COUNTY OF YOLO

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625 Court Street, Room 204 • Woodland, CA 95695
(530) 666-8195 • FAX (530) 666-8193
www.yolocounty.org

County Administrator, **Patrick S. Blacklock**
Deputy Clerk of the Board, **Julie Dachtler**

July 29, 2014

Secretary Jewell
United States Department of the Interior
1849 C Street, NW
Washington, DC 20240

Secretary John Laird
California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

Re: Comments on the Public Draft of the Bay Delta Conservation Plan

Dear Secretary Jewell and Secretary Laird:

This letter communicates comments from the County of Yolo (County) on the public draft of the Bay Delta Conservation Plan (BDCP). The County appreciates the opportunity to work with state agency staff and consultants to develop text for BDCP's Conservation Measure 2 (CM2) acceptable to both Yolo County and the California Natural Resources Agency (Resources Agency), including the development of a governance structure. The County also values Secretary Laird's February 25, 2014 letter (see Exhibit A) expressing a desire to work cooperatively with Yolo County, including the development of a memorandum of understanding to address funding for county participation in BDCP, mitigation for loss of farmland and economic impacts, and assurances and benefits for the Yolo Wildlife Area. We look forward to concluding the discussions with the Resources Agency this fall.

The County's comments on specific text in the public draft of BDCP should be read to apply to all substantially similar text appearing in the document. The County also reserves the right to provide additional comments on BDCP--including detailed legal and technical comments--as work on the BDCP continues. Yolo County's general comments are provided in this letter by chapter, but specific comments on the text are provided in Exhibit B.

Chapter 1 – Introduction

I. Arbitrary expansion of Plan Area in Yolo County

Yolo County notes the BDCP expanded the Plan Area to include areas outside of the statutory Delta in Yolo County. These areas include the Yolo Bypass and land outside the statutory Delta suitable for giant garter snake habitat. Yolo County does not believe the BDCP should arbitrarily change the Plan Area boundary to include desirable habitat and requests further discussion about the Plan Area boundary as part of the County's ongoing discussions with the Resources Agency. If the BDCP expands the Plan Area to include desirable habitat, it should also consider expanding the Plan Area to encompass additional splittail spawning habitat to reduce the need to flood the Yolo Bypass during March, April, and May.

Chapter 2 – Existing Ecological Conditions

II. Incomplete description of the Yolo Bypass and Yolo Wildlife Area

The description of the Yolo Bypass in Chapter 2 (page 2-95, lines 14-30) does not adequately describe the multiple habitat benefits of the Yolo Bypass. The description focuses primarily on waterfowl (and not does not provide a sufficiently detailed description) and fish species. It does not mention the other terrestrial species that benefit from the current land uses in the Yolo Bypass, such as the giant garter snake, Swainson's hawk, Least Bell's vireo, tri-colored blackbird, and other terrestrial species. The importance of Yolo Bypass habitat to these species is described, however, in Chapter 5. The Chapter 2 description of the Yolo Bypass should provide equal attention to all species in the Yolo Bypass.

III. Inaccurate assertion that organic matter (e.g. phytoplankton and zooplankton) is exported as a result of Yolo Bypass inundation to other regions of the Delta.

Chapter 2 (and other parts of the BDCP) asserts that seasonal floodplain inundation in the Yolo Bypass results in an export of organic matter to other regions of the Delta and therefore a potential source of food to fish species located in other regions of the Delta. The public draft further misquotes scientific studies to justify the assertion that seasonally inundated floodplain export organic matters to other regions of the Delta, including Jassby and Cloern 2000) and Moyle et al. 2007. (Specific corrections to Chapter 2 text and citations are provided in Exhibit B.) The University of California, Davis is currently seeking funds to study how the Yolo Bypass contributes production to downstream areas, but the limited evidence available suggests impacts are at best localized (pers. communication with P. Moyle). The final draft of the BDCP should remove the connection of Yolo Bypass inundation to the export of organic matter to other regions of the Delta.

Evidence also suggests tidal marsh restoration may not contribute to food production in the Delta. This research contributes further to doubts that Yolo Bypass inundation will result in an export of food to other regions of the Delta since this food must travel farther than food produced by tidal marsh restoration. *Panel Review of the Draft Bay Delta Conservation Plan: Prepared for the Nature Conservancy and American Rivers* (Mount et al. 2013) argues "the BDCP is overly optimistic about the likely benefits of tidal marsh restoration to the smelt species, particularly the extent of food production" (p.70) and "The literature does not support a confident assertion that marshes will subsidize zooplankton in open waters" (p. 73). Yolo County recognizes the BDCP organized a panel of agency biologists to discuss this issue, among other scientific issues, in August 2013 and the scientists expressed varying opinions on this issue. In addition, it was clear from this discussion there are insufficient studies to provide a clear picture of the potential relationship between tidal marsh restoration, Yolo Bypass inundation, and export of food to other regions of the Delta. As a result, the final draft of the BDCP should focus on the need for additional studies to research both the food production from tidal marsh restoration and the connection between Yolo Bypass flooding and exports of organic matter. The public draft should not express a conclusion on this matter or cite a contribution to achievement of the biological goals and objectives.

Chapter 3 – Conservation Strategy

Yolo County appreciates the opportunity to work with the Resources Agency in 2014 to suggest changes to the language in CM2. As a result of these discussions, this letter does not reiterate the line item comments on CM2 provided by Yolo County to the Resources Agency on February 28, 2014. They are included in Yolo County's public BDCP comments by reference in this letter.

IV. Remove specific flooding dates and acreage amounts associated with CM2

Yolo County requests the removal of all references to specific flooding dates and acreages associated with CM2 from the final draft BDCP in favor of language agreed to by Yolo County and the Resources Agency related to achieving the "sustainability principles" currently under development. This includes removal of Table 3.4.2-1 "Potential Operations Pattern for Fremont Weir Gated Channel and Other Considerations." Yolo County believes removal of the table is consistent with text in Secretary Laird's February 25, 2014 letter to Yolo County indicating the programmatic CM2 will not dictate the outcome of the project-level planning process:

> "It is important to recall that the ranges of amount and timing of flooding in the Yolo Bypass presented in the programmatic CM2 are flexible and do not dictate the outcome of the project-level planning process that will follow. The Department of Water Resources (DWR) will work with the YBFEPT and Yolo County to define operational parameters based on the needs of covered species, seasonal hydrologic conditions, agricultural operations, and other variables yet to be defined; moreover, it is not DWR's intention to make operational parameters for the extent, duration, timing, and frequency of flooding events binding."

As Yolo County has demonstrated with a series of technical studies, the potential impacts of extensive or late flooding in the Yolo Bypass to existing land uses is significant. It is therefore important to Yolo County that the text of BDCP reflect the opportunity expressed in Secretary Laird's letter to work cooperatively to develop operational parameters as part of the project-level planning process. Specific references to inundation dates and acreage amounts in the text that should be removed from BDCP, in addition to Table 3.4.2-1, are provided in Exhibit B. This list is not exhaustive.

V. Define "stressor reduction targets " to specify targets not mandatory

Yolo County understands BDCP consultants are working on a definition of "stressor reduction targets" that indicates the targets are not required to implement the BDCP permit. Yolo County is specifically concerned about the language in the stressor reduction targets related to providing "access to 7,000 acres of inundated floodplain habitat within the Yolo Bypass and the Cache

Slough ROA for at least 30 days in at least 70% of years" and "continuous area of floodplain habitat in Yolo Bypass of at least 7,000 acres annually between November 10 and March 23." (See pages 3.3-139, 3.3-151, 3.3-159, 3.3-179.) As per previous comments, Yolo County requests that all acreage amounts for CM2 be removed to allow for the collaborative development of operational parameters and acreage amounts during the project-level planning process. Yolo County also requests that BDCP clearly state that stressor reduction targets are not binding and are not required for permit implementation.

VI. Do not rely on exports of Yolo Bypass organic matter (e.g. phytoplankton and zooplankton) to benefit fish in other regions of the Delta.

As mentioned in the comments on Chapter 2, more study is necessary to understand whether additional flooding in the Yolo Bypass will produce an increase in organic matter and therefore food for fish in other regions of the Delta. In fact, it is unlikely that organic matter will have an major impact on downstream ecosystems, except in wet years when the contribution to the food system is not as important because of relatively high food availability. Yolo County therefore requests the removal of CM2 as one of the measures contributing to BDCP biological goals and objectives related to enhancing export of organic matter to regions outside of the Yolo Bypass. Only measures that significantly contribute to achievement of this biological objective should be listed. It is also clear from the discussion in Chapter 5 that there is significant uncertainty associated with these benefits.

BDCP specifically mentions that Yolo Bypass inundation will result in exports of organic matter on page 3.2-9, as follows:

> "*CM2 Yolo Bypass Fisheries Enhancement* contains provisions to modify Fremont Weir (lowering a portion of the weir and installing an operable gate facility), so that it can be actively managed to increase the inundation of the Yolo Bypass. Increasing the extent, duration, and frequency of floodplain inundation within the Yolo Bypass is expected to increase the extent of suitable spawning and rearing habitat available to Sacramento splittail and rearing habitat for juvenile Chinook salmon. Additionally, these changes are expected to increase the levels of phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass floodplain to Cache Slough, the lower Sacramento River, the western Delta, and Suisun Bay, thereby increasing the food supply for Chinook salmon, delta smelt, and longfin smelt in those areas."

It appears from the text of the biological goals and objectives, such as Objective L2.9 "Increase the abundance and productivity of plankton and invertebrate species that provide food for covered fish species in the Delta waterways" that BDCP is in part relying on CM2 to meet the biological goals and objectives. The rationale for Objective L2.9 is as follows:

> "**Objective L2.9 Rationale:** Achieving this objective is intended to enhance the production and export of phytoplankton and zooplankton from tidal channels into adjacent Delta waterways in support of the aquatic foodweb. Loss of intertidal communities and riparian vegetation in the Delta has probably greatly reduced the production of food resources for fish leaving the system with only an open-water

> foodweb that is highly regulated by nonnative clams. Habitat restoration with effective tidal exchange (*CM4 Tidal Natural Communities Restoration*) is expected to enhance food production. Restoration of riparian vegetation along channel margins and in floodplains (*CM6 Channel Margin Enhancement* and *CM5 Seasonally Inundated Floodplain Restoration*) and seasonal inundation in the Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*) are expected to provide similar benefits on a seasonal basis."

This reliance on CM2 to help achieve this objective is inappropriate and should be revisited. If future studies demonstrate benefits, the contribution of CM2 could be revisited through the adaptive management process. Yolo County has identified other text that should be revisited consistent with this comment in Exhibit B.

VII. Insufficient discussion of uncertainty associated with potential fish benefits of Yolo Bypass inundation

The BDCP does not sufficiently discuss the uncertainty associated with the potential fish benefits of Yolo Bypass inundation, either in the species accounts or in Conservation Measure 2. There is some discussion of uncertainty in Chapter 5, but it should be improved. The BDCP includes only one sentence in the winter-run salmon species account, for example, describing this uncertainty.

> "Juvenile winter-run Chinook salmon likely inhabit Suisun Marsh for rearing and may inhabit the Yolo Bypass when flooded, although the use of these two areas are not well understood."(See page 2A.3-3.)

Please see Exhibit C, *Draft Technical Memorandum: Potential Fish Benefits of Yolo Bypass Fish Habitat Proposals*, for a discussion by University of California, Davis fish biologist Rebecca Quinones regarding additional uncertainty about the use of the Yolo Bypass by juvenile salmon and splittail. Areas of uncertainty that should be further described include: 1) the number of juvenile salmon that will access the Yolo Bypass through an operable gate in the Fremont Weir; 2) the importance of the Yolo Bypass for juvenile salmon and splittail habitat relative to other floodplain habitat outside the BDCP Plan Area; 3) the benefits to juvenile salmon of providing habitat late in the season, since high temperature or other habitat conditions can reduce benefits; 4) the potential for predation; and 5) the number of acres splittail need to spawn successfully. BDCP should also more fully integrate information about potential uncertainties from *Panel Review of the Draft Bay Delta Conservation Plan: Prepared for the Nature Conservancy and American Rivers* (Mount et al. 2013), especially the discussion on pages 38-41.

Yolo County recognizes juvenile salmon grow significantly faster than their counterparts in the Sacramento River in a floodplain environment and there may be benefits to a limited increase in Yolo Bypass inundation. As discussed above, there are other elements of the use of the Yolo Bypass by juvenile salmon that are less well understood and could influence project design. These elements should be more fully described in the salmon species accounts, CM2, and Chapter 5. Exhibit B provides specific comments on text related to this issue.

VIII. Steelhead should be removed as a species that benefits from CM2

Yolo County appreciates the statement of scientific uncertainty about the benefits to steelhead of CM2 on page 3.3-17, specifically that "the extent to which steelhead smolts may benefit from inundation of the Yolo Bypass floodplain are uncertain, " as well as the discussion in Chapter 5. Yolo County agrees and further argues the scientific literature does not support significant benefits from CM2 for steelhead. (See discussion in Exhibit C.) Yolo County recommends removing steelhead as a species that benefits from CM2. If studies in the future demonstrate that steelhead benefit from Yolo Bypass inundation, changes to BDCP can be made through the adaptive management process.

IX. Strengthen managed wetlands biological objectives

Yolo County is surprised the goals and objectives for managed wetlands in BDCP are weak and encourages BDCP to strengthen them. Yolo County appreciates the discussion on page 3.3-83 related to the small number of wetlands acres remaining in California, most of which are managed wetlands. The BDCP species accounts also document the importance of the combination of rice fields and wetlands to the giant garter snake and other covered species, as well as migratory waterfowl. The state and federal government further have, through the Central Valley Joint Venture and other efforts, spent millions of dollars creating wetlands over the past two decades in the Yolo Bypass. Yolo County identified the following goal and objective relevant to managed wetland in Yolo County:

- Goal MWNC1 -- Managed wetland that is managed and enhanced to provide suitable habitat conditions for covered species.

- Objective MWNC1.1 -- Protect and enhance 8,100 acres of managed wetlands, at least 1,500 of which are in the Grizzly Island Marsh Complex.

This goal and objective are not clear as to whether the purpose is to protect and enhance "new" wetlands or "existing" wetlands. In Yolo County, there are 11,501 total acres of wetlands (page 12-3253 of the EIR/EIS). CM2 will impact between 931 and 2,612 acres of managed wetlands in the Yolo Bypass (page 12-2053 of the EIR/EIS). It is unclear whether the BDCP plans to put easements on existing managed wetlands owned by the California Department of Fish and Wildlife in the Yolo Wildlife Area, create new wetlands in the Yolo Bypass, or create managed wetlands outside of Yolo County to mitigate for this impact.[1] Yolo County strongly advises against creating new managed wetlands in the Yolo Bypass because of the potential impact on terrestrial species habitat and agriculture. Yolo County is also opposed to changing state-owned lands in the Bypass to a more protective land use designation as mitigation for CM2 impacts. Overall, the goal to "protect and enhance 8,100 acres of managed wetlands" seems like a modest goal given the potential impacts of CM2 on managed wetlands. The meaning of this objective should be clarified in the final draft in coordination with Yolo County and the Yolo Basin Foundation.

[1] Yolo County notes that on page 3.4-72 of BDCP, the BDCP reserves the right to secure reserve system lands through a variety of mechanisms, including "change of federal- or state-owned lands to more protective land use designation."

BDCP also should address uncertainties with the impact of CM2 on managed wetlands identified in the study 2012 Ducks Unlimited study *Waterfowl Impacts of the Proposed Conservation Measure 2 for the Yolo Bypass: A Effects Analysis Tool* (Exhibit D). BDCP should further implement drainage and water infrastructure improvements identified in Yolo County's 2014 study, *Yolo Bypass Drainage and Water Infrastructure Improvement Study* (Exhibit E), to provide greater management flexibility for the Yolo Wildlife Area.

X. Focus on splittail habitat outside the Yolo Bypass, as well as channel margins and floodplain terraces

Splittail migrate upstream to spawn in response to high flows and are unlikely to migrate upstream in dry years in which only a small amount of water is available to inundate the Yolo Bypass. Splittail also generally spawn in the lower Yolo Bypass, so there is no need to flood the upper Yolo Bypass for splittail habitat. It is also unknown how many acres splittail need to spawn in the lower Yolo Bypass, but it likely less than 10,000 acres (see Exhibit C).

The Yolo Bypass should not be the sole focus for splittail spawning habitat simply because it is within the BDCP Plan Area. If the BDCP can arbitrarily expand the Plan Area to include areas of Yolo County suitable for giant garter snake habitat, the BDCP should also expand the Plan Area to include other areas suitable for splittail spawning habitat, such as the Consumnes River floodplain and the Sutter Bypass. The BDCP even acknowledges some of these additional spawning areas:

> "When floodplain inundation does not occur in the Yolo or Sutter Bypasses, adult splittail migrate farther upstream to suitable habitat along channel margins or flood terraces; spawning in such locations occurs in all water year types (Feyrer et al. 2005). Although spawning is typically greatest in wet years, CDFW surveys demonstrate spawning takes place every year along the river edges and backwaters created by small increases in flow. In the eastern Delta, the floodplain along the lower Cosumnes River appears to be important as spawning habitat. Ripe splittail have been observed in areas flooded by levee breaches, turbid water, and flooded terrestrial vegetation (page 2A.7-4)."

The importance of improving channel margins and floodplain terraces relative to the need to flood the Yolo Bypass for splittail needs to be further explored. CM2 currently proposes splittail flooding in the Yolo Bypass once every five years if flooding does not occur naturally. This flooding, even if once every five years, could have a significant impact on agriculture and terrestrial species habitat in the Yolo Bypass. Given the already significant benefits from Yolo Bypass inundation without a proposed operable gate, the BDCP should focus on improving channel margin and flood terraces and expanding inundation in other floodplain areas. If Yolo Bypass flooding for splittail is necessary, flooding should focus on a small area in the lower Yolo Bypass and should not result in upper Bypass inundation unless flooding occurs naturally.

XI. Ensure consistency with the Yolo HCP/NCCP

The Yolo County HCP/NCCP Joint Powers Agency (JPA) is currently working on the second administrative draft of the Yolo HCP/NCCP, which covers 11 terrestrial species. The Yolo HCP/NCCP anticipates significant potential conflict with the BDCP for all conservation associated with cultivated lands, such as Swainson's hawk, giant garter snake, burrowing owl, and tri-colored blackbird conservation. Given the extent of the terrestrial species impacts from CM2 identified in the draft BDCP and the EIR/EIS, the County encourages close coordination between the BDCP and the Yolo HCP/NCCP in the months ahead to ensure the impacts to terrestrial species of CM2 are minimized. Yolo County also needs to ensure BDCP plans to acquire conservation easements in Yolo County do not negatively impact the ability of the JPA to meet permit requirements of the Yolo HCP/NCCP. The JPA will submit separate, more detailed comments, but Yolo County wanted to highlight the significant BDCP conservation proposals that could conflict with implementation of the Yolo HCP/NCCP:

- The BDCP proposes to protect 43,325 acres of Swainson's hawk foraging habitat with at least 50% in very high-value habitat in Conservation Zones 1, 2, 3, 4, 7, 8, 9, and 11. The majority of Conservation Zones 1, 2, and 3 are in Yolo County.
- The BDCP proposes to create 600 acres of connected aquatic giant garter snake habitat and 200 acres of high-value upland habitat outside the Yolo Bypass in Conservation Zone 2. The BDCP also proposes to protect 700 acres of cultivated lands (500 acres of rice) for giant garter snake in Conservation Zone 2.
- The BDCP proposes to protect, restore, or create at least 2,740 acres of rice land or equivalent value habitat for the giant garter snake in Conservation Zones 1,2, 4, or 5.
- There are many other terrestrial species conservation goals in BDCP that are documented in the Yolo County HCP/NCCP JPA's letter commenting on BDCP.

Furthermore, BDCP indicates that Yolo County is a target for conservation of cultivated lands as follows:

> "Conservation Zone 2, which hosts the majority of rice lands and other cultivated lands in the Plan Area, supports a sufficient amount of these lands to achieve of substantial proportion of the overall cultivated lands conservation target acreages (Table 3.3-2) established for the Plan Area."

It is unclear whether there are sufficient cultivated lands in Yolo County to support both the conservation targets of the BDCP and the Yolo HCP/NCCP, since acquisition of easements is based on willing sellers.

As other comments in this letter suggest, the presence of significant habitat for terrestrial species covered by the Yolo HCP/NCCP supports the need to minimize giant garter snake and other terrestrial species impacts from CM2. The BDCP specifically states, for example, that giant garter snake conservation is intended as 1:1 mitigation for the impacts of covered activities, including "the loss of rice land in the Yolo Bypass as a result of prolonged flooding from *CM2 Yolo Bypass Fisheries Enhancement*." (See page 3.3-286.) Rice lands and wetlands in the Yolo Bypass (including the Yolo Wildlife Area) provide significant habitat for the giant garter snake (page 2A.28-5). For more information about the impacts on Yolo HCP/NCCP terrestrial species habitat, please refer to the JPA's comment letter. Yolo County supports the Yolo County HCP/NCCP JPA's request to develop a Memorandum of Understanding with the state and federal government to ensure BDCP does not prevent the successful implementation of the Yolo HCP/NCCP.

XII. Yolo County needs a defined role in the adaptive management process

Yolo County recognizes ongoing discussions between Yolo County and the state related to governance of CM2 will at some point expand to include the adaptive management process. From Yolo County's ongoing meetings with BDCP consultants and Resources Agency staff, Yolo County understands biological goals and objectives for juvenile salmon rely almost exclusively on CM2. Yolo County also understands these biological goals and objectives are based on the October 29, 2012 National Marine Fisheries Services draft tech memo (Appendix 3G) that has not been peer reviewed or otherwise shared widely with the scientific community. Combined with the uncertainty about potential fish benefits expressed in Dr. Quinones draft tech memo (Exhibit C), Yolo County anticipates significant potential for changes to the biological goals and objectives related to CM2 through the adaptive management process. As a result, Yolo County requests the establishment of a subcommittee of the Adaptive Management Team specific to CM2 in which Yolo County representatives have a significant role.

Yolo County is especially interested in an ongoing adaptive management role because of continuing concern with biological objectives that reference flooding in greater than 70% of years, as discussed in Yolo County's September 2013 comments on the Administrative Draft of the BDCP (Exhibit H). Objective WRCS1.2, for example, is "create a viable alternate migratory path through Yolo Bypass in >70% of years for outmigrating winter-run Chinook salmon juveniles by year 15." Other biological objectives contain the same language. We understand from BDCP consultants and Resources Agency staff that the BDCP biological goals and objectives will not change before the permits are issued. If flooding in the Yolo Bypass is constrained to the Toe Drain in some of these years and limited to before March 1 in other years, flooding in greater than 70% of years may not have an impact on terrestrial species habitat, agriculture or other existing land uses. If extensive flooding occurs in 70% of years, however, existing land uses may be significantly affected. Yolo County is heartened by the letter from Secretary John Laird to the Yolo County Board of Supervisors on February 25, 2014 (see Exhibit C) stating the following:

> "The biological objectives for the BDCP, for example, state "Create a viable alternate migratory path through Yolo Bypass in >70% of years for out-migrating fall-run/late fall-run Chinook salmon by year 15." Such language allows for flexibility in achieving the objective because the objective does not specify the number of acres or other criteria. Uncertainty will be addressed through the adaptive management and monitoring program of BDCP, a process in which we expect Yolo County will have a significant level of involvement."

Yolo County requests that language that closely resembles the letter from Secretary John Laird on this and other issues be incorporated into BDCP. Yolo County understands the adaptive management process is the only process through which biological goals and objectives are revisited, so requests a significant role in adaptive management discussions related to the Yolo Bypass.

Chapter 4 – Covered Activities and Associated Federal Actions

XIII. Replace existing covered activities language with sustainable balance language

Yolo County requests the following language be replaced with text consistent with the sustainability principles currently under development as part of discussions between Yolo County and the Resources Agency.

> "The overall purpose is to allow water to inundate certain areas of the bypass to maximize biological benefits and reduce stranding of covered fish species in isolated ponds, minimize effects on terrestrial covered species (including giant garter snake), and accommodating other existing land uses (e.g., wildlife, public, recreation and agricultural use areas)." (See page 4-32.)

Chapter 5 – Effects Analysis

XIV. Update to hydraulic model necessary

The effects analysis is based on a footprint generated by MIKE-21, which is no longer the best model available to estimate the Yolo Bypass inundation footprint resulting from the construction of an operable gate in the Fremont Weir. In particular, the assumptions related to west side tributary flows are deeply flawed, as insufficient gauge information exists to make precise estimates of flow into the Yolo Bypass. Yet, the effects analysis assumes significant existing flows from the westside tributaries or other existing flooding, therefore reducing the impacts of CM2. The west side tributary data weaknesses, as well as other model weaknesses, are captured in a 2012 report commissioned by Yolo County entitled *Yolo Bypass MIKE-21 Model Review: Strengths, Limitations, and Recommendations for Refinement* (Exhibit F) and are not repeated here. The U.S. Bureau of Reclamation is working with the California Department of Water Resources to create a new TU-FLOW Yolo Bypass model, in part to address the concerns in the 2012 report. Yolo County has hired UC Davis modeler William Fleenor to peer review the new TU-FLOW model and develop a publicly available HEC-RAS 2D model. Yolo County expects this work will be complete by September 2014. Once the TU-FLOW model is updated to address concerns identified by Mr. Fleenor, one or both of these models should be used for the BDCP effects analysis.

XV. Revisit reliance on existing flooding in the effects analysis

The effects analysis associated with CM2, as well as the EIR/EIS analysis of CM2, relies heavily on the statement "BDCP-associated inundation of areas that would not otherwise be inundated is expected to occur in no more than 30% of all years, since the Fremont Weir is expected to overtop the remaining 70% of all years, and during those years notch operations will not typically affect the maximum extent of inundation." As Yolo County has stated many times in the past, there are at least two problems with the use of the 70% statistic. First, the statistic is closer to 60% if you use recent data that is more reliable. (See footnote on page 3.4-43 of CM2 related to this issue. Yolo County appreciates the addition of this footnote in the public review draft, but would prefer an end to the use of the 70% statistic.) Second, even if accurate, the statistic does not define the extent of Bypass flooding. It likely includes very small overtopping events that caused only localized inundation within the Bypass. This statistic thus cannot be used to define current or "natural" conditions that have any significant bearing on the effects analysis. The use throughout the BDCP and the EIR/EIS of the 70% statistic and the correlating assumption that CM2 impacts will only occur in 30% of years is indefensible.

Chapter 6 – Plan Implementation

XVI. Need process for coordinating land and easement acquisition with local governments

Yolo County has reviewed Chapter 6, including Table 6-1 related to the implementation schedule and is concerned about the over 50,000 acres of cultivated land acquisition required as part of the permit, including a significant amount in the first 10 years of the permit. Given other references in Chapter 8 and Chapter 3 to a significant amount of cultivated land acquisition in Yolo County (specifically, Conservation Zones 1, 2, and 3), the Board of Supervisors requests a better understanding of BDCP's plans regarding acquisition of cultivated land easements. Will BDCP coordinate with Yolo County regarding potential conflicts with the Yolo County General Plan? Will BDCP coordinate with the Yolo HCP/NCCP? Chapter 6 needs to include a discussion of BDCP coordination with local governments on land and easement acquisition. In addition, Yolo County requests inclusion of a process through which BDCP will coordinate with Yolo County on easement and fee title acquisition within the County in the proposed MOU, in addition to the separate MOU with the Yolo County HCP/NCCP JPA.

XVII. Yolo County role in CM2 development

Yolo County notes that implementation of seasonal floodplain habitat as part of CM2 will be initiated in year 11 of the 50-year permit and operations will begin by year 13. Fish passage improvements will be implemented in the first 10 years of the permit. As part of the proposed governance structure currently under development for CM2, Yolo County expects to play a significant role in development of the project during this 10-year period.

Chapter 7 – Implementation Structure

As discussed previously, Yolo County is cooperatively developing a governance structure to guide ongoing implementation of CM2 with the Resources Agency. The current proposal is a nine-member Executive Council, of which 4 members are appointed by Yolo County, 4 members are state/federal representatives or representatives of the state water contractors, and the ninth member is selected by consensus of the remaining eight. Yolo County is in the process of drafting the details of this governance structure and hopes to reach agreement with the Resources Agency by fall of 2014. Yolo County further hopes the U.S. Department of the Interior will also agree to this governance structure. Yolo County requests the inclusion of this governance structure in the final draft of BDCP.

Chapter 8 – Implementation Costs and Funding Sources

XVIII. Inappropriate use of 2013 UC Davis agricultural impacts analysis (Exhibit G)

The public draft cites *Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals* (Howitt et al. 2013), commissioned by Yolo County, as estimating that more frequent and longer duration bypass flooding "could result in loss of agricultural income of $740,000/year." (See page 8-15.) The public draft is citing the 2012 draft of the study, since the final study was released in April 2013. The public draft further states the flood easement cost estimate (i.e. the cost of acquiring flood easements in the Yolo Bypass to implement CM2) is based on these estimates of farm income losses. The draft does not acknowledge, however, that the estimates in Howitt et al. 2013 for the "low-impact CM2 scenario" actually ranged from $0.63 to $1.5 million, assuming flows of 3,000 and 6,000 cfs, respectively. The study also explicitly stated it was impossible to accurately predict estimated economic losses because CM2 is not yet defined.

In the absence of a proposed project, the authors created a "low-impact CM2 scenario" and assumed flooding only occurs as an extension of natural flooding. The scenario demonstrated CM2 impacts could be low if the project is designed to minimize impacts. The scenario did not include potential impacts of late flooding for splittail or other flooding that would occur in addition to the extension of natural flooding. The study further pointed out a number of additional studies that are necessary to accurately evaluate potential economic impacts, such as whether crop insurance will continue to be offered to Yolo Bypass farmers and whether banks will continue to loan to farmers in the presence of increased risk to crops from additional inundation. Therefore, the "low-impact CM2 scenario" from the study is not consistent with the CM2 footprint evaluated for the effects analysis. The estimate from this study should not be used to estimate the resulting loss of agricultural income.

XIX. Insufficient funding allocated for implementation of CM2

The public draft does not include a placeholder for compensation of ongoing economic losses, similar to the compensation paid to farmers in the Oroville Dam coldwater rice settlement or other mechanisms to which Yolo County and the Resources Agency might agree as a result of ongoing discussions by the fall of 2014. In addition, Yolo County believes the estimate of the cost of easement acquisition in the Yolo Bypass may be too low because it is based on an inapplicable estimate of farm income losses from *Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals* (Howitt et al. 2013). Given the importance of also managing Yolo Bypass lands for important terrestrial species, the public draft should base easement acquisition costs on the most recent easement acquisition in the Yolo Bypass, which is the sale of giant garter snake, tri-colored blackbird, and agricultural conservation easements on the Conaway Ranch to Tri-Cities, LLC.

XX. State and federal contractors should pay for a portion of CM2

Yolo County reiterates comments on the March 2013 administrative draft (Exhibit H) requesting the state and federal water contractors pay for a portion of CM2 implementation. The contractors are paying for a percentage of 11 out of the 22 conservation measures, according to Table 8-41, but not CM2. It is clear from the public draft that CM2 is at least in part mitigation for impacts to fish at the new North Delta intakes, so the contractors should be pay for a portion of its costs. Ongoing revenue from the state and federal water contractors is important to Yolo County because Yolo County does not want to rely on the state for ongoing payments for economic impacts from CM2, a topic currently under discussion with the Resources Agency.

Chapter 9 – Alternatives to Take

XXI. Apply plan boundary criteria uniformly

As commented earlier in this letter, the BDCP expanded the Plan Area to include land outside the Yolo Bypass because of the potential to enhance or restore giant garter snake habitat. Yet Chapter 9 states the geographic scope of the BCDP is limited to the statutory Delta, Suisun Marsh, and the Yolo Bypass. It further states that take alternatives that include actions outside this geographic scope are not consistent with the goal of the BDCP. Yolo County requests that this rule be applied equally to land outside the BDCP Plan Area. If land for giant garter snake outside the Plan Area is included in the Plan, then spawning habitat for splittail outside the Plan Area should also be included or other habitat that helps to achieve the biological goals and objectives and spreads the fish benefits between jurisdictions.

***

As discussed in this letter, Yolo County has enclosed all studies completed by Yolo County and its partners relative to CM2 (Exhibits D-G), as well as Yolo County's September 2013 comments on the Administrative Draft of the BDCP (Exhibit H). These materials provide important information about the potential to develop a CM2 proposal that achieves a sustainable balance between existing Yolo Bypass land uses and additional fish habitat.

Again, Yolo County appreciates the opportunity to work through technical issues associated with CM2 with the Resources Agency, as well as development of governance and economic mitigation proposals. We appreciate the ongoing discussions and hope to reach an agreement this fall. Thank you for your consideration of these comments.

Sincerely,

Don Saylor

Don Saylor
Chair, Yolo County Board of Supervisors

cc: Yolo County Board of Supervisors
Rep. Doris Matsui
Rep. John Garamendi
Senator Dianne Feinstein
Senator Barbara Boxer
Senator Lois Wolk
Assemblymember Mariko Yamada
Assemblymember Roger Dickinson

EXHIBIT A

CALIFORNIA natural resources AGENCY

EDMUND G. BROWN JR., Governor
JOHN LAIRD, Secretary for Natural Resources

February 25, 2014

Chair Don Saylor and Members of the Board
Yolo County Board of Supervisors
625 Court Street
Woodland, CA 95695

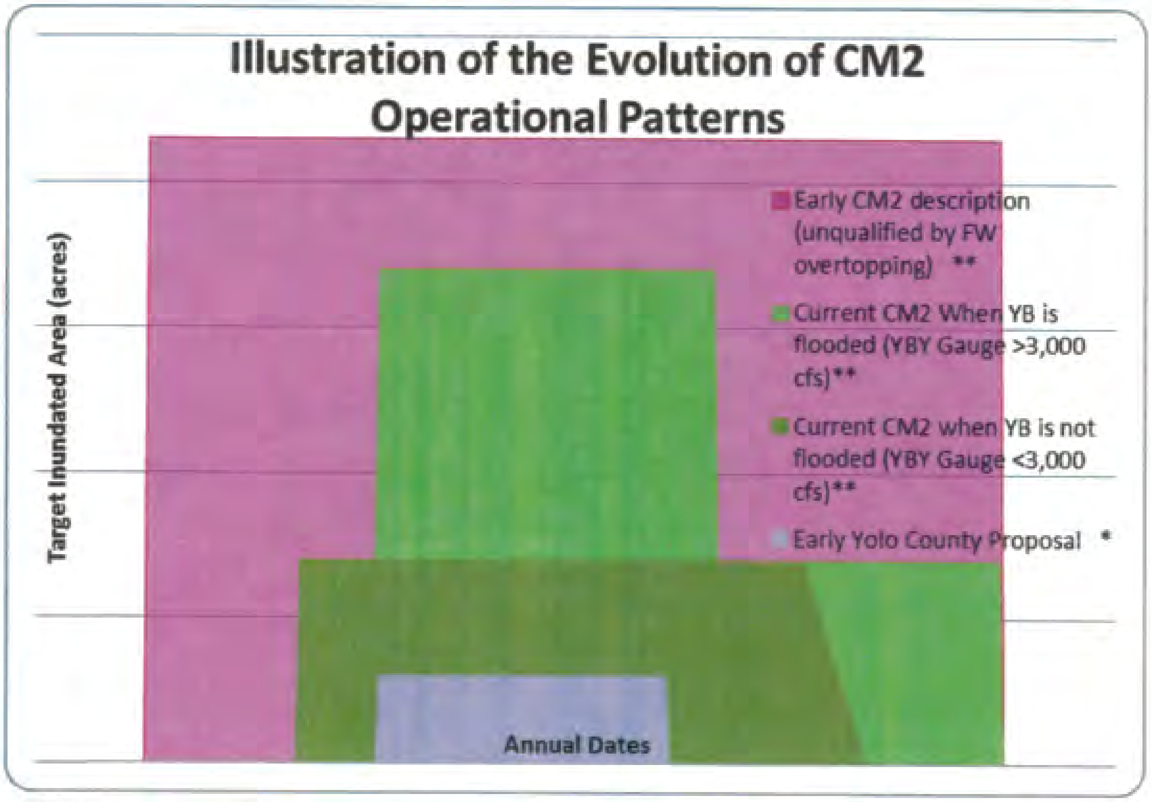
Dear Chair Saylor and Members of the Board:

I am writing to provide an update on the Bay Delta Conservation Plan (BDCP) Conservation Measure 2 (CM2) and to reassure you the state will continue to coordinate with Yolo County staff and elected officials to refine CM2 to address any further concerns prior to the final BDCP. This update will illustrate how extensively the conservation measure has been modified over the last two years in response to Yolo County requests and concerns. It is the Natural Resources Agency's goal to continue balancing the need of BDCP to enhance habitat for covered species with the existing uses of the Yolo Bypass such as agriculture, waterfowl and other terrestrial species habitat, bird watching, hunting, and other recreation.

The intent of CM2 is to provide high quality rearing habitat to achieve the greatest biological benefit (i.e., 30 days of inundation of 7,000 acres in 70 percent of years). In 2011, DWR established the Yolo Bypass Fishery Enhancement Planning Team (YBFEPT) to develop and refine CM2 in collaboration with the many stakeholders in and near the Yolo Bypass. This planning team has met 23 times since June 2011; Yolo County staff was present at many of these planning team meetings. Over the course of these meetings, revisions to CM2 in response to Yolo County concerns have been incorporated based on ongoing discussions and joint evaluations that have provided an improved appreciation of the design of a project that balances new and existing uses.

Figure 1 below highlights the changes that have occurred related to the CM2 operational patterns as a result of discussions with Yolo County. Figure 1 highlights the differences between the earlier CM2 inundation patterns proposed in the 2010 BDCP Administrative Draft compared to those proposed by Yolo County, in terms of extent and duration of Yolo Bypass inundation. The figure was developed to show the operational range that may be typical of, but not necessarily identical to, actual operational guidelines that will be developed in the course of subsequent project-specific design, planning and environmental documentation. As a result of discussions with Yolo County, the extent and duration of Yolo Bypass inundation described in the Public Draft BDCP is currently somewhere in the middle of these two starting points, though of course that description is subject to further refinement.

1416 Ninth Street, Suite 1311, Sacramento, CA 95814 Ph. 916.653.5656 Fax 916.653.8102 http://resources.ca.gov



* Only in years when Fremont Weir overtopping occurs

** When hydrology allows

It is important to recall that the ranges of amount and timing of flooding in the Yolo Bypass presented in the programmatic CM2 are flexible and do not dictate the outcome of the project-level planning process that will follow. The Department of Water Resources (DWR) will work with the YBFEPT and Yolo County to define operational parameters based on the needs of covered species, seasonal hydrologic conditions, agricultural operations, and other variables yet to be defined; moreover, it is not DWR's intention to make operational parameters for the extent, duration, timing and frequency of flooding events binding.

DWR recognizes that late season flooding in the bypass is of the greatest concern to Yolo County. While late-season flows may be necessary in some years to meet the BDCP biological goals and objectives, the frequency and acreage affected by late flows could be managed well enough such that current land uses in the Yolo Bypass would be largely maintained. Furthermore, BDCP acknowledges the uncertainty associated with the operation of the Yolo Bypass. A reasonable degree of flexibility is also provided, allowing for refinement of the metrics within objectives as the uncertainty is addressed over time. The biological objectives for the BDCP, for example, state "Create a viable alternate migratory path through Yolo Bypass in >70% of years for out-migrating fall-run/late fall-run Chinook salmon juveniles by year 15". Such language allows for flexibility in achieving the objective because the objective does not specify the number of acres or other criteria. Uncertainty will be addressed through the adaptive management and monitoring program of the BDCP, a process in which we expect Yolo County will have a significant level of involvement.

As described in the BDCP, the YBFEP and the YBFEP EIR/S will further refine CM2 during project-level planning. Through this process, the component projects of CM2 will be evaluated and refined with scientific and stakeholder input, including Yolo County. Part of this evaluation will include the development and evaluation of alternatives. These alternatives are expected to vary in ways that include the duration, extent and timing of Bypass inundation. DWR plans to fully engage with Yolo County and its representatives during the development and evaluation of these alternatives to ensure your concerns are heard and a sustainable balance of important land uses is achieved. Furthermore, the state is interested in developing a memorandum of understanding with Yolo County that could address issues related to CM2, such as: 1) funding for county participation in BDCP planning and implementation; 2) mitigation for the loss of farmland and economic impacts; 3) assurances and benefits for the Yolo Bypass Wildlife Area; and 4) other topics as needed.

As proponents of the BDCP, the state expects to develop a governance structure that includes Yolo County as a partner in the planning, environmental review, and operation of CM2. Since there is uncertainty associated with future operations of the gate in the Fremont Weir and other elements of CM2, BDCP will allow a reasonable degree of flexibility and refinement of the metrics within biological objectives as research and monitoring efforts provide new information for consideration by the state and Yolo County, as well as other relevant state and federal agencies. The state will work with Yolo County and other stakeholders to determine the manner, timing and extent of new seasonal floodplain habitat in the Yolo Bypass to achieve a sustainable balance of conservation projects and existing land uses.

Thank you for your participation in the BDCP process. I look forward to continuing to work together to improve the Delta ecosystem and provide a more reliable water supply for California.

Sincerely,

John Laird

John Laird
Secretary for Natural Resources

cc: David Murillo, Mike Connor, Mark Cowin, Chuck Bonham

I hope this letter is just one point in our continued discussions that in good faith work to resolve outstanding issues consistent with all of our goals.

EXHIBIT B

EXHIBIT B
YOLO COUNTY COMMENTS ON SPECIFIC BDCP TEXT
July 15, 2014

Chapter 1 - Introduction

No comments.

Chapter 2 – Existing Conditions

Page 2-10 – The plan notes the use of the Yolo Natural Heritage Program Vegetation GIS dataset from 2008. The Yolo County HCP/NCCP JPA updated this dataset significantly in 2014.

