAL PRODUCTION DUE TO LAND CONVERSION

All concepts remove some agricultural fields from production. Total acres removed from agricultural production range from 126 acres (Concepts A and B excluding the naturalized fields) to 643 acres (Concept C excluding the naturalized fields) (Figure 3). For all concepts this includes removing a small rice field (Field 36-4) and the dry farmed fields along the canal (Fields 3-5, 10-3, 15-4, 15-7), and Concept C removes an additional 517 acres of less frequently farmed rice (Fields 3-1W, 31-4E, 3-2, 3-3, 3-4, 10-2W) (Table 6). Figure 3.

Table 6: Agriculture Impacts by Land Use Conversion

Area Removed from Production (acres)	Concept A	Concept B	Concept C
Rice	13	13	530
Dry Farmed	113	113	113
Total	126	126	643

IMPACTS TO AGRICULTURE PRODUCTION DUE TO CHANGES IN DRAINAGE AND INNUNDATION

Outside of the concept footprints, the agricultural berms and improved drainage system offered by each concept results in multiple fields on Conaway Ranch directly adjacent to the concepts to drain more efficiently. As such, these fields have the potential to be plantable up to three additional years relative to Baseline (Figure 12) largely during times of late season flooding (i.e., 1998, 2003, 2005, and 2011). However, further upslope to the west, there are two fields that have one less plantable year than in Baseline due to increases in vegetative roughness. As such, onsite plantability outside of the concepts increases an average of 4% in Concepts A and B and 3% for Concept C (Table 7).

Outside the Ranch, the upstream-most third of LEBLS experiences one (Concept A and C) or two (Concept B) additional years of plantability, and the downstream-most field experiences a reduction in plantability, but overall there is a production benefit to LEBLS.

Table 7: Plantable Acres Results by Scenario and Region

Subregion Considered		Plantable Acres	Change in Plantable Acres		
		Baseline (Min/Max Grading Footprint)	Concept A	Concept B	Concept C
Conaway Ranch	Concept Area	126/643	-100%	-100%	-100%
	Outside Concept	4,976 /4,538	4.1%	4.0%	2.8%
	Total Property	5,120	1.1%	1.0%	-7.8%
LEBLS		834	0.5%	2.7%	2.3%
Swanston Ranch		366	0.0%	0.0%	0.0%
YBWA		3,754	-0.1%	-0.1%	-0.1%
Full Bypass		32,512	0.6%	0.6%	0.5%

3.3.2.3 HABITAT

HABITAT CREATION BY LAND USE CONVERSION

Each concept includes the inclusion of existing habitats and the conversion of agricultural lands to create additional habitats. Section 3.1.2.3 previously described the general agricultural conversion. The types of created habitat are described below in more detail.

Concepts A and C add approximately 115 acres of riparian habitat mainly along the canal in the recontoured degraded dry farmed fields. Concept B adds an additional 46 acres, for a total of 163 acres of riparian habitat in the filled reaches of the Tule Canal. Both Concepts A and B have similar amounts of additional wetland habitat (around 130 acres). Concept C adds almost 600 acres of seasonal wetland and swale habitat due to the additional converted rice fields within the concept footprint.

In addition to the increase in wetland and riparian habitat, which is important at high flows, each concept also includes swales, which initiate floodplain activation at a flow of 700 cfs. These swales increase access to low velocity, floodplain habitat for juvenile salmonids. Table 8 shows the total acres of swales available, as well as the area of enhanced canal, in each concept. While Concept A has the smallest area of enhanced canal and a medium area of swales throughout the small project footprint, Concept B has the smallest area of swales and the largest area of improved canal because the main canal is re-meandered into the swale alignment and so is considered canal instead of swale. Concept C has a large area of improved canal and the largest area of improved swales throughout the larger project footprint. Habitat mounds areas are also added to the proposed additional wetland and riparian area to offer high-water dry refugia. Concepts A and B offer 27 acres of habitat mounds, and Concept C offers 81 acres (Table 8).

All three concepts involve significant permanent or temporary changes to wetlands, waters, riparian habitats, upland habitats, and agricultural lands, but each concept attempts to mitigate for these changes through the construction of additional features. For example, the temporary impact to existing wetlands will be mitigated by the creation of new wetlands. Despite the differences in the extent of impacts and mitigation across all three concepts, all concepts enhance the ecological function of the area through the creation of swales, wetlands, open water, and riparian (Table 9). Each concept is able to provide at least a 70% increase in acres in each of these categories, with swales and wetlands able to provide mitigation ratios (ratio of impacted area to mitigated/constructed area) by area of 36 to 261 times the impacted areas.

Table 8: Habitat Creation by Land Use Conversion

Habitat Type	Concept A	Concept B	Concept C
Area of Canal (acres)	58	71	91
Area of Swales (acres)	81	30	171
Area of Habitat Mounds (acres)	27	27	81
Area Added Riparian Habitat (acres)	117	163	116
Area Added Wetland Habitat (acres)	134	131	596
Length of Adjusted Canal (miles)	2.2	4.1	3.9
Length of Added Swales (miles)	7.2	2.7	14.8

Table 9: Land Cover Type Impacts and Mitigation

Category	Land Cover Type	Concept	Full Area in Project Extent (acres)	Acres Impacted within Grading Extent		Constructed Acres (Mitigation)	Mitigation Ratios
				Temporary Impacts (acres)	Permanent Impacts (acres)		
Wetlands and Waters	Ditches & Swales	A	1.43	0.00	0.79	81.10	103:1
		B	0.22	0.00	0.83	29.73	36:1
		C	2.09	0.00	0.80	171.23	214:1
	Open Water & Ludwigia	A	32.69	26.25	0.00	58.02	2:1
		B	45.28	42.10	0.00	71.46	1.7:1
		C	45.28	42.09	0.00	90.93	2:1
	Emergent Vegetation & Wetlands	A	11.68	2.03	0.00	145.69	72:1
		B	11.62	2.51	0.00	141.61	56:1
		C	12.89	2.32	0.00	607.28	261:1
Riparian	Woodland & Scrub	A	72.10	21.82	0.00	161.63	7:1
		B	72.10	21.82	0.00	161.63	7:1
		C	81.94	36.72	0.00	159.86	4:1
Agricultural	Agricultural Land	A	127.45	0.00	112.70	0.00	--
		B	127.45	0.00	112.70	0.00	--
		C	644.48	0.00	113.01	--	--
Upland	Grasslands & Herbaceous Vegetation	A	56.24	0.00	23.39	0.00	--
		B	56.24	0.00	23.39	0.00	--
		C	56.94	0.00	41.76	0.00	--
Developed	Developed	A	0.97	0.00	0.00	--	--
		B	0.97	0.00	0.00	--	--
		C	0.97	0.00	0.01	--	--

JUVENILE SALMON REARING HABITAT

Juvenile salmon rearing habitat suitability benefits from increases in inundation depth with more usable habitat as depths increase and wetted area expands. Under Baseline, flows in the Tule Canal can readily activate the lower bench as 1) the existing agricultural berm separating Fields 36-4, 33-3, and 31-4E from the Tule Canal has been eroded away for at least two decades, and 2) the unflapped main drain allows the Tule Canal to backwater the lower bench as canal flows increase. This in turn creates for a frequently activated floodplain on the lower bench that is highly connected in Baseline. Within the concepts, the floodplain and proposed habitat features are even more highly connected to the Tule Canal and are highly suitable due to the Canal modifications, landform grading, and land use conversion from agriculture to habitat. This results in a WUA uplift of 80%, 63%, and 96% for Concepts A, B, and C (Table 10), respectively. It should be noted that the degrade of the dry farmed fields contributes significantly to the WUA uplift on the order of 79%, 62%, and 33% for Concepts A, B, and C (Table 11), respectively, generally a doubling of the benefit compared to the relative area the degraded area contributes to the concept footprints.

Outside the project area, the rice fields to the immediate west and south of the Project have decreases in habitat suitability (Figure 13). This is due to floodplain connectivity being impeded by the proposed agricultural berm. Further west and upslope, there is a slight increase in habitat suitability due to concept roughness increasing water depths.

On the neighboring lands, LEBLS experiences a decrease in habitat suitability as the concepts cause LEBLS to fill slower and drain faster during flood events with a WUA impact of up to -4.4%. On Swanston Ranch, the change in WUA is neutral with mixed changes due to the concepts altering flows continuing down the Tule Canal. In Baseline, water is able to spread out on the floodplain west of the concept footprints, while in the concepts this water remains within the concept until it reaches the elevation of the agricultural berm enhanced in the concepts. This means that water below the berm elevations drains more quickly to the Canal, increasing the volume returning to the Canal rather than moving west. This results in slight net increases in salmon WUA downstream, including areas like YBWA. Swanston Ranch is slightly net negative in terms of salmon WUA due to fields experiencing decreases in suitability slightly outweighing those fields seeing increases (<0.2% WUA change).

Table 10: Juvenile Salmon Rearing Weighted Usable Area (WUA)

Subregion Considered		WUA	Change In WUA		
		Baseline	Concept A	Concept B	Concept C
Conaway Ranch	Concept Degrade Area	2,807	257.9%	162.1%	280.6%
	Concept Outside Degrade	21,812	22.6%	31.6%	72.3%
	Full Concept	24,618	79.6%	63.2%	96.1%
	Outside Concept	84,041	-13.2%	-9.5%	-11.3%
	Total Property	108,835	-3.6%	-2.0%	13.0%
LEBLS		45,998	-4.4%	-4.1%	0.4%
Swanston Ranch		115,766	-0.2%	-0.1%	-0.2%
YBWA		308,435	0.5%	0.5%	0.5%
Full Bypass		1,484,984	0.1%	0.4%	1.3%

Table 11: Degraded Area of Concept WUA and Area Comparison

Concept	Total WUA Uplift Within Concept Footprint	WUA Uplift Provided by Degraded Area Only	Percent Concept WUA Uplift in Degraded Area	Percent Concept Area Within Degraded Area
Concept A	9,228	7,240	78.5%	41.7%
Concept B	7,325	4,550	62.1%	32.8%
Concept C	23,655	7,877	33.3%	18.2%

OTHER FISH HABITAT

All concepts prolong habitat inundation that coincides with the winter and early spring spawning and rearing period of native Delta fishes (Moyle 2002). Furthermore, habitats within the concept footprint are likely to contain an abundance of vegetation that would be inundated because of the project and would be expected to provide suitable spawning and rearing habitat for these species. Concepts A and C avoid creating additional permanent aquatic habitat; Concept B increases the length of Tule Canal, a perennial waterway, from 4 miles to 4.6 miles. Seasonal habitat inundation is hypothesized to benefit native species over exotic fish species, the latter of which tend to dominate perennial waters (Sommer et al. 2001a).

Under Concept C, the swale network would be greatly expanded to the west onto the agricultural fields. This would increase the area of habitat that would be more frequently inundated and potentially available to floodplain-spawning species compared to what would be available under Concepts A and B, especially during critically dry and dry years when floodplain inundation in the Yolo Bypass is limited or non-existent. Conversely, construction of the exterior field berms to reduce project footprint flooding influence on the agriculture lands to the west of the concept footprints would reduce the availability of inundated floodplain habitat for floodplain-spawning species, although the management of these lands for agriculture likely limits the extent of vegetation that is available to be inundated under existing conditions. Reconfiguring the proposed agricultural berm to accommodate connectivity pre-March 15 could significantly improve the availability of inundated floodplain habitat west of the concept footprints for floodplain-spawning species. Under flooded conditions, the effect of the exterior field berms on spawning habitat is likely to be negligible because the exterior field berms would be overtopped, although the duration of inundation is likely to be reduced due to improved drainage through the flap gates.

Native fish that rear in the Yolo Bypass (e.g., splittail, hardhead, hitch) are also expected to benefit from greater access to invertebrate prey items in the submerged habitats resulting from the floodplain field degrade and swale construction, especially during critically dry and dry years when floodplain inundation in the Yolo Bypass is limited or non-existent. For the same reasons described for spawning habitat above, Concept C would increase the area of habitat that would be more frequently inundated and potentially available to rearing fish compared to what would be available under Concepts A and B, particularly in critically dry and dry water year types. Reconfiguring the proposed agricultural berm to accommodate connectivity pre-March 15 could significantly improve the availability of inundated floodplain habitat west of the concept footprints for rearing species.

FISH PASSAGE

Adult salmonid and sturgeon fish passage through the Tule Canal are maintained under all concepts via the proposed narrowing of the canal which increases channel depths, improves water conveyance and therefore improves fish passage. Juvenile and adult salmonid fish passage and connectivity are further improved within each concept footprint since field grading removes stranding hazards on the floodplain and swale grading improves connectivity with multiple connections back to the canal. This improves fish passage within the concepts, but especially in Concept C where the footprint is the largest.

Juvenile fish passage into the agricultural fields west and south of the concepts initially requires overtopping of the proposed agricultural berm for juveniles to access these floodplain areas. Egress is improved in all concepts through the proposed drainage through the agricultural berm back into the concept area via flapped water control structures. Previously, egress was provided through the single main drain. The concepts increase connectivity with multiple connections through the agricultural berm; however, the flapped structures would inhibit ingress to the agricultural fields prior to agricultural berm overtopping. As previously noted, connectivity and ingress/egress could be improved upon if the proposed agricultural berm is reconfigured to accommodate connectivity pre-March 15.

BIRD HABITAT

The trends in the three bird groups (waterfowl, shorebirds, and Sandhill Crane roosting) habitat suitability are opposite of salmon. The bird groups have a maximum depth in their criteria where salmon have a minimum depth (Figure 14). Within the concepts, there is an increase in waterfowl habitat suitability of 72%, 15%, and 116% for Concepts A, B, and C (Table 12), respectively, due to an increase in passive inundation (i.e., no longer managed as winter flooded rice) at appropriate depths. Outside the concepts, while there is an increase in waterfowl habitat suitability on the lower bench across winter flooded rice fields, this is generally offset by a decrease in waterfowl habitat suitability further upslope to the west on winter flooded rice resulting in a small net benefit across the ranch as a whole.

Outside of the concept footprint, shorebird and Cranes have very little change since their maximum depth criteria is more stringent at 4 and 8 inches, respectively than waterfowl with a maximum depth of 12 inches (Figure 15 and Figure 16). Shorebirds and Crane experience decreased WUA on Conaway Ranch outside the project area.

For all three bird types in Concepts A and C, LEBLS sees a net decrease in WUA due to the area filling more slowly than in Baseline (meaning it is dry more often in the concepts). LEBLS also would experience greater depths at higher floods due to the increased concept roughness. In LEBLS, Concept B shows decreases for waterfowl and Crane habitat, but a slight increase in WUA for shorebirds. This is explained through the slower flooding of LEBLS, which results in more time shallower than 4 inches of depth on the rising and falling limb of floods.