On page 2-13 -- Chapter 2 contains the following erroneous text.

> "Seasonally inundated floodplains such as those in the Yolo Bypass and adjacent to the Cosumnes River provide an allochthonous (export) subsidy of organic matter to other regions of the Delta. Some of this floodplain-generated organic carbon, such as phytoplankton, is especially labile (available to organisms) (Jassby and Cloern 2000; Moyle et al. 2007). Also, since these floodplains are shallower, have longer residence times, and are generally warmer than the mainstem river, they have greater rates of phytoplankton production than do the channels of the rivers (Sommer et al. 2001a)."

Jassby and Cloern (2000) actually write:

> "Although primary production within the Yolo Bypass area may be highly significant for native species, organic matter exports from the Bypass to downstream habitats do not appear to be important."

Jassby and Cloern (2000) also write:

> "Unless the level of organic matter in Bypass water is an order-of-magnitude greater than river water, Bypass effects on downstream ecosystems are probably small in winter and negligible in other seasons, except perhaps in very wet years. Furthermore, based on the (admittedly sparse) evidence to date (CDWR. 1999), DOC concentrations in the Bypass, although higher than in the Sacramento River, are not remarkably so. Even in the case of extremely wet winters, the impact of any organic matter subsidy from Bypass water will be damped: residence times will be shorter and organic matter availability lower."

These quotes from the article directly contradict the text in Chapter 2 and elsewhere in BDCP, especially Chapter 3 – Conservation Strategy. It is unlikely that organic matter will have a major impact on downstream ecosystems, except in wet years when the contribution to the food system is not as important because of relatively high food availability. In addition, the use of Moyle et al. 2007 is inappropriate (pers. communication with P. Moyle). Moyle et al. 2007 is a study of Consumnes River floodplain fishes and does not deal with primary production.

Page 2-26 – Please cite the footnote developed for Conservation Measure 2 after the sentence "The Yolo Bypass flood seasonally in 70% of years."

Page 2A.4-3 – Please provide a reference for the following statement:

"Adult Central Valley spring-run Chinook salmon migrate primarily along the western edge of the Sacramento–San Joaquin River Delta (Delta) through the Sacramento River corridor, and juvenile spring-run Chinook salmon use the Delta, Suisun Marsh, and Yolo Bypass for migration and rearing."

Page 2A.5-3 – Please provide a reference for the following excerpt. Is this based on telemetry studies or screw trap studies?

"Adult Central Valley fall- and late fall–run Chinook salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway."

Page 2A.5-3 – Please mention the differences in run timing of wild versus hatchery produced fall run Chinook juveniles here.

"Fall- and late fall–run Chinook salmon must migrate through the Delta toward the Pacific Ocean and use the Delta, Suisun Marsh, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year."

Page 2A.5-4 – The statement below is misleading -- fall and late fall-run Chinook salmon will rear wherever habitat is available regardless of habitat quality and floodplain connectivity. They will rear without access to floodplain habitat, but will not grow as fast.

"Fall- and late fall–run Chinook salmon rear in streams and rivers with sufficient water flow and floodplain connectivity. "

Page 2A.5-4 – This statement does not make sense.

"They rear in these areas to form and maintain physical habitat conditions that support growth ."

Page 2A.3-5 – The following statement is misleading. Juvenile growth, survival, and recruitment are dependent on many things, not just freshwater rearing habitat, e.g.

ocean conditions, predation, and harvest pressure.

"Freshwater rearing habitat has a high conservation value because the juvenile life stage of salmonids is dependent on the function of this habitat for successful growth, survival, and recruitment to the adult population."

Page 2A.5-9 – Snider and Titus (cited below) only describes migration for the 1997-98 year, a wet year. Need to clarify that some variability in run timing is expected.

"Central Valley late fall–run Chinook salmon fry generally emerge from April through June. Late fall–run fry rear in fresh water from April through the following April and emigrate as smolts from October through February (Snider and Titus 2000)."

Page 2A.7-3 – Splittail have been found to spawn on other sites than the ones listed below, such as the Consumnes River. See Exhibit C for more details.

"Evidence of splittail spawning on floodplains has been found on both the San Joaquin and Sacramento Rivers."

Chapter 3 – Conservation Strategy

Page 3.3-118: The BDCP should consider revisiting the studies and language supporting these additional statements related to benefits of Conservation Measure 2 to the export of organic matter to other regions of the Delta, consistent with the County's comment letter. On page 3.3-118, please revisit the highlighted portion of the following text:

> "The export of marsh production can help transfer the higher production of shallow-water habitats to the less productive deepwater habitats preferred by pelagic fish species such as delta smelt, but this process can be interfered with by nonnative clams (Lucas et al. 2002; Lopez et al. 2006; Lucas and Thompson 2012). Nonetheless, there are local examples of tidal marsh production being advected and/or tidally dispersed to adjacent habitats (Lehman et al. 2008, 2010). Production from the lower Yolo Bypass, including Liberty Slough and Cache Slough marshes, stays relatively intact as it moves down the estuary (Monsen 2003). This production may contribute significantly to the greater foodweb, ultimately benefitting open-water species such as delta smelt (Brown 2004). Refer to Appendix 5.F, *Biological Stressors on Covered Fish*, for a detailed discussion of the foodweb."

On Page 3.3-108:

Please revisit the highlighted portion following text:

> "More specifically, the BDCP is expected to increase the density of zooplankton suitable for delta smelt as follows.

- Increase timing, frequency and duration of floodplain inundation in Yolo Bypass (*CM2 Yolo Bypass Fisheries Enhancement*).
- Construct new tidal wetlands (*CM4 Tidal Natural Communities Restoration*).
- Provide for greater floodplain inundation (*CM5 Seasonally Inundated Floodplain Restoration*).
- Enhance channel margin along up to 20 miles of currently leveed channel by restoring riparian, marsh, and mudflat natural communities along levees (*CM6 Channel Margin Enhancement*).
- Improve water quality conditions within the Plan Area (*CM12 Methylmercury Management* and 7 *CM19 Urban Stormwater Treatment*)"

Page 3.3-143:

Please revisit the citation for the following statement.

> "Other studies indicate that the relative survival of Chinook fall-run fry migrating through Yolo Bypass to Chipps Island was on average 50% higher than fish passing over the comparable section of the Sacramento River (Sommer, Harrell, et al. 2001)."

It is Yolo County's understanding that the Sommer, Harrell et al. 2001 study demonstrates that growth of juvenile salmon was greater in the Yolo Bypass than the Sacramento River, but that survival results were inconclusive. It is further our understanding that this is the scientific questions that the researchers working on studies on the Knaggs Ranch in the Yolo Bypass are trying to answer.

Page 3.3-143-144:

Remove the reference to inundation dates on the following excerpt, as well as other references in BDCP.

> "Once the modifications are implemented, overtopping of the Fremont Weir will be initiated as early as November and will be allowed to overtop and inundate the Yolo Bypass floodplain as late as April and into May, as conditions allow."

Page 3.3-160

Please remove the reference to Yolo Bypass inundation dates.

> "As mentioned above, juvenile fall-run Chinook salmon downstream migration timing occurs from January through June, with peak migration occurring from February through May. Based on model results presented in the effect analysis, inundation of the Yolo Bypass is expected to occur relatively infrequently during the primary fall-run Chinook salmon emigration period, resulting in a relatively low proportion of emigrating smolts entering the Yolo Bypass. However, creating

an alternative migratory pathway through the Yolo Bypass in >70% of years for emigrating juvenile fall-run Chinook salmon is expected to be achievable based upon the general timing of outmigrating juveniles (January through June, with the peak occurring February through May) and the timing of Yolo Bypass inundation (generally December to mid-April). The overtopping of the Fremont Weir and inundation of the Yolo Bypass will not cover the entire duration of the emigration period, but it will cover the majority of this period and most of the peak migration. While it is expected that modifications to the Fremont Weir will provide conditions conducive to Sacramento River flow to enter and inundate the Yolo Bypass in >70% of years, this is still being modeled, and thus the frequency, duration, and extent of inundation and the seasonal timing with respect to migrating juvenile fall-run and late fall–run Chinook salmon, as well as other runs of Chinook salmon (i.e., winter-run and spring-run) may change. Therefore, while it is currently anticipated that a viable migratory pathway through the Yolo Bypass will be achievable in >70% of years, the specific metric is not certain."

EXHIBIT C

BDCP1675

Draft Technical Memorandum
Potential Fish Benefits of Yolo Bypass Fish Habitat Proposals

Prepared for:
Yolo County

Prepared by:
Rebecca M. Quiñones, Ph.D

June 27, 2014

INTRODUCTION

This technical memorandum answers questions posed by Yolo County in response to state and federal proposals to increase the frequency and duration of Yolo Bypass inundation as part of Conservation Measure 2 within the Bay Delta Conservation Plan (BDCP) and Reasonable and Prudent Alternatives I.6 and I.7 in the federal National Marine Fisheries Service's (NMFS) Biological Opinion on the Coordinated Long Term Water Operations of the Central Valley Project and State Water Project for winter run Chinook salmon, spring run Chinook salmon, and Central Valley steelhead. The U.S. Bureau of Reclamation and the California Department of Water Resources are in charge of implementing both proposals. Special emphasis was placed on reviewing potential benefits of proposed actions to Central Valley salmonids (Chinook *Oncorhynchus tshawytscha* and steelhead *O. mykiss*) and Sacramento splittail *Pogonichthys macrolepidotus*. Of the four runs of Chinook in the Central Valley, winter (endangered) and spring run (threatened) Chinook are listed under state and federal Endangered Species Acts and are the focus of the U.S. Bureau of Reclamation's Biological Opinion process along with Central Valley steelhead and southern green sturgeon (both threatened; Table 1). Neither fall nor late fall run Chinook are formally listed. Winter, spring, fall and late-fall run Chinook, as well as Central Valley steelhead, Sacramento splittail, Pacific lamprey, river lamprey, southern green sturgeon, white sturgeon, longfin smelt and delta smelt are covered species in the BDCP (Table 1).

Table 1. List of species considered in the NMFS Biological Opinion and Bay Delta Conservation Plan (BDCP). Threatened and Endangered status of species under the Endangered Species Acts are noted as "T" and "E".

Biological Opinion	Bay Delta Conservation Plan
Central Valley winter-run Chinook (E)	Central Valley winter-run Chinook (E)
Central Valley spring-run Chinook (T)	Central Valley spring-run Chinook (T)
Central Valley steelhead (T)	Central Valley fall-run Chinook (T)
Southern green sturgeon (T)	Central Valley late fall-run Chinook (T)
	Central Valley steelhead (T)
	Sacramento splittail
	Pacific lamprey
	River lamprey
	Southern green sturgeon (T)
	White sturgeon
	Longfin smelt
	Delta smelt (E/T)

BACKGROUND

Floodplains are areas of the river channel that seasonally flood during high water events. Floodplains support high biodiversity and yet are among the most altered and threatened habitats in the world (Opperman et al. 2010). In the Central Valley, the Yolo Bypass is the largest (57,000 acres; Howitt et al. 2013) contiguous floodplain left in the Sacramento River basin. Fishes that evolved to use floodplains benefit from their relatively high productivity (e.g., chlorophyll a concentration) as compared to habitat in the river proper (Sommer et al. 2004). High productivity can result in higher prey availability to fishes using the floodplain or located just downstream (Sommer et al. 2001a). Increased prey availability leads to faster growth rates for juvenile salmon rearing in Yolo Bypass, which may enhance survival at older life stages, although existing data is inconclusive (Sommer et al. 2001c, Sommer et al. 2005). The structure of floodplains (i.e., density of aquatic vegetation, low water velocity) can also provide refuge to juvenile fishes from predators and fast flows. Adults of some species (e.g., splittail, longfin smelt) may benefit from floodplain habitats as suitable spawning habitat; for example, both splittail and longfin smelt can spawn over aquatic vegetation in the wettest sections of the floodplain. However, much uncertainty exists about the specific magnitude, duration, and timing of benefits afforded to specific species. For example, most surveys (e.g., Sommer et al. 2001c) sampled fishes from January through April over a couple or few years (e.g., 1998 and 1999 in Sommer et al. 2001c). Due to the dynamic nature of rivers in Mediterranean climate regions (Gasith and Resh 1999), as in California, habitat conditions for fishes using floodplains are expected to vary by week, month, season, and year. Consequently, benefits to fishes are likely to vary with changing conditions at different time scales.

Benefits to fishes (e.g., growth) on floodplains may not increase at a constant rate over time due to bioenergetic trade-offs as conditions change on the floodplain, especially increasing temperatures and decreasing dissolved oxygen concentration. Bioenergetic trade-offs can occur when temperatures are sufficiently high, or dissolved oxygen concentrations are sufficiently low, as to slow or reverse growth rates. Katz et al. (2013) concluded that increases in temperatures may exceed juvenile Chinook temperature tolerances in the spring (late March) and result in the exodus of fish from the floodplain. The quality of water (e.g., water temperature) inundating the floodplain may affect the duration of floodplain use by fishes. A parameter closely related to water temperature is dissolved oxygen concentration; lower dissolved oxygen concentrations are associated with warmer water. Optimal dissolved oxygen concentrations for juvenile Chinook are greater than 13 mg/L in temperatures above 10°C (reviewed in USBOR and CDWR 2012). Low dissolved oxygen concentration may reduce fitness of juvenile salmon using the floodplain and trigger emigration from floodplain habitat. In the Chehalis River floodplain, the duration of floodplain use by juvenile salmon was negatively correlated to low dissolved oxygen concentrations (Henning et al. 2006). To date, no studies have documented annual temperature or dissolved oxygen patterns throughout the Yolo Bypass.

QUESTIONS

1. How many juvenile salmon are in the Sacramento River at different times of the year? Of these fish, how many juvenile salmon can be reasonably expected to access floodplain habitat in the Yolo Bypass under different proposed alternatives? What are the factors that influence their ability to access the floodplain? What is the level of certainty associated with these estimates and what additional research would be necessary to improve that level of certainty?

2. How many of the fish expected to access the Yolo Bypass floodplain habitat are of hatchery origin? What is the likelihood that these hatchery fish will reproduce in the wild?

3. Is the Yolo Bypass the only floodplain habitat important to fish species of interest in the lower Sacramento River watershed? If not, what other areas are important to the fish species of interest (e.g., Sutter Bypass)?

4. Is floodplain habitat along the Toe Drain in the Yolo Bypass higher or lower quality than other floodplain in the Yolo Bypass, such as the western portion of Knaggs Ranch?

5. What are the benefits of providing floodplain habitat before March 1st for each species of interest? After March 1st? What are the factors that influence level of benefit to fish species of interest, such as temperature? What does the scientific community know about these factors and what information is not available? How will climate change affect these benefits?

6. What are the different mechanisms through which splittail spawning success in the Yolo Bypass can be measured, taking into consideration that different organizations will define spawning success differently? Do splittail need 10,000 acres of floodplain habitat to spawn “successfully” in the Yolo Bypass? Would “success” be possible if splittail floodplain habitat is limited to the lower Yolo Bypass, such as areas in Cache Slough? Are there other opportunities for creation of successful splittail spawning habitat outside of the Yolo Bypass?

7. How long do juvenile salmonids and splittail need to stay on the Bypass floodplain to realize significant benefits?

ABUNDANCE OF JUVENILE SALMON IN THE SACRAMENTO RIVER

Topic #1: How many juvenile salmon are in the Sacramento River at different times of year?

Exact abundance numbers for juvenile salmon found throughout the Sacramento River do not exist, except for the number released from hatcheries, but relative abundance can be estimated from trap data. The California Department of Fish and Wildlife provided Yolo County with Knights Landing rotary screw trap data for September 1997 to June 1998. This data describe the relative number of juveniles of different runs (based on size criteria) caught at the trap by Julian week. The estimate of juvenile salmon abundance in the Sacramento River near the Yolo Bypass is based on this data, but can be updated if the Department provides Yolo County with additional years of data. Yolo County may also consider development of a model in the future to estimate Sacramento River abundance, including development of ranges of potential abundance given the significant limitations of the existing data and other uncertainties. This analysis should be viewed only as an initial effort to estimate abundance during a wet year.

Based on rotary screw trap data from Knights Landing (1997-2007), juvenile salmon (all runs) can be found in the Sacramento River at Knights Landing from October through July (J. Roberts, unpublished data). Trap catches suggest that abundances in general peak from November through January, are lowest from mid-February through the beginning of April, and exhibit a smaller peak in April/May across all years. Abundance peaks and valleys differ by year, however.

Migration of juvenile salmon past Knights Landing likely occurs in three phases (as in Snider and Titus 2000). In 1997-1998, late-fall and winter run Chinook juveniles produced in the wild and spring run

Chinook dominated Phase 1 (November 16-January 3). Fall-run Chinook dominated Phase 2 (December 28 - March 7), while fall run Chinook released from Coleman National Fish Hatchery principally comprised Phase 3 (March 8 - June 21). The exact timing of migration phases differs by year as influenced by river flow and temperature. Changes in river flow and temperature are cues for juvenile salmon to initiate seaward migration and are subject to climatic and hydrologic conditions (Groot and Margolis 1991).

Bearing in mind the uncertainties associated with estimating relative abundance from one year of trap data, the estimated number of juvenile salmon passing Knights Landing in the Sacramento River in 1997-1998 was roughly 9.35 million, with no measure of variance around this estimate. This estimate was derived by combining estimates of number of fishes caught at Knights Landing (from Snider and Titus 2000) with proportions caught by Julian week (Roberts et al. 2013, unpublished data). Detailed methods used are described in Table S1 at the end of this report. This translates to approximately 1.8 million juveniles from November to the end of December, 2.7 million juveniles end of December to March, and 4.7 million juveniles from March to June (Table S1), again, keeping in mind that these are inexact, unvalidated estimates. The 1997-1998 year was classified as a wet year and abundance estimates discussed here should be viewed as relatively high. Only five of 15 years from 1997 to 2011 (from Roberts et al. 2013) were classified as wet; all other years have been drier.

As mentioned previously, estimating abundance from rotary screw trap data provides only initial information for further discussion because of significant uncertainties. Trap data should be used to understand the relative number of fishes in the system rather than as a predictive estimate of total abundance. The efficiency of traps to catch fish, for example, is influenced by flow (Gaines and Martin 2002) and turbidity (McKibbin 2012) with fewer fish caught in high flow or decreasingly turbid (high water clarity) conditions. In addition, the number of juveniles trapped varies greatly among years (J. Roberts, unpublished data). Likewise, juvenile abundance in the Sacramento River is expected to vary greatly because abundances reflect the survival of previous life stages (i.e. incubating eggs, younger juvenile salmon). Survival of each life stage can be affected by a unique suite of factors (e.g., water temperature, predation) depending on location and migration timing so estimates of abundance can be difficult to predict. Finally, abundance estimates at the trap could be affected if water is diverted through the Sutter Bypass (upstream of Knights Landing) when flows are high, providing another migration route to juvenile salmon. In 1998, flows were sufficiently high to warrant use of Sutter Bypass in January (Snider and Titus 2000).

Topic #2: Of these fish, how many juvenile salmon can be reasonably expected to access floodplain habitat in the Yolo Bypass under different proposed alternatives? What are the factors that influence their ability to access the floodplain? What is the level of certainty associated with these estimates and what additional research would be necessary to improve that level of certainty?

The level of certainty associated with estimates of the number of juvenile salmon expected to access floodplain habitat in the Yolo Bypass in any given year, also known as "entrainment," is low due to high variability in juvenile production and survival each year. Roberts et al. (2013) is the first good attempt to answer this question, but it is a Fisheries Branch Administrative Report and not a peer-reviewed scientific article. Standardized use of rotary screw trap data can continue to provide measures of relative abundances among sites and years, however, including entrainment. Abundance and entrainment estimates are highly uncertain because they do not currently consider the significant impacts to flow and temperature from climate change which can alter juvenile migration patterns (as in Crozier et al. 2008; Moyle et al. 2013). The level of certainty would be increased by tracking of fish movements as juvenile salmon migrate downstream, monitoring of the number of fish migrating past Fremont Weir under different flow conditions, and analysis of the effects of temperature and flow on run-timing and migration route selection. Such monitoring could allow for better “real-time” operation of a gate in the Fremont Weir.

The number of juvenile salmon accessing the Yolo Bypass in any given year will depend on the synchrony between migration timing and flow events sufficiently high to overtop Fremont Weir at a river stage of 32.8 ft (under existing condition) or pass through a notch with a proposed elevation of 17.5 ft (225 wide with 2:1 slopes; proposed alternative). Basically, fish need to be at or near-upstream Fremont Weir during high flow events to gain access into the Bypass. The pattern and timing of flow events will depend on hydrologic and climatic conditions specific to year, including monthly precipitation.

Roberts et al. (2013) concluded that an operable gate in the Fremont Weir would increase the number of juvenile salmon accessing the Yolo Bypass by 185%, although it was not possible to understand the exact methodology for this estimate from the report. To arrive at this estimate, Roberts et al. (2013) evaluated existing conditions for water years 1997-2011 and compared the proportion of fish that passed the Fremont Weir under annual existing conditions to the proposed operable gate in the Fremont Weir for the entire migration period. The authors assumed juvenile salmon would be evenly distributed throughout the water column and estimated the number of juvenile salmon entering the Yolo Bypass as proportional to the amount of Sacramento River flow either overtopping the Weir or moving through the operable gate. This assumption is reasonable to make until empirical data is available to better document migration behavior, but it does not accurately represent fish behavior because most migrating juvenile salmon will congregate along stream banks during the day and disperse throughout the water column at night (P. Moyle, personal observations; R. Quiñones, personal observations). This means that entrainment may be over- or underestimated depending on the location of fishes and the timing (day vs. night) of high-flow events. Entrainment may be overestimated during the day, for examples, if fishes don’t access the operable gate (e.g., because they are congregating on the stream bank opposite of the notch during the day) or underestimated if most fishes do (e.g., because they congregate on the bank with the operable gate).

Based on proportion estimates in Roberts et al. (2013) and abundance estimates discussed under Topic #1, the number of juvenile salmon expected to have entered the Yolo Bypass in Water Year 1998 is about 1.5 million juveniles between November 1997 and June 1998 (Table S1). Based on percentages reported in Roberts et al. (2013), an additional 200,000 juveniles may have accessed the Bypass had Fremont Weir been notched as proposed. (This number is specific to the 1997-98 data.) These numbers are hypothetical and only provide a starting point for discussion. The state and federal government will need to develop better estimates if an operable gate in the Fremont Weir is constructed.

The position and size of fishes prior to reaching the weir may influence choice in migration route and affect use of the operable gate to access the Yolo Bypass. Tracking of juvenile Chinook salmon near the Delta Cross Channel suggests that river position and size of individual fishes can influence migration route selection even while mostly influenced by river flow (Steel et al. 2013). Yearling juveniles may, for example, have different entrainment rates than younger fishes because their larger size makes them better swimmers (Groot and Margolis 1991). Consequently, yearling juveniles may be able to maneuver through the operable gate more efficiently than subyearling fishes. Differences of entrainment rates between yearling and subyearling juvenile salmon, however, has not been evaluated.

HATCHERY FISHES

Topic #3: How many juvenile salmon expected to access the Yolo Bypass floodplain habitat are of hatchery origin?

In 1997-1998, about 97% of the unmarked salmon and 67% of the marked salmon caught at the Knights Landing rotary screw trap were fall run Chinook salmon (Snider and Titus 2000). The Central Valley fall run Chinook population as a whole is now dominated (> 90%) by hatchery produced salmon (Barnett-Johnson 2007, Johnson et al. 2013) and naturally produced fall run Chinook are likely extirpated (Moyle et al. 2008). If the proportion of juvenile salmon accessing the Yolo Bypass is likewise dominated by fall run Chinook, then we can estimate that the large majority (> 90%) of fishes using the Bypass are of hatchery origin. Based on past hatchery release dates, most fall run Chinook juveniles would migrate through the Bypass from March through June.

Topic #4: What is the likelihood that these hatchery fish will reproduce in the wild?

Reproduction of hatchery-produced adult salmon in the wild (due to straying) appears to differ by run type. Such spawning occurs mainly in rivers below hatcheries. While salmon of hatchery origin that spawn below hatcheries often produce large numbers of young, survival of these young appears to be low due to adaptations to the hatchery environment, competition from larger hatchery fish released into the river, and manipulations of river flows for benefits other than salmon production (P. Moyle, personal communication).

Straying occurs when adult salmon return to spawn in watersheds other than the one where they were raised. Straying is a natural part of salmon behavior but is usually less than 10% in wild populations (Groot and Margolis 1991). Releases in locations away from the hatchery promote higher rates of adult straying (reviewed in California HSRG 2012) and can have detrimental effects on the ability of a species to cope with changing environmental conditions if hatchery-adapted genes are introduced into wild populations. Straying is thought to be the principal cause of genetic homogenization of Central Valley fall run Chinook (Williamson and May 2005), making the entire run more susceptible to collapse (Lindley et al. 2009).

Reproduction in the wild of fall run Chinook in the Mokelumne River has been recently studied (Johnson et al. 2013). Upon evaluating the chemical signature of ear bones, Johnson et al. (2013) proposed that about 90-99% of wild spawners were hatchery-produced fish. Similarly, about 86% of spring run

Chinook reared in the Feather River Hatchery between 2004 and 2007 that were released in San Pablo Bay strayed (California HSRG 2012b). Of the groups of Chinook likely to use the Yolo Bypass (Table 1), we can infer that straying into the wild is most likely for juveniles from Coleman National Fish Hatchery when these are released away from the hatchery in San Pablo Bay. However, it is currently impossible to estimate how many of these juveniles will use the Yolo Bypass and then return to spawn in rivers. Pit-tagging and individual tracking of fishes through their entire life cycle, from hatchery rearing, through seaward migration, to adult spawning, could provide estimates of hatchery fishes that reared in the Bypass and then strayed.

Table 2. Run type, percentage marked, and release target, location and month of Central Valley Chinook salmon reared in hatcheries. Two asterisks (**) marks groups most likely to use the Yolo Bypass for rearing, one asterisk marks groups likely to use Yolo Bypass as a migration corridor. Source: California HSRG 2012a.

Facility	Run	Marked	Release target/year	Release location/month
Nimbus Fish Hatchery	Fall Chinook	25%	4 million smolts	San Pablo Bay mid-May to mid-June
Mokelumne River Hatchery	Fall Chinook	25%	5 million smolts 2 million post-smolts	San Pablo Bay & Woodbridge Dam March to June
Merced River Hatchery	Fall Chinook	25%	1 million smolts	Various locations, San Joaquin basin April to mid-May
Feather River Hatchery	Fall Chinook	25%	6 million smolts 2 million post-smolts	Carquinez Straits April to June
	*Spring Chinook	100%	2 million smolts	Feather River April or May
Coleman National Fish Hatchery	**Fall Chinook	25%	12 million YOY	Battle Creek San Pablo Bay April
	*Late-fall Chinook	100%	1 million yearling	Battle Creek

Livington Stone National Fish Hatchery	**Winter Chinook	100%	250,000 YOY	Sacramento River late January to early February

OTHER FLOODPLAINS

Topic #5: Is the Yolo Bypass the only floodplain habitat important to fish species of interest in the lower Sacramento River watershed? If not, what other areas are important to the fish species of interest (e.g., Sutter Bypass)?

While the Yolo Bypass is potentially the largest floodplain habitat available to fish species in the lower Sacramento River watershed, fishes also successfully use other areas to complete their life cycle. For instance, Chinook salmon have successfully reared in the Consumes River floodplain (Jeffres et al. 2008), Natomas East Main Drainage Canal (Jones and Stokes Assoc. 1999) and Sutter Bypass (Hill and Webber 1999, Ward et al. 2004). Splittail have successfully spawned in floodplain habitats in the lower Consumnes River, American River, Sutter Bypass, Sacramento River, and lower Tuolumne River (San Joaquin basin; Moyle et al., unpublished report; Moyle et al. 2004). Outside of the Central Valley, splittail are also present in the Napa and Petaluma Rivers (Baerswald et al. 2007). One study (Sommer et al. 1997) found that larval densities were not statistically different in the Sutter and Yolo Bypasses, suggesting that reproductive success is similar between these sites. Furthermore, splittail can successfully spawn along stream banks and in backwaters during small increases in flow (reviewed in Moyle et al. 2004) when the Bypasses may not be flooded.

TOE DRAIN VERSUS FLOODPLAIN HABITAT

Topic #6: Is the floodplain habitat along the Toe Drain in the Yolo Bypass higher or lower quality than other floodplain habitat in the Yolo Bypass, such as the western portion of Knaggs Ranch?

The floodplain habitat along the Toe Drain should be of equal quality to other floodplain habitat in the Yolo Bypass, assuming these areas are also seasonally flooded and have similar depth and velocity characteristics. Floodplain habitat near the Toe Drain may be more suitable for some species (e.g., splittail) since they are expected to be flooded for longer periods of time because this area would be the first to inundate and last to drain. The only major concern to native fishes regarding floodplain habitat along the Toe Drain is that they would be in closer proximity to predators (e.g., striped bass *Morone saxatilis*) so mortality due to predation may be higher but the certainty of this is low. The Toe Drain is also tidally influenced from near Lisbon Weir to Liberty Island (NHI et al. 2002) so rapid changes in depth may lead to desiccation of splittail eggs and may lead to significant amounts of mortality during high flow events.

BENEFITS OF FLOOD TIMING

Topic #7: What are the benefits of providing floodplain habitat before March 1st for each species of interest? After March 1st? What are the factors that influence level of benefit to fish species of interest, such as temperature? What does the scientific community know about these factors and what information is not available?

Most species of interest will benefit the most from use of the Yolo Bypass in the fall and winter (before March 1st) but juvenile salmon, splittail, sturgeon and lamprey may still benefit from additional use of floodplain habitat after March 1st. However, the magnitude of benefits and how they differ by run timing, size and age of fish has not been evaluated. Further, inundation of the entirety of the floodplain is not necessary to realize at least some benefits to the species of interest (refer to discussion below).

Duration of beneficial conditions for growth and survival of individual fish are expected to last only as long as favorable habitat exists (e.g., cool temperatures). Favorable habitat is expected to be readily available before March 1st because flooding is more likely and air temperatures are still cool. However, the duration of benefits after March 1st is difficult to determine. Benefits to fish using floodplain habitat will be governed by parameters including temperature, dissolved oxygen concentration, prey availability and predation pressure. For instance, Jeffres et al. (2008) documented that conditions on the floodplain could result in mortality of salmon in pens, likely due to low dissolved oxygen conditions. Although unpenned fish likely leave unsuitable areas before experiencing mortality, their study indicates that some floodplain habitats can become unsuitable for juvenile salmon rearing.

The magnitude of potential benefits are dependent on habitat conditions, particularly temperature, with diminishing benefits to adults and juveniles as temperatures increase beyond 18-20°C. Katz et al. (2012) found that temperatures in their sites in 2011 increased beyond 20°C by the end of March. Although high prey availability sustained growth rates at high temperatures at Knaggs Ranch, growth rates began to decrease at temperatures above 20°C (Katz et al. 2013). However, their sites were fed by agricultural return water which may exhibit different temperature patterns than Sacramento River floodwaters. This issue remains uncertain, however, as Sommer et al. (2005) documented temperatures above 20°C in April (1998) and May (2000) during years of Sacramento River floodwaters inundated Yolo Bypass.

Temperature, dissolved oxygen concentration, and predation pressure are likely to become increasingly more stressful to fishes using the floodplain after March 1st as air temperatures increase and flooding depths decrease. Dissolved oxygen concentrations decrease with increasing water temperatures, although wind at the water’s surface in some instances can counteract these effects; temperature generally also increases with decreasing depth (Allan and Castillo 2007). Temperature, dissolved oxygen, and predation pressure have not been extensively monitored for different water years or seasons in the Yolo Bypass. Consequently, it is difficult to determine exactly when suitable conditions will end after March 1st.

Weekly monitoring of growth and survival of fishes on the floodplain concomitant with environmental conditions, such as temperature, dissolved oxygen, and prey availability, is needed to establish the duration of benefits of Yolo Bypass use. Monitoring should take place at multiple locations, during multiple water years, in the Yolo Bypass in order to capture potential heterogeneity of habitat conditions (as in Jeffres et al. 2008).

Sommer et al. (2005) estimated salmon densities of Chinook juveniles in the Yolo Bypass to range from 126 to 890 fish per hectare. This density converts (1 hectare = 2.47 acres) to a range of about 51 to 360 fish per acre. Based on a density of 300 fish per acre and the abundance estimates from Snider and Titus 2000 (see Topic #1), approximately 6,000 acres of Yolo Bypass floodplain habitat could house all 1.8 million fishes estimated to be present in the Sacramento River at Knights Landing. This equates to essentially all of the late-fall, winter, and spring Chinook migrating from November to December 1997. In comparison, approximately 9,000 and 16,000 acres could house all 2.7 million fishes (wild fall Chinook) migrating December to March and 4.7 million fishes (hatchery fall Chinook) migrating March to June, respectively, in that same water year. If the fish can survive at even higher densities, which is suggested by Katz et al. (2013), then the fish would need even less acreage in the Yolo Bypass. Obviously, not all of these fish could be diverted into the Bypass through an operable gate in the Fremont Weir because the large majority of the flows and the associated fish would remain in the Sacramento River. Roberts et al. (2013) estimate that up to 38% (late fall run Chinook in 2006) of some runs may enter the Bypass via an altered Fremont Weir. However, based on 1997-2011 averages, the proportion of fishes entering the Bypass via a notch or operable gate in any given year will more likely range from 13-18% (Roberts et al. 2013). These estimates are highly speculative because they are based on the proportion of flow moving past Fremont Weir rather than observed numbers. As discussed under Topic #1, these estimates are simply to demonstrate the potential that only a small portion of the Yolo Bypass is needed for significant fish benefits. Additional data and analysis is needed to further this discussion. The actual number that would access the Bypass or benefit from its use are unknown (Katz et al. 2012).

Delta smelt are expected to only benefit indirectly from Yolo Bypass flooding if carbon inputs are sufficient to substantially enhance prey availability in their habitats (as in Schemel et al. 1996 in NHI et al. 2002). However, studies suggest that bivalve grazing (i.e. from invasive non-native clams) under some conditions may reverse benefits from increased primary productivity (Greene et al. 2011, Lucas and Thompson 2012) that would otherwise increase delta smelt prey. It is unknown if inundation of Yolo Bypass will increase primary production sufficiently to benefit delta smelt.

Juveniles of the species of interest are expected to benefit more from floodplain habitat use than any of their adult counterparts. Juveniles are better adapted to use shallower, denser (due to aquatic plants) habitats and grow at faster rates than adults when prey are easily available.

In general, benefits to adults will be as an alternate upstream route during upstream (salmon, steelhead, lamprey) migration if the Bypass provides refuge from high water velocities and predators. Sturgeon adult prefer to migrate in deeper parts of river channels but may be attracted into the Bypass during high flows. Splittail and longfin smelt adults may benefit from spawning over aquatic vegetation in the Bypass, although longfin smelt are much more prone to use deeper, more open areas (Moyle 2002) and evidence of longfin smelt using the Bypass is very limited (P. Moyle, personal communication).

Winter run Chinook adults begin spawning migrations from January through May, peaking in mid-March. Juveniles migrate downstream of spawning areas from October to June, with peak numbers at the end April, generally staying upstream Red Bluff Diversion Dam, (Williams 2006, Moyle et al. 2008). Juveniles will rear another 5-10 months before moving towards San Francisco Estuary. Most juveniles will reach the Delta in early winter (Moyle et al. 2008). Juveniles historically likely benefitted from winter flooding in the Sacramento basin which provided floodplain habitat for rearing (Moyle et al. 2008). Most juveniles are expected to migrate through and rear in the Yolo Bypass (if accessed) before March 1st but juvenile salmonid outmigration may continue through to June.

Spring run Chinook adults begin upstream spawning migrations from February to early July. Peak adult numbers reach upper Sacramento River tributaries (Butte, Deer, Mill Creeks) in mid-April to mid-May (Moyle et al. 2008). Adults reside in streams for several months before spawning in the fall. Juveniles will hatch and subsequently rear in streams through at least the following spring. Rotary screw trap catches at Knights Landing catch juveniles from March to July (J. Roberts, unpublished data; based on length criteria) but hatchery releases of juveniles dominate trap catches in April or May (California HRSG 2013). The relative size of juveniles seems to determine how quickly they migrate to the ocean. Larger juveniles rearing in Sutter Bypass migrate quickly into ocean (Hill and Webber 1999). Consequently, larger (juveniles older than 1 year) juveniles that usually migrate after March 1 are not expected to benefit from Yolo Bypass rearing as much as younger juveniles. Young of year (YOY; juveniles less than one year old) are more likely to rear for extended periods of time in the Bypass. Most wild YOY are expected to migrate through and or rear in the Bypass before March 1st while hatchery-produced YOY are expected to migrate through the Bypass after March 1st.

Fall run Chinook adults spawn October to December. Juveniles migrate as fry and smolts in winter and spring. Historically, fall run Chinook juveniles are thought to have reared in floodplains extensively, benefitting from accelerated growth in these areas due to warmer temperatures and higher prey densities (Sommer et al. 2001c, Jeffres et al. 2008). More than 90% of fall run adults are considered to be hatchery produced. Naturally-produced (wild) fall run Chinook have very low survival rates and are the progeny of hatchery-reared adults (Moyle et al. unpublished report). Most wild YOY are expected to migrate through the Bypass before March 1st while hatchery-produced YOY are expected to migrate through the Bypass after March 1st.

Late-fall run Chinook adult migration peaks in December and January (Moyle et al. 2008), but occur from November through April (William 2006). Size criteria suggest that late-fall Chinook juveniles migrate most of the year (Williams 2006) but migration usually peaks in October (Moyle et al. 2008). Most juvenile late-fall run Chinook should migrate through the Yolo Bypass before March 1st.

Central Valley steelhead juveniles migrate from the Sacramento-San Joaquin River system from late December to the beginning of May, peaking in mid-March, with a smaller peak in fall. There is no evidence that steelhead need floodplain rearing to do well (P. Moyle, personal communication), although a few individuals were caught by Sommer et al. (2001b). Flooding of the Yolo Bypass is expected to only negligibly benefit Central Valley steelhead juveniles and may only benefit adult steelhead as an alternate migration route before March 1st.

Splittail adults migrate upstream from brackish water (low saline waters) in response to stream flow pulses from November to February (Moyle et al. unpublished report). Adults will usually spawn from March through April over annual vegetation, although earlier spawning has been observed (Moyle et al. 2004). Juveniles will rear in shallower floodplain habitats from March through April and will migrate off the floodplain during April and May, as high flows recede. Both adult and juvenile splittail would benefit the most from flooding of the Yolo Bypass after March 1st. Adult splittail likely do not need a large inundation footprint to successfully spawn as long as a "high flow" cue initiates migration onto the floodplain and submerged vegetation is present. Floodplain habitat along the Toe Drain should provide sufficient spawning and incubating habitat during some wet years (P. Moyle personal communication). Yolo Bypass is expected to flood in years when other areas would also be flooded due to high flows, making spawning habitat available in other parts of the Project Area (Sacramento-San Joaquin Delta, Suisun Marsh, Suisun Bay, and Yolo Bypass; see Question #5). Consequently, spawning habitat is readily available elsewhere in years when the Bypass is flooded. In low water years, flow through an altered Fremont Weir may not be sufficient to cue spawning migration onto the floodplain. Consequently, it is uncertain how much splittail will benefit from an operable gate at Fremont Weir. A larger inundation (beyond just the Toe Drain) footprint could provide important rearing habitat to splittail juveniles that incubated in Yolo Bypass. The exact number of acres needed for successful spawning and rearing is unknown.

Little is known about **white sturgeon** *Acipenser transmontanus* habitat use in the Central Valley. In the Columbia River, adults move upstream in fall to spawn and back to the ocean in spring (Moyle et al. unpublished report). Prior to spawning, adults move into lower parts of rivers in winter and move upstream with increased flows. Spawning occurs in response to increases in flow in late February to early June. Spawning in the Sacramento River takes place between Knights Landing and Colusa, although adults also used to enter the Feather River. No recent spawning activity has been reported in the Feather River. Spawning takes place in deep water over gravel/rocky substrate. Upon hatching, larvae swim near the river bottom, preferring deep areas. Juveniles in the Fraser River use deep areas (> 5m) with soft sediments and lots of prey (including dipteran flies). Adult white sturgeon would benefit from Yolo Bypass flooding if Conservation Measures provide a viable (i.e. deep areas), alternate migration route for adults that stray into the Bypass. Juvenile white sturgeon may benefit from feeding opportunities on the floodplain after March 1st but juveniles generally prefer deeper habitats and specific floodplain use of juveniles in the Central Valley (including Yolo Bypass) is unknown.

Green sturgeon *Acipenser medirostris* migrate into the Sacramento River to spawn in March to May, with peaks in May-June (Adams et al. 2002, Heublein et al. 2009). Adults prefer to migrate in deep parts of the channel and will hold in deep pools while migrating between fresh and salt water so the Yolo Bypass is not considered suitable habitat for adults. However, adults can get trapped behind the Fremont Weir so passage at the Weir should be addressed (Thomas et al. 2013). Adults need rocky stream bottoms for spawning in deep pools with high velocity. Larval green sturgeon have lethal temperature tolerances near summer temperatures in the Sacramento River. Age 0-1 year olds do best (bioenegetic performance) in temperatures between 15-19°C (reviewed in Beamesderfer et al. 2007). Larvae (20-60 mm) migrate downstream May-August. Juveniles can spend 1-4 years in freshwater.

Adult green sturgeon would benefit from Yolo Bypass flooding if Conservation Measure 2 provides a viable and alternate migration route to adults that stray into the Bypass. Green sturgeon juveniles are unlikely to benefit from feeding opportunities on the floodplain before and after March 1st; the best evidence suggests that they rear mainly in large river channels (Moyle et al., unpublished report). There is no evidence of deliberate systematic use of the Yolo Bypass by green sturgeon (P. Moyle, personal communication).

Little is known about **river lamprey** *Lampetra ayresi*. They have not been studied in California so information from British Columbia is used here, which may or may not reflect the habitat use of populations in California (Moyle et al., unpublished report). Adults migrate into freshwater in fall and spawn in tributaries in winter or spring. Upon hatching, larval lamprey (ammocoetes) burrow into silt-sand deposits in backwaters that are within the wetted channel. Ammocoetes transform in summer; metamorphosis takes 9-10 months. Newly transformed juveniles aggregate just upstream of salt water and enter the ocean in late spring. Juveniles spend 3-4 months in saltwater. The Yolo Bypass is not thought suitable for ammocoetes because they need perennial water with soft (easily burrowed; no large root masses) sediments. Adults migrating to spawn (before March 1st) and transformers (after March 1st) may benefit from Yolo Bypass flooding if Conservation Measures provide a viable alternate migration route.

Pacific lamprey *Entosphenus tridentatus* adult spawning migrations begin from early March to late June but migration has also been seen in January, February and July (Moyle et al. unpublished report). Adults use gravel substrates in rivers to build nests and deposit eggs. Embryos hatch in 19 days in 15°C. Ammocoetes burrow into soft sediments in perennial water. Juvenile metamorphosis and downstream migration is associated with increases in flow in winter and spring. The Yolo Bypass is not thought suitable for ammocoetes because they need perennial water with soft (easily burrowed; no large root masses) sediments. Adults migrating to spawn (before March 1st) and transformers (after March 1st) may benefit from Yolo Bypass flooding if Conservation Measures provide a viable alternate migration route.

D**elta smelt** *Hypomesus transpacificus* are mainly found downstream of the Yolo Bypass (P. Moyle, personal communication). Spawning success is highest at temperatures 15-20°C (Moyle 2002). Increased mortality is thought associated with pesticides, and predation by alien species (along with other factors). Delta smelt distribution is confined to freshwater and low salinity areas of the San Francisco Estuary. Temperatures over 25°C are lethal to adults but temperatures above 20°C increase mortality of newly spawned larvae. Actual spawning locations are unknown. However, spawning seems to take place from late February to June, with larvae being most abundant from mid-April through May (but can be seen from February to mid-July). Spawning in the wild takes place in temperatures between 7-15°C. Adults often spawn below low water margin in tidal areas, over substrate rather than vegetation. Delta smelt preferred prey are copepods. No information is available on factors that affect spatial distribution, or initiate spawning or first feeding. Delta smelt may benefit indirectly from Yolo Bypass flooding if carbon exports off the floodplain are sufficiently high to significantly increase prey availability in downstream habitats. However, the amount of carbon export necessary to significantly offset grazing by invasive clams and increase prey density in delta smelt habitats is unknown.

Longfin smelt *Spirinchus thaleichthys* live in open water bays and channels (Moyle 2002), including areas in the San Francisco Estuary and Delta (CDFG 2009). However, a few adult longfin smelt have been collected from the Yolo Bypass, most commonly in the winter and spring when flows are low (CDFG 2009). But overall, longfin smelt are rare upstream Georgiana Slough (CDFG 2009) even if found as far upstream as Rio Vista (Moyle 2002). Adults prefer open water with temperatures < 18°C (Moyle 2002) and then move upstream to spawn over stream substrates or aquatic plants. Most spawning occurs February to April at temperatures <14.5°C. Larvae are most abundant January-March but can be common also in April-July (as in 1989-1990). Juvenile numbers peak in June and July (CDFG 2009). Juveniles move further downstream than larvae. Larvae and juveniles seem to tolerate slightly warmer water but water temperatures still have to be less than 22°C (CDFG 2009). Use of the Bypass (and other floodplains) by longfin smelt adult and juveniles is minimal (P. Moyle, personal communication).

Other factors, besides temperature, that influence habitat use by adults and juveniles of the species of interest include type and density of prey, presence of predators (including birds and other fishes), dissolved oxygen concentrations, and levels of aquatic toxins (including pesticides). None of these have been adequately addressed by existing reports.

Topic #8: How will climate change affect these benefits?

The following is a modified excerpt from Moyle et al., unpublished report.

Climate change is already altering fish habitats in California and will continue to do so at an accelerating pace if trends do not change. In general, conditions are worsening for native fishes and improving for many alien fishes. For most species of native fish, the predicted outcomes of climate change are likely to accelerate current declines, potentially leading to extinction in the next 50-100 years if nothing is done to offset climatic impacts (Moyle et al. 2013). This section is focused on two major aspects of climate change that affect fish distribution and abundance in California rivers: temperature and precipitation.

Temperature. Temperatures have been rising in streams for some time and are continuing to rise (Kaushal et al. 2010). In California, there are diverse climate change models to predict future temperatures, but the more conservative models generally converge on scenarios that assume that within 50–100 years, temperatures will increase between 1°C–4°C (1.8°F–7.2°F) and 1.5°C–6°C (2.7°F–10.8°F) (Miller et al. 2003, Cayan et al. 2009). Further, annual snowpack in the Sierra Nevada and Cascade ranges is expected to diminish greatly, so stream flows will be increasingly driven by rainfall events. An increase in the ratio of rain to snow will result in more peak flows during winter, increased frequency of high flow events (floods), diminished spring pulses, and protracted periods of low (base) flow. In addition, there will be more extended droughts. These conditions will translate into warmer water temperatures at most elevations, reflecting both increases in air temperatures and reduced summer flows. From a fish perspective, the impacts of climate change are likely to be most severe on species requiring cold water (<18°C–20°C, or 64°F–68°F) for persistence, especially salmon and trout (Katz et al. 2013). Warming (more days with maximum temperatures > 20°C or > 68°F) of the more freshwater regions of the San Francisco Estuary is regarded as an additional threat to declining endemic species such as delta smelt (*Hypomesus transpacificus*) (Wagner et al. 2011).

Precipitation. Models for precipitation indicate that precipitation in California will become more variable, with more falling as rain and less as snow (Cayan et al. 2009). Generally, the total amount of precipitation by 2100 is projected to be less, although the extent of loss is highly uncertain (Cayan et al. 2009). From a fish perspective, present rain flow-dependent streams will respond somewhat differently than snowmelt-dependent streams, although, as temperatures rise, the hydrologic character of snowmelt streams will become more like those of rain flow-driven streams.

Earlier snowmelt has already moved the timing of high flows forward by 10 to 30 days, on average (Stewart et al. 2005), with annual peak discharges, in particular, occurring earlier (Cayan et al. 2009). These changes dramatically affect flows in low-elevation rivers in the Central Valley and are leading to modified operation of reservoirs (dam releases), which further affect flows. Overall, the amount of water carried by streams in California (and the rest of the western United States), if present trends continue, will decrease by 10 to 50 percent during drier months (e.g., Cayan et al. 2001).

In the Yolo Bypass increased temperatures, changes in flow patterns, and potentially diminished fog (Johnstone and Dawson 2010), will likely result in (1) shorter periods of habitat suitability during all but extreme flood events, (2) decreased frequency of natural flood events suitable for spawning of splittail and rearing of salmon, (3) more (if still infrequent) extreme ("100 yr") flood events, and (4) increased demand for water to create artificial flooding from mid-January through mid-March.

Topic #9: What are the different mechanisms through which splittail spawning success in the Yolo Bypass can be measured, taking into consideration that different organizations will define spawning success differently?

Successful spawning could be measured as the number of adults spawning on the floodplain or the number of eggs deposited per acre. However, successful spawning is measured here as the number of juveniles that move from the floodplain, into larger stream and slough channels, as flood waters recede. This measure would also evaluate benefits of splittail juveniles rearing on the floodplain.

Topic #10: Do splittail need 10,000 acres of floodplain habitat to spawn successfully in the Yolo Bypass? Would success be possible if splittail floodplain habitat is limited to the lower Yolo Bypass, such as areas in Cache Slough? Are there other opportunities for creation of successful splittail spawning habitat outside of the Yolo Bypass?

Splittail need two things for successful spawning: 1. attraction flows that initiate upstream spawning migrations into freshwater, and 2. submerged annual vegetation on which to deposit eggs (reviewed in Moyle et al., unpublished report). Aquatic vegetation also needs to stay submerged long enough for incubation to take place. Consequently, the best splittail spawning habitat is likely close to the Toe Drain, but upstream of Lisbon Weir, to minimize the risk of egg desiccation. It is fairly certain that splittail will not need 10,000 acres to spawn because spatial extent is not as necessary as the presence of spawning substrate (i.e., submerged vegetation) for successful spawning and abundant food for larval and juvenile splittail (P. Moyle, personal communication). Furthermore, successful spawning occurs in other parts of the systems (e.g., Sutter Bypass, Cache Slough, Napa River) and so is not solely reliant on the Yolo Bypass. Consequently, splittail are expected to successfully spawn even if habitat is limited to lower Yolo Bypass (e.g, areas in Cache Slough). However, the relationship between spawning success (as defined above) and size of flooded area has not been evaluated. Presumably, there is an optimal size of flooding based on numbers of adults available for spawning, size and fecundity of spawning adults, access to habitat by migrating fish, amount of suitable spawning and larval habitat (annual vegetation), production of food for juveniles and larvae, and 'escape routes' for juveniles to move off the floodplain and downstream to rearing habitats in places such as Suisun Marsh (P. Moyle, personal communication). The latter may depend on sufficient production of juveniles to compensate for predation during the outmigration period. Please refer to Questions # 5, 6 and 7, above, for more details.

Topic #11: How long do juvenile salmon and splittail need to stay on the Bypass floodplain to realize significant benefits?

The general consensus is that splittail and juvenile salmon, the species most reliant on floodplain use, need 3-4 weeks of inundation to realize significant benefits. Year class strength of juvenile splittail that stayed on the floodplain for more than 3 weeks (March to May) was 10 fold higher, as measured by abundance, than for groups that used the floodplain for less than 3 weeks (Sommer et al. 2001b). Juvenile salmon on the other hand may require a bit more time, around 4 weeks (fall-spring), to realize significant benefits. The time required is related to a time lag between when initial flooding and when prey (e.g., zooplankton, dipteran flies) are readily available to juvenile salmon (inoculation period; C. Jeffres, personal communication). Sommer et al. (2005) determined Yolo Bypass resident times of planted, tagged Chinook juveniles (from Feather River Fish Hatchery) to range from 30-56 days from 1998-2000. Presumably residence time of fish entering the floodplain naturally would be similar, although this is not known. The assumption is that almost any time spent on a food-rich floodplain would benefit wild salmon (P. Moyle, personal communication).

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SUPPLEMENTARY MATERIAL

Table S1. Estimates used to calculate total number of fishes moving in the Sacramento River past Knights Landings (Phase 1-3) and number of fish that may have entered Yolo Bypass without and with and operable gate at Fremont Weir, November 1997-June 1998

Chinook Run	**Phase 1***	**Phase 2**	**Phase 3**	**Estimated 1998 Entrainment without gate****	**Estimated 1998 Entrainment with gate****
Late Fall	20587.5	25162.5	0	10215.98	12910.65
Winter	45050	61943.75	5631.25	17851.06	25295.58
Spring	16275	4882.5	33092.5	7144.725	11446.75
Fall	1737748	2652353	4755943	1461538	1681043
Subtotals	1819661	2744342	4794667	1496750	1730696
1997-1998 Total number			9358669		

Steps used in calculations:

1. Determined Julian weeks corresponding to each Phase as defined in Snider and Titus 2000.
2. Determined the portion of each run traveling past Knights Landings during each Phase as defined in Roberts et al. 2013, unpublished data of Knights Landing Rotary Screw Trap catches (1997-2007).
3. Used abundance numbers in Snider and Titus 2000 and proportion from Roberts et al. 2013 to estimate numbers of each run migrating during each phase; sum total (~ 9.3 million) became an estimate of the number of fishes found in the Sacramento River from November 1997-June 1998
4. Used proportion of fishes entering Yolo Bypass (without and with operable gate at Fremont Weir; Roberts et al. 2013 *An empirical approach to estimate juvenile salmon entrainment over Fremont Weir*, Fisheries Branch Administrative Report 2013-01, Sacramento) with estimated total abundances to estimate number of fishes entering Yolo Bypass in 1998 WY.
5. Subtracted estimated number of fishes entering Yolo Bypass without operable gate from estimated number fishes entering Yolo Bypass with operable gate to estimate differences between the two scenarios (~234 000 fishes).

EXHIBIT D

Waterfowl Impacts of the Proposed Conservation Measure 2 for the Yolo Bypass – An effects analysis tool

July 16, 2012

Prepared by:
Kevin Petrik, Mark Petrie, Aaron Will and Jeff McCreary
Ducks Unlimited,
Western Regional Office,
3074 Gold Canal Drive, Rancho Cordova, CA 95670

Prepared for:
Bay Delta Conservation Plan - Yolo Bypass Fisheries Enhancement Planning Team

Support from:
Metropolitan Water District of Southern California
Westlands Irrigation District

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1 Executive Summary

This project is the result of initial Bay Delta Conservation Plan's Conservation Measure 2 Yolo Bypass Fishery Enhancement Planning Team meetings held during the summer and fall of 2011 to discuss the biological needs of fish species and how alteration of flood duration and frequency could affect current land uses within the Bypass. From these meetings it became clear that there was a gap in information to determine the effects from Conservation Measure 2 on other key species and habitats that benefit from the current operation of the Yolo Bypass, waterfowl in particular. Many of land uses in the Bypass provide habitat for waterfowl, notably the Yolo Bypass Wildlife Area and many private hunt clubs. These stakeholders requested that any changes to flood management in the Yolo Bypass be examined with consideration for the effects on waterfowl, among other effects. This study is an effort to describe the main drivers of waterfowl and associated recreational use in the Yolo Bypass and report on the successful development of a tool that can evaluate effects on these resources and uses due to implementation of future flood management scenarios as part of Conservation Measure 2.

2 Background

Conservation Measure 2 proposes to increase fish habitat functions and values within the Yolo Bypass through the activation of floodplain processes by increasing the frequency, duration, and amount of flooding over the Fremont Weir between November and April. In order to refine what operational scenario the Measure might operate and how the effects of that scenario on waterfowl may either be minimized or off-set, this project designed a tool that can model the effects on waterfowl and their habitat resulting from a change in Yolo Bypass flood management. Waterfowl habitat for the purpose of this project is defined as managed seasonal wetlands and winter flooded rice fields. Potential flood flows through the future operation of a gate or passive notch in the Weir have yet to be determined; however, current estimates are for allowing flows of up to an additional 6,000 cubic feet per second (cfs) in certain situations. This is the boundary condition that was used in developing the evaluation tool and is integral to the proof of concept examples as described in this report. Future scenario runs may vary the magnitude, duration and frequency of new flooding in the Bypass and their effects can nonetheless be quantified with this tool.

Wetlands and their management at Yolo Bypass Wildlife Area was the focus for the development of this tool considering that the majority of wetlands located within the Bypass are situated within its borders. Additional waterfowl habitat is also present on private hunt clubs and on winter flooded rice fields on both the Wildlife Area and private farmland throughout the Bypass.

3 Main Drivers

The four main drivers of effects on waterfowl from increased flooding in the Yolo Bypass include the changes to recreational use, loss of farming and hunting income, reductions in foraging habitat and the loss of wetland seed production due to later spring draw down. Each of these drivers is described in detail in the following sections.

3.1 Recreation/Hunt Use

The Yolo Bypass Wildlife Area (YBWA) is a popular waterfowl hunting and bird watching area with bird numbers peaking in February. It is open to the public most days except during certain Bypass flooding instances. Current procedure regulating public access at the YBWA during floods is to close the entire area soon after water overtops the Fremont Weir. Even relatively small overtoppings can inundate public access infrastructure in certain portions of the YBWA. This infrastructure is not currently capable of limiting access to only non-flooded areas, hence closing the entire area for the duration of the flood. In order to understand the relationship between the magnitude of a flood and the number of days of closure, this study used the record of Fremont Weir overtopping events and matched it chronologically with the record of YBWA closures as a metric for effects on recreation. Since there is not a direct tally of YBWA closures, the last 13 years of hunt records were examined to record the days that hunting was closed on the wildlife area. Figure 1 shows the number of days of Fremont Weir overtopping and the subsequent YBWA closures.

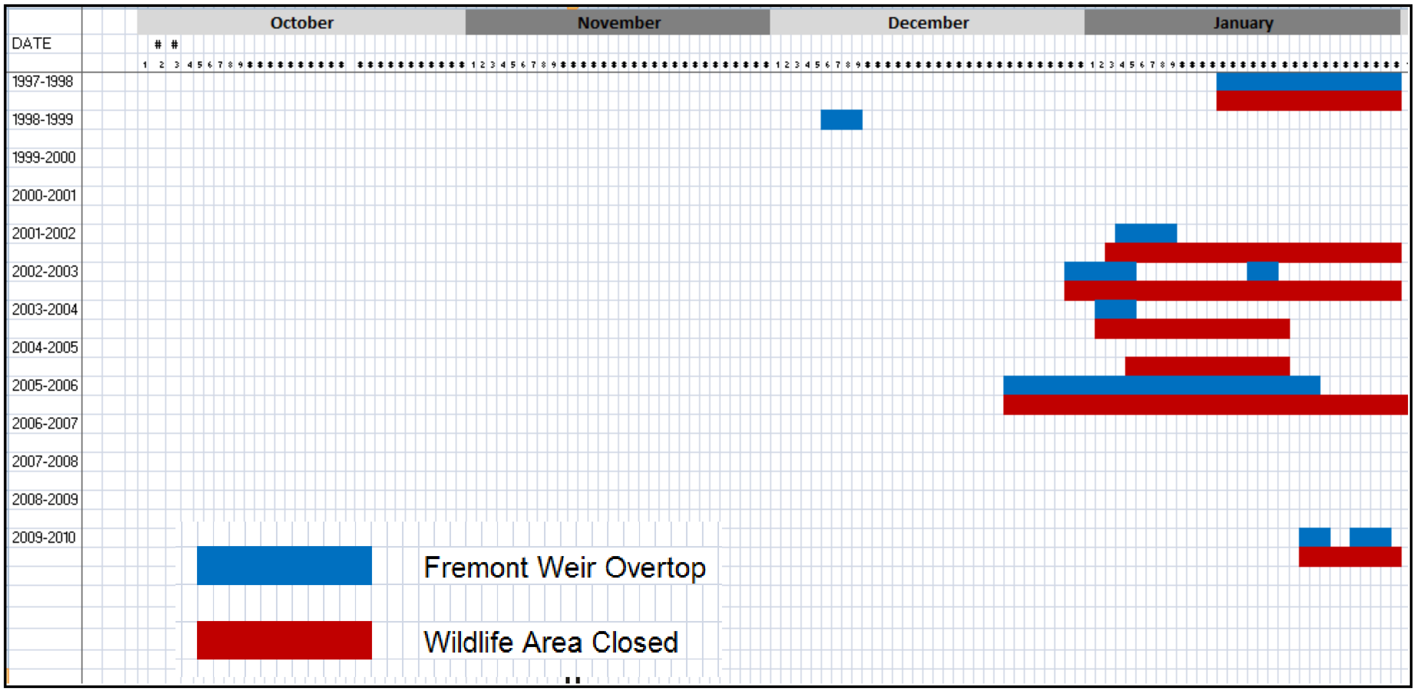

Figure 1. Dates of Fremont Weir overtopping and closure dates for the Yolo Bypass Wildlife Area

For future scenarios, the current baseline closures could be compared with new flooding due to changes in the operating of the Fremont Weir. Future scenarios would be expressed as their effect on the increase or decrease in the number of possible waterfowl hunt days each year. This has the potential to affect both public hunting opportunities on the YBWA and private hunt opportunities on duck clubs and rice fields. If the number of flooded days reach an undefined threshold, private ducks club members may lose interest in maintaining their wetland habitat if there aren't enough hunting days to make it worth their investment. This topic could be further examined when future scenarios are compared.

Over the 13 year record, the YBWA averaged 14 days of closures during the course of a hunting season, which lasts for roughly 100 days between the middle of October through the end of January. In the thirteen seasons, seven years had weir overtopping events. Several flooding events were examined in an effort to understand the time needed for the YBWA to dry sufficiently before opening back up to the public. The first event was the December 1998 event and was unique in that it was the only overtopping event that did not cause any closures. Further inspection revealed that this event had a maximum flow of 1,650 cfs, which is small enough to be fully contained in the flow channel of the Toe Drain and not flood the wildlife area.

The next unique closure event examined was the late December event in 2004. For this occurrence, the Fremont Weir did not overtop yet the YBWA was closed for two and a half weeks. It is suspected that this closure was due to flooding caused by west side tributaries. Since there are no gauging stations on many of the west side tributaries, we looked at local precipitation data to see if a large storm affected the western part of Yolo County to a much higher degree than the remainder of the Sacramento Valley upstream of the Bypass. The Berryessa precipitation station shown in Figure 2 totaled over six inches of rain in late December. An examination of stations farther up the Central Valley showed significantly less rainfall. This corroborated the premise that this occurrence captured the type of event when the Fremont Weir is not spilling, but the west side tributaries are flowing high enough that they can independently flood the YBWA and downstream duck clubs.

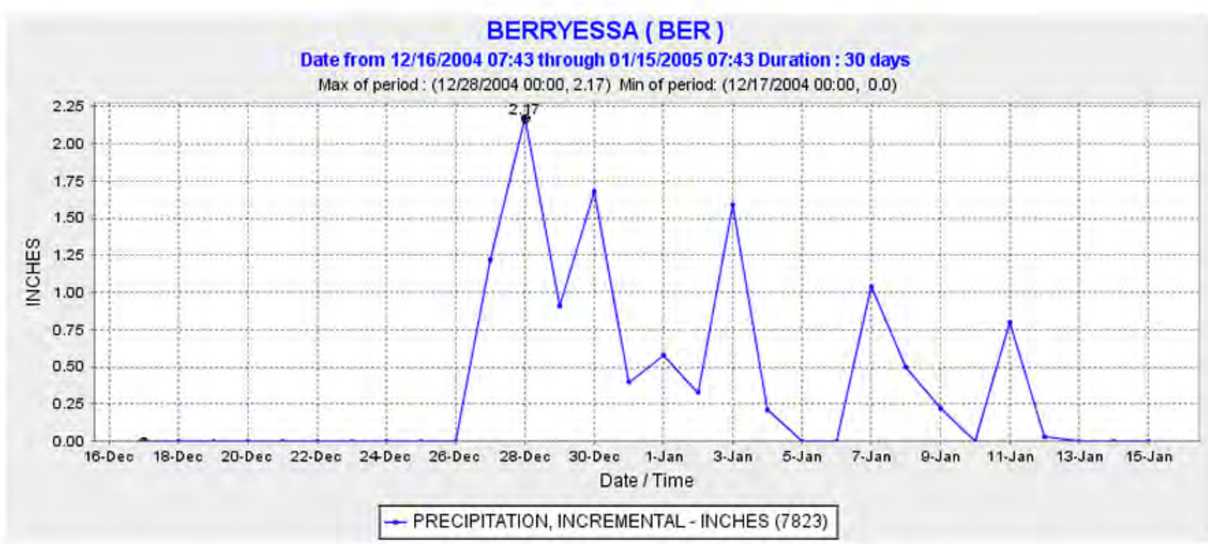

Figure 2. Precipitation at the Berryessa station from 12/16/2004 – 1/15/2005 (CDEC, 2012)

The third event that was examined was the January 2004 event that lasted less than five days and had a peak flow of 3,000 cfs over the Fremont Weir. This flow is in the lower range of the proposed notch flow events currently proposed by Conservation Measure 2. This event closed the YBWA for two weeks. Another larger overtopping event in January 2002 peaked at 35,000 cfs and the YBWA closure lasted for three weeks. Although it is a very small sampling of years, the record establishes a drying time window for the YBWA to reopen after a flood is between two and three weeks with current operating procedures. It may be possible to change the way the YBWA closes and have partial closures in order to accommodate managed flood events. However, any changes would be needed to be developed and approved by the Department of Fish and Game with respect to YBWA Management Plan.

3.2 Income Loss

The landowners in the Bypass may experience several types of income loss due to the proposed Conservation Measure 2, which could have ramifications on waterfowl habitat management. Yolo County recently completed an agricultural impact analysis that monetized the direct loss of income from farming operations and the indirect effects on the local economy (Howitt et al., 2012) from a potential Bypass flooding scenario. In the County's analysis, they examined a series of dates that represent the last day in a season for the overtopping of Fremont Weir and the resulting effects on crop planting. The study documents significant agricultural income losses from a flooding scenario that lasts past a March 24 overtopping date. For many crops, including rice, to be grown at all in the Bypass, flooding needs to end by April 10 for the east side and April 24 for the west side due to differential drying times.

In addition to the agricultural losses on growers and the local economy, the YBWA depends on income from agricultural leases including rice, grazing and other crops to support annual management and operational costs. This income is significant as it is greater than the annual appropriations from the Department of Fish and Game. Although Yolo County's study monetized potential private agricultural losses in the Bypass as a result of Conservation Measure 2, it did not specifically describe how the YBWA's wetlands could be affected by losing the agricultural lease income.

Other sources of potential income losses supporting wetland management as a result of Conservation Measure 2 may include waterfowl hunter expenditures for reservations at the YBWA or membership fees at private duck clubs. On the YBWA, increased duration and frequency of flood events can close the area to the public thereby reducing hunter access fees. On private wetlands that are managed as duck hunting clubs, there is a potential loss to property value since this value is primarily derived from the amount and quality of hunting opportunities available each year. With more flooding the annual maintenance costs may increase while the hunt days decrease. This will effectively increase the cost per day of hunting.

3.3 Deep Winter Flooding

One of the potential impacts of an increase in winter flooding due to Conservation Measure 2 is that the Bypass may be covered in deep water that precludes dabbling ducks from foraging. This guild of waterfowl prefer to forage in very shallowly flooded seasonal wetlands, but can feed in relatively deeper areas by upending as shown in Figure 3. Due to their physiology, they are limited to foraging in water depths of less than 18 inches (Nelson, 2012; Fredrickson, 1982) with preferred foraging depths less than

10 inches. This is in contrast to the diving duck guild that dives or swims to their food sources in water deeper than 18 inches. The population objectives for dabbling ducks and diving ducks in the Central Valley are shown in Figure 4; this figure also shows the corresponding dabbler species-level population objectives (CVJV, 2006).

Figure 3. Upending dabbling ducks have a limit to the depth of water that allows foraging (Garg, 2007)

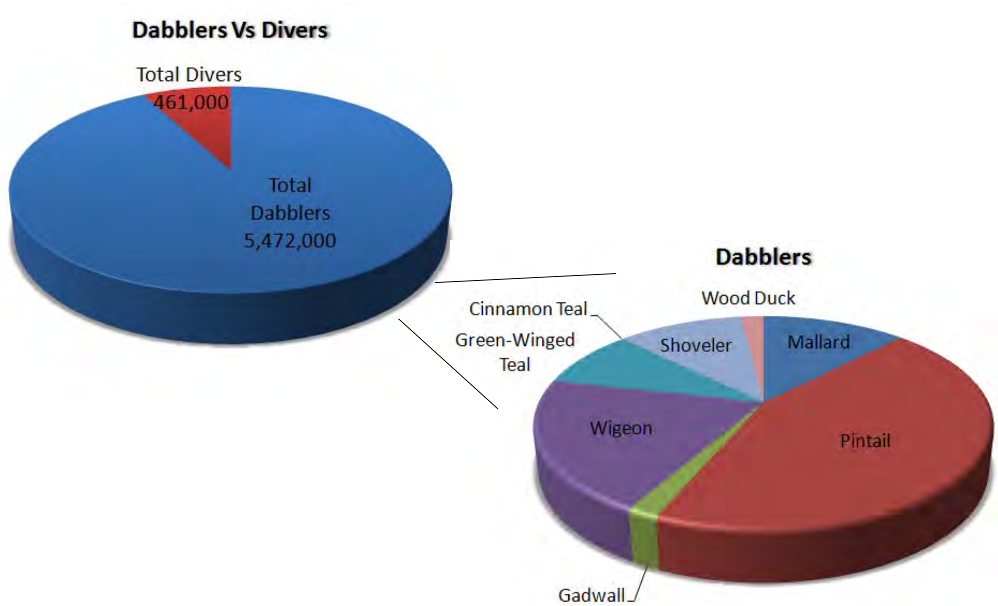

Figure 4. Dabbling duck population objectives for the Central Valley (CVJV, 2006)

The Central Valley Joint Venture's (CVJV) dabbling duck population objectives were developed for each of the major 'basins' within the Central Valley, including the Yolo Basin. To incorporate the effects of Conservation Measure 2 on dabbling ducks, a series of linked models were used as shown in Figure 5. Land cover was combined with the MIKE21 2-D flood model results and input into the BypassDepth (BDepth) GIS model. This GIS model separates the depth of each land cover class into a dry, managed, shallow or deep water category. These outputs are then used in the TRUEMET model for the Yolo Basin in combination with the Basin's waterfowl population objectives. Final output of this progression is food supply and food demand curves that show how changes in flooding affect the carrying capacity of the waterfowl population in the Yolo Basin, including the Yolo Bypass.

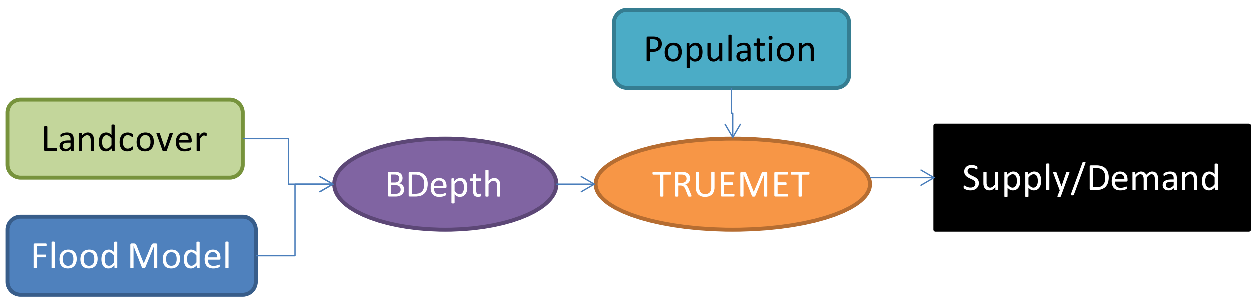

Figure 5. Data inputs and models used in the modeling of the loss of winter foraging habitat

In order to assess the future impact on the available waterfowl foraging habitat in the Yolo Bypass, the 2011 land cover, including the spatial extent of wetlands, in the Bypass was mapped. This effort was aimed at capturing the large areas of wetlands that were restored after the previous mapping effort in 1999. Additionally, the total amount of winter flooded rice base, the other key waterfowl food in the Bypass, was mapped with the assumption that only two-thirds of the rice base is planted in a normal year either due to flooding conditions or the rotation of the ground to fallow every third year. The current conditions are shown in Figure 6.

For the initial run of the BypassDepth model a high end flood flow boundary condition of 6,000 cfs from a proposed notch and additional inputs from west side tributaries (CBEC, 2010) was chosen from the Mike21 model output. This was the largest flow scenario outlined in the document and suitable for demonstrating proof of concept for the evaluation tool. The BypassDepth output is shown in map format in Figure 7.

The second set of output from the BypassDepth model is a land use specific analysis of the dry, managed, shallow and deeply flooded land in the Yolo Bypass. Each category defines the water depth or absence of it on a specific land use. Dry areas are defined as fields that receive no delivered water and are upslope of the example flood. Managed areas are wetlands or rice shallowly inundated in the fall to encourage waterfowl use and/or rice stubble decomposition. Water on these areas is managed to depths preferred by dabbling ducks. Shallow water areas include both managed and unmanaged locations that remain below the 18 inch depth threshold for dabbling ducks to continue to forage. Deep water areas are locations that were inundated by flood waters to depths deeper than 18 inches.

The top chart in Figure 8 shows the initial condition and land use acreages in the Bypass in a dry year, defined as a year with no overtopping of the Fremont Weir. In this example wetlands and rice fields are managed for water depths that promote waterfowl foraging. During a subsequent flood event of 6,000 cfs, the lower chart in Figure 8 shows the extent of the land uses outside of the flood extent as dry or managed water, and the areas inside the floodwater extent as shallow water or deep water. Following the wetland land use through this example from the top chart to the bottom chart, in the initial conditions is all managed water. In this example when the Bypass floods (lower chart), approximately 55% of the wetlands are deeply flooded and the remaining wetlands are split between being shallowly flooded by the new floodwater and those wetlands outside the flood flows that stay as managed wetlands. In relation to foraging potential and food availability, the managed and the shallow categories are equally weighted and available to foraging dabbling ducks.

The next step in the analysis, as shown in Figure 5, is taking the output from the BypassDepth model and inputting it into the TRUEMET model. The other site-specific input into TRUEMET is the waterfowl population objectives for Yolo Basin. The waterfowl population objectives are taken from the CVJV's Implementation Plan (CVJV, 2006). The objectives in Figure 9 are given at two week intervals throughout the winter season with peak waterfowl use in February. The Yolo Bypass is completely contained in the CVJV's Yolo Basin. The Bypass forms the entire east portion of the Yolo Basin as shown in the Figure 10. The inset map shows the Yolo Basin in relation to the other eight planning basins of the Central Valley. The Yolo Basin also contains roughly half of the valley portions of Yolo County and Solano County.

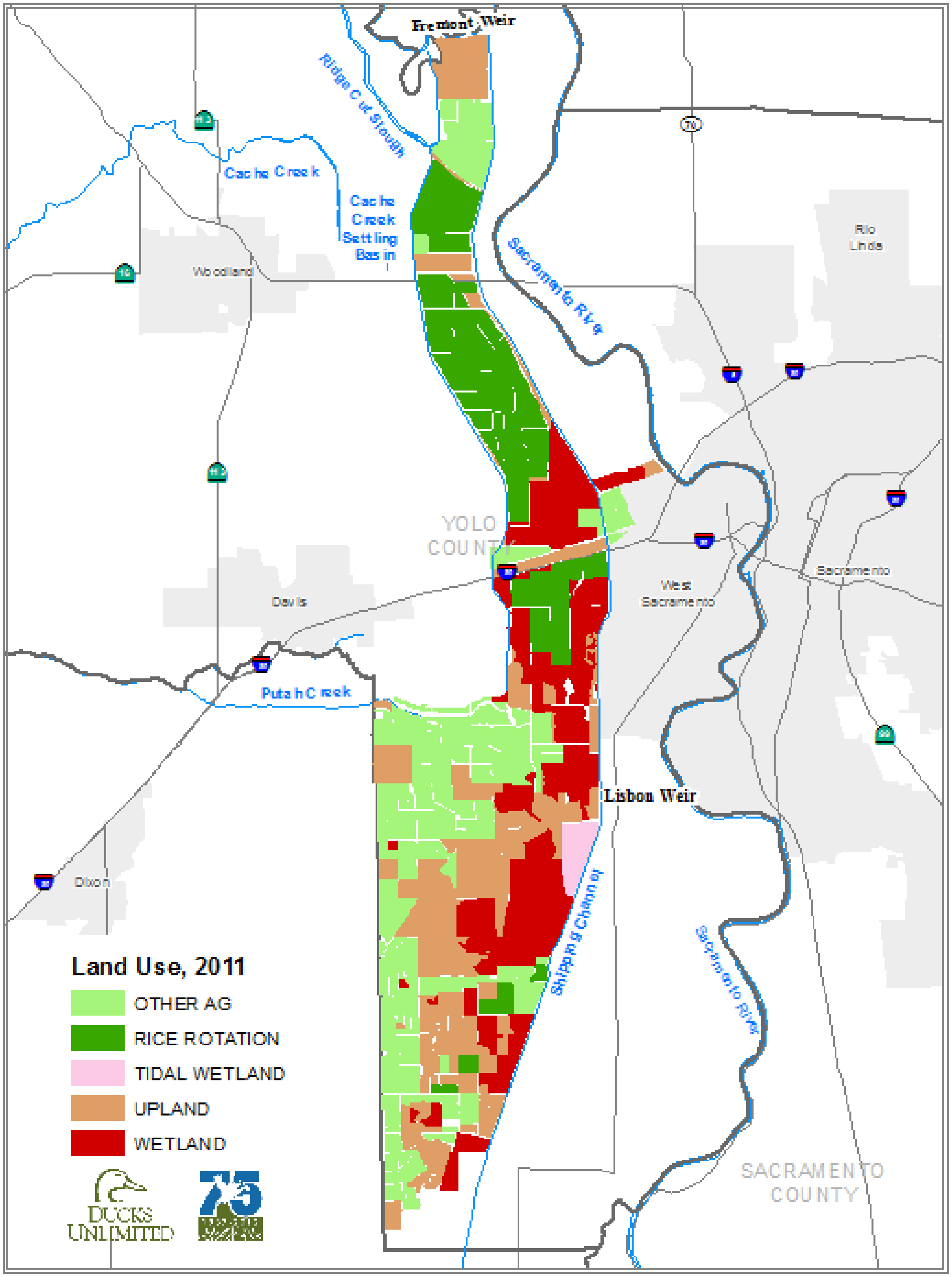

Figure 6. Updated wetland base in the Yolo Bypass, 2011

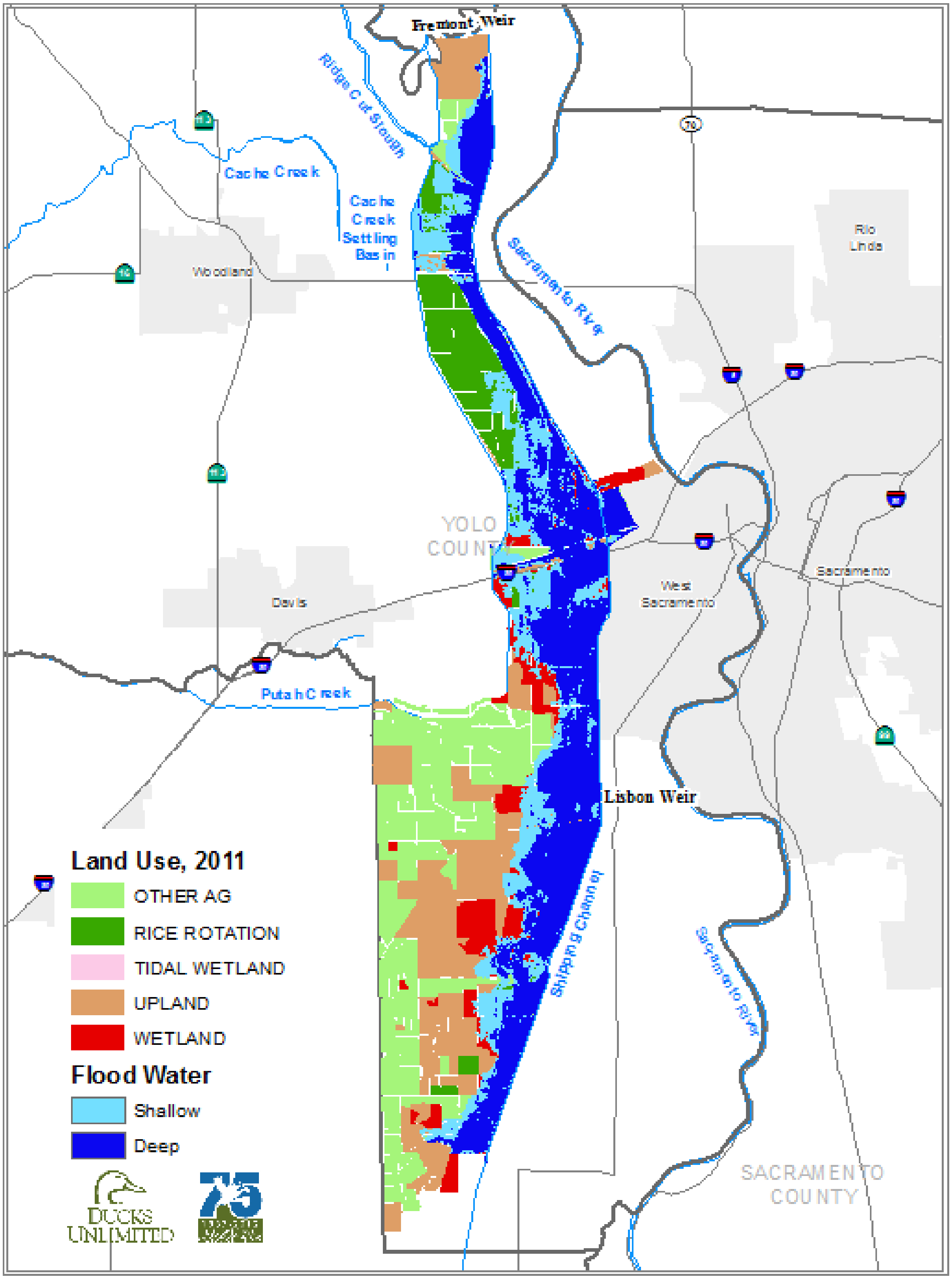

Figure 7. Map of the BypassDepth model output with Yolo Bypass land use showing most wetlands deeply flooded

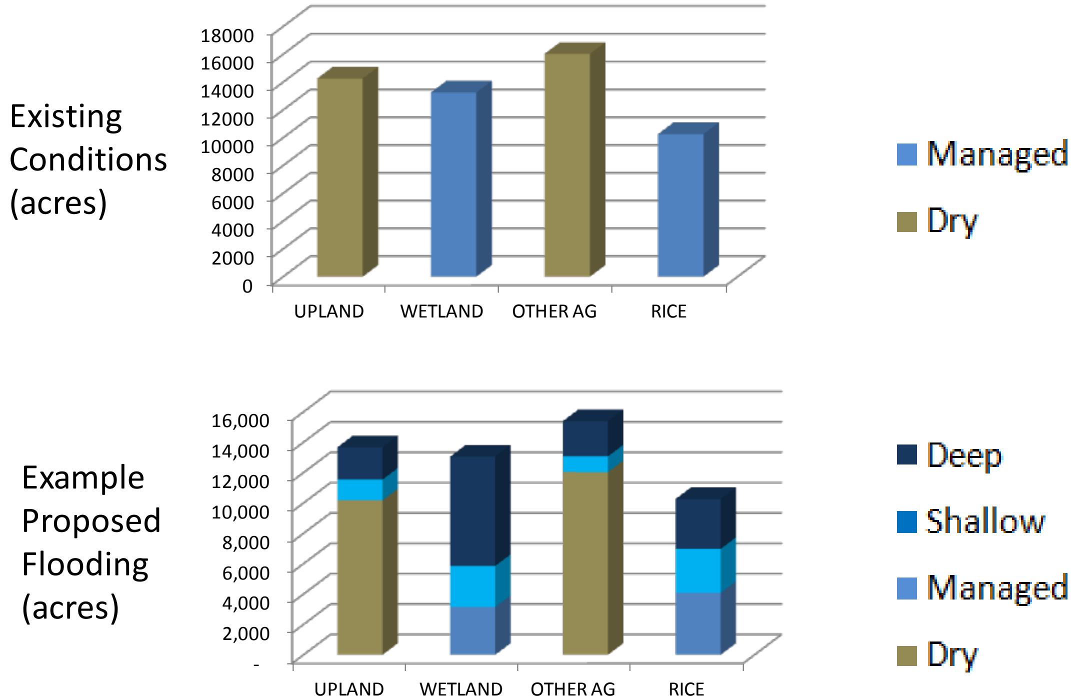

Figure 8. The Bypass Depth model initial conditions and example proposed flooding by land use

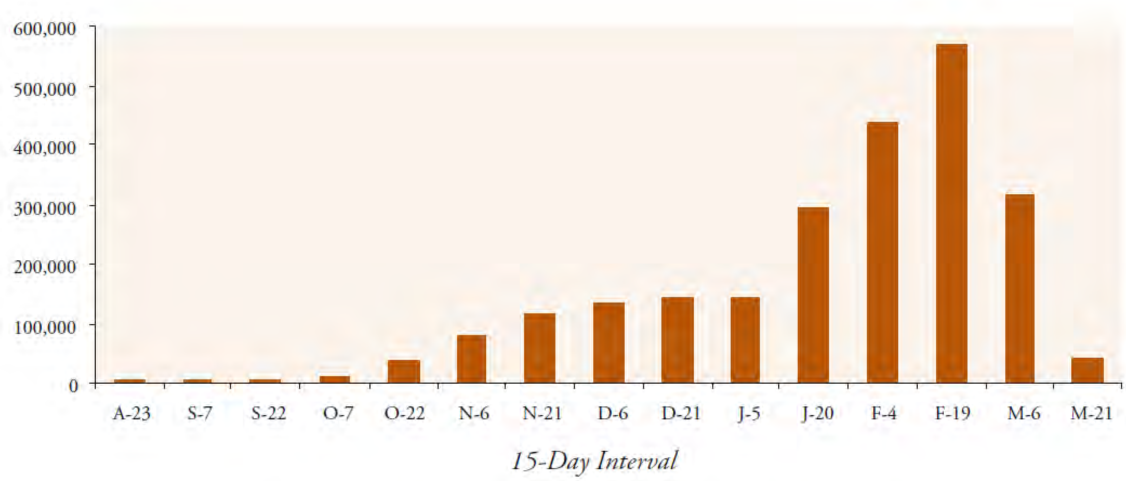

Figure 9. Population of ducks by 15 day interval for the Yolo Basin (CVJV, 2006)

Most of the waterfowl use in the Central Valley occurs in the non-breeding winter season and consists primarily of foraging to survive winter and to accumulate bodily reserves in preparation for spring migration and the breeding season. Adequate winter foraging habitat is important to increase waterfowl survival during winter, migration and to increase breeding season success. Ducks Unlimited collaborated with the CVJV to develop a bioenergetic model, TRUEMET, to establish habitat conservation objectives based on providing sufficient foraging habitat food resources to support waterfowl populations at goal levels for each of the nine basins of the Central Valley. TRUEMET is a daily ration model that calculates a waterfowl population energy demand curve and compares it to a curve for the available true metabolizable energy supplies from different food sources. The energetic demand curve is how the model expresses the daily caloric needs of waterfowl population. The available food supply curve is calculated in two week time steps throughout the winter as the supply of food resources is depleted from foraging and decomposition.