Swanston Ranch fields see slightly less WUA for all three birds as well, since the concepts allow more water to continue downstream due to the flapped culverts and concept berm holding water for longer that could backwater to the west of the concepts in Baseline.

Table 12: Mean Bird Habitat Suitability Weighted Usable Area (WUA) Results for Waterfowl, Shorebirds, and Sandhill Crane (Roosting)

Subregion Considered		WUA	Change In WUA		
		Baseline	Concept A	Concept B	Concept C
Waterfowl					
Conaway Ranch	Concept Degrade Area	486	100.2%	21.1%	173.6%
	Concept Outside Degrade	2,903	51.0%	10.3%	106.5%
	Full Concept	3,389	71.7%	14.8%	116.1%
	Outside Concept	685,534	0.8%	0.7%	0.0%
	Total Property	689,000	0.9%	0.8%	0.6%
LEBLS		7,371	-16.9%	-14.5%	-19.0%
Swanston Ranch		302,483	-0.1%	-0.1%	-0.1%
YBWA		98,007	-0.3%	-0.2%	-0.3%
Full Bypass		2,394,307	0.0%	-0.1%	-0.1%
Shorebird					
Conaway Ranch	Concept Degrade Area	81	319.8%	90.2%	435.4%
	Concept Outside Degrade	410	229.6%	40.7%	333.9%
	Full Concept	491	268.7%	62.1%	350.6%
	Outside Concept	35,966	-2.6%	-2.6%	-3.5%
	Total Property	36,464	-1.3%	-2.3%	1.2%
LEBLS		2,368	-10.1%	1.4%	-15.6%
Swanston Ranch		16,610	-1.1%	-1.2%	-1.1%
YBWA		33,869	-0.2%	-0.1%	-0.2%
Full Bypass		185,526	-1.3%	-1.7%	-0.9%
Sandhill Crane - Roosting					
Conaway Ranch	Concept Degrade Area	220	125.3%	24.7%	205.5%
	Concept Outside Degrade	1,275	70.9%	3.9%	151.2%
	Full Concept	1,495	93.2%	12.4%	159.2%
	Outside Concept	72,989	-0.4%	-0.5%	-1.1%
	Total Property	74,492	0.2%	-0.4%	2.1%
LEBLS		4,159	-14.5%	-9.8%	-19.1%
Swanston Ranch		17,518	-0.5%	-0.6%	-0.5%
YBWA		50,954	-0.7%	-0.6%	-0.7%
Full Bypass		305,842	-1.1%	-1.4%	-0.7%

Habitat suitability of the salmon and three bird types allows the evaluation of tradeoffs between species, where deeper depths will provide more suitable conditions for salmon and more shallow inundation will provide more suitable conditions for the three bird groups. This is seen in the concepts with increased depths and channel connectivity being beneficial for salmon suitability, however these conditions detrimental to bird suitability, and result in greater field impacts (both agricultural and seasonal wetlands/hunting [Section 3.3.2.2]). A narrow overlap of depth suitability does occur for Waterfowl (between 0.6 and 1ft), and narrower range for Crane (between 0.6 and 0.66 ft). This illustrates that while grading and adding swales to the concept is intended to improve the area ecologically, there is a narrow depth range where the habitat is more broadly suitable than to just one species.

SPECIAL-STATUS WILDLIFE HABITAT

Special-status wildlife with a moderate or high potential to occur within or in the vicinity of the Conoway Ranch and Tule Canal include Valley Elderberry longhorn beetle, northwestern pond turtle, giant garter snake, Swainson's hawk, white-tailed kite, tricolored blackbird, song sparrow (Modesto population), hoary bat, and western red bat. All three concepts face similar environmental constraints and regulatory challenges. All three concepts would be expected to have high mitigation costs for temporary and permanent impacts to habitat for giant garter snake and northwestern pond turtle, for potential loss of valley elderberry longhorn beetle, if elderberry shrubs are present and require removal, and for potential loss of Swainson's hawk foraging habitat, if active Swainson's hawk nests are present within the concept vicinity.

Concept A results in the least environmental disturbance; Concept B and C cause greater and more widespread habitat impacts, especially to riparian habitats and open water areas critical for aquatic and avian species. Alteration of Tule Canal (A = 2.17 miles, B = 4.14 miles, and C = 3.85 miles) would be considered a permanent impact to giant garter snake aquatic habitat, resulting in high mitigation requirements. Creation of maintained wetlands may offset mitigation required due to loss of habitat depending on inundation during the giant garter snake active season.

Northwestern pond turtle is proposed for listing under the Federal Endangered Species Act (88 FR 68370). Depending on the species status at time of construction, impacts to aquatic and upland habitat would require mitigation. Substantial mitigation may be required for permanent impacts to nesting habitat within 0.25-mile of Tule Canal.

Reconnaissance level surveys were not conducted. All habitat suitability was determined by desktop evaluations. Analysis for some species (i.e., presence of elderberry shrubs, burrows) cannot be determined based on desktop evaluations. Biological surveys will be required to determine to what extent the project would affect federal- or state-listed species, and level of consultation with USFWS and CDFW.

MANAGED WETLAND HABITAT

While implementation of the concepts would result in some impacts to neighboring managed wetland operations, these changes are small, within ±0.5% difference of the Managed Wetland Impact Score (Figure 17, Table 13). The managed wetlands that do experience the most change are predominantly located within Swanston Ranch. Hydrologic conditions, including magnitude and timing, are crucial to determining the Managed Wetland Impact score since it was evaluated from late February to June 30 of each year. Years like 1998, 2003, 2005, 2010, and 2011 have greater changes in impact score due to moderately large-sized (between 2,000 and 5,000 cfs), late season (post March 1) flood pulses independent of water year type. These flood pulses are of adequate magnitude such that concept berm overtopping is not occurring. This means the concept can convey these flood pulses through the concept footprints when they would otherwise activate the floodplain west and south of the concept under Baseline. This changes how water moves downstream in the Tule Canal due to the concepts. It is important to note that specific fields within Swanston Ranch experience increases and decreases to Managed Wetland Impact score in individual water years across the period of record, which can drive a net increase or decrease to the property as whole. However, when averaged across the analysis period there is a slight net decrease in the score indicating a slightly positive benefit overall. This net decrease is driven by the main drain on the border between Conaway Ranch and Swanston Ranch having lower water levels in it, which means less water is able to drain to the southwest of Conaway Ranch as well, both of which limit berm overtopping from that drain in the concepts on the Swanston Ranch fields closest to that drain. In the YBWA, there is a slight net increase in the score driven by minor impacts to a select few fields.

Table 13: Mean Managed Wetland Impact Scores (Lower Scores mean Less Impact)

Subregion Considered	Managed Wetland Impact Score	Change in Managed Wetland Impact Score		
	Baseline	Concept A	Concept B	Concept C
Swanston Ranch	126,395	-0.4%	-0.4%	-0.5%
YBWA	189,505	0.3%	0.3%	0.4%
Full Bypass	499,126	0.2%	0.2%	0.2%

3.3.2.4 FINANCIAL

Financial viability is a function of several factors, particularly construction costs, mitigation costs, long-term operations and maintenance costs, changes in agricultural production and compensation for land value. Each of these factors are briefly described below.

CONSTRUCTION COSTS

Construction costs were developed for concept implementation as summarized in Table 14. and detailed in Appendix J. Costs are inclusive of material mobilization, insurance, surveying costs, habitat construction (dewatering, clearing and grubbing, excavation, and local fill placement), seeding, improvements to drainage infrastructure, and construction oversight. Unit costs were primarily based on similar projects in the Yolo Bypass (Lower Yolo Restoration Project, McCormack Williamson Tract Project) along with other relevant sources as needed to capture all project elements. Two cost estimates were developed for each concept, one that assumes excess material would be hauled off-site, and one that assumes reduced earthwork to avoid having to haul material off-site. Each of these concepts produces an excess of excavated material. For the upper cost estimate, it was assumed that this excess volume would be off hauled to be beneficially used in the project vicinity. For the lower cost estimate, it was assumed the excavation volumes were limited to only the amount that would be needed for constructing the concept features. The latter reduces costs not only by limiting the amount of earthwork for each concept, but by eliminating costly material hauling. The reduction in earthwork would be achieved by reducing the amount of floodplain lowering within the dry farmed fields to the west of the Tule Canal. Construction costs for each concept for the full earthwork version are shown in Table 14. Reduced earthwork construction costs are shown for Concepts B and C. The earthwork balancing method described above cannot be applied to Concept A without impacting the channel network.

Table 14: Construction Cost Estimates

Concept	Habitat Area (ac)	Full Earthwork Cost	Full Earthwork Cost/Acre ($/ac)	Reduced Earthwork Cost	Reduced Earthwork Cost/Acre ($/ac)
Concept A	251.0	$29,276,200	116,638	N/A	N/A
Concept B	294.1	$42,410,200	144,203	$33,888,100	115,226
Concept C	711.5	$44,501,300	62,545	$29,109,900	40,913

MITIGATION COSTS

Mitigation costs for the project could be incurred for temporary impacts to existing species and habitats in the project area as well as for loss of agricultural lands, per the Yolo County Ordinance. For the purposes of this Study, it was assumed that temporary impacts to existing habitats and species could be avoided through detailed project design. Permanent conversion of agricultural lands would be subject to a 1:1 replacement ratio. Because the project is larger than 20 acres, it would not be eligible for the County's In-Lieu Agricultural Mitigation Fee payment. Acquiring agricultural lands to comply with the County's mitigation ordinance would be an additional financial burden to the project. Assuming an agricultural land value cost of $6,000/acre to $10,000/acre, the cost for acquiring mitigation lands could range from $756,000 to $1.2 million for Concept A (conversion of 126 acres) and from 3.8 million to $6.4 million for Concept C (conversion of 643 acres).

OPERATIONS AND MAINTENANCE COSTS

Long-term operations and maintenance (O&M) costs for permanent and seasonal wetlands can vary widely based on the specific wetland type, size, required maintenance activities, and site conditions. A study conducted for the US Environmental Protection Agency looking at 28 case studies in 2004 found annual O&M costs ranged from $6/acre to $2,100/acre (Center for Natural Lands Management, 2004). The average annual O&M cost was $51/acre ($84.64 in 2024 dollars) with a median cost of $122/acre ($202.54 in 2024 dollars).

Operations and maintenance activities typically consist of:

- Routine maintenance, including activities such as debris removal, vegetation maintenance (mowing, invasive plant control), and cleaning of structures;
- Periodic maintenance, including harvesting wetland plants, repairing structures or sediment removal;
- Erosion repair; and
- Invasive species control.

Assuming the median cost from the study noted above, adjusted to 2024 dollars, the annual O&M costs for the Project would range from approximately $90,000/yr for Concept A (448 acres) to $211,000/yr for Concept C (1,042 acres). Over a 20-year period these O&M costs could total $1.8 million to $4.2 million depending on the final concept design and the amount of maintenance required.

LOST AGRICULTURAL PRODUCTION AND COMPENSATION FOR LAND VALUE

Conversion of agricultural lands to permanent habitat will result in a loss of agricultural production and an associated loss of revenue. These impacts may be offset through gains in the ability to farm other areas of the Ranch more frequently due to improvements in drainage and reductions in inundation, as described in more detail in Section 3.3.2.2. However, it is expected that there will be some loss of production and associated revenue.

Conversion of lands to permanent habitat will also preclude the use of these lands for other purposes which will affect the overall value of the lands. This loss of value could be compensated for through a conservation easement. The value of such an easement would need to be determined through an appraisal process, but could be expected to add to the overall financial costs of implementing the Project.

3.3.2.5 WATER SUPPLY

WATER SUPPLY

None of the concepts are expected to impact water supply for upstream and downstream users. Diverters should experience no impact to water supply during the agricultural season when flows in the canal are not influenced by flood pulses and BNP operations. The concepts have been configured to not allow swale and floodplain activation via the Tule Canal for flows less than 700 cfs, which are typically less than this most of the summer. Similarly, diverters should experience no impact to water supply during the non-agricultural season for flooding up and maintaining winter flooded rice and managed wetlands, especially for flows greater than 700 cfs, as the concepts accommodate flow through. It is also acknowledged that the active diverters immediately downstream rely upon (or will eventually rely upon) tidal pumping at Lisbon Weir to recharge the Toe Drain as the primary source for their points of diversion.

DRAINAGE

Changes were made in all concepts to improve onsite drainage for the Ranch. Under baseline, drainage to the Tule Canal occurs via a drainage canal collection system terminating at a single large main drain and a single smaller derelict drain (Figure 6). Both drains are unflapped because there is not reliable all-weather access for debris removal and maintenance. For each of the concepts, the proposed agricultural berm includes a new drainage canal primary collector and multiple flapped water control structures (i.e., main drain plus six others in Concept A and B and five others in Concept C) through the agricultural berm (Figure 9), which then drain into the concept. The improvements to the agricultural berm also increase accessibility for maintenance of the drainage system.

Upstream of the project area, the Upper Elkhorn Basin discharges into the Tule Canal via gravity or pumping at the RD 1600 pumping plant. At low flows, the concepts all have minimal effects on the water stages at this location. Stages increase here by less than 0.5 ft during lower flows. However, the concepts show some increases in stage during high flows. Maximum stages during high flow events increase by 0.5-1 ft, with Concept B having the largest impact regardless of flow. Some backwatering is observed during higher flows due to increased roughness in the concept area for the proposed wetland and riparian landcover, and from the constricted channel capacity. Concept A and B have the smallest footprints of increased roughness and therefore should have the least impacts, but because Concept C is also paired with increasing flow access to LEBLS, it minimizes the backwater effects. Therefore, Concept C has the smallest impact on the stages at the RD1600 pumping plant, then Concept A, and Concept B .

GROUNDWATER

The improved connectivity and increased frequency of activation on the concept floodplain, especially in the concept swales, is expected to increase groundwater recharge as the lands will be inundated more often. This may, however, be partially offset by the decrease in depth and frequency of inundation in the lands to the west and south of the concepts. While the uplift within the concept is expected to be greater than the loss of groundwater recharge outside the concept, no quantitative analysis has been performed to demonstrate this. Additionally, the water that remains within the concept footprint due to the enhanced agricultural berm will move downstream and improve groundwater recharge downstream.

3.3.2.6 WATER QUALITY IMPACTS

All concepts optimize the canal capacity along Conaway Ranch to approximately 1,000 cfs. This narrows and deepens the canal which aims to increase velocities in the canal and create deeper depths. The deeper depths and narrower channels will decrease channel temperatures, which could have positive effects on water quality. Water temperature is an important variable for water quality considerations, as it affects dissolved oxygen and methylmercury levels. Dissolved oxygen increases with decreased water temperature and the production of toxic methylmercury decreases with decreasing temperatures, both of which are positive outcomes for water quality.

Reducing the canal capacity will increase velocities, especially at low flows, and allow for less invasive aquatic vegetation establishment, and more frequent flushing flows. Each concept adjusts different lengths of the Tule Canal (Table 8), with Concept A having the most limited footprint, so canal geometry modifications in this concept would have the least benefit. Concepts B and C reduce the capacity for the full length of the concepts and would be the greatest opportunity for flushing invasive aquatic weeds. Concept B includes the canal re-meandering, which could result in more variable channel velocity, but the realigned canal is still an improvement from Baseline because of its reduced conveyance capacity. Currently there is an operation and maintenance need on the Tule canal to address aquatic weed pressure, and with the improvements to the canal in this reach the demand for maintenance should be reduced.

The added floodplain swales will support low velocity habitat and inundate at moderate flows (i.e., >700 cfs). The lower velocity habitat could increase invasive weed pressure, but because these are seasonally inundated and are not expected to be activated during the summer and hence should not a concern for the establishment of invasive aquatic weeds. The swales will also receive routine annual maintenance, which will suppress aquatic and terrestrial weeds.

3.3.2.7 RECREATION

Winter flooded rice across a majority of the Ranch within the Bypass provides significant private waterfowl hunting opportunities. Waterfowl hunting is managed by an operator via a year-to-year lease.

LAND USE CONVERSION

Many fields within the Ranch and inside the Bypass are open to waterfowl hunting in return for an annual fee payment to CPG. The entire Conaway Ranch is eligible for hunting except where impractical due to structures or proximity to neighboring properties. All fields in the Bypass are eligible for hunting.

Currently a total of 5,070 acres of land on the Ranch within the Bypass are open to hunting based on the field unit analysis described in Section 2.2. In Concepts A and B, Fields 33-3 and 10-2E (152 acres) were the only fields open to waterfowl hunting (Table 15, Figure 3). In Concept C, the expanded footprint includes waterfowl hunting on rice Fields 3-1W, 3-2, 3-3, and 3-4 (289 acres). To be conservative, it was assumed that converted lands would result in a 100% loss of hunting opportunities on those converted lands. However, there may be potential for continued waterfowl hunting if proper consideration is given to support this activity.

Table 15: Acres of Hunting Land Removed from Use

Area Removed from Hunting (acres)	Concept A	Concept B	Concept C
Rice	0	0	289
Naturalized	152	152	152
Total (% of Total Ranch Area)	152 (-3%)	152 (-3%)	441 (-9%)
Total Remaining	**4917**	**4917**	**4629**

WATERFOWL HUNTING

Waterfowl Hunting impact scores consistently decrease from Baseline to concepts indicating an improvement in waterfowl hunting opportunities. This can be seen on Ranch lands outside the concepts experiencing a decrease in Waterfowl Hunting impact score by 12% in Concepts A and B and 9% in Concept C (Table 16). The negative percentages indicate less impact, reflecting a positive benefit of the project. Most of the benefit occurs on the Ranch outside the Project, but Swanston Ranch also experiences a minor benefit. However, the Ranch on the whole experiences a decrease in impact score of 11.7%, 11.7%, and 9.6% for Concepts A, B, and C, respectively.

Table 16: Mean Change in Waterfowl Hunting Impacts Scores

<table>
<tr><th colspan="2" rowspan="2">Subregion Considered</th><th>Waterfowl Hunting Impact Score</th><th colspan="3">Change in Waterfowl Hunting Impact Score</th></tr>
<tr><th>Baseline (Min/Max Footprint[1])</th><th>Concept A</th><th>Concept B</th><th>Concept C</th></tr>
<tr><td rowspan="3">Conaway Ranch</td><td>Concept</td><td>0/71,392</td><td>n/a[2]</td><td>n/a[2]</td><td>-100%</td></tr>
<tr><td>Outside Concept</td><td>681,651/553,173</td><td>-11.7%</td><td>-11.7%</td><td>-9.2%</td></tr>
<tr><td>Total</td><td>681,651/560,530</td><td>-11.7%</td><td>-11.7%</td><td>-9.6%</td></tr>
<tr><td colspan="2">Swanston Ranch</td><td>488,056</td><td>-1.2%</td><td>-1.2%</td><td>-0.9%</td></tr>
<tr><td colspan="2">YBWA</td><td>2,213,485</td><td>0.1%</td><td>0.1%</td><td>0.1%</td></tr>
<tr><td colspan="2">Full Bypass</td><td>4,346,874</td><td>-1.6%</td><td>-1.6%</td><td>-1.3%</td></tr>
</table>

Note: negative percentages indicate less impact, reflecting a positive benefit.

[1] Where applicable, the first Baseline number represents the minimum footprint impact score, and the second number is the score based on the maximum footprint. The percentage changes for Concept A and B are with respect to the minimum footprint while Concept C is with respect to the maximum footprint.

[2] These are not applicable because, while 152 acres of fields currently open to hunting were absorbed into the concept (Table 15), the waterfowl hunting metric was calculated for all winter inundation-managed fields. Field 33-3 is open to hunting and so is acreage of land removed from hunting, but since active winter managed inundation does not occur on this field, it so was not evaluated for waterfowl hunting.

4 FINDINGS

This feasibility study evaluates a range of concepts along the Tule Canal through Conaway Ranch's property. Three concepts were developed and tailored to demonstrate the feasibility of potential enhancements in alignment with the Project's goals and objectives. The evaluation criteria developed and applied in this feasibility study are intended to cover a range of conditions. The compatibility of each concept in relation to the evaluation criteria is summarized in Table 17. Dark green indicates the concept met the goals and objectives, medium green reflects the concept is moderately compatible, and light green reflects a less compatible concept.

Table 17: Concept Evaluation

Goal	Eval Criteria	Concept A	Concept B	Concept C
Flood		Very Compatible	moderately compatible	less compatible
Agriculture		Very Compatible	Very Compatible	moderately compatible
	Land Use Change	Very Compatible	Very Compatible	moderately compatible
	Ag Compatibility	Very Compatible	Very Compatible	moderately compatible
Habitat		moderately compatible	moderately compatible	Very Compatible
	Land Use Change	moderately compatible	moderately compatible	Very Compatible
	Juvenile Habitat	less compatible	less compatible	Very Compatible
	Fish Passage	Very Compatible	Very Compatible	Very Compatible
	Bird Habitat	moderately compatible	moderately compatible	Very Compatible
	Managed Wetland	moderately compatible	moderately compatible	moderately compatible
	Terrestrial Habitat	moderately compatible	less compatible	moderately compatible
	Aquatic Habitat	moderately compatible	moderately compatible	Very Compatible
Financial		less compatible	less compatible	moderately compatible
Water Supply		Very Compatible	Very Compatible	Very Compatible
	Water Supply	Very Compatible	Very Compatible	Very Compatible
	Drainage	Very Compatible	Very Compatible	Very Compatible
	Groundwater	moderately compatible	moderately compatible	Very Compatible
Water Quality		moderately compatible	Very Compatible	Very Compatible
Recreation		Very Compatible	Very Compatible	moderately compatible
	Land Use Change	moderately compatible	moderately compatible	less compatible
	Waterfowl Hunting	Very Compatible	Very Compatible	Very Compatible

****Very Compatible*, *moderately compatible*, *less compatible***

Concept A ranks strongly in relation to flood conveyance, agricultural compatibility, waterfowl habitat suitability, recreation compatibility, and financial impacts. It is less effective at improving juvenile salmon rearing habitat. Concept B is very similar to Concept A in its performance except that it is significantly more expensive to construct due to realignment of the Canal. Concepts A and B are both beneficial to juvenile habitat within their footprints, however in their current configuration, show minor decreases in suitability outside the Project footprint. By contrast, Concept C more than offsets impacts outside of the

Project due to the habitat benefits accrued within the expanded footprint. However, Concept C is less effective in terms of flood conveyance and agricultural compatibility due to the permanent conversion of rice fields to habitat. Considering overall costs and benefits, Concept C is the most promising alternative, especially if earthwork within the dry farm fields can be reduced.

Concept A is a minimal concept, with the smallest project footprint (448 acres) and smallest extent of floodplain grading. Modifications were limited by the Ranch property boundaries. It maintains the existing Canal alignment; however, the capacity was modified along the project footprint to optimize floodplain inundation. For the flood impacts modeled during a 100-year event, all concepts fell within the threshold of 0.1 ft at the KLRC index point. Concept A has the smallest flood impact when considering WSE changes with the Yolo Bypass, increasing the flood stage up to 0.15 ft directly upstream of the concept, just downstream of County Road 22, and up to 0.1 ft in the Bypass up to 4.25 miles upstream, just north of Knights Landing Ridge Cut.

Concept A removes multiple fields from agricultural production (namely dry farmed fields), but improved drainage results in additional plantable years in fields outside the Project area compared to Baseline. Losses in agricultural production could be potentially mitigated by gains in plantable acres outside of the Project area. Hydrospatial analysis showed an 80% increase in juvenile salmonid habitat within the concept and a minor (3.6%) decrease within the entire Ranch property. Waterfowl, Shorebirds, and Sandhill Crane habitats improved within the Project area (72%, 268%, and 93%, respectively) with slight net positives for Waterfowl and Sandhill Cranes and a minor reduction for Shorebirds on the entire property. Much like juvenile salmonid habitat, this is attributable to drainage changes. Full earthwork/construction costs of Concept A are $29,276,200, or $116,638/acre.

Concept B expands on Concept A with the addition of private and State-owned sections of the Tule Canal (479 acres). This concept realigns and modifies the capacity of the Canal throughout the project footprint. Concept B increases flood stages up to 0.2 ft directly upstream of the concept, with smaller flood impacts extending slightly further upstream. Impacts to agricultural fields within the Project area are largely mitigated by gains in plantable acres outside of the Project area. Habitat changes include a 63% increase in juvenile salmonid WUA with the Project area, and very minor reduction (-2%) for the entire property. Mean Bird Habitat WUA increased for the concept (Waterfowl 15%, Shorebird 62%, and Sandhill Crane 12%), with minor changes for the entire property (Waterfowl 0.8%, Shorebirds -2.3%, and Sandhill Crane <-1%). The construction costs of Concept B are $42,410,200 ($144,203/acre) or $33,888,100 ($115,226/acre) for the reduced earthwork alternative.

Concept C expands the Project footprint to the east to include the full degrade of the remnant east levee toe, and to the west to include existing agricultural fields (1042 acres). It maintains the existing Canal alignment; however, the capacity is modified along the whole project footprint to optimize floodplain inundation. The dry farmed fields are degraded in the same location as Concepts A and B; however, the swale network and habitat mound placement are expanded to the west, which increases the overall conveyance of the project.

Concept C has the largest flood impact raising flood levels by up to 0.3 ft directly upstream and 0.1 ft at KLRC. Concept C flood impacts could be mitigated through subsequent design refinements to manage roughness, especially near the inlet to LEBLS. Concept C removes the most land from agricultural production, but shows the largest habitat improvement. Agricultural lands could potentially be recovered by Ranch operations in other locations, or through further refinements to the concept to improve agricultural compatibility. Juvenile salmon WUA increased close to 100%, with notable benefits to the entire property (13%). The full concept showed substantial increases in bird habitat (Waterfowl 116%, Shorebirds 350%, Sandhill Crane 159%) with minor gains for the entire property.

Due to the proposed agricultural berm impacting hydraulic connectivity between the lands within and outside the Project area, only Concept C has a large enough floodplain footprint to have a net increase in salmon WUA on the full Ranch property. Conversely, the proposed agricultural berm improves suitable depths for waterfowl more often outside the Project area. The changes to WUA for shorebirds and cranes follow similar trends as waterfowl, only with a smaller magnitude. All of the concepts improve habitat suitability within the concept footprint for all four evaluated species/groups. All three concepts reduce managed wetland and hunting impacts on Conaway Ranch and Swanston Ranch.

The impacts on drainage and water supply throughout the Bypass are minimal. Conaway Ranch drainage is improved by the concepts, which limit field impacts during floods. The higher agricultural berm affects water flow during small floods and river pulses. While water quality is generally improved, potential debris obstructions at flapped culverts could lead to ponding and invasive aquatic vegetation encroachment. These issues can be mitigated by routine maintenance, with the concepts activating infrequently enough such that invasive aquatic vegetation have insufficient duration and frequency of inundation to provide suitable conditions for growth.

5 RECOMMENDED CONCEPT

The concepts developed and analyzed within this study cover a range of scales and evaluation criteria. The benefits have been demonstrated to vary by concept, with further refinement needed to optimize the preferred approach. A hybrid design is therefore recommended that would include considerations from all three preliminary concepts, with further optimization to address each of the project goals.

A primary objective of the preferred concept is that it would be flood neutral. The concept designs and landcover changes resulted in modeled flood stages increases up to 0.3 ft directly upstream of the concepts, with increases greater than 0.1 ft confined to the region south of KLRC for all concepts.
Refining landcover changes, especially opposite the inlet to LEBLS to limit impacts to the flow split during flood flows, can likely mitigate this issue.

The agricultural considerations of any proposed land use change are of critical importance to the Ranch. Concept A and B both show the potential for an increase in plantable acres or agricultural production outside of the concept footprint. Considering the broader scope, the significant loss of agricultural land is unlikely to be entirely mitigated and needs to be balanced by the productivity of the converted lands.

Therefore, a project of such magnitude must demonstrate economic viability to be pursued. The implications of the Big Notch Project also need to be considered within any recommended approach and factored into both the Ranch and project economics.

To promote the economic viability of any proposed concepts, it is essential to demonstrate a cost-benefit analysis in relation to earthwork volumes. The realignment of the Tule Canal, as depicted in Concept B, was found to offer negligible improvements in habitat suitability while incurring significantly higher costs and resulting in a larger flood impact. Based on these reasons, re-meandering the Canal will not be included in future proposals. The majority of concept earthwork is proposed in the degraded fields on the east side of the Ranch. This region provides the largest habitat gains, with flood benefits from the additional transient water storage on the lowered ground. To limit cost, the recommended future concept could reduce degrade activities across the dry farmed fields while still providing a high degree of connectivity to the Tule Canal, but this consideration is only viable for a concept with a larger connected area like Concept C. Opportunities to reduce earthwork in the dry farmed fields could also be further explore.