The major food supplies for ducks in the Yolo Basin are seasonal wetlands, winter-flooded rice and harvested corn fields. Previous runs of the TRUEMENT model for the Yolo Basin in the 2006 CVJV Implementation Plan were based on data now out dated and do not reflect the current Bypass land use. In addition, three sources of crop data were used to estimate the existing agricultural food sources for the remainder of the Basin. Rice acres were extracted for the last 15 years from the Yolo County Agricultural Commissioner's annual crop reports. The second source was the Department of Water Resources Land Use Survey available in GIS format that allows for the geographic separation of rice inside the Yolo Basin as opposed to the entire county. Figure 11 shows that approximately half of the rice grown in the County is inside the Yolo Basin. The third source of rice information was the new GIS rice base layer for 2009 produced by Ducks Unlimited. This layer showed a slight drop in rice within the basin while the county trend was for more rice acres. With the dramatic fluctuations in rice acreage over the past 15 years, this analysis uses a conservative value as shown as the dashed line the Figure 11.

Corn was shown to be an even more unstable food source when its acreage was plotted over the same time period. During the past 15 years, corn has been as high as 65,000 acres in the Yolo County and Solano County and as low as 6,000 acres. Based on GIS analysis of two time periods of DWR Land Use Survey data, the corn in the basin can be between 45% and 70% of the corn in Solano County and Yolo County. For this example run, half of the corn acreage in 2009 was used as an input in the TRUEMET model.

The TRUEMET model run in Figure 13 uses the updated 2011 current conditions in the Yolo Basin. Over the course of the winter season the resulting supply and demand curves show a food supply curve that is initially high, but is consumed over the course of the season to a point in March where the birds deplete the food resource just as they leave for their migration northward. This existing conditions run is for a dry year when the Fremont Weir is not overtopped.

To test the model's robustness, two additional boundary conditions were run to test how the Basin's carrying capacity responded. The first was an overtopping event that lasted the month of January. The second was a winter-long flood that lasted from November 15 – April 15.

The January flow condition assumed the full proposed 6,000 cfs flow from a notch as well as west side tributary inputs from the MIKE21 model. This example uses the output from the BypassDepth model and holds that depth for four weeks. Figure 14 shows the decrease in food supply during January. In February the Bypass flood water levels would drop and all wetland seed and rice grain resources would again be available to foraging waterfowl. Since all remaining food resources would be available when bird populations peak in mid-February, the Basin's food supply would last into March, near the same longevity as the current conditions example.

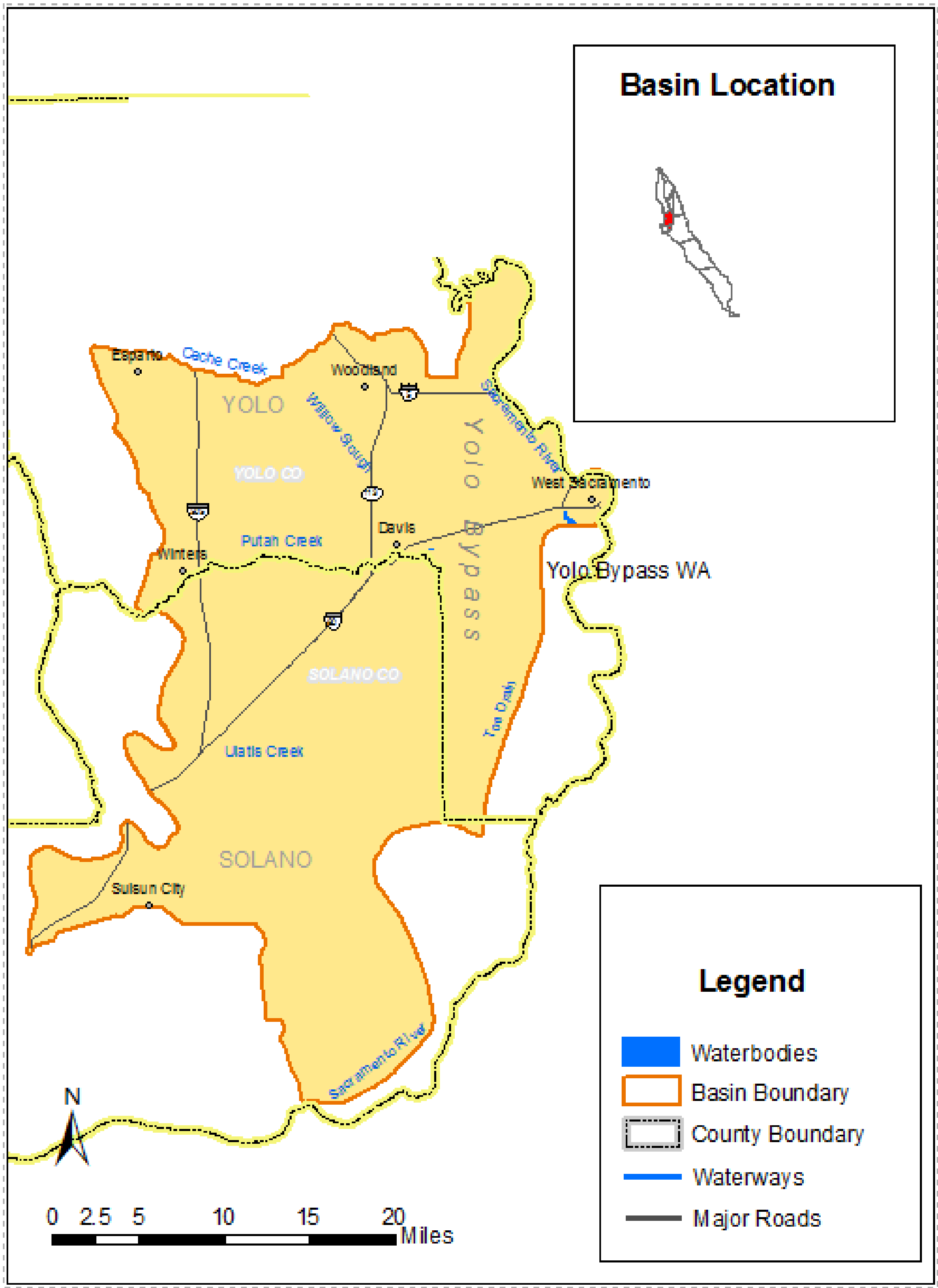

Figure 10. Map of the Yolo Basin including the Yolo Bypass

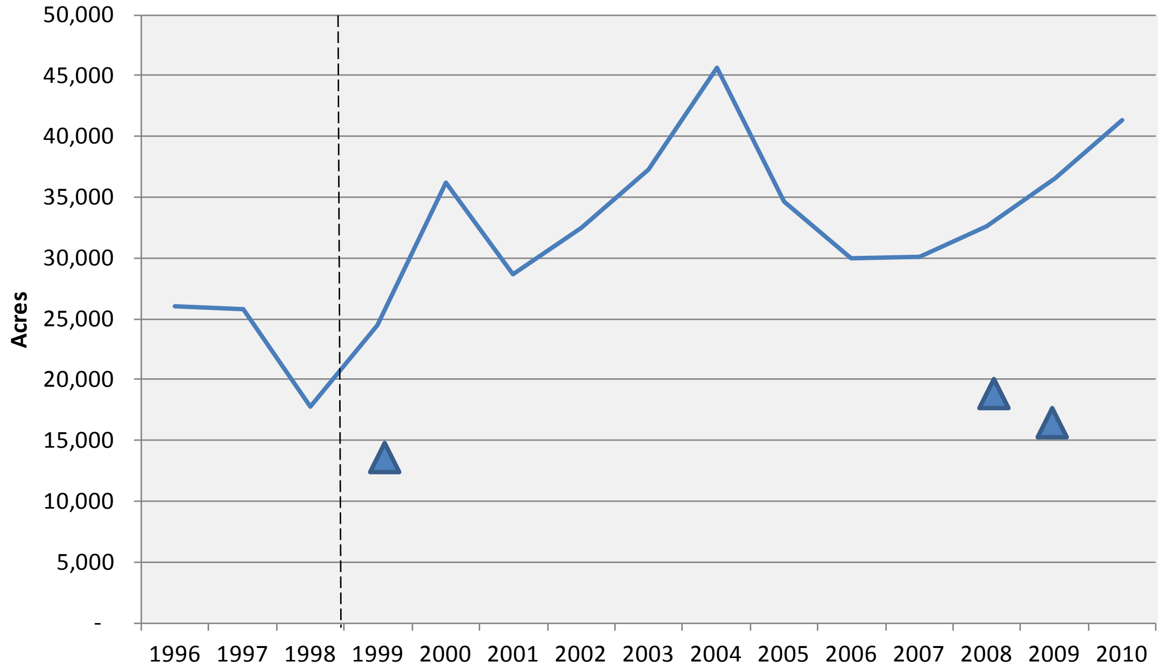

Figure 11. Rice acreage in Yolo County and Yolo Basin

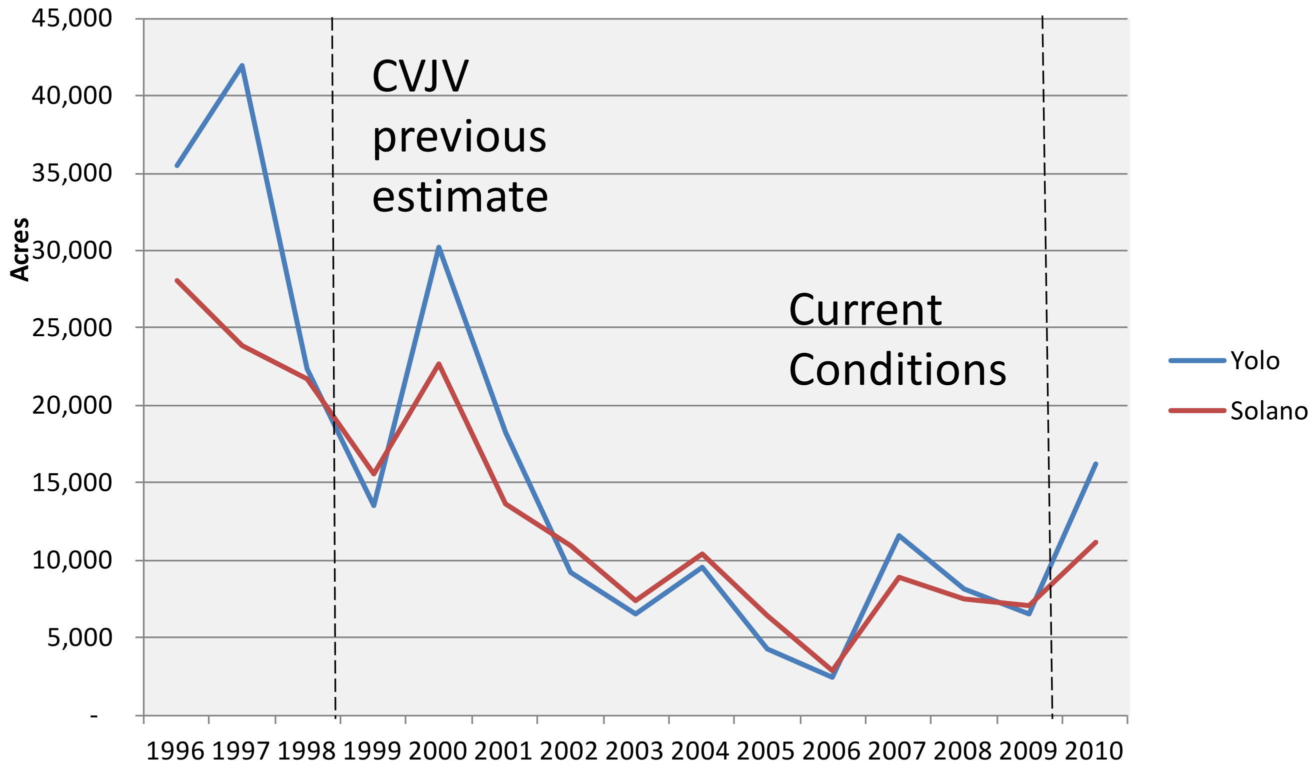

Figure 12. Corn acreage in the two counties that are part of the Yolo Basin

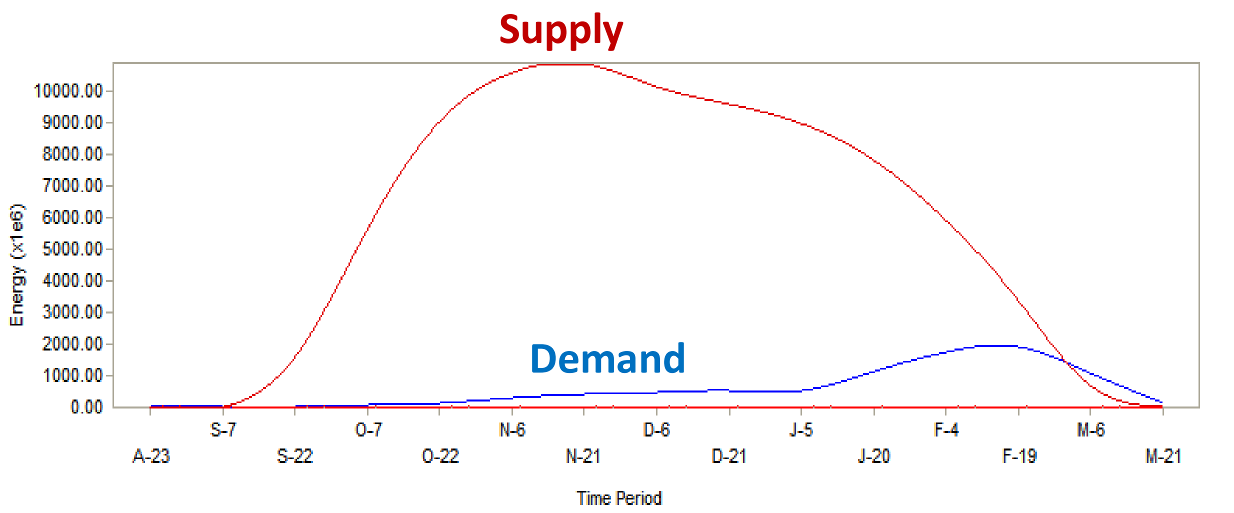

Figure 13. TRUEMET model output for the existing conditions for a dry year in the Yolo Basin

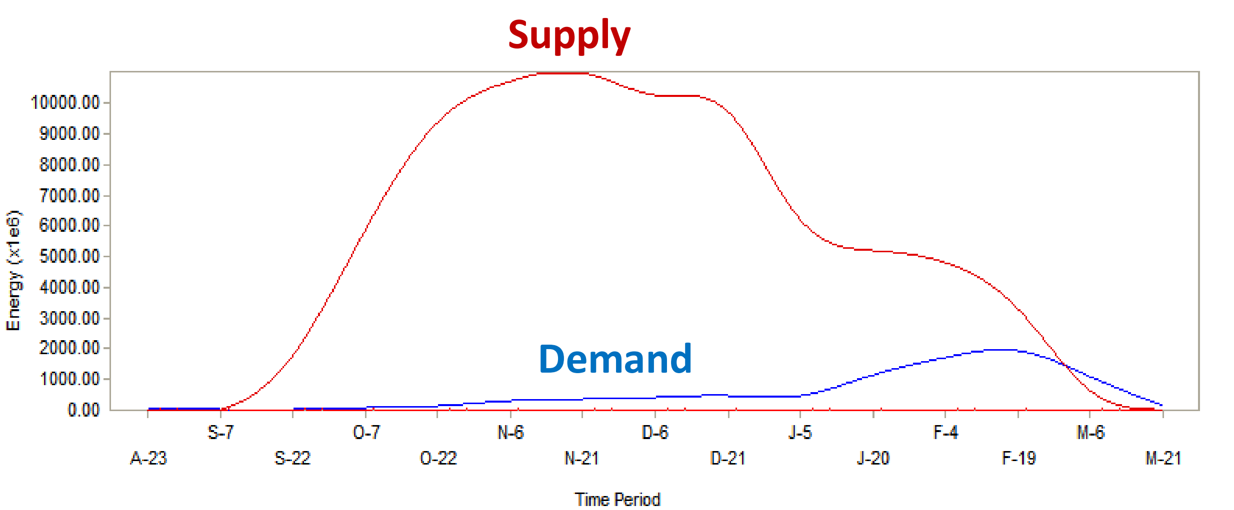

Figure 14. Example TRUEMET run with a January 6,000 cfs notch event and west side tributaries

The second boundary condition run was a winter-long flood event of the same magnitude, 6,000 cfs with west side tributaries. This flood event would start November 15 and end April 15. Even with much of the Yolo Bypass under deep water in the early- to mid-winter, waterfowl have enough food supplies from agricultural sources to maintain population objectives. The carrying capacity of the Basin crashes, as shown in Figure 15, in February when the food supply is depleted. This is at the same time as waterfowl population would be at their highest and food demand is approaching its highest. Another effect of flooding through spring in the Bypass may be a reduction of wetland plant seed production the following year. This potential effect is examined as the fourth driver of the model in the next section.

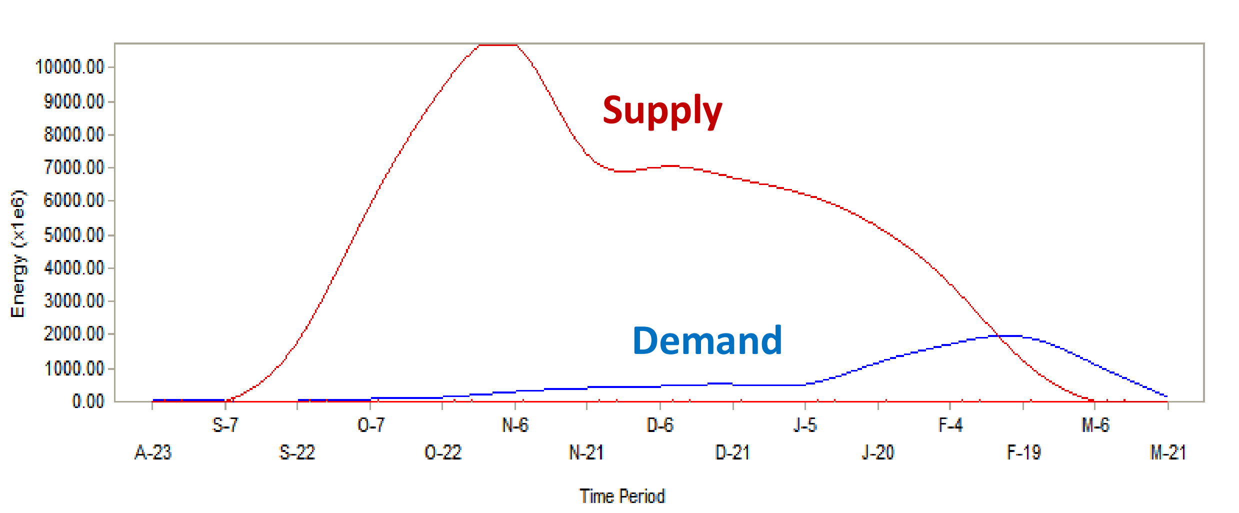

Figure 15. Example of TRUEMET run with a winter long 6,000 cfs notch event and west side tributaries

3.4 Spring Seed Production Loss

The CVJV calibrated the TRUEMET model by measuring energetic values and overall production of seasonal wetland plant seeds in the Central Valley. Different seasonal wetland areas in the Valley are managed for certain wetland plants. Interviews with wetland managers at the YBWA and Bypass private duck clubs were conducted to determine the types of wetland vegetation grown and their timing of seasonal wetland spring draw down. On the YBWA, swamp timothy is the primary plant grown in the seasonal wetlands. This plant provides high seed yield and energy, and is low enough in height to provide the open sheet water habitat that is preferred by dabbling ducks.

Current seasonal wetland water management practices include pulling the water control structure boards on about half of their wetland cells in advance of a pending flood event before floodwaters arrive. This prevents infrastructure damage on some water control structures from the high volumes of flowing water. After the higher water from the flood recedes and some high elevation roadways are exposed, managers try to access the wildlife area as soon as they are able to put the boards back into the drainage structures to retain water within the managed ponds for shallow inundation as the high flood water recedes. These wetlands are topped off with a last supply of delivered water in February then allowing for a slow evaporation of the ponds beginning in March. Wildlife managers monitor the germination rate of swamp timothy along the pond borders. When it reaches a certain threshold during the first two weeks of April, the water is drained rapidly to promote maximum growth.

On the private ducks clubs in the Yolo Bypass, the main vegetation favored by wetland managers is a mix of watergrass and smart weed. These species attract a diverse array of dabbling duck species and provide some vegetative cover preferred by mallards, a highly favored ducks species by hunters. These plants have a much different water management regime. With the hunting season ending in late January, some clubs partially drop their water levels in mid-February to concentrate the water and the invertebrates. Full draw down occurs one month later in mid-March and is a slow process lasting 2-3 weeks. To promote maximum production of wetland seeds and weed control, land managers perform early season irrigation by flooding the wetland unit and holding stable water levels for 2-4 weeks in May.

Overall, late season draw downs in managed wetlands can contribute to annual weed dominance rather than target waterfowl plants (Meeks, 1969). This effect has been documented for swamp timothy in two studies in the Central Valley (Rahilly et al., 2010 and Naylor, 1999). In the Rahilly study, a two year experiment was conducted that documented the effects on swamp timothy seed production by delaying draw down by 4-6 weeks. In this study, seed production was not significantly affected after one year; however, after two spring seasons of delayed draw down there was a 25-30% drop in seed production. Since the study only covered two years, it is unknown how many seasons it would take for seed production to rebound when a wetland is returned to a normal spring draw down schedule. In an effort to put delayed spring draw downs in the context of the Yolo Bypass, the historical record of the Fremont Weir overtopping in late March was examined in Figure 18. In the last 40 years, only one time period had flooding extended into March in two consecutive years, 1973-74 and 1974-75. This was prior to the establishment of the YBWA.

No known studies document the effect of delayed draw down on watergrass. An examination of the literature on watergrass germination yielded that watergrass can germinate soon after the draining of a seasonal wetland in March, April or May. Although many private duck clubs in the Bypass drain their watergrass wetlands in March, they may be able to drain later and still get maximum seed production. Interviews with pubic area wetland managers farther up the Sacramento Valley on this topic acknowledged that some wetland managers can hold water through early May and not experience noticeable seed loss. Any changes in the water management by private duck clubs in the Yolo Bypass to accommodate later spring flooding may have other costs associated with it since many of these areas do not have on-site managers.

To model the effect of seed production loss in the Yolo Bypass from delayed draw down, the land use basemap with 6,000 cfs flooding was examined to quantify which wetlands are directly affected by the flooding footprint and which wetlands are indirectly affected by being adjacent to flooding. Wetlands abutting a flooded area would have their drains already full. Since the outflow control structures would be below the water surface level in the drainage canals, there would not be any down slope elevation gradient to drain the water from the wetland unit. In this boundary condition example the vast majority of the wetlands are either directly under the floodwaters or adjacent to the flooded footprint and would not be able to drain in time for normal seed germination, as shown in Figure 16. Further topographic analysis would be necessary to exactly determine which fields would not be inundated yet unable to drain.

In the TRUEMET seed loss model run, the seasonal wetlands that grow swamp timothy have a 25% reduced food value following two years of delayed draw down. The resulting supply and demand curves are shown in Figure 17. Although the supply loss is observed for much of the winter season, its impact on the basin's carrying capacity is only significant in February when the waterfowl population peaks and the food resource is completely depleted.

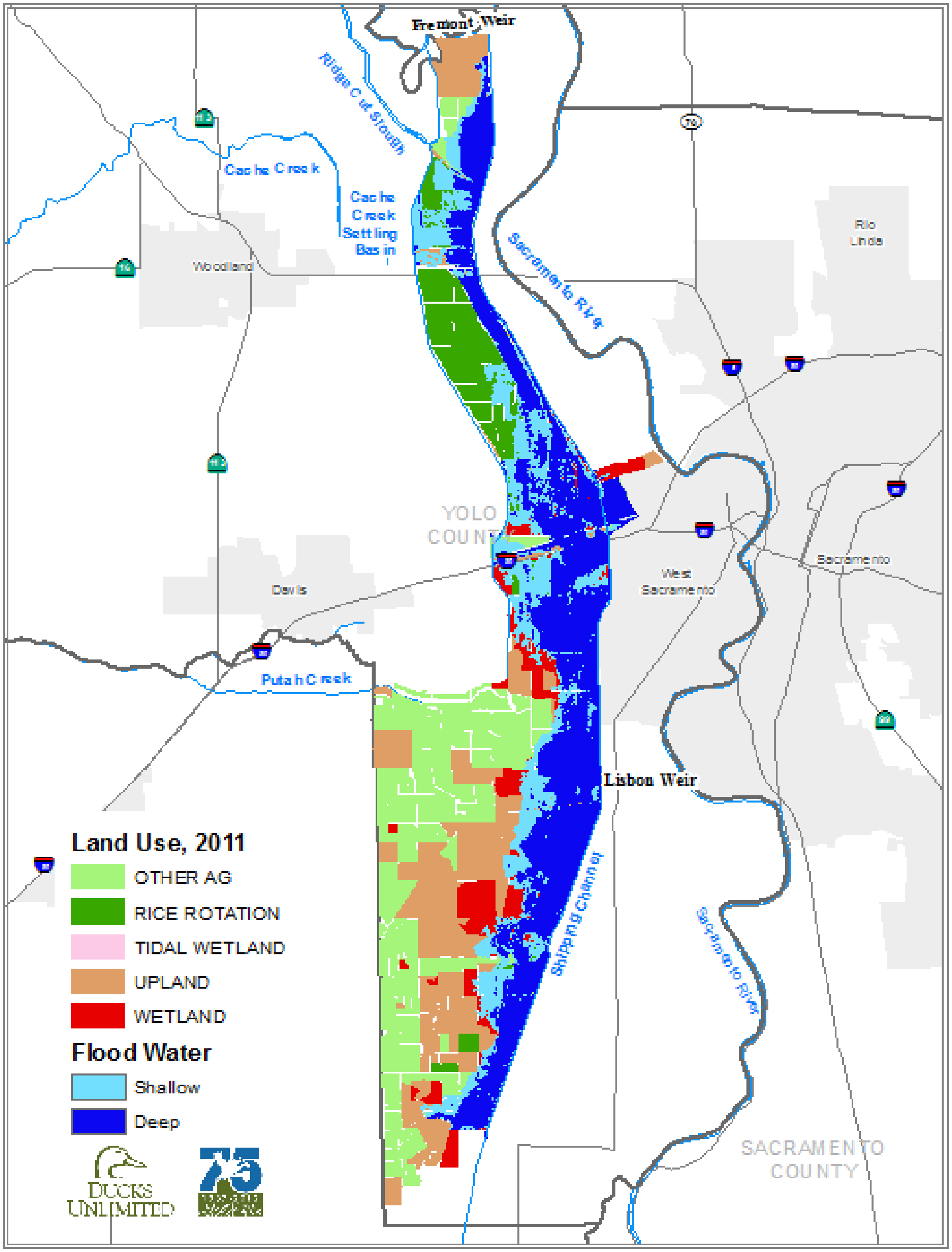

Figure 16. Direct and indirect wetlands affected by late spring draw down

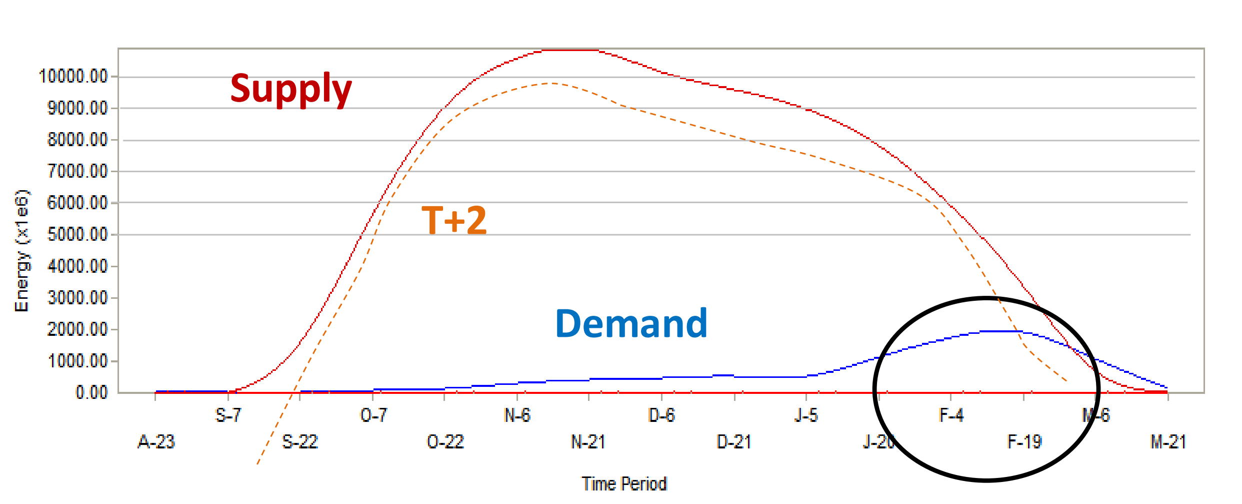

Figure 17. TRUEMET supply and demand curves for current conditions and for delayed draw down plus two.

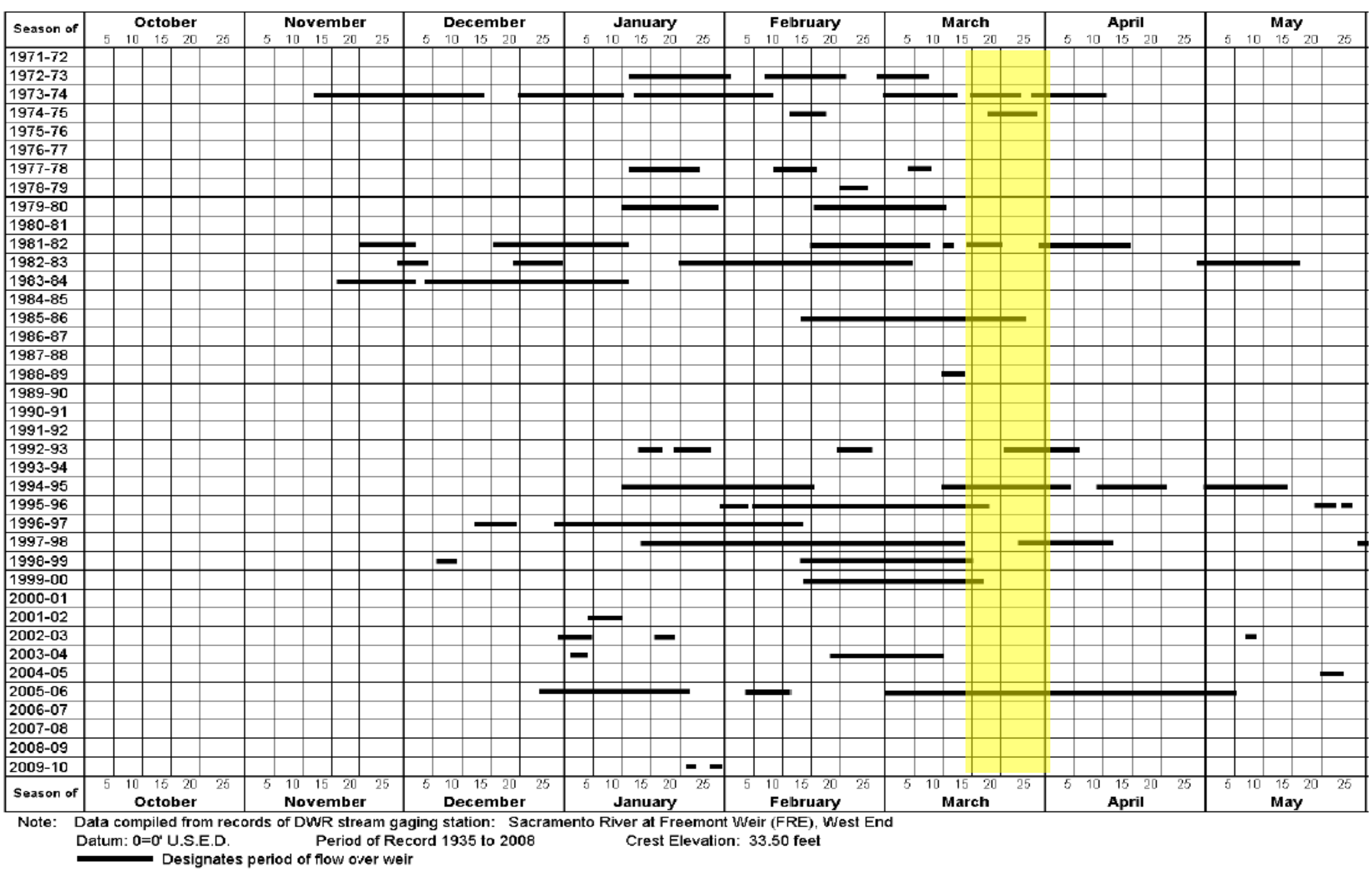

Figure 18. Fremont Weir overtopping dates 1971-2010 with late March highlighted

4 Waterfowl Breeding

Although the changes to Yolo Bypass operations are not expected to significantly affect waterfowl during the breeding time period, the study authors wanted to briefly review the annual breeding chronology of locally nesting waterfowl. In the Yolo Bypass nesting season starts in late March. Nest initiation peaks in late April and can continue into early June. Birds use their nests approximately 50 days for egg laying, incubation and hatching (G. Yarris, personal communication, March 6th, 2012). Waterfowl typically nest near water in grasslands or seasonally dry wetlands. In the May breeding population surveys flown by the Department of Fish and Game, the one aerial transect that covers a portion of the Yolo Bypass has consistently counted high values of mallard breeding pairs. Further discussions would be needed to translate these counts into basin wide breeding numbers. Based on this breeding chronology, breeding is not expected to be significantly impacted if the Fremont Weir notch flooding finished by the end of March. One scenario that would have major impact on nest success is if a dry early spring is followed by a late flood event. This timing would allow waterfowl to establish nests in April and then inundate these nests in late April or May. Depending on how late a flood arrives in the spring, some birds may renest later in the spring.

5 Conclusions

The study's goal was to develop a modeling tool that can be employed to evaluate potential effects on waterfowl from increased duration and frequency of flooding within the Yolo Bypass from Conservation Measure 2. The developed tool incorporates topographic and land use data sets with MIKE21 projected flood depths and extent from a 6,000 cfs event. This tool links the resultant loss of waterfowl foraging habitat from deep flooding to the TRUEMET model so a reduction in waterfowl carrying capacity can be calculated as an effect. The two boundary conditions of a month long and winter long flood event demonstrate proof of concept that all variations of potential flooding scenarios in Conservation Measure 2 and associated effects on waterfowl can be evaluated with this tool.

Additionally, the following conclusions became apparent in the development of the evaluation tool.

- The most sensitive time of the year for waterfowl populations in relation to Conservation Measure 2 is in February when the waterfowl numbers are highest and the food supply is the lowest. This is a critical time period as birds need enough fat reserves to migrate north to their breeding grounds.
- Controlled floods on the order of the notch flooding examples in early and mid-winter temporarily removes food supply from waterfowl populations, but does not impact the annual carrying capacity of the Yolo Basin.
- Consecutive year flooding after mid-March would significantly decrease the seed production of wetland plants and fully deplete food resources at the peak of the annual waterfowl numbers.
- The financial sustainability of the YBWA depends on the agricultural income from some of its leased property. New management of the floodway may require the replacement of this income stream.

- Hunters who use the YBWA or private waterfowl hunt clubs in the Bypass current lose approximately two weeks of hunting opportunities according to the baseline flooding regime. One measure of impact for future scenarios is how they change the number of available hunt days. Changes in infrastructure may allow the YBWA to partially close due to managed flooding and lessen the effect on hunting opportunities.
- Elevation data on the west side tributaries is needed to improve the MIKE21 flood model to more accurately depict the extent and depth of flooding in the Bypass.
- Flood events that continue into April have the potential to substantially impact breeding waterfowl in the Yolo Bypass.

6 Next Steps

Several steps are needed to improve the accuracy of the modeling effort and to support the establishment of Conservation Measure 2 and quantify its impact on waterfowl populations and waterfowl habitats in the Yolo Bypass. The first step is a more comprehensive review and calibration on the MIKE21 2-D flood model. Current model documentation states that the water depth in some areas of the Bypass may differ by as much as one foot from the modeled water depths. With a foraging threshold of 18 inches for dabbling ducks, it is important that some of the uncertainty in water depth be minimized. Yolo County is currently reviewing the Mike21 model and this effort should be supported.

A portion of the errors in the Mike21 model is model assumptions of the west side tributaries. Currently, two west side tributaries are not properly modeled and are falsely assumed to enter the Bypass on the east side as proper bathymetry is not available for their channels. The elevation data should be collected and Mike21 should be rerun to show more accurate water extents for each flooding scenario.

A major uncertainty in the modeling of future flooding scenarios on waterfowl populations is the impact of a delayed spring draw down on seed production by wetland plants in subsequent years. Current studies show significant losses can occur with multiple years of delayed draw down, but it is unknown how quickly or slowly seed production can rebound in wetland plants when spring draw down is returned. Any pilot studies to study changes in the operation of Yolo Bypass should include a seed-head study to examine the potential effects of flooding on spring seed production.

The example 6,000 cfs flood flow analyzed in this report is from the MIKE21 model as reviewed in CBEC, 2010. In May, 2012 the CBEC modeling group revised their flood model and produced a new flooding footprints and depths. Future runs of this waterfowl effects analysis tool will use the updated flood model data.