Based on habitat suitability, the findings have shown both increases and decreases for the species evaluated. Salmonid connectivity is of critical importance and habitat gains are strongly influenced by the enhancement of the agricultural berm on the western edge of the concept boundary. The berm benefits agriculture by reducing field impacts, increasing plantable acres, and enhancing waterfowl habitat. The unintended side effect that warrants further refinement, is the modeled decline in salmon habitat suitability outside of the concept footprint when compared to the Baseline. To address this connectivity issue, there are three potential considerations: 1) add operable combination gates to the drainage culverts through the proposed agricultural berm, 2) add operable gates to the east-west oriented section of the proposed agricultural berm, and 3) do not construct the proposed agricultural berm enhancements. By adding operable combination gates, the culverts could remain open to allow backwater inundation until March 15, at which point the gates would return to their flapped position. Similarly, operable gates in the east-west section of berm could remain open to allow flow through into the rice fields south of the concept until March 15, at which point the gates would be closed wherein juvenile salmon egress would be accommodated via the drainage improvement in the berm (versus being limited to the main drain under Baseline). Allowing inundation pre-March 15 increases juvenile access similar to Baseline, but post March 15 inundation restrictions improve agricultural viability on fields outside the concept. However, foregoing proposed berm enhancements, especially those that affected flows north to south, would effectively return lands outside the concept to their Baseline condition, resulting in no potential benefits to agricultural production (as well as waterfowl hunting benefits).

6 NEXT STEPS

Phase 2 of the Tule Canal Wetland Corridor Enhancement Feasibility Study will be a direct continuation from this current study. Under Phase 2, concept evaluation within a multi-benefit framework will be completed leading to the development of a hybrid concept and an update to the Feasibility Study. The preferred concept will be advanced into a 10% design package suitable for soliciting future project funds.

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Appendix G: Geotechnical Memorandum, Tule Canal Enhancement Project
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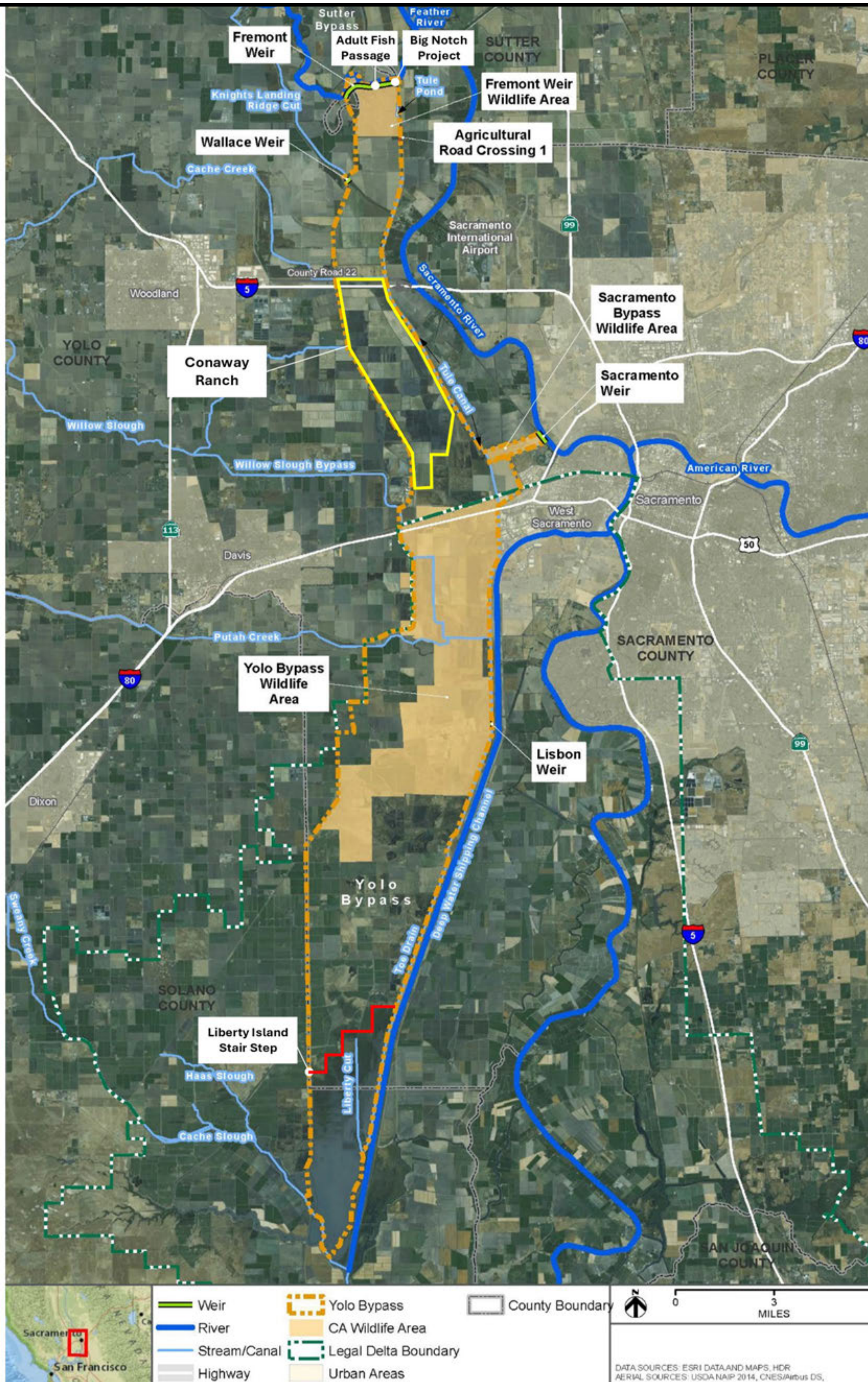
Appendix I: Cultural Resources Analysis for the Conaway Tule Canal Enhancement Project
Appendix J: Tule Canal Wetland Corridor Enhancement: Construction Cost Estimates

10 FIGURES



Notes: Edited from: Figure 1−1 Project Area from DWR, 2019.

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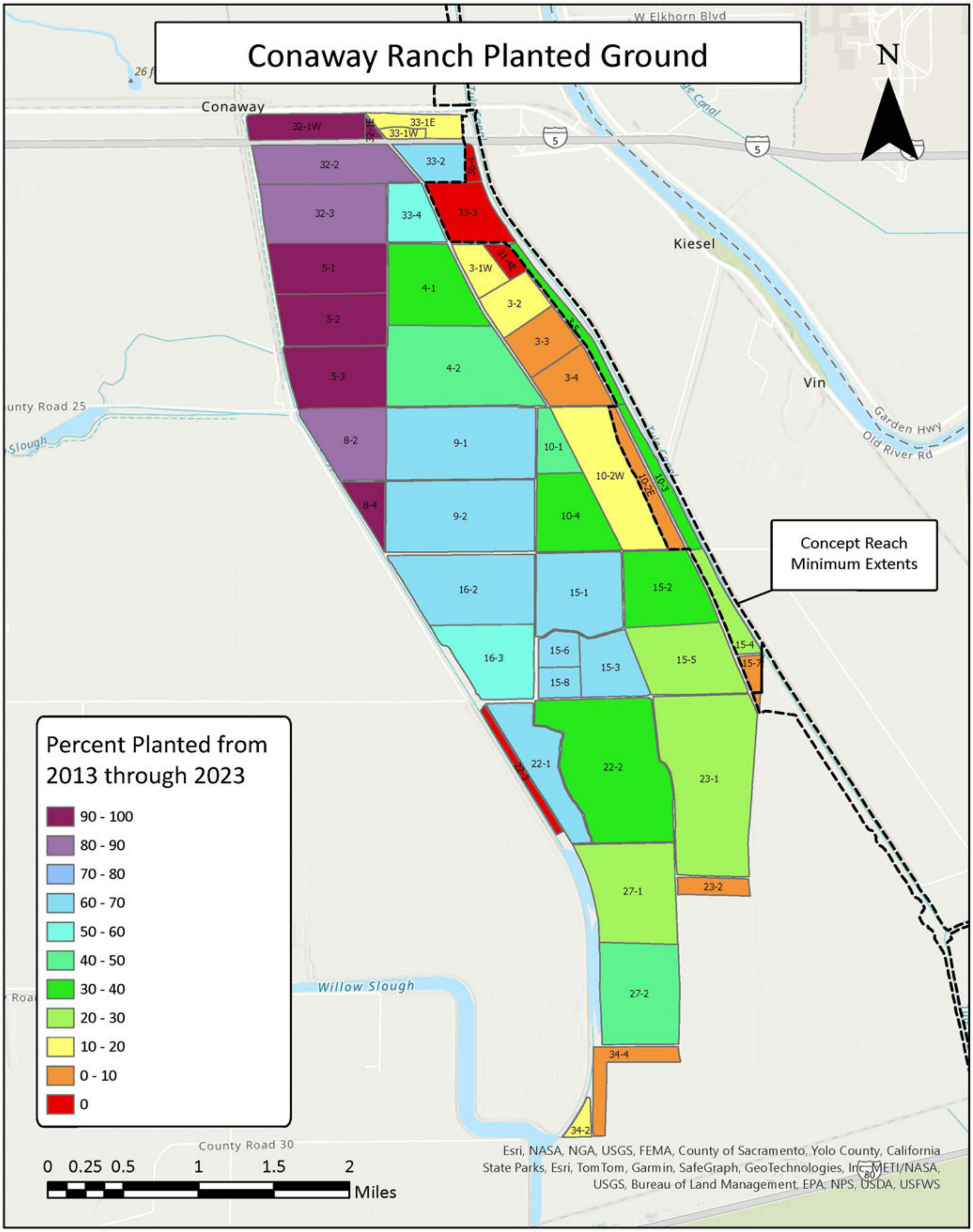
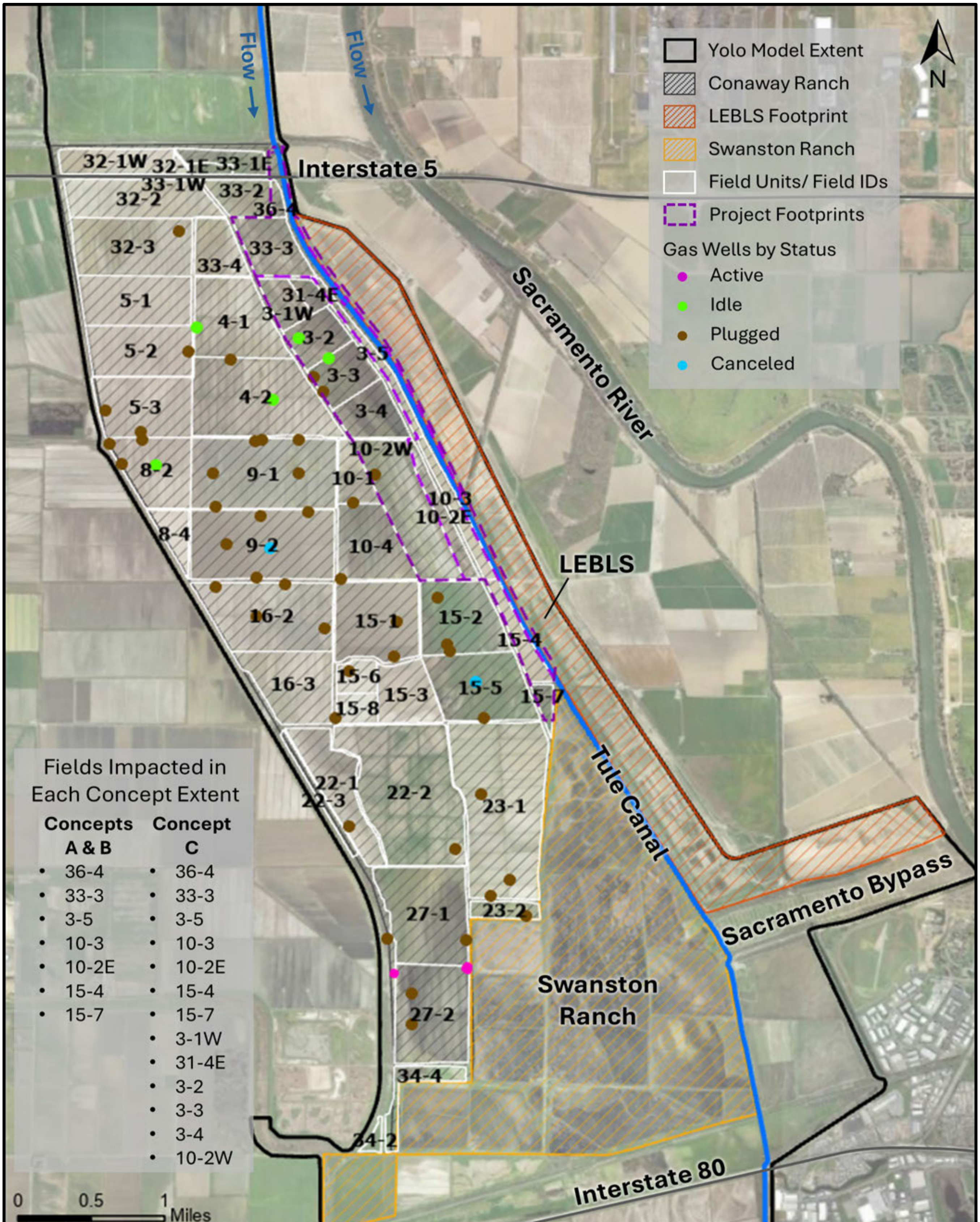
Tule Canal Wetland Corridor Enhancement

Yolo Bypass Overview

Project No. 23−1003	Created By: DWR/JLD	Figure 1



Notes:	cbec eco engineering A Verdantas Company	*Tule Canal Wetland Corridor Enhancement* **Conaway Ranch Percent of Years 2013−2023 Planted**		
		Project No. 23−1003	**Created By: TB**	**Figure 2**



Notes:

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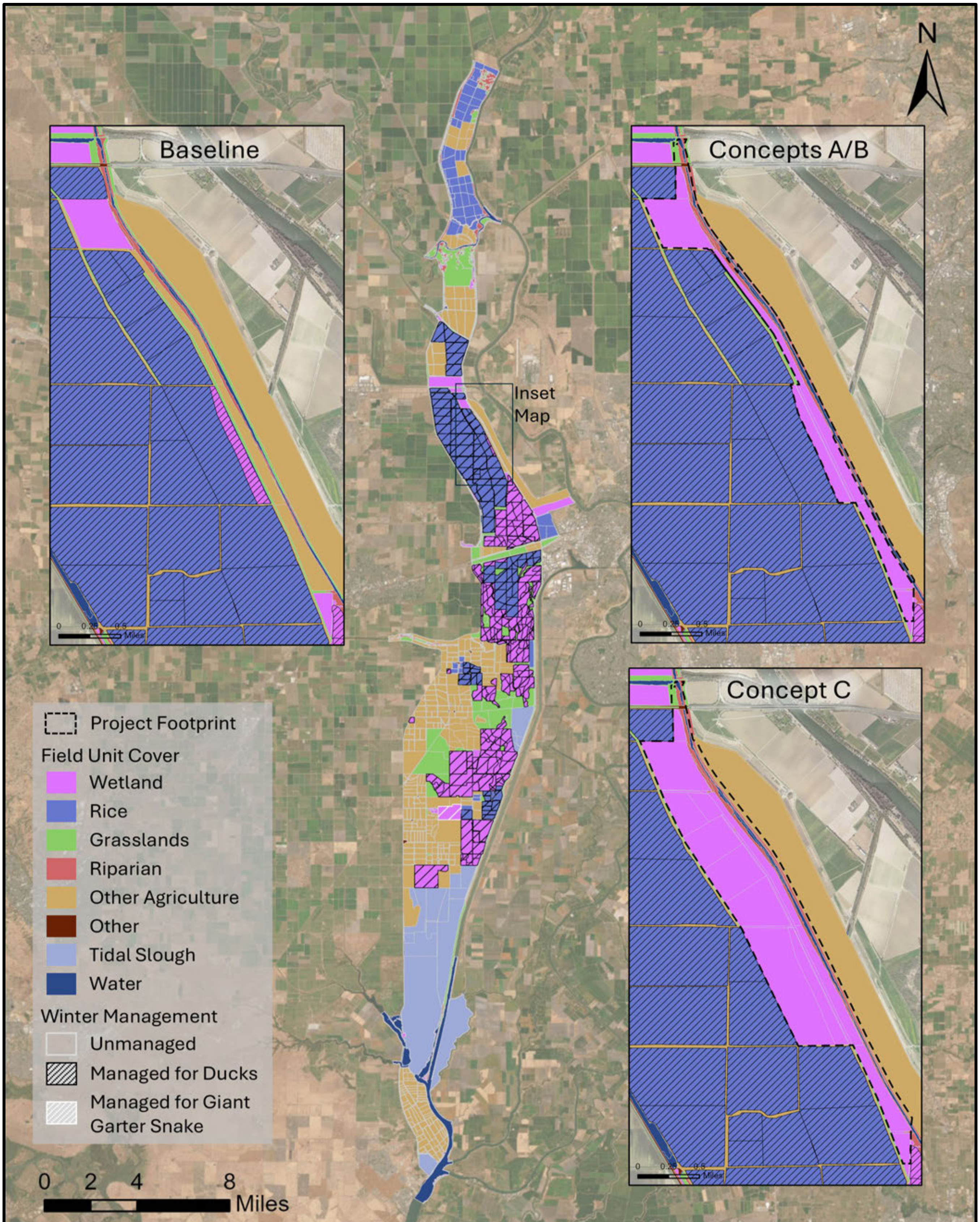
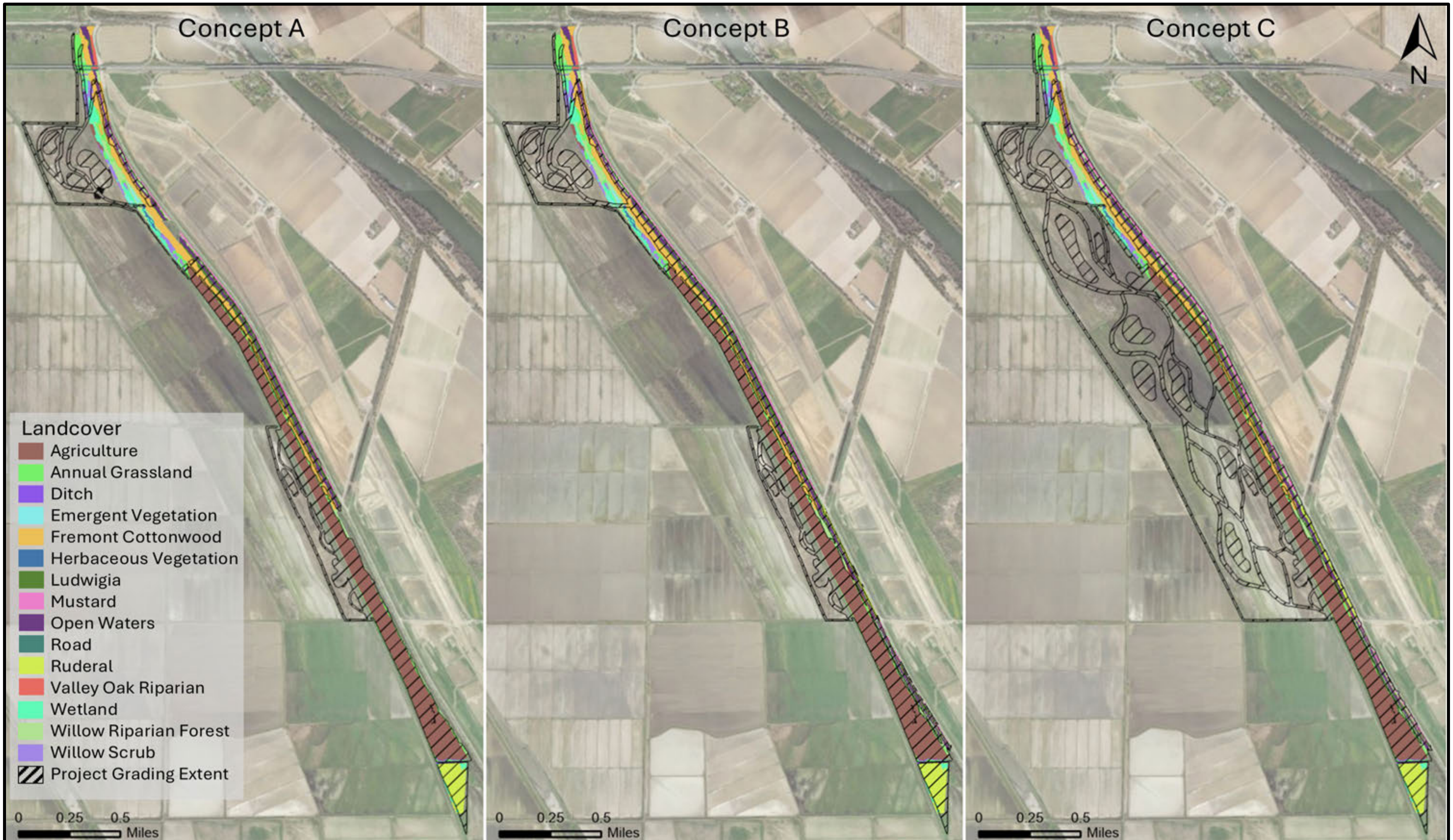
Tule Canal Wetland Corridor Enhancement

Conaway Ranch Site Overview

Project No. 23−1003	**Created By: JLD**	**Figure 3**



Notes:	cbec eco engineering A Verdantas Company	*Tule Canal Wetland Corridor Enhancement* **Yolo Bypass Field Units and Landcover**		
		Project No. 23−1003	**Created By: JLD**	**Figure 4**



Notes: Landcover mapping completed by ICF

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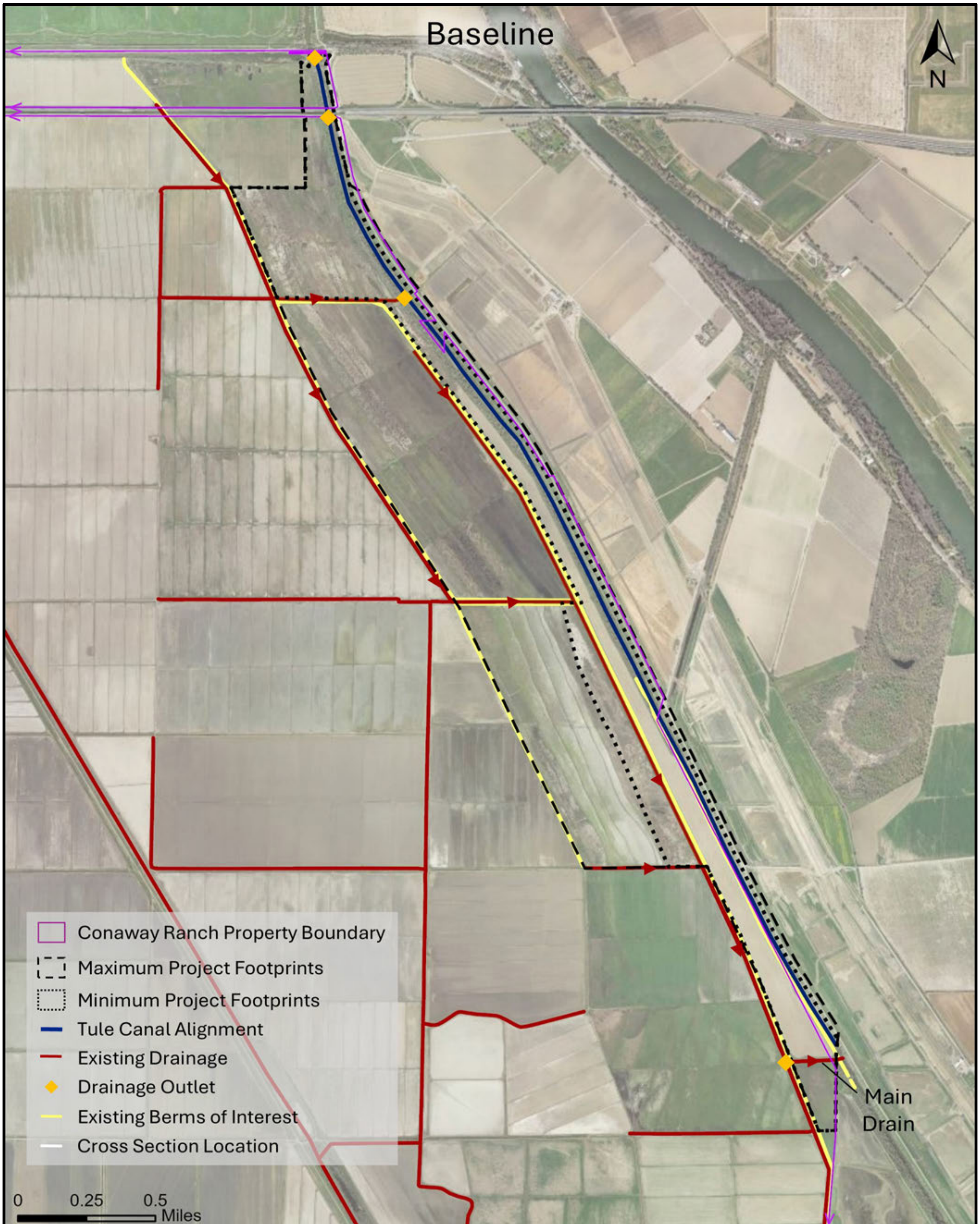
Tule Canal Wetland Corridor Enhancement

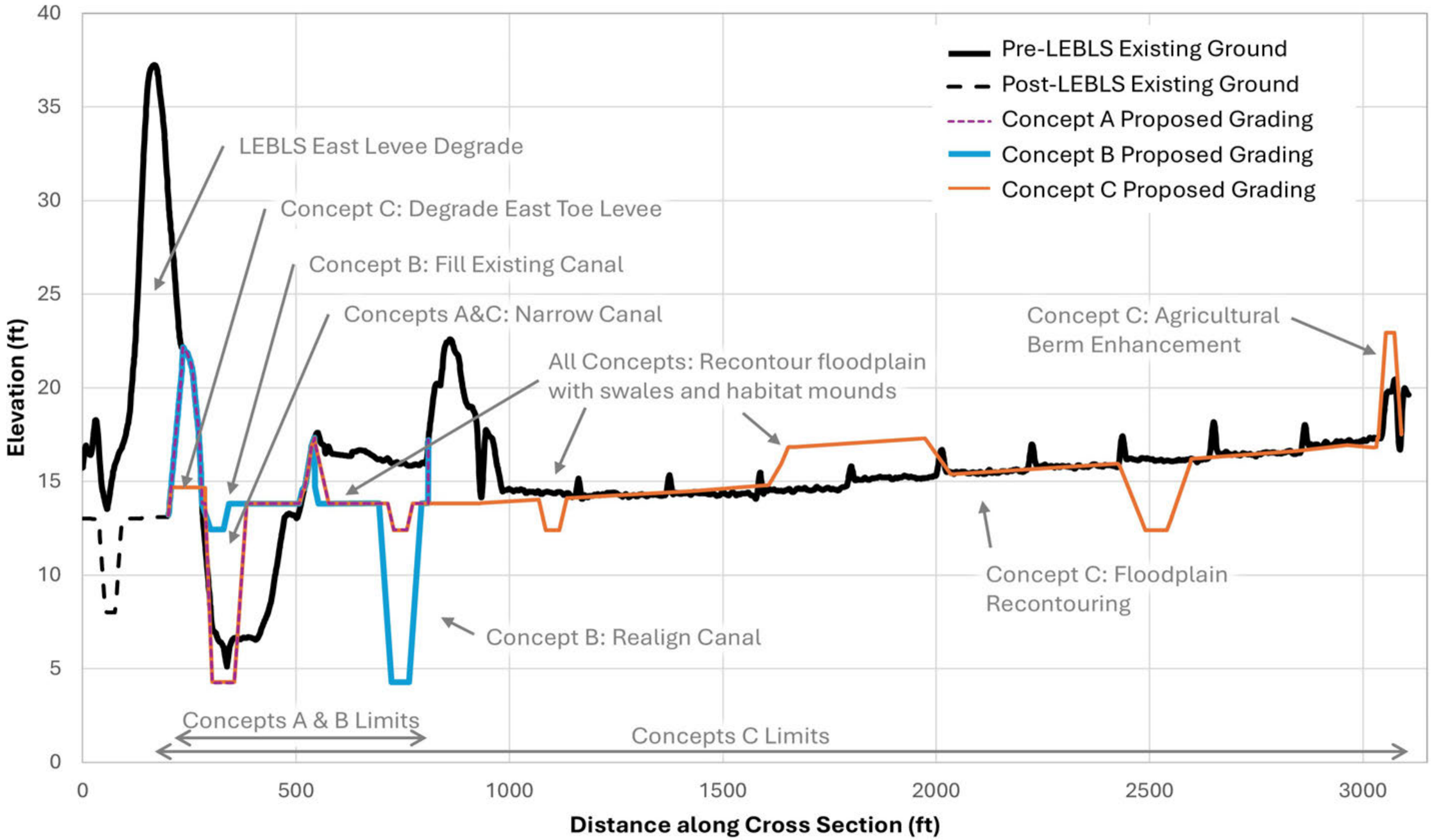
Existing Landcover and Proposed Grading Extents

Project No. 23–1003	Created By: JLD	Figure 5



Notes:	cbec eco engineering A Verdantas Company	*Tule Canal Wetland Corridor Enhancement* **Project Area Existing Conditions**	
		Project No. 23−1003	**Created By: JLD**

Figure 6



Notes: Cross section location is shown in Figure 5.