Conservation Measure 2 flooding scenarios are not currently identified. Specific flood scenarios including magnitude, duration and frequency need to be refined so that the waterfowl effects can be quantified. Future scenario runs of this tool will quantify each of the 4 main drivers in relation to the impact over baseline conditions.

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EXHIBIT E

BDCP1675

YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY

FINAL REPORT

Prepared for: Yolo County

Prepared by:

yolo basin foundation

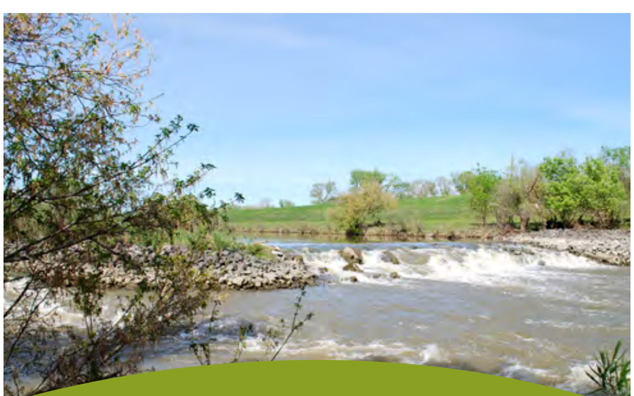
cbec eco engineering

CONSEROSOLUTIONS

DOUGLAS ENVIRONMENTAL

Project number: 12-1039

April 2014



YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY

Prepared for
Yolo County

Prepared by
Chris Bowles and April Sawyer, cbec, inc.
Robin Kulakow, Yolo Basin Foundation
Petrea Marchand, Consero Solutions
Doug Brown, Douglas Environmental

April 2014

cbec Project #: 12-1039

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GLOSSARY OF ACRONYMS

Acronym	Meaning
BDCP	Bay Delta Conservation Plan
BMP	Best Management Practices
CDFW	California Department of Fish and Wildlife
CM2	Conservation Measure 2, BDCP
CNRA	California Natural Resources Agency
CVP	Central Valley Project
Dixon RCD	Dixon Resource Conservation District
DOI	U.S. Department of Interior
DWR	California Department of Water Resources
GCID	Glenn-Colusa Irrigation District
GGS	Giant garter snake
HEC-RAS	Hydrologic Engineering Center – River Analysis System
KLOG	Knights Landing Outfall Gates
KLRC	Knights Landing Ridge Cut
NAVD88	North American Vertical Datum of 1988
NAWCA	North American Wetland Conservation Act
NMFS	National Marine Fisheries Service
NRCS	Natural Resource Conservation Service
O&M	Operations and Maintenance
RD 1600	Reclamation District 1600
RD 2068	Reclamation District 2068
RPA	Reasonable and Prudent Alternative
SWP	State Water Project
SYMVCD	Sacramento-Yolo Mosquito and Vector Control District
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USED	United States Engineering Datum
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Service
WRP	Wetlands Reserve Program
YBF	Yolo Basin Foundation
YBWA	Yolo Bypass Wildlife Area

EXECUTIVE SUMMARY

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers, as well as proposes actions to increase the availability and enhance the quality of data related to these improvements. Yolo County proposed the study to address potential impacts on agriculture and wetlands of proposals by the California Natural Resources Agency and the U.S. Department of the Interior to increase the frequency and duration of inundation in the Yolo Bypass for seasonal fish habitat. While these improvements will not fully address potential impacts, they will help reduce drainage times, improve water delivery, and otherwise increase the likelihood the Yolo Bypass will continue to support multiple important land uses in the future. This study is one of a series of studies commissioned by Yolo County as part of the County's ongoing efforts to document land uses in the Yolo Bypass, analyze potential changes to land uses as a result of fish habitat proposals, and suggest actions to ensure successful integration of land uses. Yolo County thanks the Conaway Preservation Group for providing funding to undertake the study.

The Bay Delta Conservation Plan (BDCP) Conservation Measure 2 (CM2), sponsored by the California Natural Resources Agency and the U.S. Department of the Interior, proposes to construct an operable gate in the Fremont weir to allow increased seasonal floodplain inundation from the Sacramento River to benefit juvenile salmonids and Sacramento splittail. The proposal would also improve fish passage over the Fremont Weir. In addition, the 2009 National Marine Fisheries Service (NMFS) Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (Biological Opinion) Reasonable and Prudent Alternative (RPA) Action I.6.1 (NMFS, 2009) requires the U.S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR) to increase rearing habitat for juvenile salmonids in the lower Sacramento River Basin during the December to April time period. The Biological Opinion includes an initial performance measure of 17,000 to 20,000 acres, on a return rate of approximately one to three years, depending on water year type. Yolo County and other stakeholders are concerned the proposed project will permanently impact agriculture, managed wetland habitat, flood control, and public uses in the Yolo Bypass.

The study team collected information and project ideas from the people who know the Yolo Bypass best: the farmers, landowners, wetlands managers, and water managers with many years of experience working in the Bypass. The state and federal government can use this study to help ensure the successful continuation of farming and wetland management if Yolo Bypass fish habitat proposals are implemented. The improvements also can be implemented independent of any fish habitat projects. The results of this study are intended to assist Yolo County and other stakeholders secure future funding for priority projects or feasibility studies.

The objectives of the study include the following:

- Coordinate with Yolo Bypass stakeholders to characterize existing conditions and constraints; (see Section 2)
- Collect limited field reconnaissance and survey data to support characterization of existing conditions (see Section 2);

- Coordinate with Yolo Bypass stakeholders to identify improvements (see Section 2);
- Prioritize projects based on identified criteria (see Section 3);
- Summarize conceptual projects related to drainage and water infrastructure improvements, including rough cost estimates (see Section 3); and
- Provide recommendations for further studies as needed (see Section 3).

The study team obtained information regarding improvements to drainage and water supply infrastructure from over 15 interviews with landowners, farmers, water managers, wetland managers and others with extensive knowledge and experience with Yolo Bypass and drainage water supply systems. The team contacted as many people as possible from within each management area or property boundary to participate in this study. The team conducted formal interviews in person with detailed maps and by phone. The Yolo Basin Foundation organized a stakeholder meeting in April 2013 to review maps of drainage systems throughout the Bypass and evaluate potential projects. Additionally, the team collected limited field data to verify water operations. The Yolo Basin Foundation organized a second stakeholder meeting in October 2013 to review draft project descriptions, recommended studies, and priorities.

The study team used feedback from participants, research on the relative potential benefits, permitting requirements, and approximate cost estimates to assess initial priorities, as well as other factors for the recommended projects. Recommended projects are intended to benefit agriculture and managed wetlands drainage and water supply operations, but may have some ancillary benefits to fish habitat. The team considered potential overlap with existing efforts in the Yolo Bypass to improve fish habitat, however, for coordination purposes and to assess potential funding sources. These efforts include proposed measures in the BDCP CM2 Yolo Bypass Fisheries Enhancement, NMFS 2009 Biological Opinion RPAs I.6 and I.7, USBR and DWR Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIR/EIS and the Fish Restoration Program Agreement between California Department of Fish and Wildlife (CDFW) and DWR.

Appendix A summarizes the twelve recommended projects. These projects provide unique opportunities to improve drainage and water supply conditions in the Yolo Bypass for agricultural and wetland operations. The projects are separated into location-specific improvements (Projects 1 through 9) and Bypass-wide improvements (Projects 10 through 12). Additionally, four studies were identified for future analysis. The following is a list of projects and studies.

Proposed projects:

- Project 1: Wallace Weir Improvements
- Project 2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
- Project 3: Lisbon Weir Improvements
- Project 4: Conaway Main Supply Canal Augmentation
- Project 5: Davis Wetlands Water Supply Improvements
- Project 6: South Davis Drain Input Reconfiguration
- Project 7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
- Project 8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

- Project 9: Stormwater and Summer Tailwater Re-Use and Supply
- Project 10: Local Agricultural Crossing Improvements
- Project 11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency
- Project 12: Westside Tributaries Monitoring

Proposed studies:

- Study 1: Bypass Sedimentation Rate Changes due to Managed Flooding
- Study 2: Vegetation Management with Increased Frequency and Duration of Flooding
- Study 3: Plan to Manage Beaver Canal Damage and Obstructions
- Study 4: Management Entity Model

The study team prioritized these projects based on the team's knowledge and familiarity with the Yolo Bypass, results of the quantitative and qualitative assessments performed on each project, and input from stakeholders. The following projects are recommended in priority order from 1 to 12. 1 is the highest priority and 12 is the lowest priority. The study team based this prioritization on 14 ranking criteria described in the report. A project was assigned a high, medium, or low ranking for each criteria. The prioritization below is based on the total number of "high" rankings that each project received. It is important to emphasize, however, that all projects are recommended for implementation. The prioritization provides information to guide the order in which projects are developed and implemented.

High priority projects:

1. RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
1. RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
3. RP-6: South Davis Drain Input Reconfiguration
3. RP-10: Local Agricultural Crossing Improvements
3. RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

Medium priority projects:

6. RP-3: Lisbon Weir Improvements
7. RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
7. RP-4: Conaway Main Supply Canal Augmentation
7. RP-12: Westside Tributaries Monitoring

Low priority projects:

10. RP-1: Wallace Weir Improvements
11. RP-9: Stormwater and Summer Tailwater Re-Use and Supply
12. RP-5: Davis Wetlands Water Supply Improvements

1 INTRODUCTION

The California Natural Resources Agency (CNRA) and the U.S. Department of the Interior (DOI) are currently developing scenarios to increase the frequency and duration of inundation in the Yolo Bypass to improve seasonal fish habitat. BDCP Conservation Measure 2 proposes to construct an operable gate in the Fremont weir to allow increased seasonal floodplain inundation from Sacramento River water for the benefit of juvenile salmonids and Sacramento splittail, in addition to proposed fish passage improvements. The 2009 NMFS Biological Opinion Reasonable and Prudent Alternative (RPA) Action I.6.1 also requires the USBR and DWR to increase rearing habitat for juvenile salmonids in the lower Sacramento River Basin during the December to April time period with an initial performance measure of 17,000 to 20,000 acres, on a return rate of approximately one to three years, depending on water year type. RPA Action I.6.1 was identified in the June 4, 2009 NMFS Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (NMFS 2009 Biological Opinion). Yolo County and other stakeholders are concerned a proposed project implementing Conservation Measure 2 or RPA Action 1.6.1. will permanently impact agriculture, managed wetlands habitat, flood control, and other important land uses in the Yolo Bypass.

Irrigated agriculture and managed wetlands comprise major land uses within the Yolo Bypass, contributing to the local economy and habitat for terrestrial species, including some listed species. The local, state and federal government worked with community leaders to create the Yolo Bypass Wildlife Area in 1997 with state and federal funding. The Yolo Bypass Wildlife Area is currently managed as diverse wetland habitat for resident and migratory species along the Pacific Flyway with some 100,000 waterfowl overwintering in the Yolo Bypass Wildlife Area each year (CDFW, 2008). The Yolo Basin Foundation, a non-profit organization, hosts school field trips and a variety of other educational activities in the Yolo Bypass Wildlife Area, providing educational opportunities to local communities. Multiple landowners Bypass-wide provide additional waterfowl habitat through private hunt clubs. Additionally, tens of thousands of acres are farmed or grazed, including thousands of rice acres, providing additional economic and habitat benefits. Finally, the Yolo County Habitat/Natural Community Conservation Plan Joint Powers Agency, comprised of the City of Winters, the City of West Sacramento, the City of Woodland, the City of Davis, UC Davis, and Yolo County, are in the process of completing a countywide habitat conservation plan for selected terrestrial species. The plan includes conservation strategies to protect species, such as giant garter snake, found in the Yolo Bypass.

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that could improve the operations of agriculture and wetlands under current or proposed flooding regimes. Information for the study was obtained through interviews and data collection. The study team interviewed landowners, farmers, water managers and other key stakeholders with knowledge and interest in Yolo Bypass water management in person or by phone. Limited field reconnaissance and surveys were conducted in prioritized areas. From these individual meetings and data collection, the team created maps of existing conditions and water operations across property boundaries. The team also created sub-regions that divide the Yolo Bypass up into geographic areas from north to south for the purposes of compiling a mosaic of information for future planning efforts. In addition, the team identified the potential benefits of projects to future agriculture and wetland management.

This report presents the results of the study, first describing the existing land use functions, drainage and water supply infrastructure schedules, and sub-regional constraints. Sub-regions are described from north to south, divided into regions for coordination with landowners in the following areas: 1) north of Interstate 5, 2) between Interstates 5 and 80 and 3) south of Interstate 80. The study team synthesized recommendations from interviews with the team's regional hydrologic, management and policy expertise to recommend 12 projects and 4 studies. An overview map of the locations of the 12 recommended projects is provided by Figure 1. The team then prioritized projects in a first effort to guide Bypass management and funding opportunities. To improve the availability and quality of data related to proposed beneficial projects, the team also recommended improvements to future collection of westside tributary inflow data.

1.1 BACKGROUND

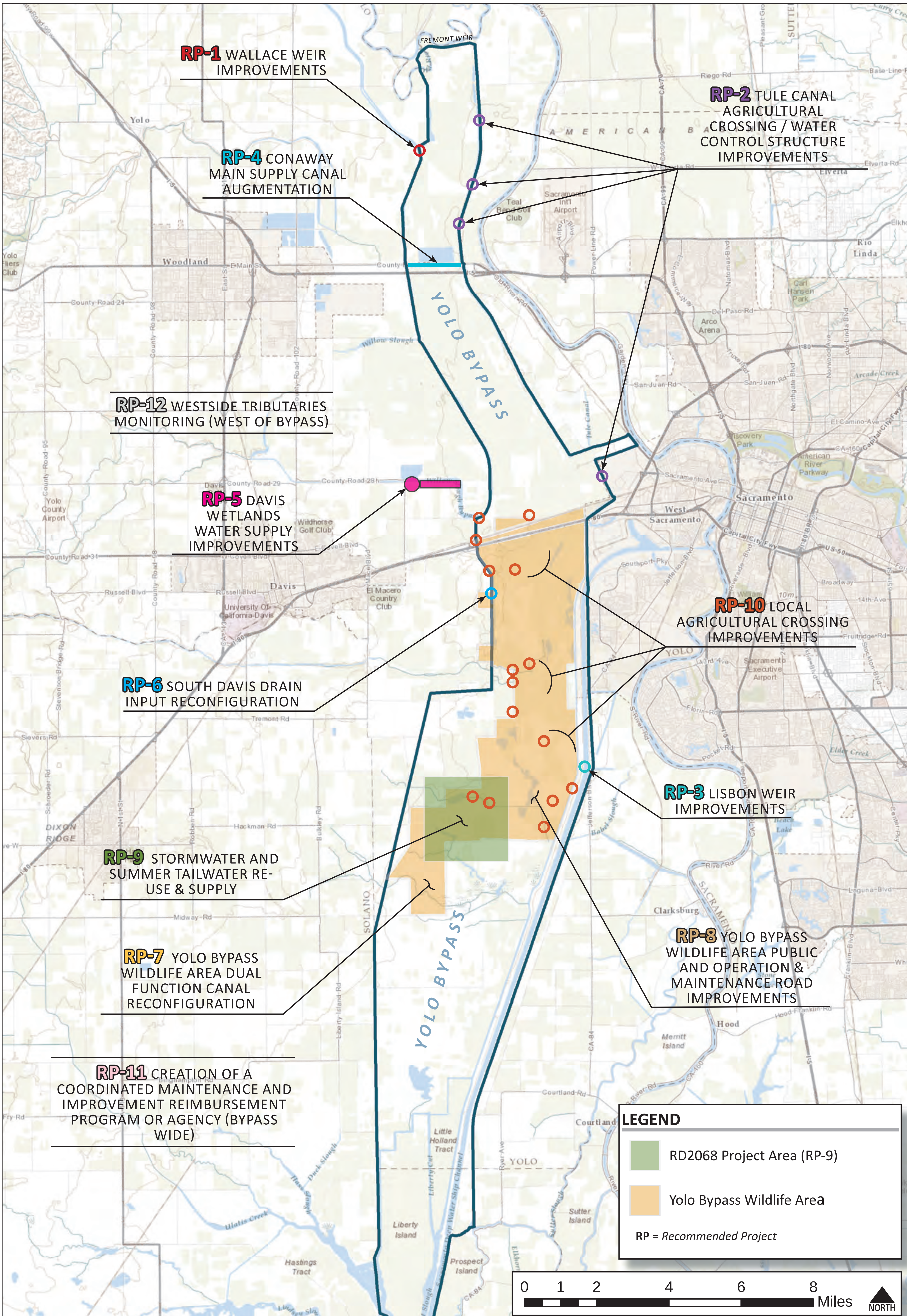
1.1.1 STUDY AREA

The 59,000-acre Yolo Bypass conveys a design flow from 343,000 cfs at Fremont Weir to 500,000 cfs at Rio Vista including inflows from Sacramento Weir (112,000 cfs). In addition, the "westside tributaries" to the Bypass drain the western foothill watersheds and include Putah Creek, Cache Creek, Willow Slough Bypass and the Knights Landing Ridge Cut Canal. The Yolo Bypass also receives inputs of treated wastewater from the cities of Woodland and Davis (typically minor during flooding, but significant during the dry season), and stormwater from the City of West Sacramento (albeit minor during flooding).

The southern terminus of the study was just north of Yolo Ranch where wetland restoration planning efforts are underway. The western terminus was bounded by the Yolo-Solano County Line. The study team coordinated with Solano County as Solano and Yolo County share similar economic and agronomic environments. Solano County has already identified needed drainage and water supply infrastructure improvement projects in the Bypass, however, so Solano County opted not to participate in this study. Additionally, projects identified in this study should be considered in collaboration with other projects under development, such as Putah Creek realignment actions and other restoration projects further upstream in the Putah Creek riparian corridor.

1.1.2 PREVIOUS STUDIES

Many key components leading to the development of this study originate from the Westside Option, a management scenario described by the Yolo Basin Foundation (YBF) with support from others (YBF, 2010a). While the original goal of the Westside Option was to improve rearing habitat for juvenile salmon, it aimed to do so in a way that would minimize impacts on agriculture and wetlands. Specifically, several key objectives outlined in the Westside Option are considered in this study including 1) avoiding negative impacts on the floodway function of the Yolo Bypass, 2) supporting agricultural production as location and timing of flooding affects yield (Howitt et al., 2013) and, 3) supporting



Notes:

cbec

Yolo Bypass Drainage Study

Yolo Bypass Drainage and Water Infrastructure Projects

Project No. 12-1039 CREATED BY: SPW

Figure 1

April, 2014

existing habitat values in the Yolo Bypass, including migratory and resident shorebirds, waterfowl and other terrestrial species. These objectives are consistent with the purpose of this study.

Yolo County's recent study, "Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals" (Howitt et al., 2013) analyzed the potential impacts on agriculture from fish habitat proposals. This study relied on one-dimensional hydraulic modeling results without westside tributary inputs for a range of inundation scenarios (i.e., only assuming Fremont Weir operable gate flows) to analyze impacts on crop yield based on last day of flooding. This was the best available information at the time, but new hydraulic modeling results should be available in 2014. As discussed in this report, better information about west side tributary flows is still needed.) The study also relied on crop data validated by Yolo Bypass farmers and assumptions about drainage and field preparation times provided by in-person interviews with Yolo Bypass farmers. The study analyzed twelve scenarios selected by the authors, as Biological Opinion and BDCP alternatives were and are still not fully developed. Scenarios included five release end dates at Fremont Weir (February 15th, March 24th, April 10th, April 30th, and May 15th) and a "Low-Impact CM2 Scenario" with variable end dates extending natural overtopping events based on water year type and available Sacramento River water. All scenarios were analyzed at two flow rates: 3,000 cfs and 6,000 cfs. The scenarios analyzed differ from actual proposals to varying degrees and do not explicitly represent BDCP CM2 or RPA Action 1.6.1. conceptual future operations. The model developed to support the study can be used to analyze specific alternatives in the future, however.

The study found that 7,700 and 15,800 acres of land used for agricultural production could potentially be impacted, amounting to $200,000 to $8.9 million in total annual losses (in 2008 dollars) to Yolo County depending on the scenario. While not representative of actual BCDP proposed operations, the "Low-impact CM2 Scenario", showed a range of losses from $625,000 to $1.5 million. The study concluded that while some flooding for fish is possible with minimal impacts, flooding in March and April will result in significant yield impacts, and late spring flooding could result in the end to agricultural production on inundated acres. If actions are taken to minimize impacts of proposals and the operational needs of farmers and wetland managers are considered, there may be potential to minimize economic impacts.

Ducks Unlimited prepared a report describing the impact on waterfowl as a result of possible CM2 scenarios outlining four main drivers: 1) recreation hunt/use, 2) income loss, 3) foraging loss due to deep winter flooding, and 4) seed production loss due to late season flooding (Ducks Unlimited, 2012). They found that Yolo Bypass Wildlife Area closures due to Fremont Weir overtopping occurred for 14 days on average during the mid-October to late January duck hunting season during a 13-year period with seven overtopping events from 1997 to 2010. A two- to three-week drying time window after these flood events was estimated before public access was granted. The potential increase in the cost per day of hunting and property value loss due to changes in hunting opportunities were noted. It was also noted that foraging habitat for dabbling ducks, whose populations peak in the Yolo Bypass in February, may be impacted by CM2 deep winter flooding as dabbling ducks require depths less than 18 inches (less than 10 inches preferred). Finally, they reported the impacts on seed production for waterfowl food supply. To promote maximum growth of Swamp Timothy, a prevalent forage species in the Yolo Bypass Wildlife Area, water operations are managed to flood through February allowing ponds to evaporate in March, monitored through early April and then rapidly drawn down. The preferred vegetation for management on private duck clubs, watergrass and smart weed, require a slow draw down over two to three weeks in mid March and irrigation for two to four weeks in May. Late season draw downs promote undesirable vegetation growth (Ducks Unlimited, 2012).

The most recent description of land use within the Yolo Bypass is included in "Appendix: A Summary of the Agricultural Land Uses and Managed Wetlands in the Sacramento – San Joaquin Delta" (Ducks Unlimited, 2012) to support the Delta Methylmercury Total Maximum Daily Load (TMDL) Nonpoint Sources Workgroup for Managed Wetlands and Irrigated Agriculture (NPS Workgroup) "Knowledge Base for Nonpoint Sources Methylmercury Control Study" (NPS Workgroup, 2012). This study estimates that within the TMDL study area including the North and South Yolo Bypass (in the leveed and non-leveed portions from Fremont Weir to just north of Rio Vista including Yolo and Solano Counties), approximately 5,000 acres are currently used for winter flooded irrigated agriculture, 68,000 acres are used for other irrigated agriculture, and 12,350 acres and 650 acres for seasonal and permanent managed wetlands, respectively. The 16,770-acre Yolo Bypass Wildlife Area managed by the California Department of Fish and Wildlife (CDFW) provides 7,000 acres of habitat to promote an increase in waterfowl and other bird populations, restored using approximately $24 million in state and federal funding since 1997.

These previous efforts and studies have helped managers understand land use and the potential impacts to farming and wetland management associated with increases in the frequency and duration of inundation in the Yolo Bypass.

1.2 GOALS AND OBJECTIVES

This study identifies drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers, as well as proposes actions to increase the availability and enhance the quality of data related to these improvements. Yolo County proposed the study to help address potential impacts on agriculture and wetlands of proposals by the California Natural Resources Agency and the U.S. Department of the Interior that increase the frequency and duration of inundation in the Yolo Bypass for seasonal fish habitat. While these improvements will not fully address potential impacts, they will help reduce drainage times, improve water delivery, and otherwise increase the likelihood the Yolo Bypass will continue to support multiple important land uses in the future. The results of this study are intended to assist Yolo County and other stakeholders in securing future funding for projects or feasibility studies to benefit Yolo Bypass agriculture and wetland operations.

The objectives identified to meet these goals include the following:

- Coordinate with Yolo Bypass stakeholders to characterize existing conditions and constraints;
- Collect limited field reconnaissance and survey data to support characterization of existing conditions;
- Coordinate with Yolo Bypass stakeholders to identify specific improvements;
- Perform preliminary prioritization based on a simple rationale;

- Provide conceptual project summaries related to drainage and water infrastructure improvements; and
- Provide recommendations for further studies.

2 YOLO BYPASS DRAINAGE AND WATER SUPPLY CHARACTERIZATION AND INITIAL RECOMMENDATIONS

2.1 EXISTING DRAINAGE AND WATER SUPPLY INFRASTRUCTURE, CONSTRAINTS AND IMPROVEMENTS BY GENERAL REGION

To characterize the existing agricultural and wetland management operations in the Yolo Bypass, the study team held numerous interviews with landowners, farmers, water managers, wetland managers and others with extensive knowledge and experience in the system. The study team also held two meetings with stakeholders who were interviewed during the process to develop and confirm recommendations and to facilitate conversation among stakeholders regarding land management. The team contacted as many people as possible from within each management area or property boundary to participate in this study, resulting in 15 formal interviews and several other phone or email exchanges with various parties knowledgeable of drainage and water supply functions in the Yolo Bypass.

The following section summarizes the existing drainage and water supply operations and recommended improvements by three general regions: 1) Fremont Weir to Interstate 5 causeway; 2) Interstate 5 to Interstate 80; and 3) Interstate 80 to just north of Yolo Ranch. The study team included all improvements in this section that stakeholders recommended, but the team also prioritized the recommended improvements as discussed in Section 3.4. Discussion of selected projects for further development is provided in Section 3 and Appendix A.

In addition to floodwater spilling over the Fremont Weir, the Yolo Bypass receives rainfall runoff, agricultural tailwater drainage, bypass flood flows, stormwater and treated wastewater effluent from several locations, primarily originating from the west. Four main tributaries, hereafter referred to as the westside tributaries, convey variable amounts of runoff, stormwater and flood flows: the Knights Landing Ridge Cut Canal, Cache Creek, Willow Slough via the Willow Slough Bypass, and Putah Creek.

The Fremont Weir, located between river miles 81.7 and 83.4, and built in 1924 to reduce Sacramento River levels and minimize flooding, is a fixed concrete weir constructed by US Army Corps of Engineers. It is 9,120 feet long, with an earthfill section dividing it into two parts. The crest of the concrete weir section is at elevation 33.5 feet (no vertical datum given), and the crown of the earthfill section is at an elevation of 47.0 feet (no vertical datum given) (U.S. Army Corps of Engineers 1955). It currently overtops when the Sacramento River exceeds a range of 32.1 to 32.9 ft elevation, NAVD88. The Yolo Bypass Management Strategy (Chapter 2 – Existing Conditions in the Yolo Bypass, Jones & Stokes, 2001) provides information about the historical daily inflow hydrology to the Yolo Bypass for these four tributaries from 1968 to 1998. cbec recently updated this hydrologic dataset through 2011 for a DWR modeling effort (cbec, 2012). During the period from 1968 to 2011, or 44 years, Fremont Weir spilled or "overtopped" during 29 of those years or 2 out of 3 years (66% of years) according to the updated hydrology dataset. The study "Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals" evaluated a shorter timeframe of 26 years (1984 and 2009) because of concern about the accuracy of the data from 1968 to 1983, during which the Fremont Weir spilled during 15 of those years or 58% of years. Typical overtopping events do not result in complete inundation of the Yolo Bypass.

See Appendix B of this report for a complete summary of existing knowledge about the westside tributaries, low flow hydrology as estimated or described by the Yolo Bypass Management Strategy (herein, Management Strategy) (Jones & Stokes, 2001), and recommendations for validating these estimation equations or for future data collection.

2.1.1 NORTHERN YOLO BYPASS – FREMONT WEIR TO INTERSTATE 5

2.1.1.1 North of Knights Landing Ridge Cut Cross Canal

Existing Function and Constraints

The northern Yolo Bypass is bounded by United States Army Corps of Engineers (USACE) project levees to the east and west. The approximately 1,400-acre CDFW Fremont Weir State Wildlife Area conveys flood flows just south of the Fremont Weir, currently set to overtop when the Sacramento River exceeds 32.9 ft NAVD88 (33.5 ft USED). According to recent DWR surveys, the crest elevation varies from 32.1 to 32.9 ft elevation, NAVD88. Scour channels have formed across the Fremont Weir State Wildlife Area, with LiDAR based land elevations that range from 31 feet NAVD88 at the northwest corner to 20 feet NAVD88 at the southeast corner near the Tule Canal (DWR, 2005).

Immediately south of the State Wildlife Area, TeVelde Ranch farms approximately 1,700 acres. This area is on a row crop rotation of tomatoes and corn planted ideally in April or early to mid-May of each year. Planting by mid-May requires a least a month of field preparation and 2-4 weeks to allow fields to drain (Howitt et al., 2013). The corn cultivated here is used for silage, or harvested with the cob, husk, and leaves, which can be harvested at higher moisture and thus can be planted relatively late (J. Brennan, personal communication). Land elevations range from 25 feet NAVD88 to 16 feet NAVD88 from northwest to southeast respectively (DWR, 2005). Irrigation supply to the TeVelde Ranch is sourced from the KLRC as backwater behind Wallace Weir supplemented by water from up to seven wells. Supply is conveyed in a canal approximately 100 feet wide northward that continues into the State Wildlife Area. At the northern property line of the TeVelde property, a smaller canal approximately 25 feet wide conveys supply eastward toward an agricultural crossing on the Tule Canal where a pipe through the levee gravity feeds water to RD1600 east of the Bypass levee (see Figure 2). All fields on TeVelde Ranch are leveled to drain from northwest to southeast toward the Tule Canal.

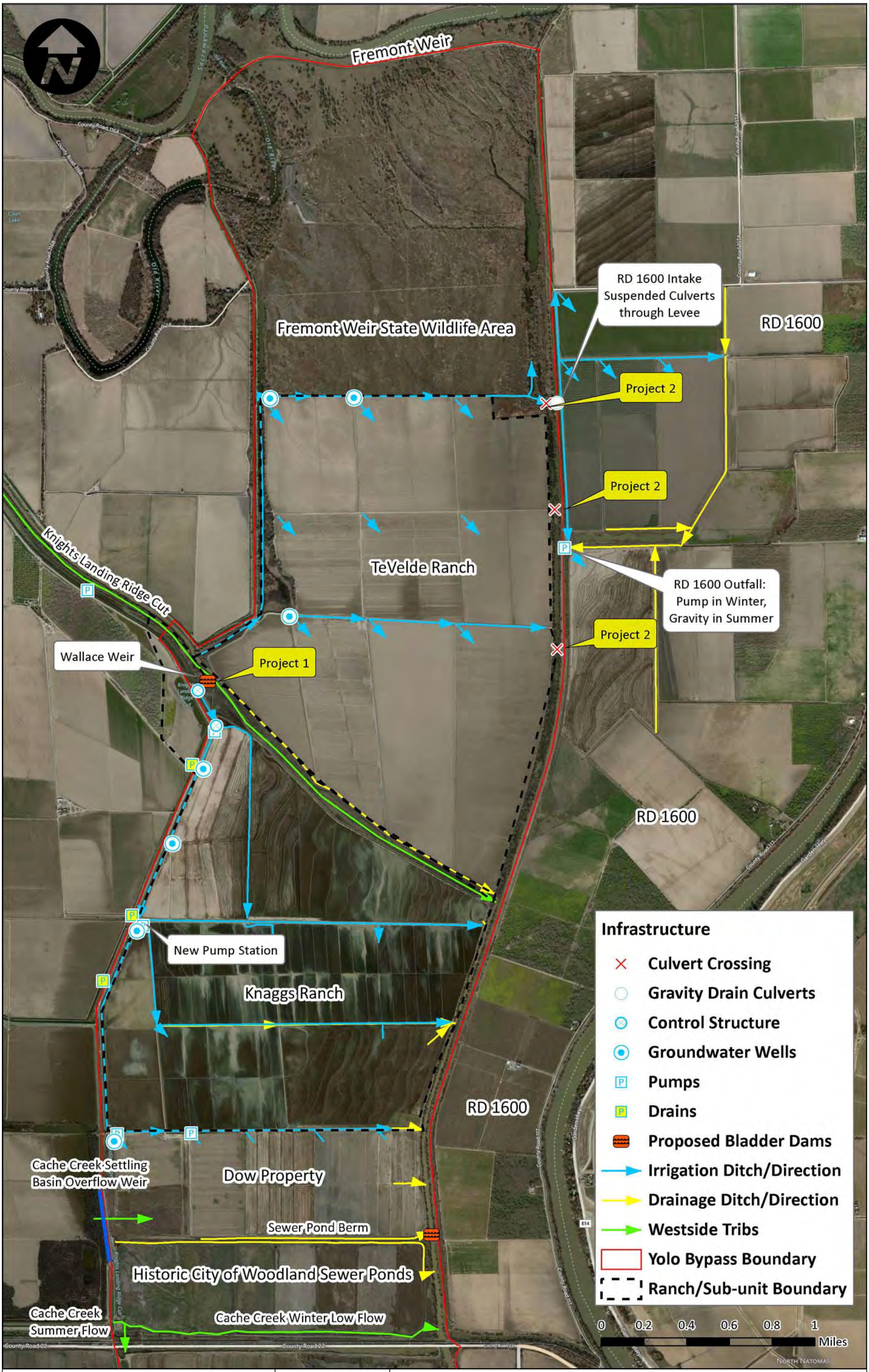
The RD 1600 canal system partially depicted in Figure 2 drains back to the Tule Canal south of a second agricultural crossing where water is pumped into the Tule Canal in the winter and flows by gravity in the summer. While areas just east (outside) of the Bypass levee are not flooded during overtopping events, these areas sit on "heavy ground" with high clay content and can experience seepage when flow is receding down the Tule Canal that can potentially prolong field preparation and productivity in these areas. Sacramento River Ranch, a 3,600-acre mitigation bank between the east Bypass levee and Sacramento River, is owned by Wildlands, Inc. with potential for wetlands, agricultural and species mitigation (map available online at http://www.wildlandsinc.com/map).

Three agricultural crossings exist on the Tule Canal north of the KLRC (see Figure 2). The northernmost crossing is at the north property line of the TeVelde property, the second is about 0.5 mile south, and the third is another 0.6 mile south. The northernmost agricultural crossing is generally not used as a road but rather as a berm to impound water upstream for supply to RD 1600. The middle crossing is the most heavily utilized and the south crossing is primarily used by operations on the Sacramento River Ranch east of the levee. The middle and south crossings have 36-inch culverts that provide for hydraulic connectivity of the Tule Canal during the summer period.

Improvements

Further research is needed to assess the extent of benefit to agriculture and wetlands as a result of improvement to the three agricultural crossings north of KLRC. TeVelde Ranch may benefit from a Bypass-wide recommendation to enhance key agricultural crossings (e.g. along the Tule Canal as discussed above) for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass. See Appendix A and Section 3.2 for details on recommended projects.

The three agricultural crossings north of KLRC have been identified as impediments to fish passage by several other efforts working to improve fish habitat in the Yolo Bypass. Specifically, the BDCP Conservation Measure 2 identifies a related project “Component Project 9: New or Replacement Impoundment Structures and Agricultural Crossings at the Tule Canal and Toe Drain” as a Phase 1 (Years 1 – 5) Category 3 Project. Additionally, NOAA Fisheries and DWR’s Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan has identified seasonal road crossings and agricultural impoundments in the northern Yolo Bypass as locations for improvement to satisfy the NMFS 2009 Biological Opinion RPA I.6.1 (Appendix C: Yolo Bypass Actions).



Notes: annotated on large scale map with John Brennan on Jan 23, 2013. Image courtesy BingMaps 2009. RD 1600 area bounded by east Bypass levee, Sac River and County Road 22.

cbec eco engineering

Yolo Bypass Drainage and Water Infrastructure Improvement Study

North of Interstate 5 Causeway – Existing Function

Project No. 12-1039 | Created By: AMS | **Figure 2**

2.1.1.2 Knights Landing Ridge Cut Cross Canal to Interstate 5

Existing Function and Constraints

Knaggs Ranch farms two parcels in the Bypass, which are primarily used to cultivate rice. Additionally, Knaggs is currently in the process of buying a property just south of the current property line. Improvements to the irrigation and drainage system at Knaggs are currently underway, including installation of a new main pump station ("New Pump Station" on Figure 2), extensive canal cleaning and rebuilding as well as field leveling to accommodate multiple uses such as habitat enhancement. In addition to rice farming, Knaggs participates in the National Audubon Society shorebird habitat variable drawdown program and is in the third year of a Yolo Bypass Floodplain Fishery Enhancement Pilot Study to evaluate winter rearing habitat requirements and preferences of juvenile salmonids on rice fields (UCD & DWR, 2012).

Knaggs Ranch is primarily supplied by diversions through two control structures near Wallace Weir and by supplemental well water (see Figure 2). Wallace Weir road deck elevations on the permanent structure sit at 28.4 feet NAVD88, with 2013 earthen berm elevations sloping down to approximately 24 feet NAVD88 on the western end. Field elevations at the northwest corner of the Knaggs property sit at 24 ft NAVD88 and slope to the east on a field-by-field basis to about 10 feet NAVD88 near the Toe Drain at the southeast corner. After the recent system improvements, rice farming operations on Knaggs are able to flood fields in a two- to three-day period to compete with weeds, but prior operations flooded fields in a 10- to 15-day period. Planting proceeds in about a 3-week sequence. After about 110 to 120 days from seeding, all drain boards are pulled and fields drain over an approximately 3-week period. Harvest occurs at approximately 145 days from seeding, or 30 days after drainage. Fields are then flooded as soon as possible after harvest for waterfowl management. From February through March, Knaggs implements a variable drawdown regime for shorebird habitat management. During flood periods, impacts to Knaggs are primarily in the vicinity of Cache Creek Overflow Weir. Some scour occurs on the north side of a berm just north of the City of Woodland historic sewer ponds (see Figure 1). Additionally, seepage due to ponded water in the Cache Creek Settling Basin impacts Knaggs' farming operations by delaying planting of western fields and may result in salt extrusion to soils in the Bypass.

Improvements

Knaggs managers have identified improvements to Wallace Weir as necessary to improve water supply management. A specific example of the need for improvement at this location occurred in early spring 2012. The timing and magnitude of available upstream runoff and diversions to flood rice fields in the Glenn-Colusa Water District can typically occur sooner than in the Yolo Bypass. Due to upstream diversions around the time when the earthen berm was installed, water levels in the Wallace Weir diversion pool were inadequate for diversion into the Knaggs supply system. This was exacerbated by minimal runoff immediately after weir installation delaying Knaggs diversion until water levels rose to an adequate level. These instances can delay planting dates. An improvement at Wallace Weir would be to install an adjustable height structure for improved control to allow earlier or more reactive impoundment (e.g. to runoff events) if necessary. See Appendix A and Section 3.2 for details on recommended projects.

Several BDCP Conservation Measure 2 projects target similar needs to improve water supply facilitated by Wallace Weir or to change seasonal operations to facilitate seasonal habitat needs. Specifically, the following were identified as BDCP Conservation Measure 2 Component Projects relevant to Wallace Weir potential future operations:

- Component Project 3: Fish-Rearing Pilot Project at Knaggs Ranch (not to exceed 10 acres) - (Phase 1 or before, Category 1 Action)
- Component Project 4: Expanded Fish Rearing at Knaggs Ranch - (Phase 1 or 2, Category 3 Action)
- Component Project 13: Use of Supplemental Flow through Knights Landing Ridge Cut - (Phases 1 and 2, Category 3 Action)

Finally, Knaggs Ranch may benefit from a Bypass-wide recommendation to replace key agricultural crossings (e.g. along the Tule Canal as discussed above) for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A and Section 3.2 of this report.

2.1.2 CENTRAL YOLO BYPASS –INTERSTATE 5 TO INTERSTATE 80

2.1.2.1 Conaway Ranch

Existing Function and Constraints

Conaway Ranch (Conaway) farms approximately 6,500 acres in the Yolo Bypass (see Figure 3), primarily as rice. Approximately 1,400 acres have been entered in the Natural Resource Conservation Service (NRCS) Environmental Quality Incentive Program Bay Delta Initiative for Waterbird Habitat for heterogeneous mudflut habitat by variable field by field drawdown. Additionally, Conaway is managed for giant garter snake (GGS) habitat.

Conaway is supplied primarily by Sacramento River lifted by the Sacramento River Pumping Station with a capacity of 400 cfs. The Tule Canal Siphon conveys flow under the Toe Drain to the Conaway Cross Canal. The siphon is undersized, however, compared to pump and canal capacity for 400 cfs. The Cross Canal has a bottom width of approximately 50 to 75 feet and side slopes of 2 horizontal to 1 vertical or flatter, running immediately south of County Road 22 (see Figure 3). Additionally, Cache Creek summer low flows through the Settling Basin are diverted under County Road 22 into the Cross Canal. The Conaway Main Canal supplies water southward along the toe of the west Bypass levee, with three agricultural crossings accessing from outside the Bypass (Figure 3). Water is generally supplied and drained in ditches from the north to south, then west to east direction. Land elevations slope from approximately 25 feet NAVD88 at the northwest corner to 15 feet at the southeast corner near the Toe Drain (DWR, 2005). Three main drains exit the closed system with single 42 to 54 inch culverts with slide gates, the largest being at the Toe Drain just north of Swanston Ranch. The ditch along the southern boundary of Conaway functions as a dual supply and drainage pathway. Conaway managers are currently studying internal drainage constraints with a report scheduled to be completed spring of 2014.