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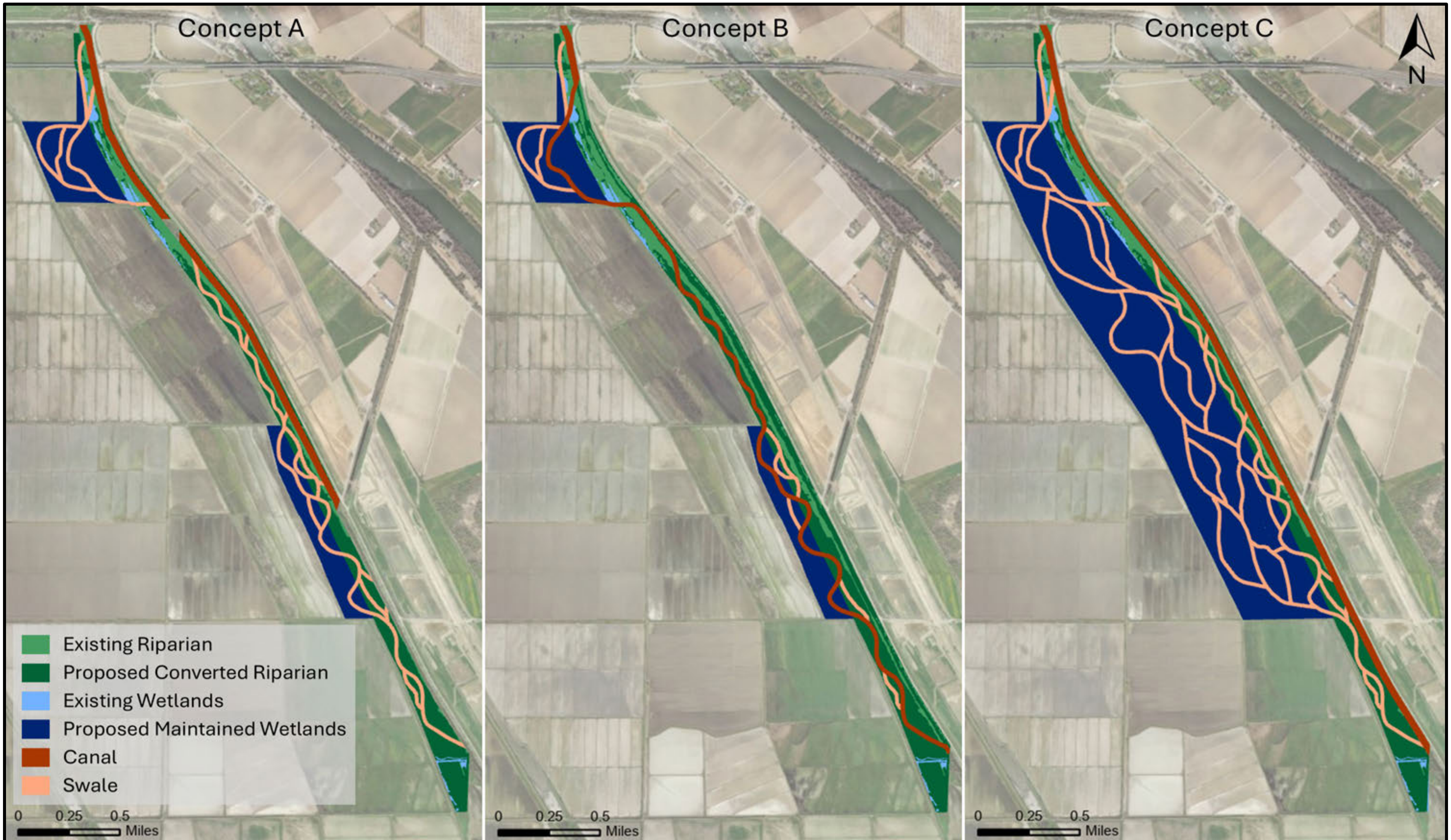
Tule Canal Wetland Corridor Enhancement

Example Cross Section Proposed Terrain Changes

Project No. 23–1003	**Created By: JLD**	**Figure 7**



Notes:

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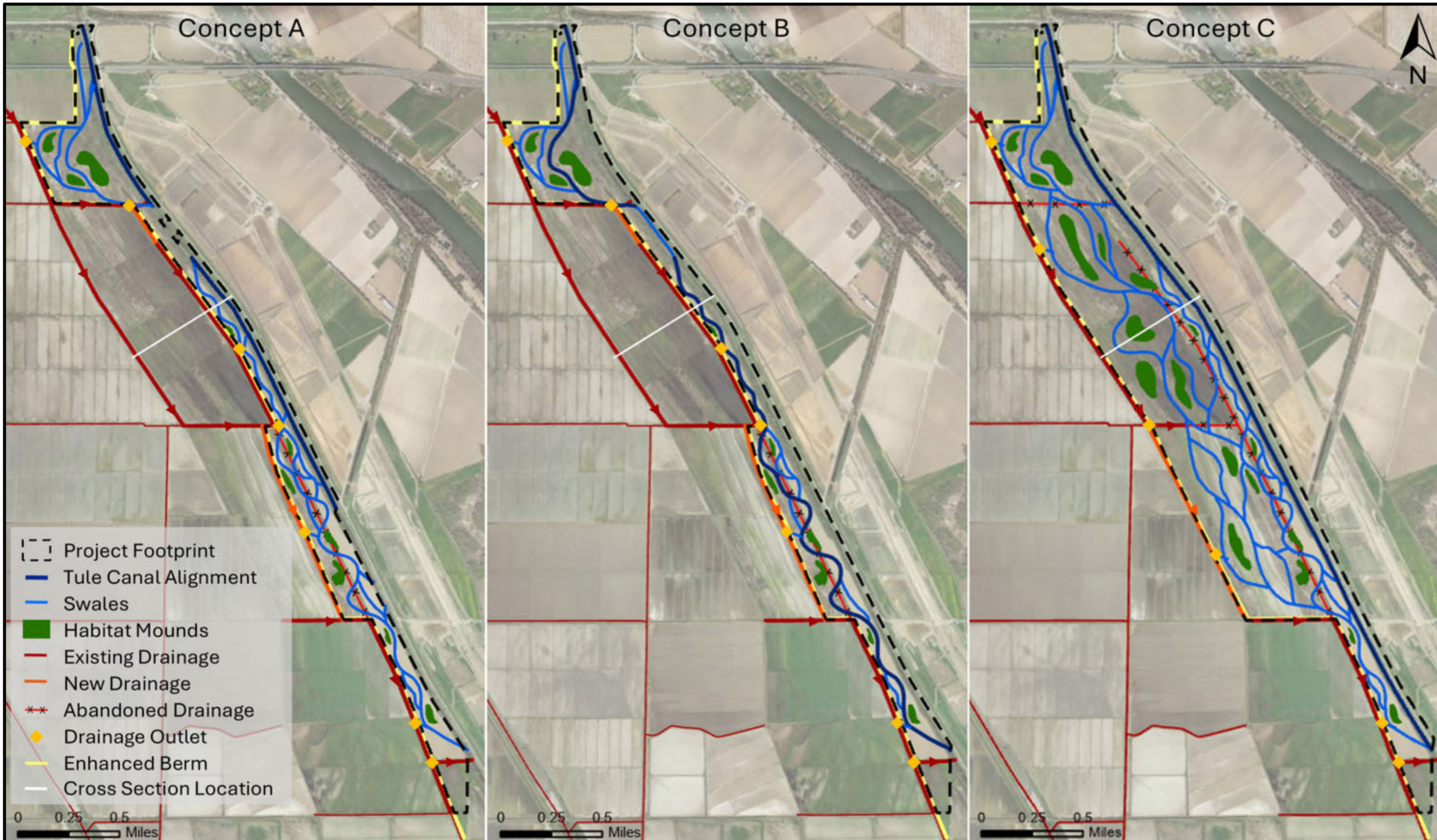
Tule Canal Wetland Corridor Enhancement

Proposed Landcover

Project No. 23–1003	**Created By: JLD**	**Figure 8**



Notes:

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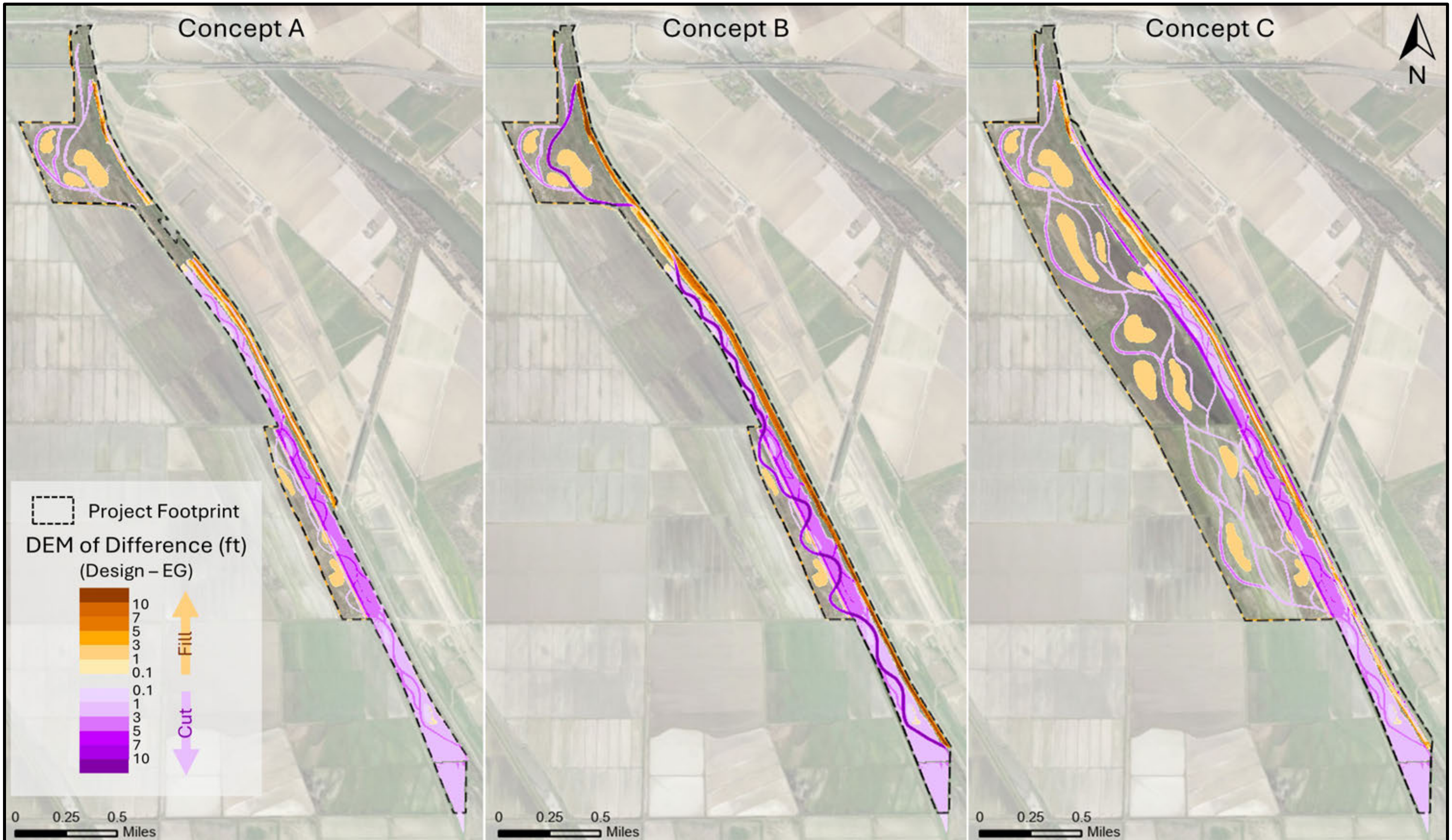
Tule Canal Wetland Corridor Enhancement
Project Area Proposed Conditions

Project No. 23–1003	Created By: JLD	Figure 9



Notes:

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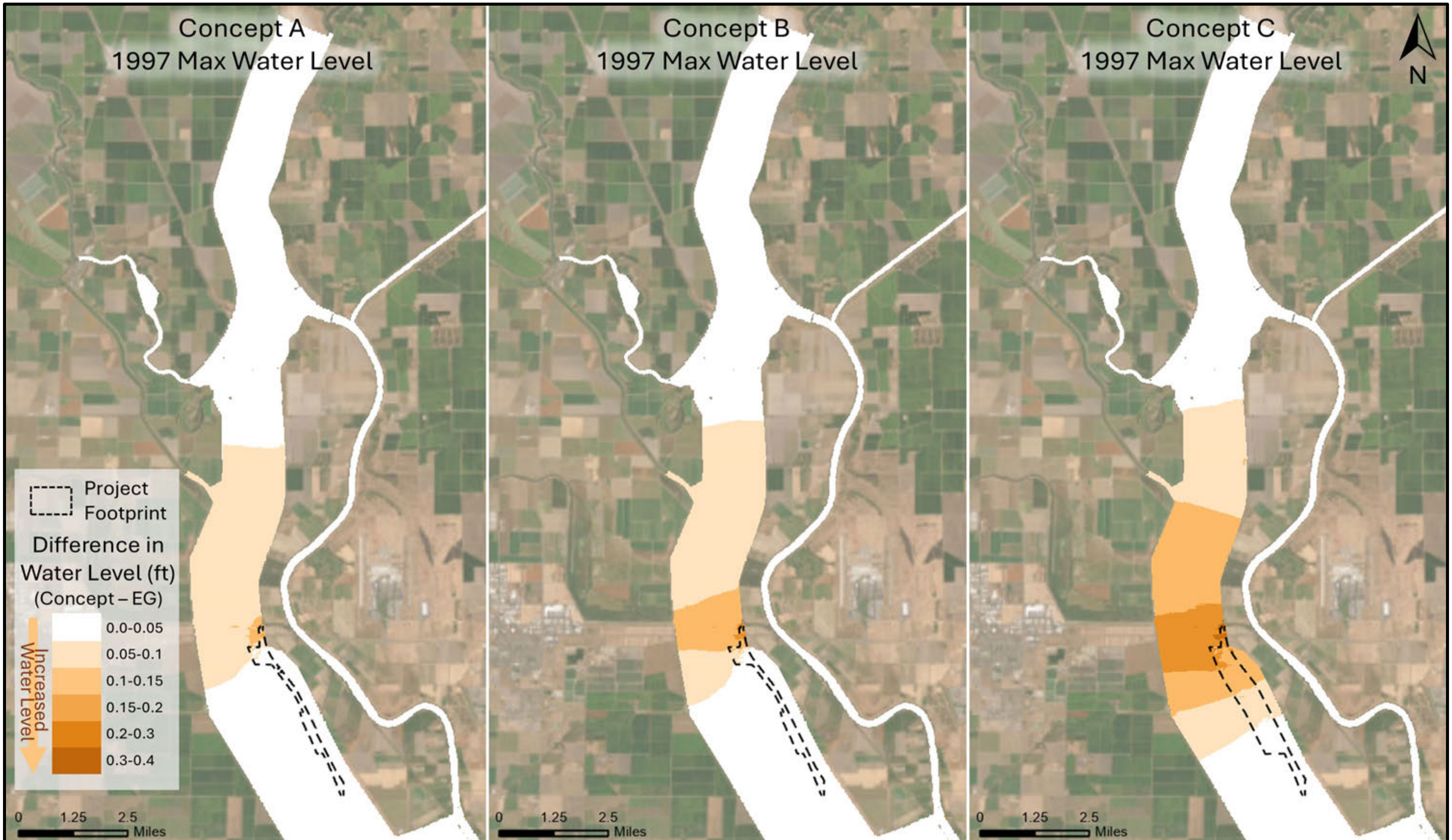
Tule Canal Wetland Corridor Enhancement

Proposed Terrain Changes, Cut and Fill

Project No. 23–1003	Created By: JLD	Figure 10



Notes:

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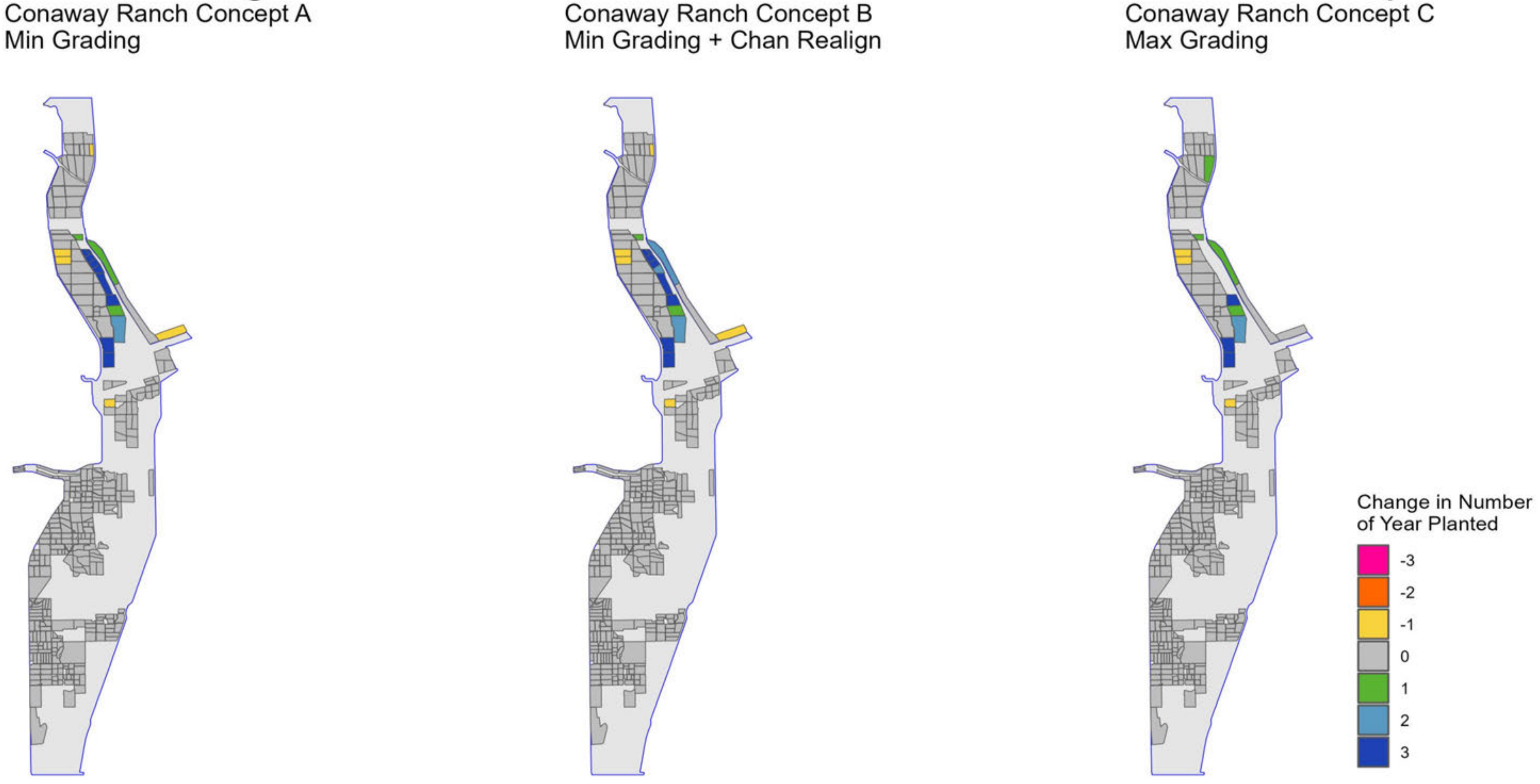
Tule Canal Wetland Corridor Enhancement

Potential Flood Impact

Project No. 23–1003	**Created By: JLD**	**Figure 11**

Agriculture Impacts

Change in Number of Plantable Years from Baseline to Concept



Notes:

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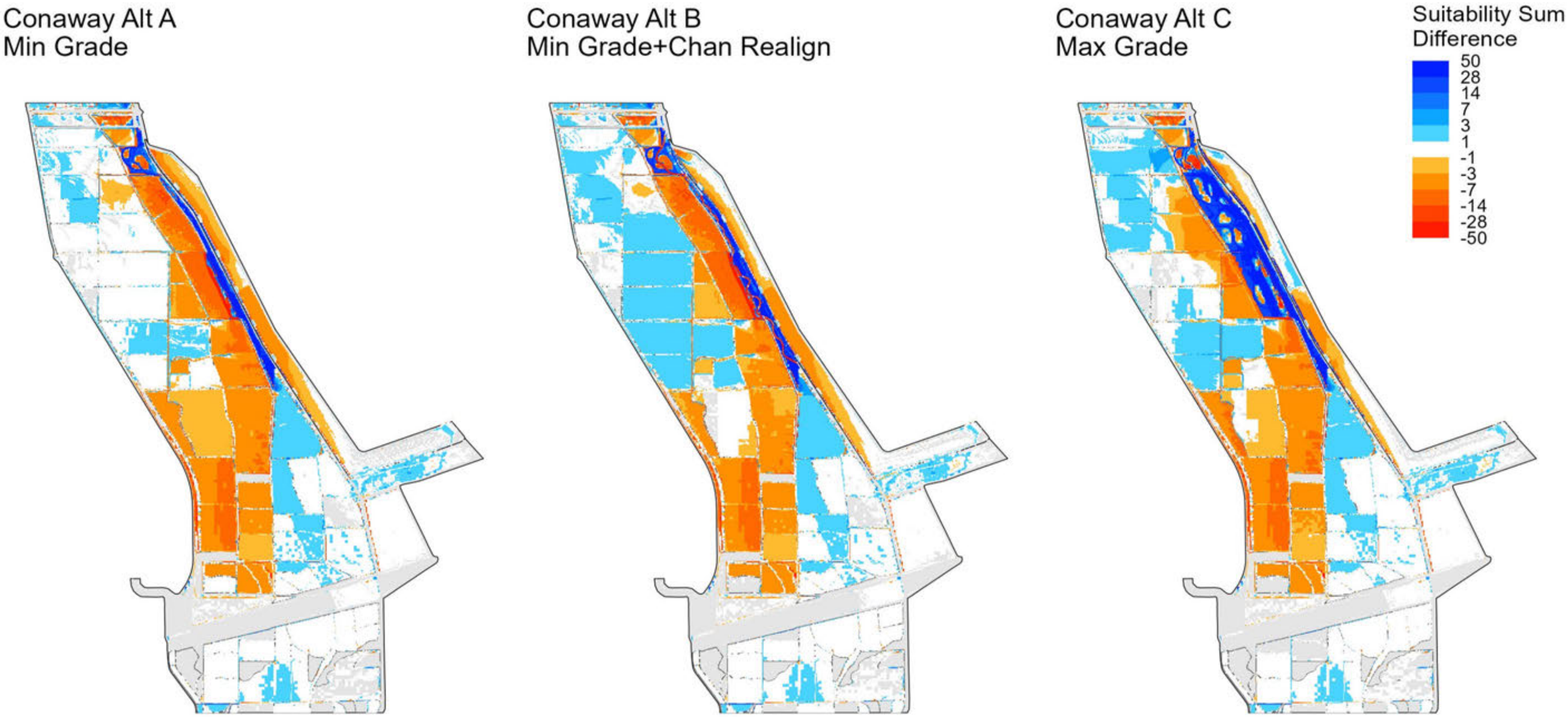
Tule Canal Wetland Corridor Enhancement

Agriculture Impact: Change in Plantable Years

Project No. 23–1003	Created By: JLR	Figure 12

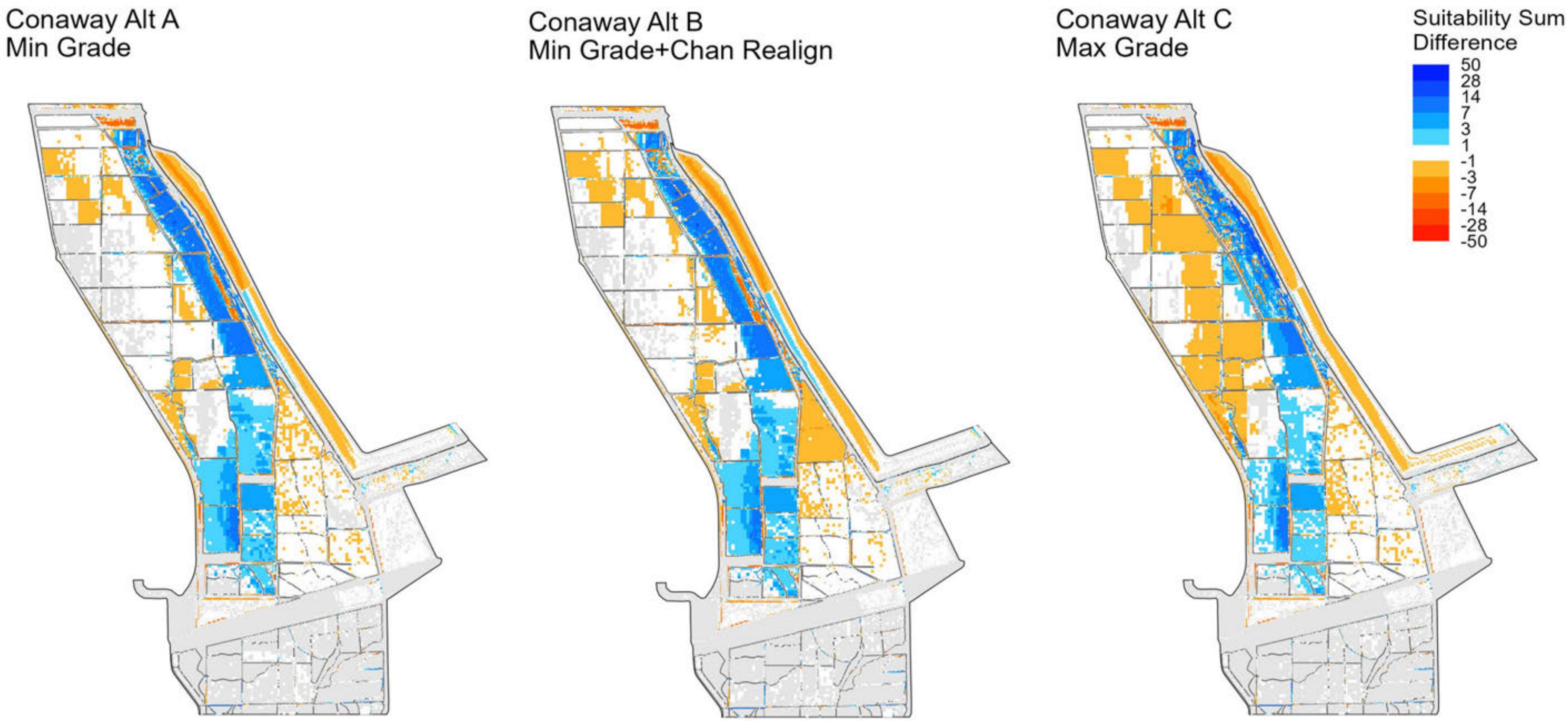
Mean Across All WY - Salmon



Notes:

	Tule Canal Wetland Corridor Enhancement **Change in Juvenile Salmon Suitability**		
cbec eco engineering A Verdantas Company	**Project No. 23–1003**	**Created By: JLR**	**Figure 13**

Mean Across All WY - Waterfowl



Notes:

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Tule Canal Wetland Corridor Enhancement