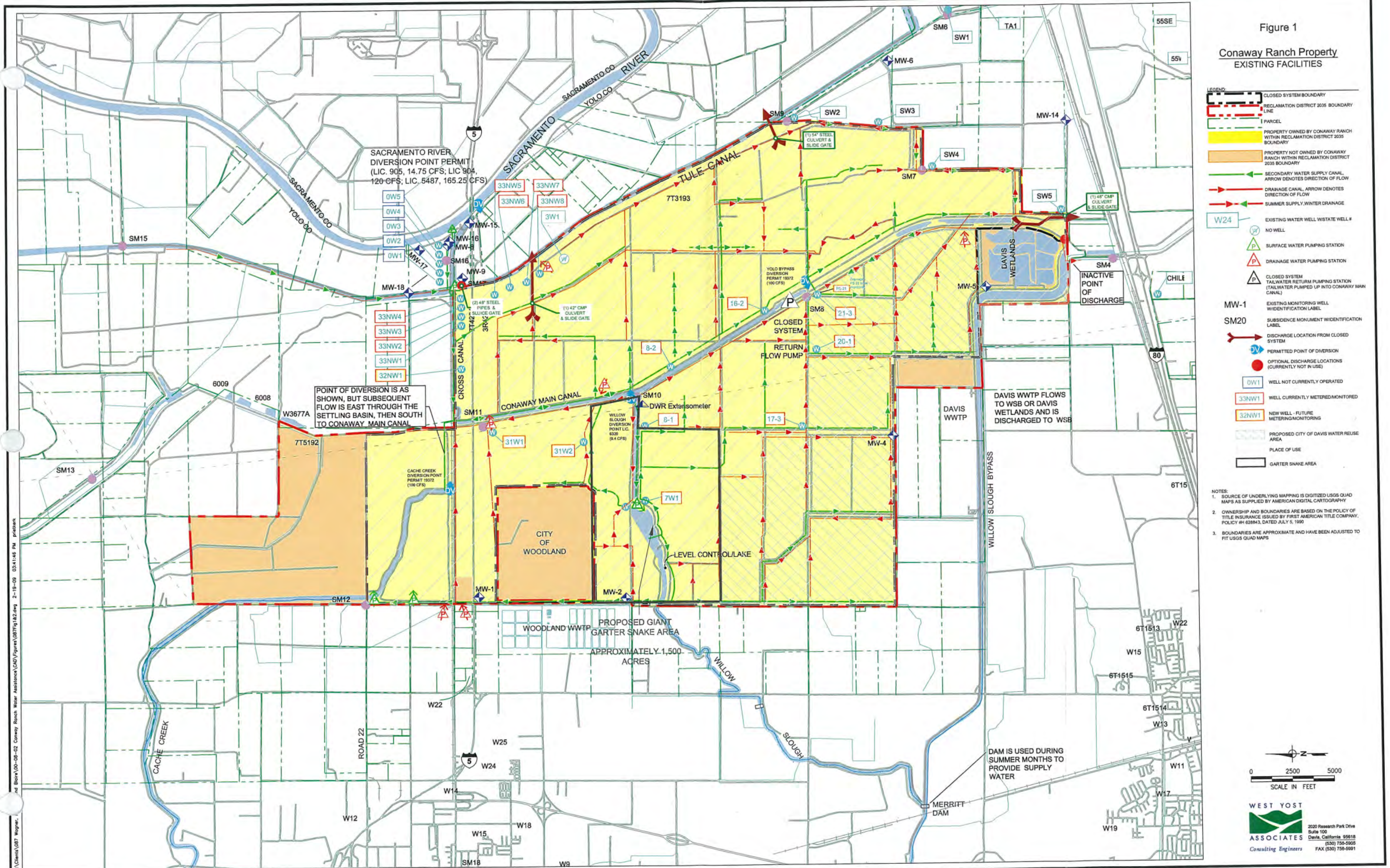
Maintenance operations on Conaway include maintaining canals and ditches on a field-by-field basis dependent on yearly or seasonal needs. Beaver activity causes drainage impediments that can require removal on a weekly or more frequent basis especially during flood and drain periods. The earthen berm on the south side of the Conaway Cross Canal requires repair after flood events due to scour caused by the concentration of high velocity flows within the constrained area between the Toe Drain and the parallel berm in this vicinity. Bypass inundation also results in siltation within the Cross Canal, resulting in a need for canal rehabilitation. Cross Canal berm rehabilitation can be delayed by late flood events which have the potential to impact supply to the entire ranch inside and outside the Yolo Bypass. It should be noted that water management on Conaway Ranch includes future supply to the Davis-Woodland Water Project, though the two systems will be structurally separate. See the Davis-Woodland Water Supply Project Final Environmental Impact Report for details (City of Davis, 2007).

Improvements

The main infrastructure project suggested to improve supply conditions on the Conaway Ranch includes reinforcing the Cross Canal with concrete lining along the eastern half of the southern berm to reduce maintenance needs after Yolo Bypass flood events and improve the security of supply. An alternative to secure Conaway's irrigation supply at the Cross Canal involves modifying the Tule Canal Siphon Intake to a design flow of 400 cfs and constructing a box culvert facility across the Bypass, sealed from flood inundating flows, to minimize scour and siltation issues. See Appendix A and Section 3.2 for details on recommended projects.

Conaway Ranch lies within Reclamation District 2035, and receives surface water from the Sacramento River Pumping Station. The pump intake is currently unscreened and therefore could possibly entrain anadromous salmonids. RD 2035 entered into an agreement with the Woodland Davis Clean Water Agency to jointly finance, construct and operate a new water intake facility that would be compliant with fish screening and Central Valley Flood Protection Board encroachment permitting. The Conaway Preservation Group and the cities are pursuing funding for this project, so it is not included in the list of recommended projects in this report. It is a good candidate for the list of projects if it is not funded in the next year. More information about additional specific drainage constraints and suggested improvements should become available after the completion of Conaway's internal drainage study in spring of 2014.

Drainage could also be improved by implementing electronic controls on main drain slide gates to allow for remote-controlled operation as access to the manually control slide gates is often not possible during floods. In addition, the Conaway Ranch may benefit from a Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance, as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A .



Notes: "Conaway Ranch Property: Existing Facilities" Map provided by Mike Hall. Prepared by West Yost.

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Conaway Ranch – Existing Function

Project No. 12-1039	Created By: AMS	**Figure 3**

2.1.2.2 Swanston Ranch

Existing Function and Constraints

Swanston Ranch is an approximately 2,400-acre area with several parcels under United States Fish and Wildlife Service (USFWS) conservation easements. Several private duck club owners utilize the area for hunting purposes. Farming primarily occurs in the southeastern parcels. One parcel is also owned by CDFW. The irrigation supply system, originally designed for rice farming, operates by lifting water from the Toe Drain into a canal that runs northward through the Thompson property, as well as by control at the risers in the Willow Slough low flow channel (see Figure 4). The Swanston Ranch temporary agricultural crossing impounds water in the Toe Drain for diversion and consists of three culverts, one six-foot open culvert, and two four-foot culverts with boards at the intakes and earth fill. Water supply is also supplemented by wells.

Once the system is closed in the summer, no water is pumped from the Toe Drain. In the fall, fields are flooded as early as possible in late September to fully charge the system for mid-October duck hunting season. Pumping into the fields typically ceases by mid-December when the system is fully charged and as the duck hunting season comes to a close in January. High tides, especially during king tide periods in December, improve supply but can also cause high velocities that scour the Swanston temporary agricultural crossing shown on Figure 4. In the spring, water is typically drained off the fields around April to comply with mosquito abatement. Swanston wetland managers have expressed interest in managing for brood pond, or semi-permanent wetland habitat used for waterfowl rearing, where water would be left to evaporate or fed into such areas into the summer.

Drainage after large flood events on Swanston Ranch is primarily concentrated southward along the western levee toe then eastward in the Willow Slough low flow channel, along the railroad abutments toward the Toe Drain. Additionally, floodwaters recede overland to the Toe Drain. Access from the western levee to the main internal road system (Figure 4) is often restricted for consecutive days when the Willow Slough Bypass is conveying flood flows from upstream, reducing the number of hunting days on Swanston. This crossing has eight 48-inch culverts in parallel with an earth deck. See Appendix B for more detail regarding Willow Slough inflows. Land elevations slope from about 14 feet NAVD88 at the northwest corner of the Calfee property to 11.5 NAVD88 feet at the railroad abutments along the railroad tracks. An historic drainage pathway from the southeast corner of the Dougherty property connects to the Toe Drain immediately upstream of the Interstate 80 causeway. An additional historical pathway exists under the Interstate 80 and railroad abutments on the western edge of the Bypass. This location is filled in with sediment and does not perform a significant drainage function. Frequent maintenance operations are required on Swanston Ranch to keep canals free from blockages created by beavers during the flood and drain periods and annual maintenance is needed to clean canals of vegetation and sediment.

The Swanston Ranch group of landowners and managers are in the process of developing a mutual water company to utilize cost sharing to address maintenance, supply and drain operations on a per acre basis. This process and organization may serve as a model for other regions in the Bypass in the future to deal with land and water management.

Improvements

Improvements at Swanston Ranch include replacing priority agricultural culvert crossings to reduce maintenance needs due to beaver blockages and to improve access during periods when Willow Slough Bypass conveys flow from the west. Some crossing locations along the main access road have existing control structures that should be assessed for conveyance. Existing culvert crossings, such as (but not limited to) those shown on Figure 3 can be replaced with railcar crossings with concrete abutments. This improvement falls under the Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance (see Appendix A). In addition, Swanston Ranch may benefit from potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A. See Section 3.2 for details on recommended projects.

Notes: Red circles denote potential culvert crossings for replacement under Project 11: Local Agricultural Crossing Improvements. Aerial courtesy of BingMaps, 2009.

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Yolo Bypass Drainage and Water Infrastructure Improvement Study

Swanston Ranch – Existing Function

Project No. 12-1039	Created By: AMS	**Figure 4**

2.1.3 CITY OF DAVIS INPUTS TO THE YOLO BYPASS

2.1.3.1 North of Interstate 80

Existing Function and Constraints

The Yolo Bypass receives winter stormwater and summer tailwater returns or effluent from the Willow Slough Bypass, Davis Wetlands and Davis Wastewater Treatment Plant (see Figure 5 for a regional map of the general drainage patterns from the City of Davis). Channel A is a main drainage pathway conveying winter stormwater from most of Davis north of Interstate 80 as well as summer tailwater returns from fields in the vicinity. Summer tailwater typically proceeds directly into the Willow Slough Bypass. In the fall and winter, water is lifted at a pump near the junction of Channel A with the Willow Slough Bypass and conveyed to the City of Davis Wetlands (Davis Wetlands). Constraints are associated with the ability to pump water out of Channel A up to a smaller canal that routes water from the south side of the Willow Slough Bypass to the north side and into the Davis Wetlands (Figure 5). During the summer and fall months, the water is too low in the channel for the pump as designed. A secondary issue, currently faced in the winter, is channel conveyance capacity. Once the stormwater ponds fill to a certain level, water backs up into the conveyance channel and overflows at low areas. The current conveyance configuration can also result in poor water quality entering the Bypass and flooding at the Swanston Ranch west levee access. Some wastewater treatment plant effluent is also treated in the Davis Wetlands. First flush rain events carrying higher concentrations of pollutants are sometimes conveyed for treatment in the Davis Wetlands, but not all events.

Improvements

Improvements to City of Davis drainage diversion where Channel A meets the Willow Slough Bypass may improve water quality conditions in the Yolo Bypass. Replacing and modifying water conveyance structures along the Channel A input to Willow Slough for diversion to the Davis Wetlands for treatment may enhance the reliability of capturing first flush events originating in Channel A. See Table A-1 for a comparative description of this potential project and Section 3.2 for details on recommended projects.

2.1.3.2 South of Interstate 80

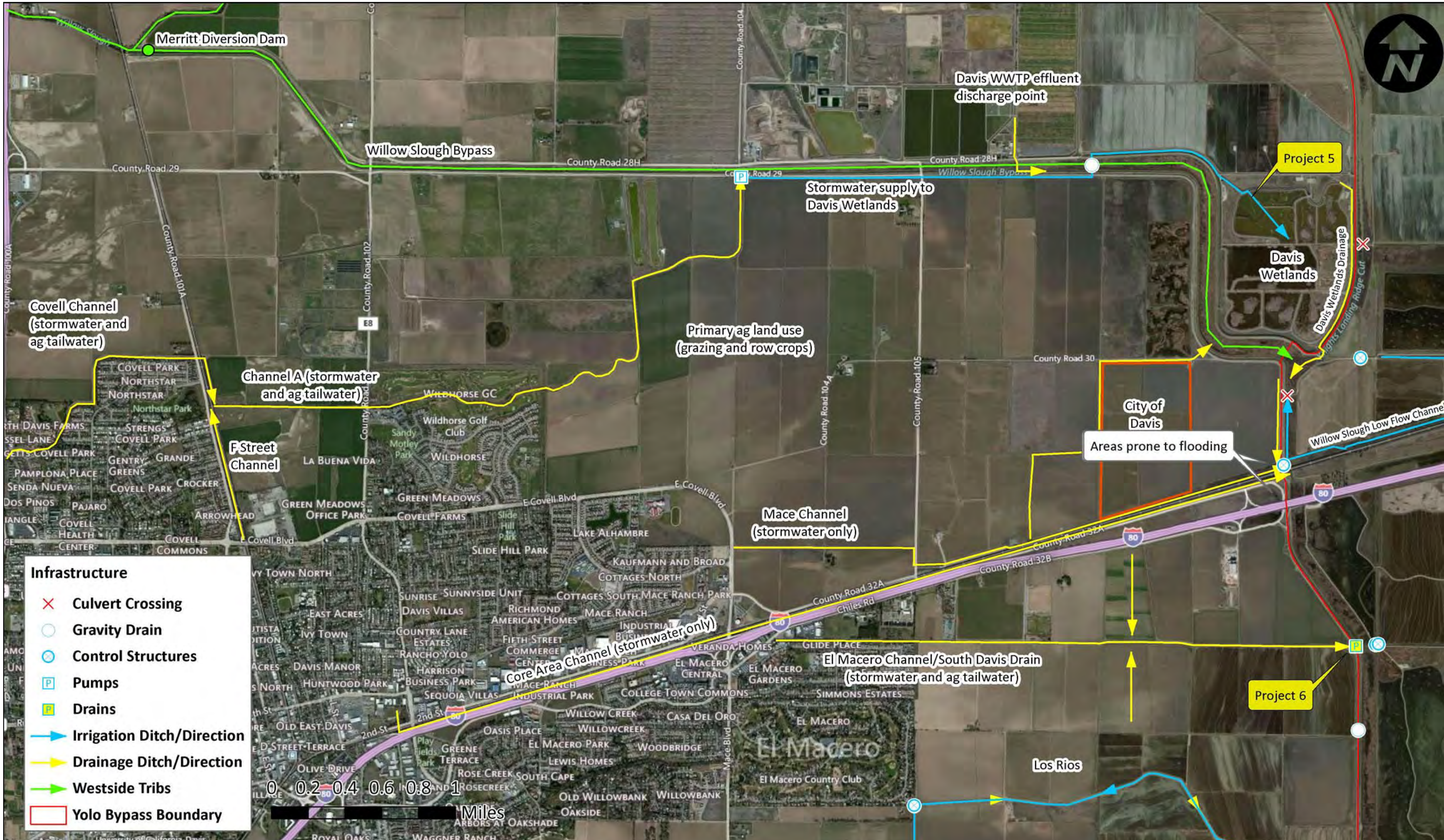
Existing Function and Constraints

South Davis stormwater and agricultural tailwater runoff from surrounding fields are conveyed by the El Macero Channel or South Davis Drain (see Figure 5). This channel runs from Davis to the Yolo Bypass west levee where the El Macero Pumping Station operates two 250 HP pumps and one 40 HP pump during winter months to drain stormwater runoff. It drains agricultural tailwater through the levee into the Bypass. The pumped water can overwhelm the ability of the Yolo Bypass Wildlife Area to drain effectively, creating ponded conditions and wet soil conditions. This can impact access for public use and O&M on some roads on the west side of the Yolo Bypass Wildlife Area. It can also limit the ability to drain as needed for optimum moist soil management. Moist soil management practices are used by Yolo

Bypass Wildlife Area and duck club managers to encourage growth of seed-producing native wetland plants by mimicking seasonal wet and dry cycles of natural wetlands. Moist-soil habitats are wet during spring, dry during summer, and wet again during fall and winter. The Yolo Bypass Wildlife Area system is typically already at capacity when the El Macero pumps are turned on in the winter. These impacts to the system are due to the road configuration, flood time water levels and canal capacity and condition (e.g. location of beaver blockages, vegetation thickness and canal capacity loss due to sedimentation). In addition, if runoff rates exceed the ability of these pumps to convey water into the Yolo Bypass, accumulation can occur on adjacent farmland area and potentially impact winter or early spring farming operations for winter wheat and rice. This scenario is common in many locations in the Yolo Bypass as pumping outside water into the Bypass impacts operations.

Improvements

The suggested improvement at this location near the South Davis Drain includes lowering an existing gravity drainage pipe to relieve flood pressure. With the current configuration, the gravity drain culvert south of the South Davis Drain sits at a relatively high elevation. By lowering this culvert, drainage pressure on the El Macero pumps could potentially be reduced. In addition, this entry point is further south of the main public and O&M access roads to the Yolo Bypass Wildlife Area. Changes to canal configurations (e.g. converting dual function supply and drain canals to separate canals) in the Yolo Bypass Wildlife Area could cause culvert drain lowering at the west levee to be unnecessary. See Section 2.1.4.1 below for more details on Yolo Bypass Wildlife Area operations and suggested improvements and Section 3.2 for details on recommended projects.



Notes: Aerial courtesy of BingMaps 2009.

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Yolo Bypass Drainage and Infrastructure Study

City of Davis to Bypass – Existing Function

Project No. 12-1039 | Created By: AMS | **Figure 5**

2.1.4 SOUTHERN YOLO BYPASS –INTERSTATE 80 TO NORTH OF YOLO RANCH

2.1.4.1 Northern Yolo Bypass Wildlife Area – North of Lisbon Weir

Existing Function and Constraints

The Yolo Bypass Wildlife Area is a 16,770-acre area of farmland, managed wetlands and pasture. The existing supply and drainage infrastructure for this area has been mapped by Ducks Unlimited in coordination with Wildlife Area managers in recent years (Figure 6, Petrik, 2012). The land is managed for multiple uses with varying water supply and drainage needs during the year. There are approximately 6500 acres of managed wetlands located throughout the Yolo Bypass Wildlife Area. Rice farming is done on 1500-acre Glide Causeway Ranch, under a lease with DeWit Farms.

The Toe Drain serves as the main supply source for fall flood up of the managed wetlands from October to December, that is necessary to maintain water levels throughout the winter as well as during the spring and early summer months for moist soil management. Moist soil habitat that produces seed and other food for waterfowl are wet during spring, dry during summer, and wet during fall and winter. The US Army Corps of Engineers initially funded drainage and supply infrastructure facilities and habitat restoration through Section 1135 funds. Ducks Unlimited and the California Waterfowl Association improved the wetlands infrastructure later using grants from the North American Wetland Conservation Act (NAWCA).

Rice grown on Glide Causeway Ranch immediately south of Interstate 80 (located completely within Yolo Bypass Wildlife Area) and bounded to the east and west by managed wetlands, requires spring flooding and fall drainage and then a post-harvest flood up while the adjacent wetlands typically require spring drainage and fall flooding. The Glide Causeway Ranch rice fields are also managed for winter waterfowl and summer shorebird habitat (CDFW, 2008). Coordinating the timing and location of these multiple uses often presents management challenges, especially because several main conveyance pathways function as dual drainage and supply canals (purple arrows on Figure 6).

Beaver blockage removal, vegetation maintenance and sediment removal to maintain conveyance in canals occurs on a weekly to yearly basis depending on specific location and management needs. Canals oriented north-south typically require less maintenance than those oriented east-west due to scouring flows from inundation. Spraying for noxious weeds, including water primrose, occurs twice per year. Removal of silt occurs on an as needed basis. Beaver blockages are removed on an as needed basis, but can be needed weekly or sub-weekly. In the vicinity of the historic railroad trestles in the lower part of the Yolo Bypass Wildlife Area, canal maintenance is particularly challenging due to elevated beaver activity (see Figure 6).

Lisbon Weir creates a tidal backwater pool in the Toe Drain that provides the primary irrigation source for the Yolo Bypass Wildlife Area. Water is lifted by a series of pumps located throughout the Yolo Bypass Wildlife Area as described in the Yolo Bypass Wildlife Area Land Management Plan (CDFW, 2008), denoted in Figure 6. The elevated pool created by the Lisbon Weir holds the water that flows in during high tide. Lisbon Weir consists of a porous rock structure with a crest elevation ranging from 5.0 feet at the crest thalweg to approximately 5.8 feet NAVD88 along the cobble crest as surveyed in the late spring of 2013 by cbec staff. Three steel flapgates to the immediate west of the rock structure trap water at low tides and have an overtopping elevation of approximately 4.7 feet NAVD88.

Lisbon Weir is owned by CDFW and managed and maintained by the Mace Irrigation System agreement (CDFW, and AKT (Los Rios Farms and Alhambra Pacific Joint Venture)). In most years (especially after major flood events), Los Rios performs maintenance operations on the rock structure. An excavator is walked out from the east levee and reclaims cobbles from the pool downstream of the weir placing them back on the crest. This effort typically takes one day with one operator and one supervisor plus planning efforts. The crest elevation of the rock is based on the working knowledge of the managers and operators. Rock is replaced approximately every 4 to 5 years or as needed. This effort takes approximately 2 to 3 days plus planning. The last time rock was replaced, 5 loads were added to the crest. These operations are relatively low cost and easily implemented by Los Rios.

Nine drainage canals convey water toward the Toe Drain between the railroad tracks north of I80 above Lisbon Weir. Two main drainage pathways are open channel connections to the Toe Drain (see Figure 6). One pathway is Putah Creek's straight channel east of the Los Rios Check Dam, a flash-board riser dam. The other pathway is the dual canal north of the Putah Creek outflow with the main lift pumps for the Yolo Bypass Wildlife Area. During periods of flooding, Putah Creek flows out of bank upstream of the Los Rios Check Dam for flows greater than 1,000 cfs with the boards removed, requiring periodic road maintenance within the Yolo Bypass Wildlife Area. The stop logs (or boards) controlling the Los Rios check dam are removed by December 1 each year as mandated by the Putah Creek Accord.

A CEQA analysis for a Lower Putah Creek realignment is currently underway with funding from the California Department of Fish and Wildlife (CDFW) Ecosystem Restoration Program. This grant is managed by the Yolo Basin Foundation (YBF) and is currently in the concept design planning stages. The realignment would move Putah Creek flows through the Tule Ranch south to the tidal wetlands just south of Lisbon Weir. This action is in the Salmonid Biological Opinion, Lower Putah Creek Enhancement (RPA I.6.3)

Several drains have culvert crossings or control structures (sluice gates/stop logs) at the Toe Drain depending on whether the canal functions as a dual supply/drain or solely as a drain. Culvert outfalls to the Toe Drain on the Yolo Bypass Wildlife Area are typically 36 to 48 inches in diameter from main drains and 18 to 24 inches from local field drains.

Public and O&M access during flood periods is a key concern and constraint for Yolo Bypass managers. Specific locations, with low lying road elevations such as the "Rice Corner" and the "Y" on Figure 6, or locations 1 and 2 on Figure A-5, have restricted access during the early stages of flooding. As the Ducks Unlimited (2012) study found, Fremont Weir overtopping impacts public access to the Yolo Bypass Wildlife Area, with an average of 14 days of closures during the duck hunting season from mid-October to January. This is usually followed by 2 to 3 weeks of drying time before public access is resumed.

Drainage from South Davis via the El Macero Channel (South Davis Drain) also contributes to flooding along the main driving route for public and O&M access.

Improvements

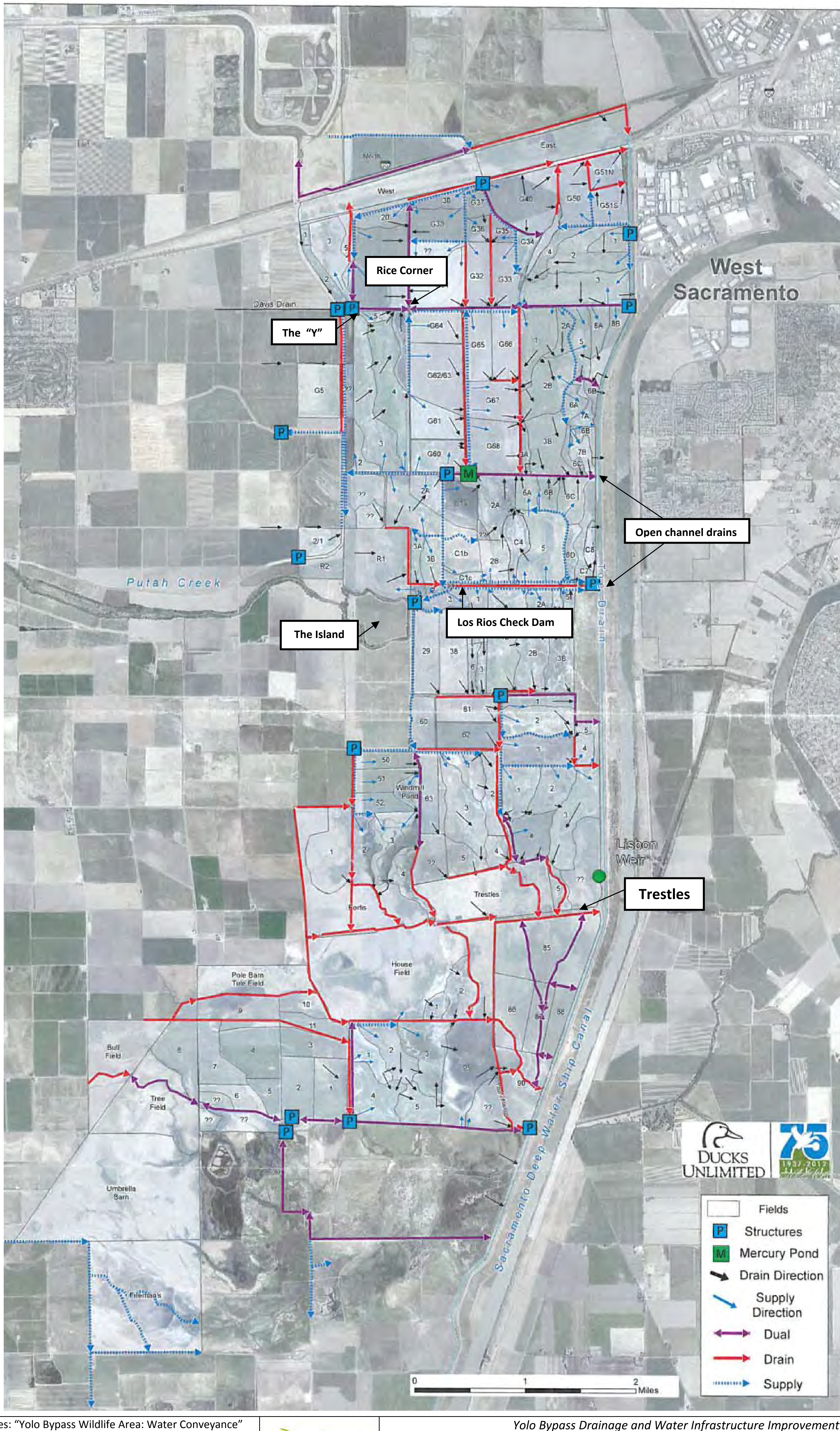
Several improvements have been suggested to benefit the multiple uses within the Yolo Bypass Wildlife Area. The following improvements are summarized in Appendix A, Table A.1 and synthesized into more detailed project descriptions in and Section 3.2.

Suggested O&M improvements include augmenting the gravel on the main public access and O&M roads, raising low roads inundated during early stages of flooding (e.g. at the "Rice Corner"), expansion of the drainage canals and installation of larger diameter culverts along the Toe Drain, and reconfiguration of the dual supply and drainage canals. Reconfiguration of the canals consists of creating separate parallel ditches to facilitate multiple uses with variable temporal and spatial operational needs. Main dual pathways suggested for reconfiguration are prioritized in Appendix A, Figure A-7. In addition, the "Second Lift" along the dual supply to Los Rios has been identified for replacement to improve supply, see Figure A-7.

Improvements to key agricultural crossings will increase access and facilitate equipment crossing. Several agricultural crossings have been identified in prioritized order for improvement and are included in Appendix A, Figure A-10. At the "Rice Corner" and the "Y", low road elevations combined with the convergence of three dual drains and a single supply canal present operational challenges. Reconfiguration would alleviate flooding of roads as well as improve operations of water delivery and drainage. At the existing rail car crossing to the "Island", the rip-rap abutments to the rail car crossing do not support heavy equipment access to the "Island" and need improvement or replacement. At the Los Rios Check Dam, suggested improvements include increasing the maximum load (currently 20 tons) and widening the existing deck (currently 16 feet wide) to facilitate equipment crossing. The existing Check Dam crossing has one handrail; some equipment can only cross in one direction. Equipment typically transported includes: discers, mowers and excavators. Rice production could be planned in the future on the fields immediately south of the Check Dam, thus rice harvesters would also need to be transported. An additional 2 to 4 feet in width on this crossing would improve safety and operations.

Changes at Lisbon Weir could potentially improve summer supply availability or drainage given favorable tides in conjunction with other drainage improvements mentioned above. Potential changes include installing an adjustable height structure as well as more flap gates or easily removable gates, enhancing the gate technology to control gate operations remotely, and increasing the Lisbon pool capacity by dredging or widening the Toe Drain in this vicinity.

Other efforts have also identified Lisbon Weir for improvement, specifically BDCP Conservation Measure 2 Component Project 10: Lisbon Weir Improvements (Phase 1, Category 3 Action) and the NMFS 2009 Biological Opinion RPA Action I.6.4 to improve the reliability of agricultural diversions and reduce maintenance requirements while providing better fish management opportunities in Putah Creek and the Toe Drain (NMFS, Appendix 2A, 2009).



Notes: "Yolo Bypass Wildlife Area: Water Conveyance" Map created and provided by Kevin Petrik, Ducks Unlimited (2012). Specific improvements for the YBWA are given in Appendix A.

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Yolo Bypass Wildlife Area Water Conveyance (Petrik, K., 2012)

Project No. 12-1039	Created By: AMS via DU	**Figure 6**

2.1.4.2 Los Rios Farms

Existing Function and Constraints

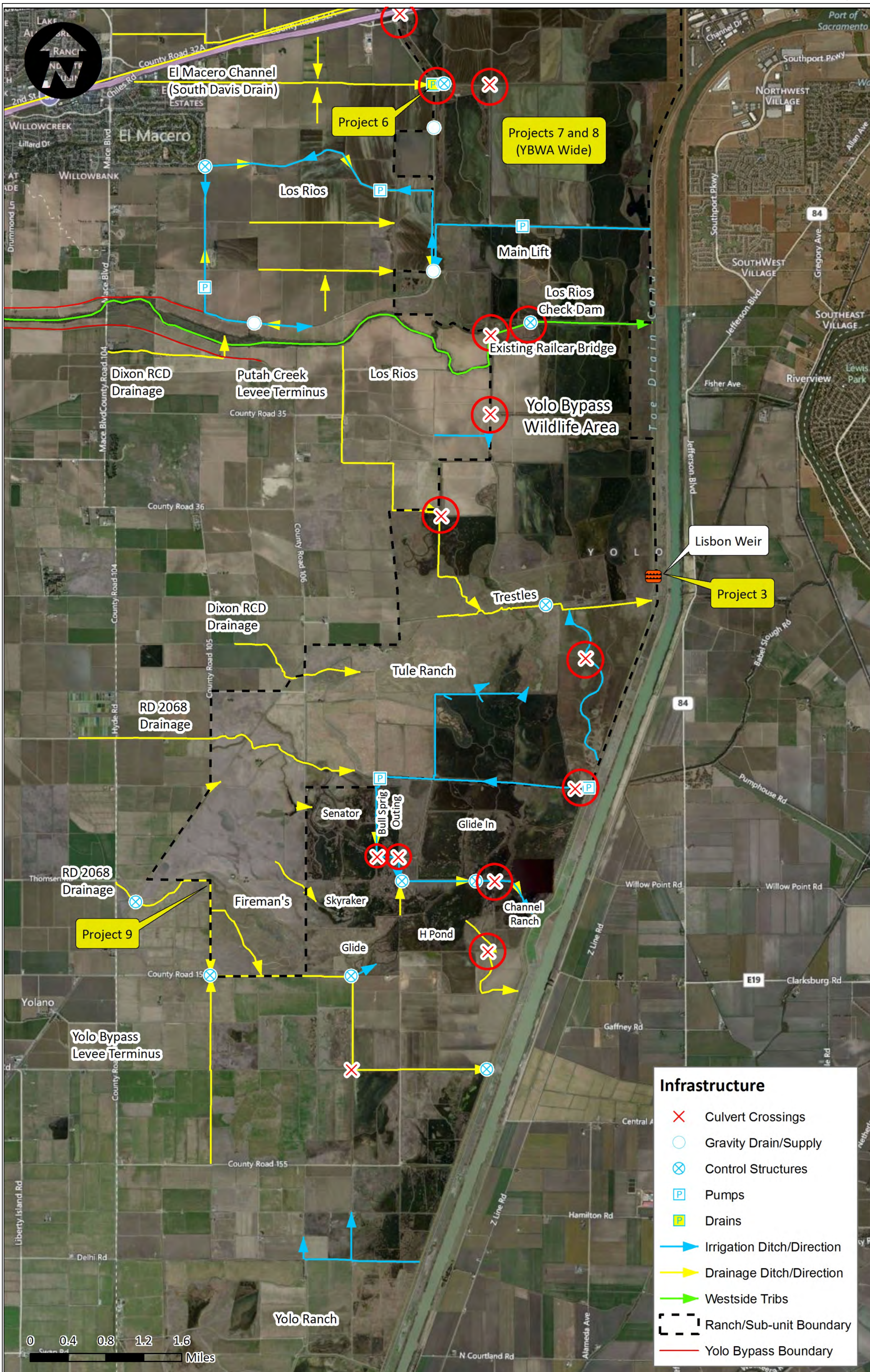
Los Rios Farms owns and manages farmland, seasonal and permanent wetlands, riparian habitat, and grassland communities. Los Rios is located west of the Yolo Bypass Wildlife Area and is bisected by Putah Creek. Los Rios Farms also leases land from CDFW to produce tomatoes, grain crops and rice. Los Rios further grazes cattle north of the trestles on the Tule Ranch as directed by CDFW for vegetation management in wetland ponds and adjacent uplands. Water for these operations is diverted from Putah Creek starting in the spring through July 15th and from the Toe Drain. Well water is also pumped for irrigation.

Summer water from the Toe Drain is lifted at the Main Lift in the Yolo Bypass Wildlife Area (see Figure 7) and moved toward the west levee to irrigate several thousand acres outside the west levee of the Bypass. The pumped water is moved south and through the levee (Figure 7). A dual drain and supply channel runs a loop with a control structure at the corner near the El Macero Country Club. Two central drainage ditches convey tailwater back toward the Yolo Bypass west levee.

The South Davis Drain runs through Los Rios Farms with pumps at the west Bypass levee as discussed in previous sections. A drainage ditch runs along the western levee toe with a drain pipe through the levee and into the Yolo Bypass Wildlife Area approximately 0.5 mile south of the El Macero Pumps.

Improvements

Los Rios Farms irrigation operations could benefit from improvements at Lisbon Weir. In the vicinity of the South Davis Drain, the gravity drain 0.5 mile south of the El Macero Pumps could be modified to a lower elevation to alleviate flood pressure in the region to the north, inside and outside the Bypass. See Table A-1 for a comparative description of the Libson Weir. Improvements to agricultural crossings mentioned in Section 2.1.4.1 (Yolo Bypass Wildlife Area – North of Lisbon Weir, refer to above section), especially the existing railcar crossing over Los Rios Check Dam on Figure 7, could benefit Los Rios drainage. The improvements could facilitate efficient drainage to the Toe Drain and reducing backwater effects that may propagate to the El Macero Pumps and the existing gravity drain. Improvements at the Los Rios Check Dam would also make it possible to bring larger equipment over the crossing.



Notes: Red circles denote agricultural crossings and/or associated structures for improvement under Project 11. Aerial courtesy of BingMaps 2009.

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Southern Yolo Bypass – Existing Function

Project No. 12-1039 | Created By: AMS | **Figure 7**

2.1.4.3 Southern Yolo Bypass Wildlife Area - Tule Ranch

Existing Function and Constraints

The Tule Ranch is an approximately 9,000-acre area located completely within the Yolo Bypass Wildlife Area (CDFW, 2008) south of Putah Creek. Tule Ranch is a combination of pasture, row and field cropland, wetlands, vernal pools and riparian areas. Schene Cattle Company grazes cattle on the Tule Ranch through a lease with CDFW. The area is depicted on the Ducks Unlimited Yolo Bypass Wildlife Area Water Conveyance Map (Petrik, 2012, Figure 6). The water supply to the Tule Ranch is sourced from the Toe Drain below Lisbon Weir or from west side drainage originating from the Dixon RCD drainage system or Reclamation District 2068 (RD 2068) (see Figure 7).

Mechanical vegetation and silt removal are primary management concerns in these areas, as discussed for the northern Yolo Bypass Wildlife Area. Late spring flooding of pastureland drowns out desirable annual rye grass and promotes cockle burr and sweet clover growth. Fields with extensive cockle burr are a nuisance for wetland managers and farmers and have low value for grazing cattle. Cockle burr requires mechanical removal adding to maintenance costs.

Improvements

Tule Ranch operations in the southern Yolo Bypass Wildlife Area would benefit from a Bypass-wide recommendation to replace key agricultural crossings for improved access and drainage and reduced maintenance as well as potential involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A, Table A.1. In addition, a noxious weed program to offset potential changes in the timing and duration of flooding would be favorable to Yolo Bypass Wildlife Area farmers and managers. Finally, Lower Putah Creek Realignment efforts should be considered in conjunction with the suggested improvements to Tule Ranch operations.

2.1.4.4 Southern Duck Clubs

Existing Function and Constraints

Several private duck clubs provide wetland habitat and hunting opportunities south of the Yolo Bypass Wildlife Area. Supply and drainage infrastructure in this area are shown on Figure 7. The Toe Drain serves as the main supply source to flood these fields from October to December during wetland flood-up and hunting season as well as during the spring and early summer months for moist soil management. Additional drainage water from the west flows out of the RD 2068 service area. Drainage within the system proceeds to a main ditch along the northern border of H Pond then through Channel Ranch to the Toe Drain (Figure 7). Several of the drainage and supply infrastructure facilities and other habitat improvements were funded through North American Wetland Conservation Act (NAWCA) grants.

Duck club operations vary from limited (e.g. allowing ponds to evaporate after hunting season) to proactive (e.g. accessing multiple times to clean out canals and remove drain boards) during the spring depending on the ownership. A caretaker for the Senator Duck Club manages water operations on that parcel and to some extent on other parcels. Beavers are very active in the area requiring frequent, sometimes daily, blockage removal especially during fall flood-up and spring drawdown. Vegetation and sediment maintenance are also primary management concerns in this area.

Improvements

Improvements to drainage conditions in this vicinity include enlarging the H Pond drain that exits through Channel Ranch and replacing the downstream-most culvert agricultural crossing on that drain with a railcar crossing (see Figure 7) to open up conveyance during inaccessible periods and reduce maintenance costs. In addition, several drains within the individual parcels could be widened. Since each parcel operates relatively independently, drainage and supply conflicts commonly arise. This area could benefit from the Bypass-wide recommendation for further study, such as identifying the potential to develop a management entity or a mutual water company. In addition, individual owners could potentially benefit from involvement in a Coordinated Maintenance and Improvement Reimbursement Program.

2.1.4.5 Westside Drainage from Dixon RCD

Existing Function and Constraints

The Dixon RCD drainage area conveys winter runoff and agricultural tailwater to two locations leading to the Yolo Bypass (see Figure 7): 1) to Putah Creek through the south Putah Creek levee approximately 1.25 miles downstream of the County Road 104 bridge and 2) into the Pole Barn Tule Field in the Yolo Bypass Wildlife Area (noted on Figure 7). The Dixon RCD drainage area is well upstream of the Yolo Bypass, however, during flood events, water surface elevations in the Yolo Bypass and Putah Creek are elevated so much that they restrict the ability of the two areas listed above to drain efficiently.

Improvements

No specific improvements have been identified. Yolo Bypass land managers' involvement in a Coordinated Maintenance and Improvement Reimbursement Program as suggested for the entire Bypass in Appendix A, Table A.1, however, may improve drainage conditions especially to the Pole Barn Tule Field in the Yolo Bypass Wildlife Area. In addition, Lower Putah Creek Realignment efforts should evaluate future management at the Dixon RCD drainage outfalls.

2.1.4.6 Westside Drainage from RD 2068

Existing Function and Constraints

RD 2068 manages contracts for drainage with Dixon RCD and the Main Prairie Water District in addition to the 13,200 acres within its actual service area. Thus, RD 2068 provides water conveyance for an area of approximately 30,000 acres, the majority of which is outside of the RD 2068 service area. Approximately 2,160 acres or 16% of the 13,200 acres in the RD 2068 service area lie within Yolo County (Figure 7). Four main drains lead to the Yolo Bypass or surrounding area from RD 2068, three of which discharge within Yolo County:

1) At the east end of Hackman Rd. into the Tule Ranch (Yolo Bypass Wildlife Area) with an easement to the Toe Drain
2) At the east end of Midway Rd. via a control structure
3) To Shag Slough via a drainage pumping station at the southern extent of Yolo Ranch
4) To Hass Slough (outside of the Yolo Bypass), primarily during the winter months.

Improvements

Potential supply improvements to benefit RD 2068 and Yolo Bypass Wildlife Area users include the reuse of drainage water within RD 2068 and diversion of excess drain water, when available, for use by CDFW at or near the Midway Road area. Potential users of the RD 2068 recycled drain water need it for early fall and winter flood up. Water is typically available for use in the Yolo Bypass Wildlife Area mid-May through early November. It is most reliable during the irrigation season and during times when storm water is present.

2.2 ADDITIONAL BYPASS WIDE MANAGEMENT CONSIDERATIONS

2.2.1 MOSQUITO ABATEMENT

The control of vectors such as mosquitoes is a Yolo Bypass-wide management concern as the Yolo Bypass is close to population centers. The Sacramento-Yolo Mosquito and Vector Control District (SYMVCD) provides mosquito abatement services to Sacramento County and Yolo County. The SYMVCD operates under a system of Best Management Practices (BMPs) including physical, biological and chemical control. SYMVCD promotes a proactive management approach by meeting with farmers and wetland managers to produce local plans for drainage and maintenance. Additionally, the District provides ditch maintenance equipment and personnel to improve conditions in problematic breeding areas. Maintenance of vegetation and sediment within the Yolo Bypass is a key concern, including maintaining mosquito fish swales for biological control and disking fields in mosaic patterns to promote clumps of cattail rather than large stands. The reduction of pesticide use is also a key management goal.

A few locations within or near the Yolo Bypass have been identified as problematic drainage areas by the SYMVCD. The first is on the Colusa Drain at the Yolo-Colusa County Line near Dunnigan. During rice water drainage in August/September within the Colusa Drain outside of Yolo County, approximately 3 to 4 weeks before the Yolo Bypass farmers drain irrigated rice fields to prepare for harvest, the Wallace Weir backwater causes water to back up into the Teal Ridge Duck Club property and requires mosquito abatement actions (see Figure 8A). The second is near the constriction under the Interstate 80 causeway on the Toe Drain (see Figure 8B). The third is on the duck clubs in the southern Bypass where supply and drainage are limited by a lack of the cooperative water management system between several landowners (see Figure 8C). Actions described in Section 3 and Appendix A may help improve drainage conditions in these areas and potentially reduce the need for mosquito abatement activities.

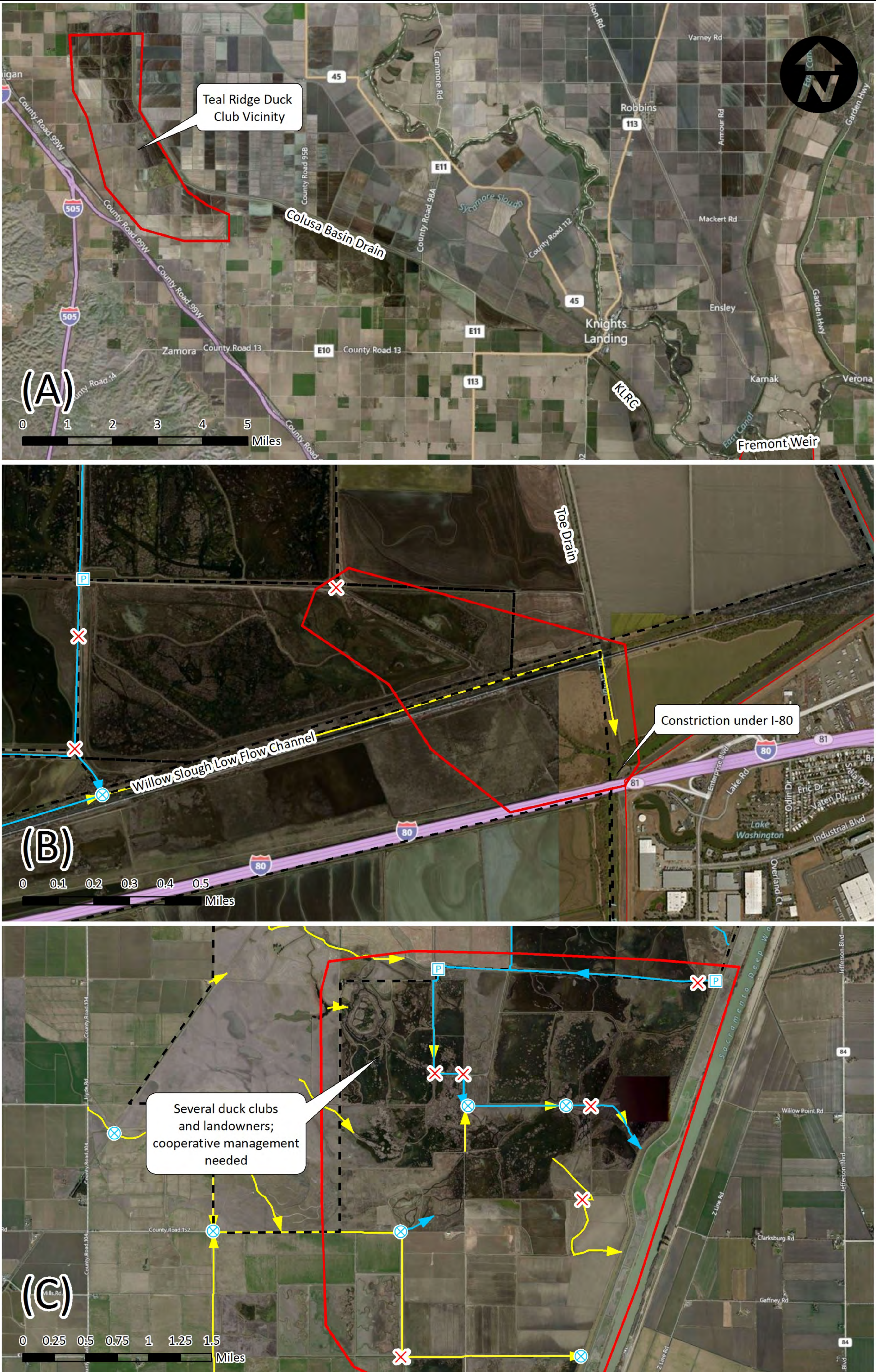
2.2.2 METHYLMERCURY PRODUCTION

Methylmercury (MeHg) is a bioavailable neurotoxin to living organisms. It is present in the sediment and waterways of the Sacramento – San Joaquin River Delta. The biogeochemical processes driving mercury transport and transformations in surface waters are complicated, involving transport from air, tributaries, and sediments. Processes include methylation and demethylation in water and sediments, sediment-associated transport, and bioaccumulation in complex food webs.

The Central Valley Regional Water Quality Control Board developed requirements for the Sacramento – San Joaquin Delta Estuary Methylmercury Total Maximum Daily Load (TMDL), to ensure that discharges to the Sacramento – San Joaquin River Delta have acceptable or lower concentrations of methylmercury (MeHg). The Board planned implementation in two phases. Phase 1, initiated October 2011 with expected completion of October 2020, is intended to focus on studies and pilot projects to develop management practices to control MeHg inputs into the Delta. Phase 2, intended to begin in 2022 and complete in 2030, will focus on implementing methylmercury control programs for dischargers as well as inorganic mercury reduction programs (Water Board, 2011).

To develop a Control Study workplan for the Phase 1 TMDL requirements, the Delta Methylmercury TMDL Nonpoint Source Workgroup for Managed Wetlands and Irrigated Agriculture (NPS Workgroup) was formed. The NPS Workgroup has recently produced reports synthesizing existing data, identifying key knowledge gaps, and proposing management strategies for the future. These reports include *Knowledge Base for Nonpoint Sources Methylmercury Control Study* (August, 2012), as well as the *Methylmercury Control Study Workplan Outline* (September 2012), which plans to prioritize studies based on issues of concern and provide guidance on developing cost-benefit analyses.

MeHg issues are important to consider during potential project implementation as future changes to agricultural discharge management will likely be required with TMDL implementation. In addition, future changes to the Yolo Bypass flooding regime as a result of BDCP CM2 or other actions may affect methylation rates or spatial distribution. Pulsed systems (e.g. seasonal wetlands and floodplains) tend to methylate more than tidal wetlands, which typically show net zero methylation (Stephen McCord, personal communication). The degree to which patterns like this can be managed by land use type is still under development by the NPS Workgroup.



Notes: Locations were identified based on past abatement efforts in these areas. Aerial courtesy of BingMaps 2009.

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Yolo Bypass Drainage and Water Infrastructure Improvement Study

Drainage Concerns for SYMVCD

Project No. 12-1039	Created By: AMS	**Figure 8**

3 SELECTED PROPOSED IMPROVEMENTS

3.1 SUMMARY OF RECOMMENDED PROJECTS AND STUDIES

On April 9, 2013, the study team held a meeting to discuss specific improvements suggested by interested stakeholders during individual outreach meetings. The purpose of this meeting was to ask for stakeholder feedback regarding the identified improvements and to verify the initial findings of the study. Following that meeting, the study team continued to collaborate with additional participants by phone and email correspondence, as well as follow up with additional questions based on the initial findings. Table A-1 summarizes the main improvements identified as potentially beneficial to supply and drainage infrastructure.

As part of an initial effort to assess relative priority, the study team used feedback from participants and research into the potential benefit, permitting requirements and rough cost estimates, among other factors, for the recommended projects. Projects recommended through this study are intended to benefit agriculture and managed wetlands drainage and supply operations; however, potential overlap with existing efforts in the Yolo Bypass intended to improve fish habitat was considered for coordination purposes. These efforts include proposed measures in the BDCP's CM 2, the NMFS 2009 Biological Opinion RPAs I.6 and I.7, USBR and DWR Yolo Bypass Salmonid Habitat Restoration and Fish Passage EIR/EIS and the Fish Restoration Program Agreement between CDFW and DWR.

Appendix A provides one-page project summaries of twelve Recommended Projects from Table A.1. Some projects were suggested during the interview process and may provide unique opportunities to improve drainage and supply conditions in the Yolo Bypass for agricultural and wetland operations. Some projects overlap with concurrent efforts to improve fish habitat in the Bypass as noted in Table A.1 (e.g. BDCP, RPAs I.6 and I.7, and the Fish Restoration Program Agreement). The projects are separated into location-specific improvements (Projects 1 through 9) and Bypass-wide improvements (Projects 10 through 12). Additionally, four studies were identified for future analysis as described in Table A.1 and listed below. Details regarding the studies are provided in Table A.2.

Recommended Projects (RP) include:

- RP-1: Wallace Weir Improvements
- RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
- RP-3: Lisbon Weir Improvements
- RP-4: Conaway Main Supply Canal Augmentation
- RP-5: Davis Wetlands Water Supply
- RP-6: South Davis Drain Input Reconfiguration
- RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
- RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
- RP-9: Stormwater and Summer Tailwater Re-Use and Supply
- RP-10: Local Agricultural Crossing Improvements

- RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency
- RP-12: Westside Tributaries Monitoring

Recommended Studies (RS) include:

- RS-1: Bypass Sedimentation Rate Changes due to Managed Flooding
- RS-2: Vegetation Management with Increased Frequency and Duration of Flooding
- RS-3: Plan to Manage Beaver Canal Damage and Obstructions
- RS-4: Management Entity Model

The projects and studies listed above are described in more detail in the following section.

3.2 DETAILS OF RECOMMENDED PROJECTS

The study team is recommending each of these projects as a result of conversations with landowners, farmers, wetland managers and other stakeholders in the Yolo Bypass, based on existing constraints and improvements described in Section 2 above. A brief description of each project is provided below.

3.2.1 RP-1: Wallace Weir Improvements

(See Project Sheet RP-1 in Appendix A)

Replacement of the existing earthen Wallace Weir will allow for greater year-round control of water surface elevation within the KLRC and Colusa Basin Drain. It is an aging structure and the earthen section must be installed and removed on a yearly basis, using very labor-intensive methods to meet requirements for flood conveyance in the Bypass. The current system does not optimize irrigation on up to 4,000 acres in the Yolo Bypass north of Interstate 5. The Wallace Weir is also the southernmost structure in the Colusa Basin Drain/KLRC. The next control structure upstream in this water system is the Davis Weir located at the southeast corner of the Colusa National Wildlife Refuge, forty miles upstream from the Wallace Weir. The historical Davis Weir was replaced with an operable bladder dam in 2010 by Glenn Colusa Irrigation District (GCID), which gives the GCID the capacity to control flow recirculation within their district. Upgrades to the Wallace Weir would make it possible to more easily balance water levels with the Davis Weir.

Upgrading Wallace Weir will allow for coordination of the two weirs, improving system performance and providing multiple management benefits in terms of the ability to balance water levels and flows between the two weirs. It will also allow water to be managed for potential fisheries and waterfowl habitat south of Wallace Weir. The existing configuration could be replaced with a gated structure. Sliding gates could augment the operation of the weir and a permanent access road crossing could be installed on top of the structure. The new weir could consist of a series of tilt up gate structures, or flash boards, spanning the majority of the channel. These could be lifted easily at time of flow regulation for irrigation purposes. At the end of the irrigation season, the gates could be lowered or removed for the purposes of flood conveyance. On one side of the channel, three sluice gate structures could be installed to provide flow regulation for irrigation. Alternatively, a more automated, but more costly, method could be implemented using a rubber bladder dam.

3.2.2 RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements

(See Project Sheet RP-2 in Appendix A)

Four agricultural structures currently span the Tule Canal, to provide agricultural access for farm machinery from the west to the east of the Tule Canal and impound water for irrigation. In the winter, some of these structures are washed out due to higher flood flows in the Yolo Bypass and must be replaced every spring. Existing agricultural crossing structures include multiple small diameter culverts placed in the channel and backfilled with earth/granular material to allow machinery access. Existing structures include re-buildable earthen crossings for RD 1600 at the north end of Tule Canal and for Swanston Ranch just south of the Sacramento Bypass. A 25-foot wide canal at the property line between the Fremont Weir State Wildlife Area and TeVelde Ranch conveys water supply eastward towards the northerly earthen crossing on the Tule Canal, at which point a pipe through the levee delivers water by gravity to RD 1600 east of the Bypass levee. This feature is washed out by flood flows and is sometimes blocked by beaver activity. The Swanston Ranch structure includes an earthen dam with culverts and flashboard risers with a rock base to secure the culverts in the Tule Canal after the earthen fill is removed or washed out. Additionally, various minor crossings exist for east-west access tracks that could also be included in the improvement plans, as shown on the project sheet for RP-2.

Improvements could include placement of concrete or bottomless arch culverts (ARMCO or similar), with a larger diameter than the existing structure, overlaid with more permanent road access built from granular road-base or asphalt material. Replacement with more permanent solutions would reduce maintenance activities for farmers, improve fish passage along the Tule Canal/Toe Drain, and drainage of wetlands in certain areas.

3.2.3 RP-3: Lisbon Weir Improvements

(See Project Sheet RP-3 in Appendix A)

Currently the Lisbon Weir consists of a 100-foot wide rock weir placed across the Toe Drain in the southern Yolo Bypass. It is a critical part of the irrigation system for surrounding agricultural land and wetlands. Annual maintenance of the rock weir is necessary when it is degraded by flood flows. Sometimes maintenance is hampered by excessive flows in the Toe Drain. In conjunction with three tide (flap) gates on the west side, the rock weir is used to regulate upstream water levels. The weir creates the pool that serves as the first lift for the pumps that raise the water supply for farming and filling managed wetlands. The series of three flap gates allows flood tides to surcharge the Toe Drain upstream of the weir. Ebb tides are able to pass back over the weir if surcharge elevations exceed the weir crest elevation. While the flap gates on the west side of the weir allow for some fish passage upstream on a flood tide, fish may benefit from additional passage improvements.

Improvements could include placement of an operable variable height weir (Obermeyer or similar) approximately 100 feet wide, similar to the Davis Weir in Colusa County (GCID). Concrete sidewalls/abutments would be required. Agricultural and wetland benefits could occur due to greatly reduced frequency of maintenance and improved temporal control of upstream water levels. The existing flap gates could be replaced with a more fish-passage friendly design.

3.2.4 RP-4: Conaway Main Supply Canal Augmentation

(See Project Sheet RP-4 in Appendix A)

A substantial portion of the water supply for the 17,000-acre Conaway Ranch comes from the Sacramento River via the Conaway Main Supply Canal. Existing high velocity flow scours holes in an earthen berm south of the main supply canal (see Figure A-4), particularly during Bypass flooding. Regular maintenance (preferably before the irrigation season in April) is needed to repair the berm and ensure canal integrity, but is dependent on local drainage conditions and access. Future increases in flooding frequency (as proposed by elements of the Central Valley Flood Protection Plan (CVFPP), RPA Action 1.6.1., and the Bay Delta Conservation Plan (BDCP)) could increase maintenance and repair frequency or make maintenance difficult prior to the irrigation season. If inundation duration is extended as proposed, the inability to adequately maintain the earthen berm could jeopardize the water supply for large farming operations.

Improvements could include repair/replacement of up to 7,900 linear feet of ditch from the Toe Drain, heading west to the western boundary of the Bypass. Proposed methods could include re-grading the ditch, filling scour holes, and re-lining the ditch with reinforced gunite/concrete lining. An alternative project is also proposed to replace the open ditch with three-celled, 6-feet-tall by eight-foot-wide (3 cells x 6’ x 8’) box culvert. This latter project would minimize filling of the conveyance with silt and sand from Yolo Bypass flows. Access points (manholes) would be constructed along the facility to allow for inspection and maintenance, as necessary. Benefits could include substantially improved water supply reliability for agriculture and reduced maintenance costs.

3.2.5 RP-5: Davis Wetlands Water Supply

(See Project Sheet RP-5 in Appendix A)

The existing supply to the Davis Wetlands originates from agricultural tailwater and stormwater from the City of Davis. This is part of a treated wastewater effluent system. As such, the wetlands are inundated for periods at any time of the year. In contrast, typically, managed wetlands in the Bypass are only flooded from November to March. The ability to pump water out of Channel A up to a smaller canal that routes water from the south side of the Willow Slough Bypass to the north side and into the Davis Wetlands is constrained. During the summer and fall months, the water is too low in the channel for the pump as designed. Channel conveyance capacity is a secondary issue in the winter months. Once the stormwater ponds fill to a certain level, water backs up into the conveyance channel and overflows at low areas. The current conveyance configuration can also result in poor water quality entering the Bypass and flooding at the Swanston Ranch west levee access. Future supply may be reduced from some city sources due to updated wastewater discharge requirements.

Improvements include capturing first flush events during the October-November period by reconfiguring the pump design to lift water from Channel A to the Davis Wetlands supply canal. This reconfiguration would also enhance access to the summertime agricultural irrigation runoff, improving existing habitat and potentially helping to treat some of the sediments or other constituents resulting from the runoff. The size of the channels could be increased to improve conveyance in the winter months.

Capturing fall first flush events and summer agricultural runoff would primarily benefit the lower aquatic ecosystems (i.e. lower levels of potential sediments and nutrients to benefit aquatic species). Other benefits include increased habitat availability for waterfowl and shorebirds in the existing wetlands. Additionally, west levee access could potentially be improved if upstream conveyance to the Davis Wetlands is upsized.

3.2.6 RP-6: South Davis Drain Input Reconfiguration

(See Project Sheet RP-6 in Appendix A)

The west Yolo Bypass levee creates a drainage barrier that requires frequent pumping, leading to flooding issues both in and outside of the Yolo Bypass. The City of Davis has a pump station (Southeast Davis Drain Pumps) that is used to lift drain water into the Bypass at a cost to the city. Drainage is poor along the west Bypass levee for farm fields just west of the levee. A drainage ditch at the west levee toe runs parallel to the levee. The closeness of this ditch potentially compromises the levee stability. Drain pumping during storm runoff and during times of high agricultural runoff creates flooding problems for the Yolo Bypass Wildlife Area, flooding roads and restricting public access. Continuous high flows related to agricultural runoff make management of water levels in adjacent wetlands difficult. Managing water levels in these ponds is key to creating high quality habitat during the winter and fall months. Future increased inundation and an elevated Toe Drain Canal surface could continue to impede drainage from west to east.

There is an existing gravity drain pipe through the west levee near the South Davis drain pumps. It is placed too high for adequate gravity drainage. A new drain pipe at the appropriate elevation could be installed for drainage when the Bypass is not flooded. Another alternative would be to dig a new drain ditch along the west levee. A low lift pump could be installed to recycle the drain water into an existing farm irrigation canal. The new drain ditch could be located so that it does not jeopardize the west levee. The drain ditch would greatly reduce the city of Davis' pumping costs, improve farm field drainage, improve levee stability, and reduce Yolo Bypass Wildlife Area flooding.

3.2.7 RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration

(See Project Sheet RP-7 in Appendix A)

The existing system was originally designed for agricultural operations with several dual supply/drain canals that can cause issues for coordinated water management in a multi-use area. The system currently, however, also supplies and drains water for managed wetlands in the YBWA. When agricultural operations need water supply for irrigation, wetlands may need to drain. Such circumstances create a situation where it is not possible to manage wetland ponds individually.

Individual management of ponds is a key feature to creating diverse habitat while also managing vegetation, minimizing mosquito larvae populations and controlling avian disease during specific times of the year. Existing drain outlet elevations and tides at Lisbon Weir dictate how rapidly drainage can occur. If Toe Drain surface water levels are elevated as a result of future increases in the duration and frequency of Yolo Bypass flooding, drainage from west to east would be further impeded.

Improvements could include rehabilitating existing canals and constructing new drainage and supply canals to facilitate wetland and farming operations, especially in early spring. Timing of wetland drawdown in early spring is important for the germination of nutritious wetland plants and is also important for controlling mosquito populations. Timing is also critical for controlling the germination and growth of noxious weeds. Quick drainage following flooding is important for public access and operation and maintenance of facilities. Canal improvement will accelerate the winter flood up of managed wetlands and therefore improve early season migratory bird habitat. A faster flood up also would allow for removal of the Los Rios check dam prior to the December 1 deadline to improve access to the creek for fall run Chinook salmon. A more detailed feasibility analysis will be required to fully identify which canals will need to be reconfigured.

3.2.8 RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

(See Project Sheet RP-8 in Appendix A)

The existing elevations along roadways at the “Rice Corner” and “Y” restrict public access during early stages of flooding (see Figure A-8). These are important access points for public use and operation and maintenance of water supply and drainage structures. These roads flood as Toe Drain levels rise making the entire west side of the YBWA (4,600 acres) inaccessible for public use even during relatively small flood events. Not all existing operation and maintenance roads are gravel or all-weather roads that allow access immediately after a flooding event. Future increases in the duration and frequency of flooding will increase the need for maintenance of these roads as flood waters recede. The Discover the Flyway program for schools relies on access to the west side of the YBWA. The number of students served by the program decreases even during relatively small flood events. The impact will increase if the duration and frequency of flooding increases. Access to the west side of the YBWA is also important for other public uses including hunting and wildlife viewing.

Improvements include raising access roads and surfacing with “all-weather” materials as shown on Figure A-8. Benefits include improved public and operation and maintenance access.

3.2.9 RP-9: Stormwater and Summer Tailwater Re-Use and Supply

(See Project Sheet RP-9 in Appendix A)

The existing configuration of canals and pumps does not maximize water supply to potential contracted users when available as a result of winter storms or summer tailwater runoff since it is not possible to transfer, divert, or pump water efficiently to various parts of the system using the current infrastructure. Improvements include several control structure installations or upgrades, one pump station installation and one upgrade, as well as canal creation and improvements. Benefits include improved summer and/or winter supply to potential contracted users, and potential habitat and water quality improvements.

3.2.10 RP-10: Local Agricultural Crossing Improvements

(See Project Sheet RP-10 in Appendix A)

Existing local agricultural crossings consist of rudimentary culvert and fill materials that require persistent maintenance to minimize blockages due to beaver activity and invasive aquatic vegetation. Certain existing agricultural crossings experience access restrictions during flood events.

Improvements to culvert crossings include replacing existing crossings with clear span decks consisting of either rail car bridges or other structural techniques. Benefits include reduced maintenance costs, improved water delivery, drainage for agriculture and managed wetlands, and improved conveyance during flooding and low water operations. Control of mosquito populations may also improve. Landowners and wetland managers indicated that rail car bridges generally are less likely to be blocked by beaver dams than culverts. Improvements to water control structures may consist of similar clear span decks with concrete abutments with the addition of sluice gates or flashboard riser combination gates. These gates can be removed in the winter for improved drainage by creating a larger flow conveyance area.

3.2.11 RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

(See Project Sheet RP-11 in Appendix A)

Existing agricultural operations and wetland managers control vegetation and siltation in irrigation and drainage canals at landowners' expense even though the Yolo Bypass provides system wide benefits as part of the Sacramento River Flood Control project. Existing agriculture and managed wetland canals, crossings, fields and pumps require frequent maintenance, including removal of silt, invasive aquatic vegetation, and beaver blockages. Removal of flood debris on bridges, crossings, streambanks, and fields is also necessary after large flood events. Future increased inundation and frequency of flooding could increase maintenance needs and costs incurred to landowners and managers.

Landowners could participate in the maintenance and improvement program through a state funded reimbursement process. Or, the state or special district could hire a dedicated labor force and purchasing equipment through grants or other funding sources. The program would need to be managed by one or two full time staff, probably a general manager, and a labor/engineering supervisor. If the program includes a dedicated labor force, operating costs could significantly increase. Alternatively, a Yolo Bypass "Keeper" approach could be adopted, similar to the Putah Creek Streamkeeper, a position created by the Putah Creek Accord in 2000. System-wide benefits would include improved conveyance during flooding, improved water supply operations for proposed fish habitat management, improved drainage of lands on the receding limb of the hydrograph, and improved access during and after flood events. Public and private landowners in the Bypass would benefit from reduced maintenance costs and improved access.

3.2.12 RP-12: Westside Tributaries Monitoring

(See project sheet RP-12 in Appendix A.)

Since westside tributary inflows play an important role in Bypass inundation, understanding the timing and magnitude of inflows is needed to determine their relative influence compared to larger inflows from the Fremont and Sacramento Weirs. Better data is needed to synthesize past and future hydrology datasets for the purposes of modeling existing conditions and future management scenarios. For example, discussion on future management scenarios has included the consideration of modifying the inundation regime for the Yolo Bypass during flood events. In terms of balancing habitat and agricultural objectives, the magnitude, frequency, duration, timing, depth, area, and rate of change of floodplain inundation are all critical parameters to understand thoroughly. The westside tributary inflows affect these parameters significantly. A brief summary of available data for each tributary is provided below:

- Flow estimates entering the Yolo Bypass at Knights Landing Ridge Cut (KLRC), were approximated prior to 2009 based on Colusa Drain flows at Highway 20, rough rainfall runoff estimates for the un-gauged portion of Colusa Basin, and flows to the Sacramento River via the Knights Landing Outfall Gates (Outfall Gates). This resulted in flow estimates with large uncertainty. In 2009, flow gauging on KLRC downstream of the Outfall Gates (CDEC ID RCS) was initiated by DWR North Central Region Office (NCRO).
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin). This resulted in flow estimates with large uncertainty. Beginning in 2009, the USGS gauged total outflows from the Settling Basin. Flow measurements for Cache Creek are based solely on the USGS gauge on Cache Creek where water enters the western side of the Bypass. These measurements do not account for storage or attenuation in the Settling Basin.
- Data for flows entering the Yolo Bypass via the Willow Slough Bypass are based on scaled Interdam Runoff estimates for Putah Creek since the Willow Slough Bypass has never been gauged.
- Flows entering the Yolo Bypass at Putah Creek are based on Putah Diversion Dam (PDD) total outflow (low flow plus flood flow releases) 20 miles upstream along with seepage loss estimates and conditional criteria when Monticello Dam is spilling. Only low flows (i.e., less than 100 cfs) are gauged on Putah Creek by Solano County Water Agency (SCWA) downstream of PDD at several locations.
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin). This resulted in flow estimates with large uncertainty. Beginning in 2009, the USGS gauged total outflows from the Settling Basin. Flow measurements for Cache Creek are based solely on the USGS gauge on Cache Creek where

water enters the western side of the Bypass. These measurements do not account for storage or attenuation in the Settling Basin.

A summary of improvements and potential benefits for each tributary follows. See Appendix B for more details:

- Knights Landing Ridge Cut: DWR NCRO should continue the RCS monitoring program, continue to refine the low flow rating curve, and extend the rating curve for flows above 1,600 cfs. Future funding for continued monitoring at this location needs to be confirmed with DWR. In addition, a more accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- Cache Creek: In addition to operating the USGS gauging station just downstream of I-5, the USGS should continue monitoring the total outflow from the Cache Creek Settling Basin. Future funding for continued monitoring at this location should be confirmed with the USGS. In addition, a more accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- Willow Slough Bypass: The main recommendation here is to install flow and stage monitoring stations along the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy using scaled Interdam Runoff can be validated and potentially modified.
- Putah Creek: The US Bureau of Reclamation and Solano Irrigation District (SID) Putah Diversion Office (PDO) have been monitoring and recording flows on Putah Creek between Monticello Dam and Lake Solano. More recently, SCWA has been monitoring low flows (i.e., less than 100 cfs) and stages at eight stations along Putah Creek from the PDD to Los Rios Check Dam primarily during the growing season to verify fish pulse flows. Locations within the Yolo Bypass are not suitable for flow rating above 100 cfs due to backwater conditions from the Toe Drain. It is recommended that monitoring is expanded at the I-80 station by rating it for higher flows for historical verification and for use in future modeling efforts. It is also recommended that the outflows to Putah Creek (i.e., releases and flood flows) be reported and archived on a subdaily time step rather than just daily. Further validation of the Interdam Runoff (between Monticello Dam and Putah Diversion Dam) is also recommended.

The tributary inflows to the Bypass are extremely important elements of any future studies. Currently, inflows for all these tributaries are estimates at best. Westside tributary inflows play a major part in inundation of the Bypass prior to the Fremont Weir spilling. It is critical to better understand their relative contribution, so that future monitoring and modeling studies accurately represent realistic inundation conditions in the Bypass.

3.3 DETAILS OF RECOMMENDED STUDIES

3.3.1 RS-1: Bypass Sedimentation Rate Changes due to Managed Flooding

Future increased duration and frequency of flooding could increase sedimentation rates. Stakeholders have expressed interest in a better understanding of the potential for increased sedimentation in canals and associated increased maintenance efforts and costs.

This study would develop a methodology and assess existing sedimentation rates in the Toe Drain/Tule Canal, and existing ditches throughout the Bypass. Future potential changes to sediment rates could potentially be inferred from hydrologic data and model results. Sedimentation near west side tributaries should be considered, as east side flooding could impact velocities and settling rates upstream.

3.3.2 RS-2: Vegetation Management with Increased Frequency and Duration of Flooding

Farming practices in the Yolo Bypass help maintain waterways and keep fields free of woody riparian vegetation, directly benefiting the flood conveyance function of the entire system. Future conversion of agricultural lands to habitat other than managed wetlands could lead to vegetation proliferation at unknown rates in the designated floodway and potential for more manual vegetation thinning to maintain flood conveyance.

This study would develop a methodology to assess the type and growth patterns of vegetation on lands within a managed flooding context similar to proposed scenarios under CM2 or other scenarios. In the study the following could also be assessed: 1) changes in forage value of wetland and grassland plants, 2) effect on the growth of vegetation needed for nesting cover, 3) effect on conveyance capacity and 4) maintenance of ditches.

3.3.3 RS-3: Plan to Manage Beaver Canal Damage and Obstructions

Beavers can damage or impede drainage and supply pathways by blocking water control structures with lodge construction and creation of burrows. Existing water supply and drainage operations remove mammal blockages and damage to canals as needed. This study would develop a plan to improve protocols and resources for managing beaver impacts to water systems.

3.3.4 RS-4: Management Entity Model

Coordinated water management, especially between smaller private landowners operating land for similar uses (e.g. small private duck clubs), poses a challenge. Some landowners have begun the mutual water company development process to facilitate efficient use of resources and management activities based on per/acre assessment fees. This study would develop a model of a coordinated water management plan for landowners and other Bypass stakeholders.

3.4 PRELIMINARY PROJECT PRIORITIZATION

The study team prioritized these projects based on the team's knowledge and familiarity with the Yolo Bypass, results of the quantitative and qualitative assessments performed on each project, and input from stakeholders. In a stakeholder meeting held on October 11, 2013, participants reviewed the preliminary priorities and ranking system and provided comments. The team made changes to the priorities where appropriate based on feedback both at the stakeholder meeting and subsequent follow up. It should be noted that these priorities are designed to provide guidance only. A project can move forward, regardless of priority, only if funding is available and the landowner is willing. The projects also may change as a result of further conversations with landowners, farmers, wetland managers, resource managers and state and federal agencies.

3.4.1 Prioritization Methodology

The study team identified 14 criteria on which to rate the recommended projects. Criteria were either subjective, based on study team experience and conversations with stakeholders, or quantitative, based on current available data. Criteria are listed in priority order based on the goal of this study: to identify drainage and water infrastructure improvements in the Yolo Bypass that benefit farmers and wetlands managers. The Bypass has a complex set of operational and management constraints and functions, however, so the study team considered additional criteria. Three tiers were created. The tiered criteria are listed below, and are ranked in a tabular matrix on each individual project sheet in Appendix A for RP-1 through RP-12:

- Tier 1
    - Agricultural benefit: an overall assessment of a combination of several criteria such as the ability to irrigate and drain more efficiently, access and maintain land, and prepare land for growing crops and harvest.
    - Migratory waterfowl or shorebird benefit: an overall assessment of a combination of several criteria such as the ability to flood up and drain habitat at various seasonal intervals, access and maintain land.
- Tier 2
    - "Shovel readiness": an assessment of the amount of feasibility or design preparatory work needed to begin the project.
    - Ease of permitting: an assessment of the anticipated complexity of obtaining the permits required to construct or implement the project.
    - Potential for matching funding: an assessment of the potential to obtain matching funding for agencies or entities with potentially mutual interests in the project.
    - Eligibility for grants: an assessment of the potential for grant funding to construct the project from agencies or other entities.
    - Estimated benefit acreage: a preliminary quantitative estimate of the number of acres that could potentially benefit from project implementation.
    - Cost estimate: a preliminary quantitative estimate of project implementation costs based on preliminary project descriptions.

- Tier 3
  - Flood benefit: an assessment of perceived project potential to reduce flood impacts. Lower flood stage and reduced maintenance costs.
  - Listed species benefit: an assessment of perceived project potential to benefit listed species.
  - Public benefit: an assessment of perceived acres of project wetlands for public hunting, bird watching, etc.
  - Water quality benefit: an assessment of perceived project potential to benefit or improve water quality of tributaries and supply sources or existing Yolo Bypass water bodies.
  - Other environmental benefit: an assessment of perceived project potential to benefit ecological or environmental resources in the Yolo Bypass.

The tiered criteria in each project sheet RP-1 through RP-12 were ranked as either 1) not benefiting the Yolo Bypass, 2) benefiting the Yolo Bypass to some degree (low, medium or high) or 3) unknown benefit at this time. The number of each criteria ranking was summed up in Appendix A, Table A.1, which lists all tiered criteria and projects for an overall project ranking.

3.4.2 Preliminary Prioritization Results

The following projects are recommended in priority order from 1 to 12. 1 is the highest priority and 12 is the lowest priority. This prioritization is based on the total counts of high only. However, it is important to emphasize that ALL projects are recommended for completion but the process outlined here is an attempt to prioritize in case funding is insufficient to complete all projects imminently. See Figure 9 for the summary or rankings from Appendix A, Table A.1:

High priority projects:

1. RP-7: Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration
1. RP-8: Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements
3. RP-6: South Davis Drain Input Reconfiguration
3. RP-10: Local Agricultural Crossing Improvements
3. RP-11: Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

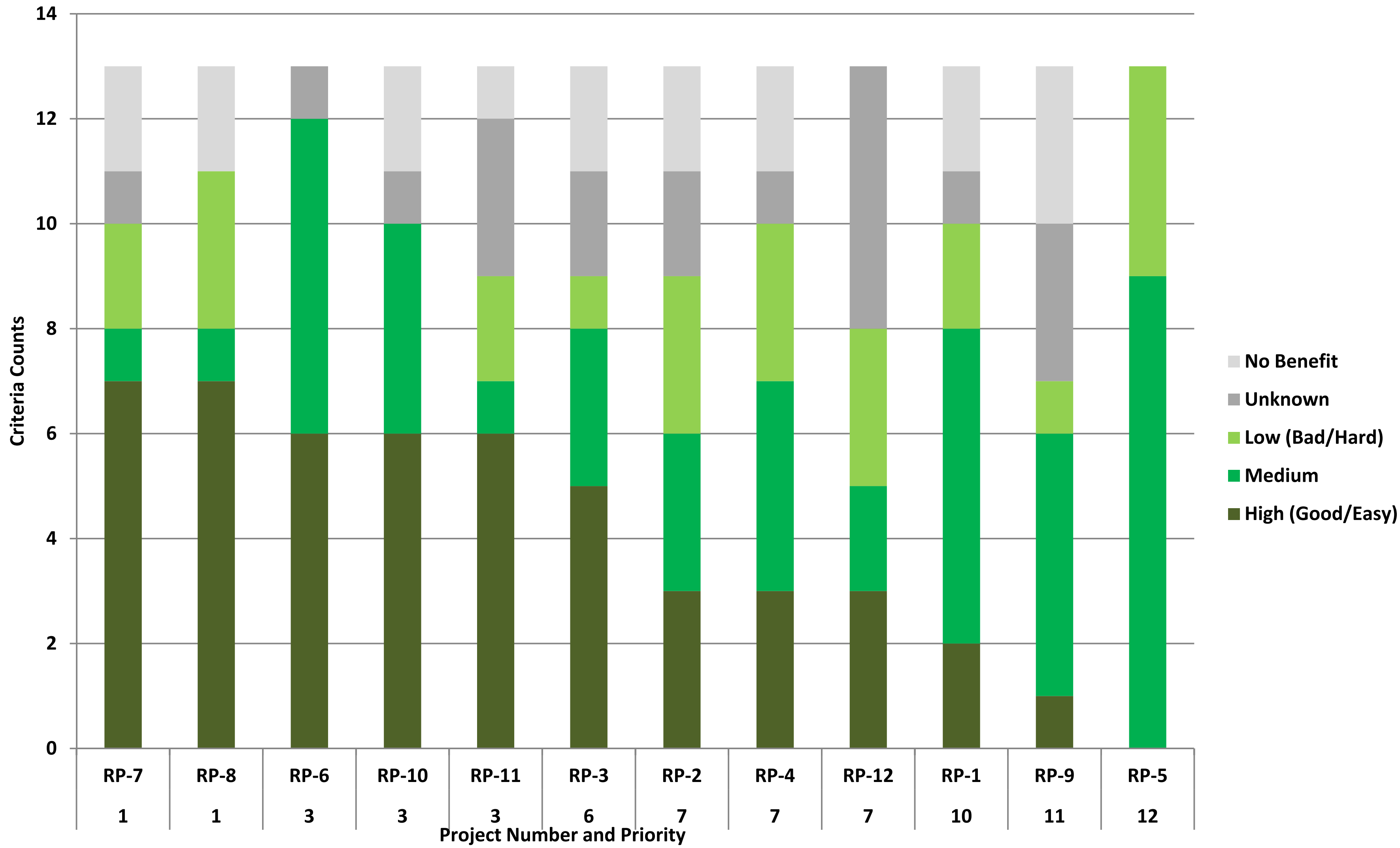
Medium priority projects:

6. RP-3: Lisbon Weir Improvements
7. RP-2: Tule Canal Agricultural Crossing/Water Control Structure Improvements
7. RP-4: Conaway Main Supply Canal Augmentation
7. RP-12: Westside Tributaries Monitoring

Low priority projects:

10. RP-1: Wallace Weir Improvements
11. RP-9: Stormwater and Summer Tailwater Re-Use and Supply
12. RP-5: Davis Wetlands Water Supply Improvements

These projects should all be recommended to funding agencies in order to accelerate projects with potential benefit to farmers, wetland managers, the environment, and the public generally. These projects should also be considered for addition to the Project List supported by the Coalition for Delta Projects.