Change in Waterfowl Suitability

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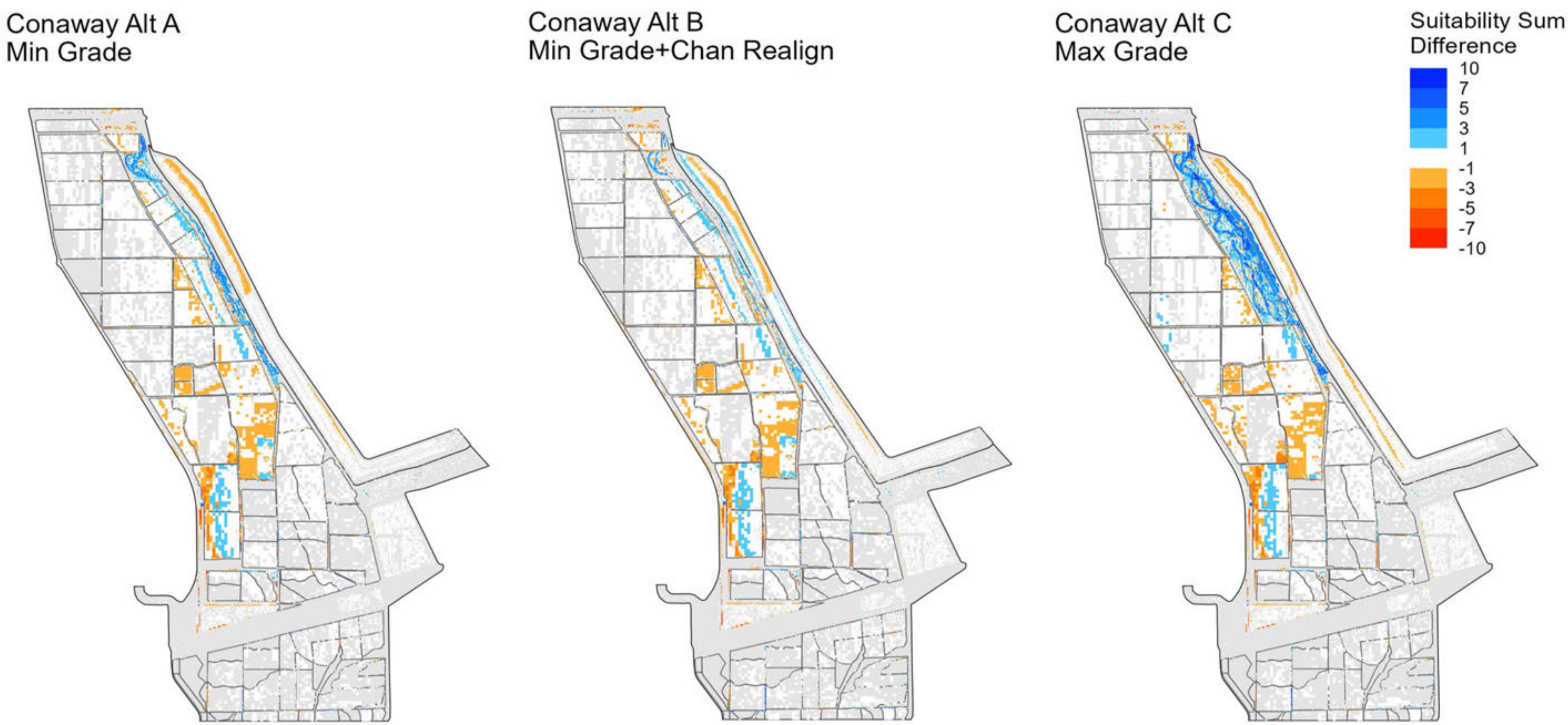
Mean Across All WY - Shorebird



Notes:

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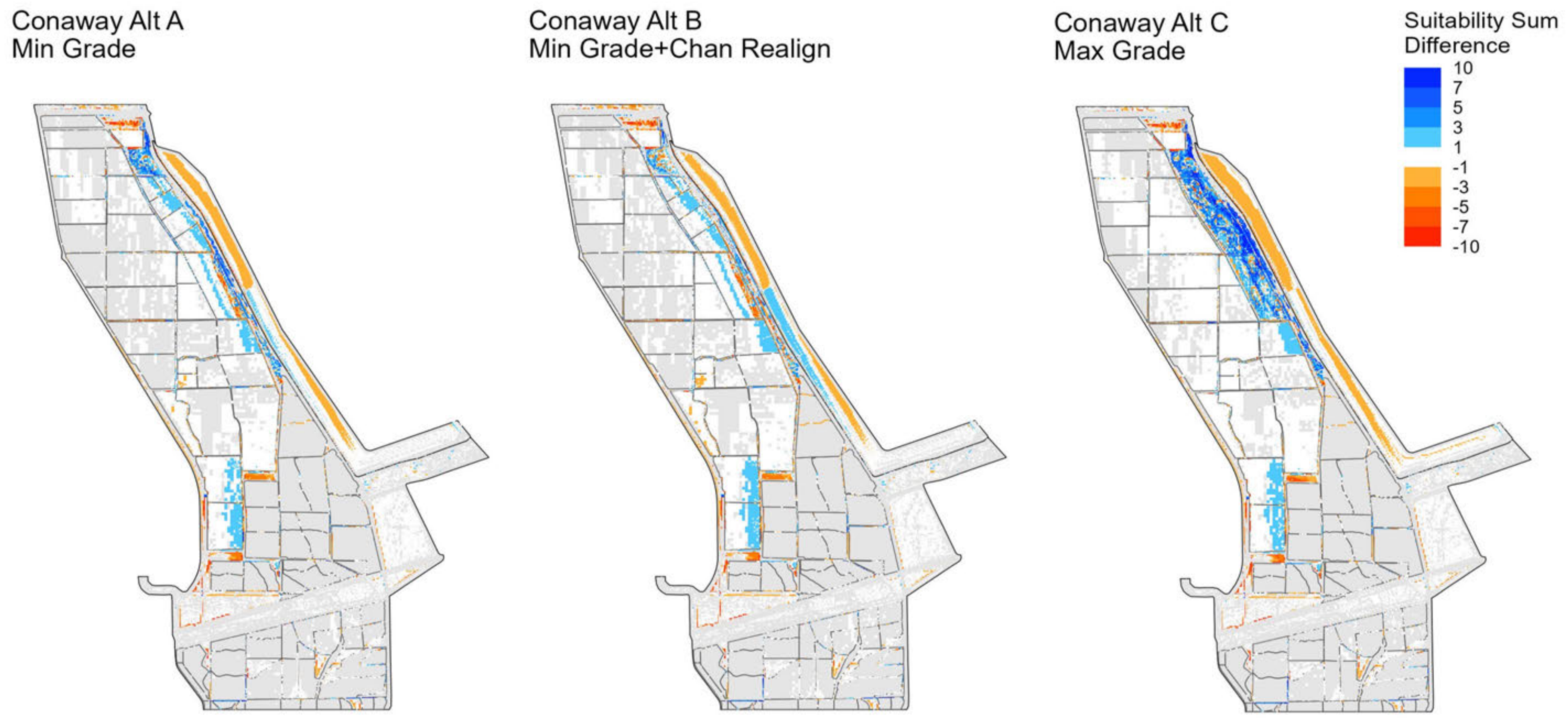
Tule Canal Wetland Corridor Enhancement

Change in Shorebird Suitability

Project No. 23–1003	**Created By: JLR**	**Figure 15**

Mean Across All WY - Sandhill Crane - Roosting



Notes:

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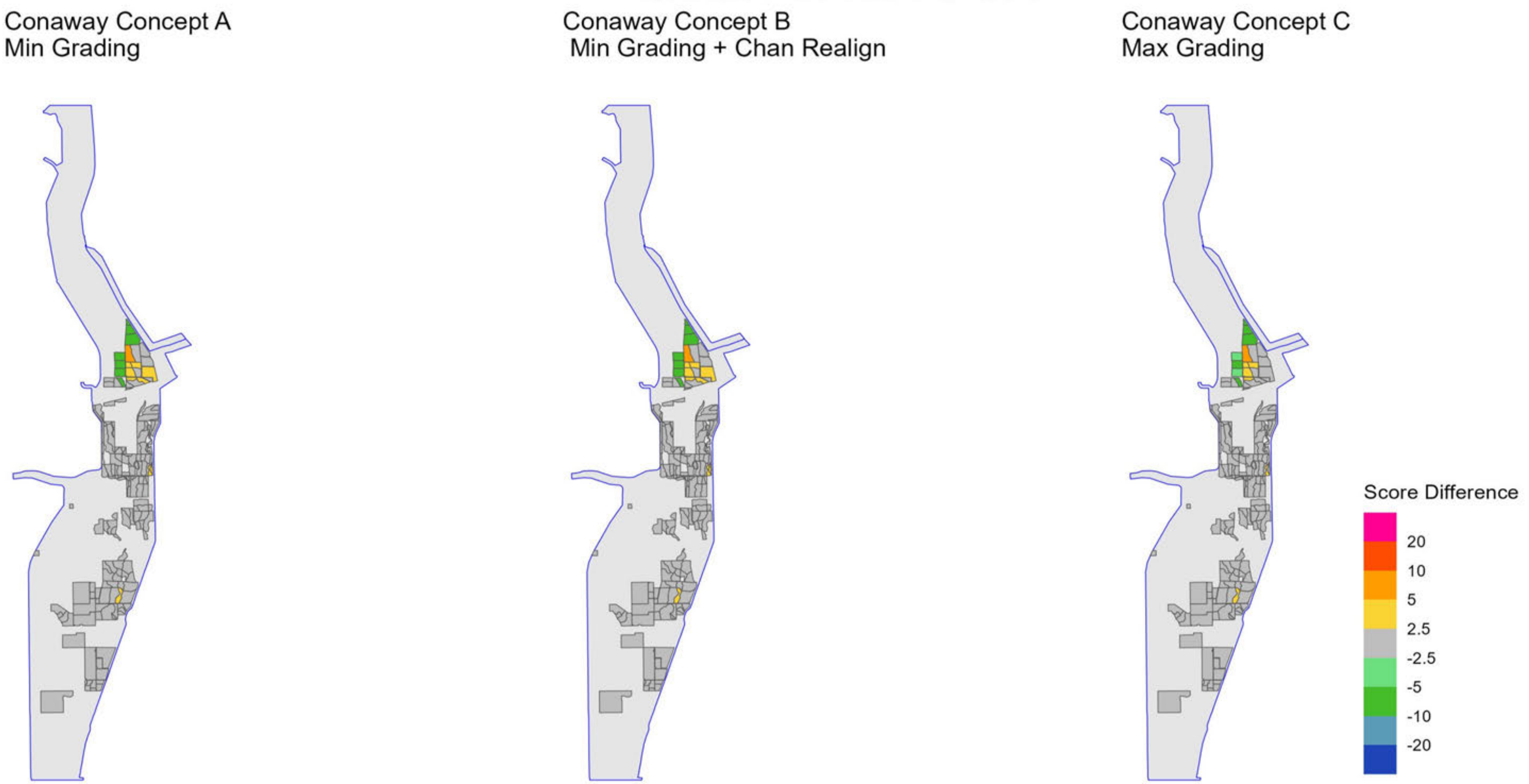
Tule Canal Wetland Corridor Enhancement

Change in Sandhill Crane Suitability

Project No. 23–1003	**Created By: JLR**	**Figure 16**

Change in Managed Wetland Impact Score from Baseline - Conaway Ranch Alternatives

Mean Across All WY



Notes:

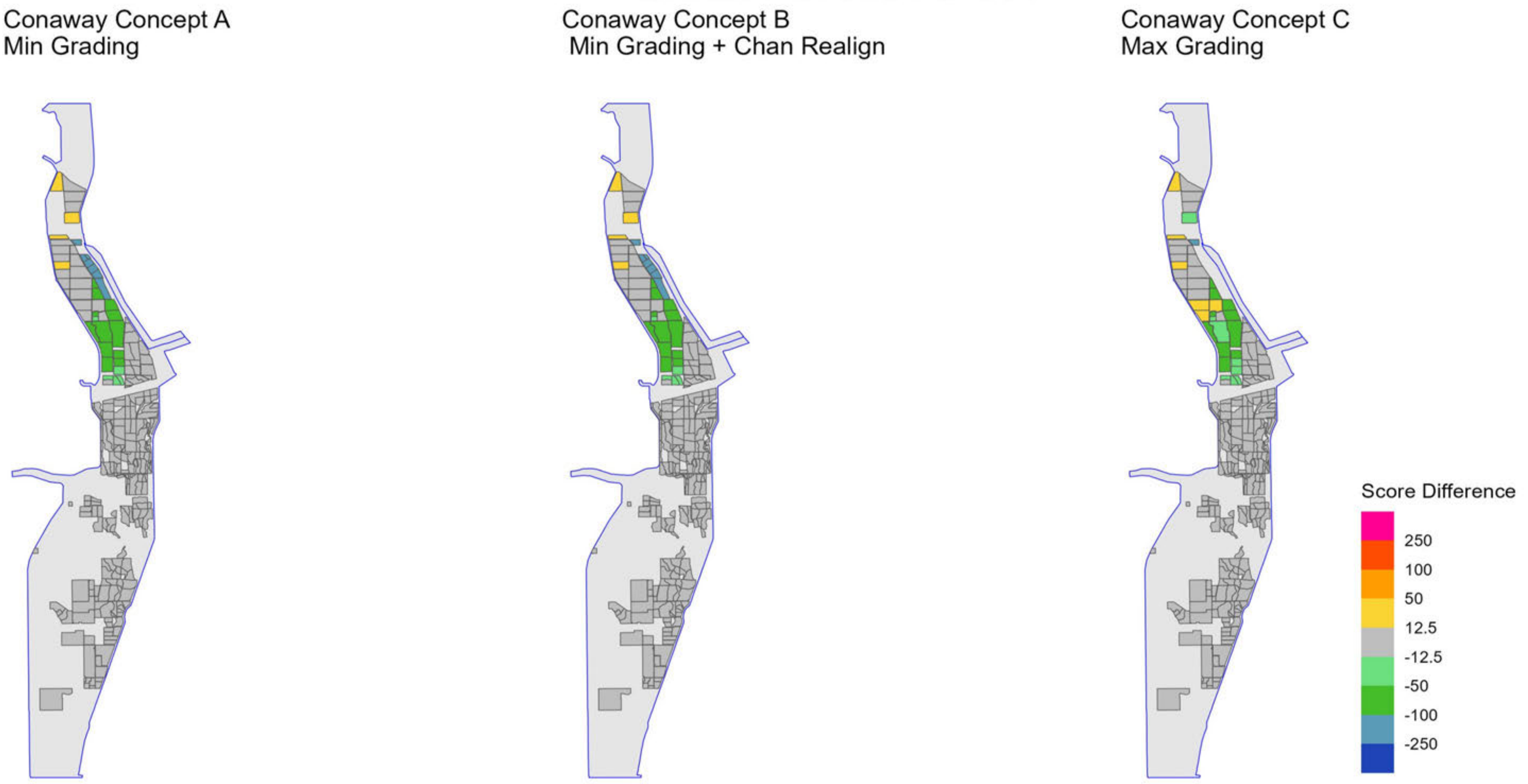
Tule Canal Wetland Corridor Enhancement

Change in Managed Wetland Impact Score

Project No. 23–1003	Created By: JLR	Figure 17

Change in Waterfowl Hunting Impact Score from Baseline - Conaway Ranch Alternatives

Mean Across All WY



Notes:	cbec eco engineering A Verdantas Company	*Tule Canal Wetland Corridor Enhancement* **Change in Hunting Impact Score**		
		Project No. 23–1003	**Created By: JLR**	**Figure 18**