Notes: Listed by sum of high counts from Appendix A, Table A.1

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Preliminary Project Prioritization Results

Project No. 12-1039	Created By: AMS	**Figure 9**

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5 LIST OF PREPARERS

April Sawyer, B.S., Ecohydrologist
Chris Bowles, Ph.D., P.E., Project Manager
Chris Campbell, M.S., Technical Review
Petrea Marchand, Study Team Review
Robin Kulakow, Study Team Review
Doug Brown, Study Team Review

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Manny Bahia, DWR
John Brennan, Knaggs Ranch
Ann Brice, Yolo Basin Foundation
Doug Brown, Douglas Environmental, consultant to Yolo County
Kent Calfee, Swanston Ranch Duck Club
John Currey, Dixon Resource Conservation District
Jack DeWit, DeWit Family Farms
Bill Fleenor, UCD
Dick Goodell, Glide-In Ranch
Mike Hall, Conaway Ranch
Mike Hardesty, RD 2068
Larry Jahn, Los Rios Farms
Marianne Kirkland, DWR
Robin Kulakow, Yolo Basin Foundation
Spencer Larson, Yolo Bypass Wildlife Area, CDFW
Mike Lear, Swanston Ranch
Petrea Marchand, Consero Solutions, consultant to Yolo County
Stephen McCord, McCord Environmental
John McNerney, City of Davis Public Works
Kevin Petrik, Ducks Unlimited
Paul Phillips, California Waterfowl Association
Chris Rocco, Yolo Bypass Wildlife Area, CDFW
Dave Rodriguez, City of Davis Public Works
Tom Schene, Schene Cattle Company
Greg Schmid, Los Rios Farms
Marty Scholl, Sacramento Yolo Mosquito and Vector District
Jeff Stoddard, Yolo Bypass Wildlife Area, CDFW
Robyn Suddeth, UCD
Bob Swanston, Swanston Ranch
Eric TeVelde, Landowner
John Whitcombe, Swanston Ranch, Duck Club

APPENDIX A

RECOMMENDED PROJECT AND STUDY SUMMARIES AND PRIORITIZATION

YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY

Prioritization Matrix
April 2014

Priority of Criteria	PROJECT METRIC	RP-1 – Wallace Weir Improvements	RP-2 – Tule Canal Agricultural Crossings/Water Control Structure Improvements	RP-3 – Lisbon Weir Improvements	RP-4 – Conaway Main Supply Canal Augmentation	RP-5 – Davis Wetlands Water Supply	RP-6 – South Davis Drain Input Configuration	RP-7 – Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration	RP-8 – Yolo Bypass Wildlife Area Public and Operations and Maintenance Road Improvements	RP-9 – Stormwater and Summer Tailwater Re-Use and Supply	RP-10 – Local Agricultural Crossing Improvements	RP-11 – Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency	RP-12 – Westside Tributaries Monitoring
		Recommended Project											
1	Agricultural benefit [1]	M	M	H	H	L	H	H	H	M	H	H	L
1	Migratory waterfowl or shorebird habitat benefit [2]	M	No	H	H	M	H	H	H	M	H	H	L
2	"Shovel readiness" [3]	No	No	No	No	L	M	M	H	L	M	No	M
2	Ease of permitting [4]	M	H	M	M	M	M	H	H	H	H	M	L
2	Potential for local matching funding [5]	M	U	U	U	M	H	L	L	U	M	L	H
2	Eligibility for grants [6]	H	H	M	L	M	M	H	H	U	H	U	H
2	Estimated benefit acreage [7]	M	M	H	H	M	H	H	H	U	H	H	H
2	Cost estimate [8]	M	M	M	M	M	M	L	M	M	M	M	M
3	Flood benefit [9]	L	L	L	L	M	H	H	No	M	M	H	U
3	Listed species benefit	H	H	H	M	L	M	U	No	No	U	U	U
3	Public benefit (hunting, education, access, etc) [10]	No	L	H	M	M	H	H	H	M	H	H	U
3	Water quality benefit	L	L	No	L	M	M	No	L	No	No	U	U
3	Other environmental benefit	U	U	U	No	L	U	No	L	No	No	L	U
	High (Good/Easy)	2	3	5	3	0	6	7	7	1	6	6	3
	Medium	6	3	3	4	9	6	1	1	5	4	1	2
	Low (Bad/Hard)	2	3	1	3	4	0	2	3	1	0	2	3
	Unknown	1	2	2	1	0	1	1	0	3	1	3	5
	No (Benefit)	2	2	2	2	0	0	2	2	3	2	1	0
	Final Ranking [11]	**10**	**7**	**6**	**7**	**12**	**3**	**1**	**1**	**11**	**3**	**3**	**7**

[1] Agricultural benefit is an overall subjective assessment of a combination of several criteria such as the ability to irrigate and drain more efficiently, access and maintain land, and prepare land for growing crops and harvest.

[2] Migratory waterfowl or shorebird habitat benefit is an overall subjective assessment of a combination of several criteria such as the ability to flood up and drain habitat at various seasonal intervals, access and maintain land.

[3] Low "shovel readiness" means that little preparatory work (feasibility or design) has been undertaken. High means that designs could quickly and easily be produced.

[4] Ease of permitting relates to the overall anticipated complexity of obtaining the permits required to construct the project (High is easier).

[5] Low < 10%, 10% < Medium < 30%, High > 30%

[6] Low < 10%, 10% < Medium < 30%, High > 30%. Matching funds from landowners, local government or other organizations.

[7] Low < 3,000 acres, 3,000 acres < Medium < 6,000 acres, High > 6,000 acres acres must be in Yolo County.

[8] For Cost Estimate evaluation criteria, H, or High (Good/Easy), means that the cost is low. L, or Low (Bad/Hard), means that the cost is high. Low > $3,000,000 and $3,000,000 > Medium > $100,000 and High < $100,000.

[9] Lower flood stage. Reduced maintenance costs.

[10] Acres of project wetlands for public hunting, bird watching, etc.

[11] Ranking based on high criteria.

BDCP1675 TABLE A.2

YOLO BYPASS DRAINAGE AND WATER INFRASTRUCTURE IMPROVEMENT STUDY:

Recommended Studies
April 2014

Number	Study Name	Description of Existing and Future Need	Study Components
RS - 1	Bypass Sedimentation Rate Changes due to Managed Flooding	• Future increased inundation area, duration and frequency of flooding could increase sedimentation rates	• Develop methodology and study existing sedimentation rates in the Toe Drain/Tule Canal and existing ditches throughout the Bypass. • Sedimentation near west side tributaries should be considered, as east side flooding could impact velocities and settling rates upstream.
RS - 2	Vegetation Management with Increased Frequency and Duration of Flooding	• Future conversion of agricultural lands to habitat other than managed wetlands could allow vegetation proliferation at unknown rates in the designated floodway	• Develop methodology and study the type and growth patterns of vegetation on lands within a managed flooding context similar to current proposed scenarios. - Assess changes in forage value of wetlands and grassland plants. - Assess the effect on the growth of vegetation needed for nesting cover. - Assess the effect on carrying capacity/maintenance of ditches.
RS - 3	Plan to Manage Beaver Canal Damage and Obstructions	• Beavers can impede drainage and supply pathways with lodge construction and creation of burrows • Existing water supply and drainage operations remove mammal blockages damage to canal as needed.	• Develop a plan to improve protocols and resouces for managing beaver impact to water systems.
RS - 4	Management Entity Model	• Coordinated water management, especially between smaller private landowners operating land for various or similar uses poses a challenge • Some landowners in the Yolo Bypass have begun this process in to facilitate efficient use of resources and management activities based on per acre assessment fees	• Develop guidelines for landowners interested in establishing a Mutual Water Company or other management entity.

Recommended Project 1 (RP-1):

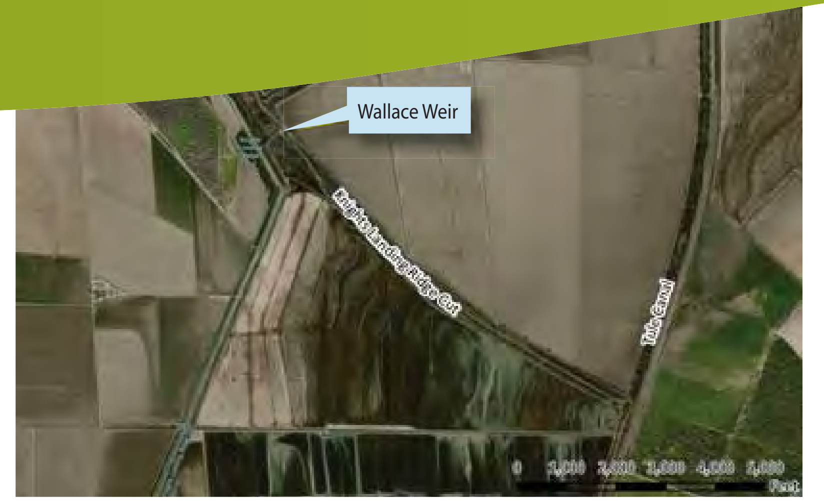
Wallace Weir Improvements

Location:

Terminus of the (Knights Landing) Ridge Cut (KLRC) and west levee of the Yolo Bypass (Bypass), approximately three miles north of Interstate 5 and five miles northeast of the City of Woodland.

Recommendations:

Replace or modify the existing Wallace Weir earthen and concrete structure used to manage irrigation flows from the KLRC into the Bypass with a sluice gate structure.



Description of Problem:

Replacement of the existing earthen Wallace Weir will allow for greater year-round control of water surface elevation within the KLRC and Colusa Basin Drain. It is an aging structure and the earthen section must be installed and removed on a yearly basis, using very labor-intensive methods to meet requirements for flood conveyance in the Bypass. The current system does not optimize irrigation on up to 4,000 acres in the Yolo Bypass north of Interstate 5. The Wallace Weir is also the southernmost structure in the Colusa Basin Drain/KLRC. The next control structure upstream in this water system is the Davis Weir located at the southeast corner of the Colusa National Wildlife Refuge, forty miles upstream from the Wallace Weir. The historical Davis Weir was replaced with an operable bladder dam in 2010 by Glenn Colusa Irrigation District (GCID), which gives the GCID the capacity to control flow recirculation within their district. Upgrades to the Wallace Weir would make it possible to more easily balance water levels with the Davis Weir.

Description of Improvements and Potential Benefit:

Upgrading Wallace Weir will allow for coordination of the two weirs, improving system performance and providing multiple management benefits in terms of the ability to balance water levels and flows between the two weirs. It will also allow water to be managed for potential fisheries and waterfowl habitat south of Wallace Weir. The existing configuration could be replaced with a gated structure. Sliding gates could augment the operation of the weir and a permanent access road crossing could be installed on top of the structure. The new weir could consist of a series of tilt up gate structures, or flash boards, spanning the majority of the channel. These could be lifted easily at time of flow regulation for irrigation purposes. At the end of the irrigation season, the gates could be lowered or removed for the purposes of flood conveyance. On one side of the channel, three sluice gate structures could be installed to provide flow regulation for irrigation. Alternatively, a more automated, but more costly, method could be implemented using a rubber bladder dam.

RECOMMENDED PROJECT #1	Wallace Weir Improvements					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit			X			Improved spring water supply availability. Balancing water with Davis Weir.
Migratory waterfowl or shorebird habitat benefit			X			Improved control for seasonal habitat flooding.
"Shovel readiness"	X					Needs completion of feasibility study and design.
Ease of permitting			X			This project would require CEQA compliance, likely in the form of a Negative Declaration or an Environmental Impact Report, although it may qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). This project would also likely require a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, and an Encroachment Permit from the Central Valley Flood Protection Board.
Potential for local matching funding			X			Landowners benefiting from the project may be willing to contribute matching funds.
Eligibility for grants				X		Multi-benefit aspects of project, benefits outside of Yolo County, and availability of matching funds will increase eligibility for grants.
Estimated benefit acreage			X			Over approximately 4,000 acres in Bypass.
Cost estimate			X			Up to $500,000 if series of sluice gates used. For a more automated and sophisticated approach, the project could cost up to $1,700,000.
Flood benefit		X				Improvements to the weir may increase the rate of draining after bypass inundation.
Listed species benefit				X		Will minimize upstream passage of listed fish species into the KLRC to prevent stranding. Improved control for seasonal inundation could provide Bypass fish habitat.
Public benefit (hunting, education, access, etc)	X					Improvements to the weir may increase the rate of draining after bypass inundation.
Water quality benefit		X				Some reduction in turbidity caused during current removal of earthen berm.
Other environmental benefit					X	

Potential Benefit Region: Colusa Basin, agriculture in Yolo Bypass north of I5, fish farming activities at Knagg Ranch, TeVelde Ranch, Sacramento River Ranch & RD1600 users.

Potential Partners: Conaway Ranch, Glenn Colusa Irrigation District, Knagg Ranch, Cal Marsh and Farm Ventures, California Trout, California Waterfowl Association

Potential Constraints: Coordination with operation of Davis Weir by Glenn Colusa Irrigation District (GCID).

Estimated Cost and Proposed Funding Source(s): $500,000 to $1,700,000 depending on type of structure.

Potential Implementation Timeline: Moderate (3-5 years).

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

Recommended Project 2 (RP-2):

Tule Canal Agricultural Crossing/ Water Control Structure Improvements

Location:

Four locations along Tule Canal within the Yolo Bypass, north of Interstate 80.

Recommendations:

Replace current agricultural crossings with more permanent solutions.

Figure A-2. Tule Canal/Toe Drain crossings and control berms

Description of Problem:

Four agricultural structures currently span the Tule Canal to provide agricultural access for farm machinery from the west to the east of the Tule Canal and impound water for irrigation. In the winter, some of these structures are washed out due to higher flood flows in the Yolo Bypass and must be replaced every spring. Existing agricultural crossing structures include multiple small diameter culverts placed in the channel and backfilled with earth/granular material to allow machinery access. Existing structures include re-buildable earthen crossings for RD 1600 at the north end of Tule Canal and for Swanston Ranch just south of the Sacramento Bypass. A 25-foot wide canal at the property line between the Fremont Weir State Wildlife Area and TeVelde Ranch conveys water supply eastward towards the northerly earthen crossing on the Tule Canal, at which point a pipe through the levee delivers water by gravity to RD 1600 east of the Bypass levee. This feature is washed out by flood flows and is sometimes blocked by beaver activity. The Swanston Ranch structure includes an earthen dam with culverts and flashboard risers with a rock base to secure the culverts in the Tule Canal after the earthen fill is removed or washed out.

Description of Improvements and Potential Benefit:

Improvements could include placement of concrete or bottomless arch culverts (ARMCO or similar) with larger diameter than the existing structure, overlaid with more permanent road access built from granular road-base or asphalt material. Replacement with more permanent solutions would reduce maintenance activities for farmers, improve fish passage along the Tule Canal/Toe Drain, and drainage of wetlands in certain areas.

RECOMMENDED PROJECT #2	Tule Canal Agricultural Crossing Improvements					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit			X			Reduced maintenance costs. More reliable access to fields. Improved drainage of fields after inundation event.
Migratory waterfowl or shorebird habitat benefit	X					
"Shovel readiness"	X					Needs completion of design, but should be relatively straightforward.
Ease of permitting				X		These agricultural crossings would require CEQA compliance but would likely qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). If the construction includes disturbance within the watercourse, they may require a Streambed Alteration Agreement from the California Department of Fish and Wildlife and a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers. An Encroachment Permit from the Central Valley Flood Protection Board may also be required.
Potential for local matching funding					X	Need to have further discussion with landowners.
Eligibility for grants				X		Multi-benefit aspect of projects, as well as current interest from DWR's Fish Passage Improvement Program, will increase eligibility for grants.
Estimated benefit acreage			X			Approximately 2,000 to more than 5,000 acres.
Cost estimate			X			Total = $2,330,000: 3 x 90' railcar crossings @ $108,600 each = $325,800; 2 gates – 25' wide = $100,000; Swanston Crossing will need an Obermeyer weir and a crossing above it, with fish-friendly flap gates. Assume costs similar to Lisbon Weir improvements, plus a little more excavation, and concrete work for abutments of railcar crossing - $1.9M
Flood benefit		X				Reduced risk of blockage of Tule Canal.
Listed species benefit				X		Improved fish passage.
Public benefit (hunting, education, access, etc)		X				
Water quality benefit		X				Some minor reduction in turbidity since frequent replacement will not be required.
Other environmental benefit					X	

Potential Benefit Region: Lands within Yolo Bypass from I-80 to Fremont Weir.

Potential Partners: Yolo Bypass landowners from I-80 to Fremont Weir.

Potential Constraints: Replacement of crossing structures will require careful consideration of fish passage design requirements to maximize habitat and swimming conditions.

Estimated Cost and Proposed Funding Source(s): $2,330,000.

Potential Implementation Timeline: Short (1-3 years).

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

Recommended Project 3 (RP-3):

Lisbon Weir Improvements

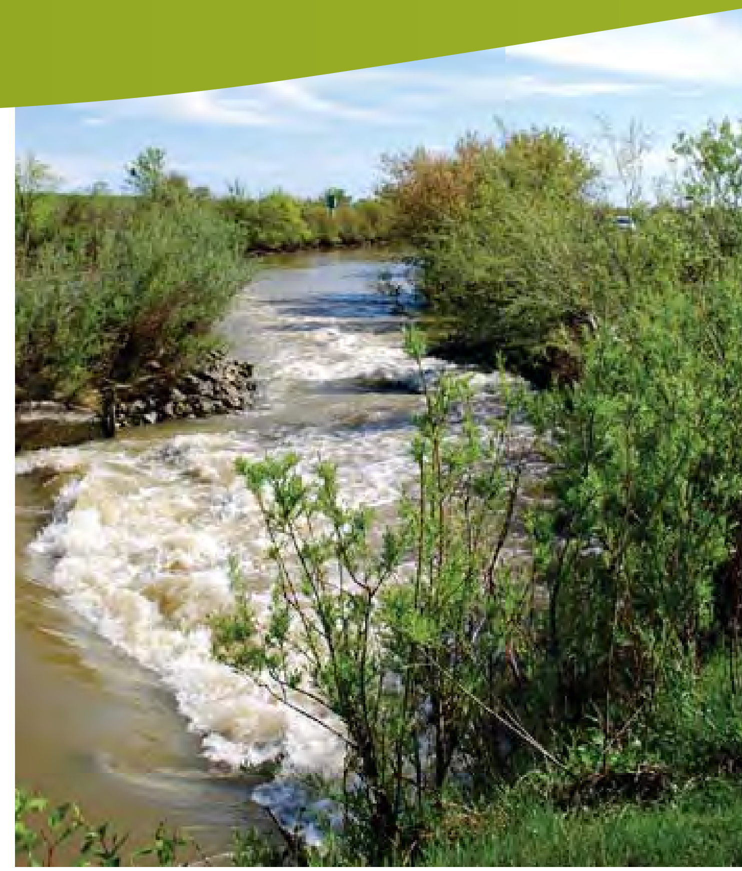
Location:

The Toe Drain adjacent to Yolo Bypass Wildlife Area, approximately 6.5 miles south of Interstate 80.

Recommendations:

Replace current rock weir with operable variable height weir and improved flap gates.

Figure A-3. Lisbon Weir area



Description of Problem:

Currently the Lisbon Weir consists of a 100-foot wide rock weir placed across the Toe Drain in the southern Yolo Bypass. It is a critical part of the irrigation system for surrounding agricultural land and wetlands. Annual maintenance of the rock weir is necessary when it is degraded by flood flows. Sometimes maintenance is hampered by excessive flows in the Toe Drain. In conjunction with three tide (flap) gates on the west side, the rock weir is used to regulate upstream water levels. The weir creates the pool that serves as the first lift for the pumps that raise the water supply for farming and filling managed wetlands. The series of three flap gates allows flood tides to surcharge the Toe Drain upstream of the weir. Ebb tides are able to pass back over the weir if surcharge elevations exceed the weir crest elevation. While the flap gates on the west side of the weir allow for some fish passage upstream on a flood tide, fish may benefit from additional passage improvements.

Description of Improvements and Potential Benefit:

Improvements could include placement of an operable variable height weir (Obermeyer or similar) approximately 100 feet wide, similar to the Davis Weir in Colusa County (GCID). Concrete sidewalls/abutments would be required. Agricultural and wetland benefits could occur due to greatly reduced frequency of maintenance and improved temporal control of upstream water levels. The existing flap gates could be replaced with a more fish-passage friendly design.

RECOMMENDED PROJECT #3	Lisbon Weir Improvements					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Improved supply for farming and managed wetland operations. Possible improved drainage on receding limb of hydrograph.
Migratory waterfowl or shorebird habitat benefit				X		Improved supply for managed wetland operations.
"Shovel readiness"	X					A feasibility study conducted in close coordination with local landowners is needed to identify alternatives and determine benefits to agriculture, wetlands and fish passage.
Ease of permitting			X			This project would require CEQA compliance, likely in the form of a Negative Declaration or an Environmental Impact Report, although it may qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). This project would also likely require a Streambed Alteration Agreement from the California Department of Fish and Wildlife, a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, and an Encroachment Permit from the Central Valley Flood Protection Board.
Potential for local matching funding					X	Need to have further discussions with landowners.
Eligibility for grants			X			Multi-benefits aspect of project and benefits to Yolo Wildlife Area increase eligibility for grants.
Estimated benefit acreage				X		Approximately 21,000 acres (16,000 - YBWA, 2,000 – AKT and 3,000 – Los Rios)
Cost estimate			X			$1,700,000 - $2,500,000
Flood benefit		X				Improved management could improve drainage on receding limb of hydrograph.
Listed species benefit				X		Improved fish passage.
Public benefit (hunting, education, access, etc)				X		Improved drainage to facilitate public and O&M access.
Water quality benefit	X					
Other environmental benefit					X	

Potential Benefit Region: Lands upstream of Lisbon Weir using Toe Drain water for irrigation. Fish passage upstream of Lisbon Weir.

Potential Partners: DWR. Landowners (Los Rios Farms, AKT Farms and Yolo Basin Wildlife Area).

Potential Constraints: Fish passage optimization. Replacement of crossing structures will require careful consideration of fish passage design requirements to maximize habitat and swimming conditions.

Estimated Cost and Proposed Funding Source(s): $1,700,000 - $2,500,000.

Potential Implementation Timeline: Moderate (3-5 years).

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

Recommended Project 4 (RP-4):

Conaway Main Supply Canal Augmentation

Location:

Conaway Ranch immediately south of County Road 22, in the Yolo Bypass.

Recommendations:

Concrete line a section of the main supply canal. Alternately, pipe main supply across the Bypass in this location.

Figure A-4. Conaway Main Supply Canal area

Description of Improvements and Potential Benefit:

Improvements could include repair/replacement of up to 7,900 linear feet of ditch from the Toe Drain, heading west to the western boundary of the Bypass. Proposed methods could include re-grading the ditch, filling scour holes, and re-lining the ditch with reinforced gunite/concrete lining. An alternative project is also proposed to replace the open ditch with three-celled, 6-feet-tall by eight-foot-wide (3 cells x 6' x 8') box culvert. This latter project would minimize filling of the conveyance with silt and sand from Yolo Bypass flows. Access points (manholes) would be constructed along the facility to allow for inspection and maintenance, as necessary. Benefits could include substantially improved water supply reliability for agriculture and reduced maintenance costs.

Description of Problem:

A substantial portion of the water supply for the 17-acre Conaway Ranch comes from the Sacramento River via the Conaway Main Supply Canal. Existing high velocity flow scours holes in an eastern berm south of the main supply canal (see Figure A-4), particularly during Bypass flooding. Regular maintenance (preferably before the irrigation season in April) is needed to repair the berm and ensure canal integrity, but is dependent on local drainage conditions and access. Future increases in flooding frequency (as proposed by elements of the Central Valley Flood Protection Plan (CVFPP), RPA Action 1.6.1, and the Bay Delta Conservation Plan (BDCP) could increase maintenance and repair frequency or make maintenance difficult prior to the irrigation season. If inundation duration is extended as proposed, the inability to adequately maintain the earthen berm could jeopardize the water supply for large farming operations.

RECOMMENDED PROJECT #4	Conaway Main Supply Canal Augmentation					
Project Metric	No	Yes Low	Yes Med	Yes High	Un-known	Comments
Agricultural benefit				X		Improved supply reliability. Reduced maintenance costs.
Migratory waterfowl or shorebird habitat benefit				X		Improved supply reliability. Reduced maintenance costs.
"Shovel readiness"	X					Feasibility study and design completion necessary.
Ease of permitting			X			This project would require CEQA compliance, likely in the form of a Categorical Exemption or a Negative Declaration, although it may qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). This project would also likely require a Streambed Alteration Agreement from the California Department of Fish and Wildlife, a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, and an Encroachment Permit from the Central Valley Flood Protection Board. Since the canal may be GGS habitat, mitigation may be required at additional cost.
Potential for local matching funding					X	Need to discuss with Conaway Ranch owners.
Eligibility for grants		X				
Estimated benefit acreage				X		Up to and potentially exceeding 17,000 acres.
Cost estimate		X				$5,200,000 for 7,900 linear feet (approximately $660,000 per 1000 linear feet) of open, concrete lined channel. $22,212,000 for culvert option.
Flood benefit		X				
Listed species benefit			X			Improved water supply management for seasonal inundation to provide bypass fish habitat.
Public benefit (hunting, education, access, etc)			X			Landowners currently allow docent-led tours and other educational activities.
Water quality benefit		X				Lower turbidity water due to less channel erosion and scour.
Other environmental benefit	X					

Potential Benefit Region: Conaway Ranch, City of Davis.

Potential Partners: Conaway Ranch, City of Davis.

Potential Constraints: Environmental issues related to permitting of construction project through potentially sensitive habitats. Availability of funding.

Estimated Cost and Proposed Funding Source(s): $5,200,000 for 7,900 linear feet (approximately $660,00 per 1000 linear feet) of open concrete lined channel. $22,212,000 for culvert option.

Potential Implementation Timeline: Long (5+ years).

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

Recommended Project 5 (RP-5):

Davis Wetlands Water Supply

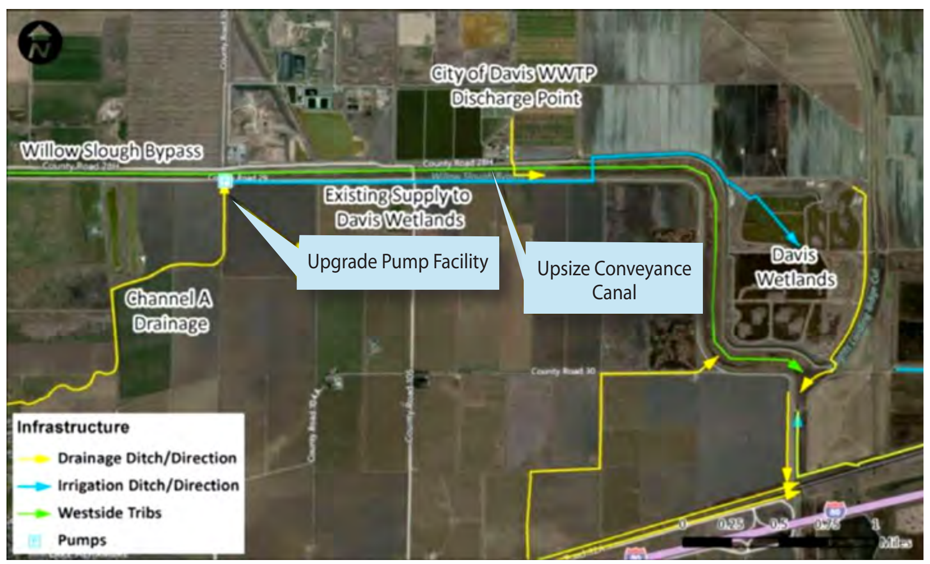
Location:

The Davis Wetlands is immediately north of the Willow Slough Bypass, outside of the Yolo Bypass (see Figure A-5 below).

Recommendations:

Upgrade Channel A supply channel and pump to Davis Wetlands. Potentially route some Willow Slough Bypass floodwater to wetlands.

Figure A-5. Davis Wetlands Supply Canal area



Description of Problem:

The existing supply to the Davis Wetlands originates from agricultural tailwater and stormwater from the City of Davis. This is part of a treated wastewater effluent system. As such, the wetlands are inundated for periods at any time of the year. In contrast, typically, managed wetlands in the Bypass are only flooded from November to March. The ability to pump water out of Channel A up to a smaller canal that routes water from the south side of the Willow Slough Bypass to the north side and into the Davis Wetlands is constrained. During the summer and fall months, the water is too low in the channel for the pump as designed. Channel conveyance capacity is a secondary issue in the winter months. Once the stormwater ponds fill to a certain level, water backs up into the conveyance channel and overflows at low areas. The current conveyance configuration can also result in poor water quality entering the Bypass and flooding at the Swanston Ranch west levee access. Future supply may be reduced from some city from sources due to updated wastewater discharge requirements.

Description of Improvements and Potential Benefit:

Improvements include capturing first flush events during the October-November period by reconfiguring the pump design to lift water from Channel A to the Davis Wetlands supply canal. This reconfiguration would also enhance access to the summertime agricultural irrigation runoff, improving existing habitat and potentially helping to treat some of the sediments or other constituents resulting from the runoff. The size of the channels could be increased to improve conveyance in the winter months.

Capturing fall first flush events and summer agricultural runoff would primarily benefit the lower aquatic ecosystems (i.e. lower levels of potential sediments and nutrients to benefit aquatic species). Other benefits include increased habitat availability for waterfowl and shorebirds in the existing wetlands. Additionally, west levee access could potentially be improved if upstream conveyance to the Davis Wetlands is upsized.

RECOMMENDED PROJECT #5	Davis Wetlands Water Supply					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit		X				Some improved access to irrigation runoff.
Migratory waterfowl or shorebird habitat benefit			X			Improved supply for managed wetlands. Dependent on future NPDES.
"Shovel readiness"		X				Level of design by City of Davis is uncertain.
Ease of permitting			X			This project would require CEQA compliance but may qualify for the Existing Facilities, the Replacement or Reconstruction, or the Small Habitat Restoration Projects Categorical Exemptions (Class 1, 2 or 33 Exemptions). To qualify for the Class 33 Exemption, wetland habitat benefits would need to be incorporated into the project. This project may also require a Streambed Alteration Agreement from the California Department of Fish and Wildlife and a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers.
Potential for local matching funding			X			City of Davis could potentially provide matching funds from utility fees if an eligible expenditure. Need to follow up with City of Davis. Potential for matching funding is contingent upon: A) Modification to the NPDES Permit; B) future of wetlands operation.
Eligibility for grants			X			Project lacks multiple benefits because no currently part of a stormwater program. Need to research stormwater specific grants.
Estimated benefit acreage			X			Up to and potentially exceeding 4,000 acres comprised of 400 acres of Davis Wetlands and 3,600+ acres of irrigated farmland and waterfowl habitat/duck clubs.
Cost estimate			X			$1,200,000
Flood benefit			X			Reduced flooding at west levee access.
Listed species benefit		X				Could benefit giant garter snake.
Public benefit (hunting, education, access, etc)			X			Improved access for public via Swanston Ranch west levee resulting from canal improvements. Public outreach to educate public of benefits of improvements.
Water quality benefit			X			Potential water quality improvement.
Other environmental benefit		X				Some minor benefits due to improved water quality.

Potential Benefit Region: Davis Wetlands, Swanston Ranch, DFW managed land north of I-80.

Potential Partners: City of Davis, Swanston Ranch landowners.

Potential Constraints: Water rights considerations downstream of the diversion point on Swanston Ranch as well as Department of Fish and Wildlife land. Water from Willow Slough Bypass below diversion combined with tailwater from west canal join to surcharge Willow Slough ditch north of RR tracks for both DFW and Swanston.

Estimated Cost and Proposed Funding Source(s): TBD.

Potential Implementation Timeline: Moderate.

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

Recommended Project 6 (RP-6):

South Davis Drain Input Reconfiguration

Location:

Near the junction of the El Macero Channel (South Davis Drain) and the Yolo Bypass

Recommendations:

Lower the gravity drain pipe through levee 0.5 mile south of the El Macero pump station, owned and operated by the City of Davis (Figure A-6).

Figure A-6. South Davis Drain area

Description of Improvements and Potential Benefit:

There is an existing gravity drain pipe through the west levee near the Davis drain pumps. It is placed too high for adequate gravity drainage. A new drain pipe could be installed for drainage when the Bypass is not flooded.

Another alternative would be to dig a new drain ditch along the west levee. A low lift pump could be installed to recycle the drain water into an existing farm irrigation canal. The new drain ditch could be located so that it does not jeopardize the west levee. This alternative would greatly reduce the Davis pumping costs, improve farm field drainage, improve levee stability, and reduce Yolo Basin Wildlife Area flooding.

Description of Problem:

The West Yolo Bypass levee creates a drainage barrier that requires frequent pumping, leading to flooding issues both in and outside of the Yolo Bypass. The City of Davis has a pump station (Southeast Davis Drain Pumps) that is used to lift drain water into the Bypass at a cost to the city. Drainage is poor along the west Bypass levee for farm fields just west of the levee. A drainage ditch at the west levee toe runs parallel with the levee. The closeness of this ditch potentially compromises the levee stability. Drain pumping has created flooding problems for the Yolo Bypass Wildlife Area, flooding roads and restricting public access. Future increased inundation and an elevated Toe Drain Canal surface could further impede drainage from west to east.

RECOMMENDED PROJECT #6	South Davis Drain Input Reconfiguration					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Potential to improve drainage on receding limb of hydrograph.
Migratory waterfowl or shorebird habitat benefit				X		Improved drainage for moist soil management practices in YBWA.
"Shovel readiness"			X			Relatively simple design plans required.
Ease of permitting			X			This project would require CEQA compliance but may qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). This project would also likely require a Streambed Alteration Agreement from the California Department of Fish and Wildlife and a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, depending upon the level of disturbance within the canal and whether jurisdictional wetlands are affected. An Encroachment Permit from the Central Valley Flood Protection Board would also be required if the gravity drainpipe through the levee is installed.
Potential for local matching funding			X			Need future discussions with City of Davis and landowners. Some landowners indicated willingness to contribute.
Eligibility for grants			X			Matching fund availability and YBWA benefits will increase eligibility for funding.
Estimated benefit acreage				X		Up to and potentially exceeding 8,000 acres of agricultural land /wetlands.
Cost estimate			X			$750,000
Flood benefit				X		Potential to reduce flooding in YBWA and on west side of west levee.
Listed species benefit					X	Could improve giant garter snake habitat.
Public benefit (hunting, education, access, etc)				X		Improved drainage to facilitate public and O&M access to YBWA.
Local economy benefit				X		Related to improved management of public and O&M access.
Water quality benefit	X					
Other environmental benefit					X	

Potential Benefit Region: Yolo Bypass Wildlife Area managed wetlands, Glide Causeway Ranch rice lease (DeWit Farms).

Potential Partners: Los Rios Farms, DeWit Farms, California Department of Fish and Wildlife, Wildlife Conservation Board, Yolo Basin Foundation.

Potential Constraints: USACE permitting for new pipe through a Project levee.

Estimated Cost and Proposed Funding Source(s): $750,000.

Potential Implementation Timeline: Moderate (3-5 years).

Other: This project could be combined with YBWA Dual Function Canal Reconfiguration (RP-7), YBWA Public and O&M Road Improvements (RP-8) and, Local Agricultural Crossing Improvements (RP-10) to benefit users inside and outside the Bypass.

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

Recommended Project 7 (RP-7):

Yolo Bypass Wildlife Area Dual Function Canal Reconfiguration

Location:

Yolo Bypass Wildlife Area south of I-80. (See Figure A-7 on reverse).

Recommendations:

Construct up to 90,000 linear feet of parallel supply and drain canals for 8 conveyance pathways (see area numbers on Figure A-7 on reverse). Replace pumps of concern ("Second Lift" on Figure A-7). Lower elevations of drain outlets in Toe Drain if feasible. Improve trash racks to reduce maintenance at pumps.

Description of Problem:

The existing system was originally designed for agricultural operations with several dual supply/drain canals that can cause issues for coordinated water management in a multi-use area. The system currently, however, also supplies and drains water for managed wetlands in the YBWA. When agricultural operations need water supply for irrigation, wetlands may need to drain. Such circumstances create a situation where it is not possible to manage wetland ponds individually. Individual management of ponds is a key element of creating diverse habitat while also managing vegetation, minimizing mosquito larvae populations and controlling avian disease during specific times of the year. Existing drain outlet elevations and tides at Lisbon Weir dictate how rapidly drainage can occur. If Toe Drain surface water levels are elevated as a result of future increases in the duration and frequency of Yolo Bypass flooding, drainage from west to east would be further impeded.

Description of Improvements and Potential Benefit:

Improvements could include rehabilitating existing canals and constructing new drainage and supply canals to facilitate wetland and farming operations, especially in early spring. Timing of wetland drawdown in early spring is important for the germination of nutritious wetland plants and is also important for controlling mosquito populations. Timing is also key for controlling the germination and growth of noxious weeds. Quick drainage following flooding is important for public access and canal improvement will accelerate the winter flood up of managed wetlands and therefore improve early season migratory bird habitat. A faster flood up also would allow for removal of the Los Rios check dam prior to the December 1 deadline to improve access to the creek for fall run Chinook salmon. A more detailed feasibility analysis will be required to fully identify which canals will need to be reconfigured.

RECOMMENDED PROJECT #7	YBWA Dual Function Canal Reconfiguration					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Improved supply for farming operations.
Migratory waterfowl or shorebird habitat benefit				X		Improved supply for managed wetland operations.
"Shovel readiness"			X			Relatively simple design plans required.
Ease of permitting				X		This project would require CEQA compliance but may qualify for the Minor Alterations to Land Categorical Exemption (Class 4 Exemption). This project would also likely require a Streambed Alteration Agreement from the California Department of Fish and Wildlife, a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, and an Encroachment Permit from the Central Valley Flood Protection Board.
Potential for local matching funding		X				The Yolo Basin Foundation and farmers that lease land on the Yolo Bypass Wildlife area are the only potential sources of matching funds and probably do not have sufficient funds for a significant contribution.
Eligibility for grants				X		Given that the YBWA is state owned and managed and the multi-benefit aspects of the project, there is a good chance of receiving grants. There are listed plants, animals and invertebrates at the Tule Ranch. There are also multiple opportunities for partnerships with agencies and conservation organizations.
Estimated benefit acreage				X		Up to and potentially exceeding up to 17,000 acres.
Cost estimate		X				Area 1: $4,000,000. Area 2: $550,000. Area 3: $5,000,000. Area 4: $1,000,000. Area 5: $850,000. Areas 6&7: $2,400,000. Area 8: $205,000.
Flood benefit				X		Improved drainage during small floods and flood recession.
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved drainage to facilitate public and O&M access.
Water quality benefit	X					
Other environmental benefit	X					

Potential Benefit Region: Yolo Bypass Wildlife Area managed wetlands (7,000 acres managed by DFW), Los Rios Farms (300 acres of row crops and grazing on several thousand acres), Glide Causeway Ranch (1500-acre DeWit Farms rice lease), Tule Ranch cattle grazing (9,000-acre Schene Cattle Company grazing lease). Potential to indirectly benefit privately managed wetlands to the north and south of the YBWA.

Potential Partners: California Department of Fish and Wildlife, Los Rios Farms, DeWit Farms, Dixon RCD, California Waterfowl Association, Ducks Unlimited, and Yolo Basin Foundation.

Potential Constraints: TBD.

Estimated Cost and Proposed Funding Source(s): Area 1: $4,000,000. Area 2: $550,000. Area 3: $5,000,000. Area 4: $1,000,000. Area 5: $850,000. Areas 6&7: $2,400,000. Area 8: $205,000.

Potential Implementation Timeline: Moderate (3-5 years).

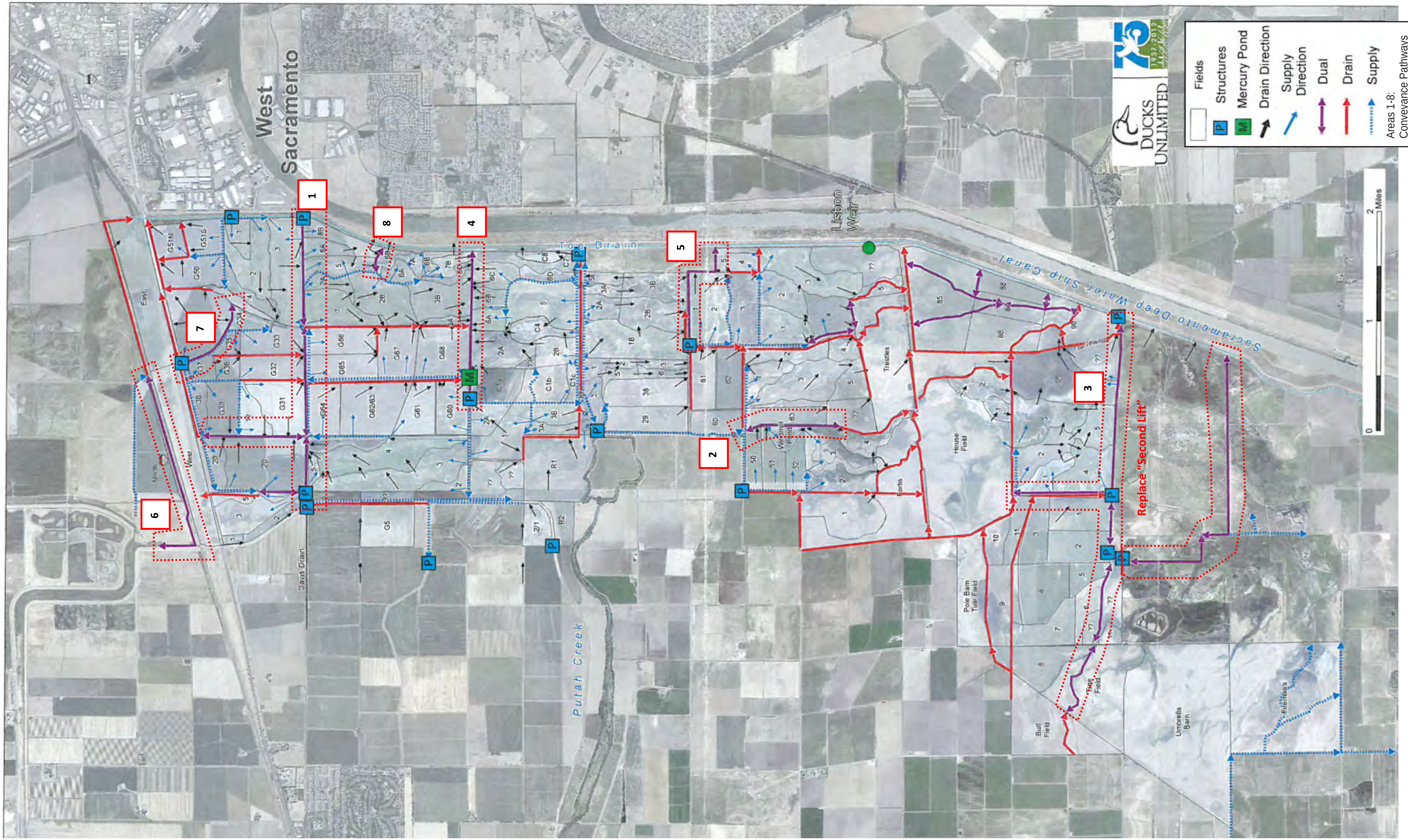
Other: This project could be combined with YBWA Public and O&M Road Improvements (RP-8) and, Local Ag Crossing Improvements (RP-10) to improve the system wide operations for supply and drain efficiency. This type of action could also benefit other systems, including the privately managed wetlands immediately south of the YBWA to improve coordinated water management.

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

Figure A-7


West Sacramento
Toe Drain
Lisbon Weir
Sacramento Deep Water Ship Canal
Putah Creek
Davis Drain
Replace "Second Lift"
Trestles
House Field
Pole Barn Tule Field
Bull Field
Umbrella Barn
DUCKS UNLIMITED
1937-2012
Fields
Structures
Mercury Pond
Drain Direction
Supply Direction
Dual
Drain
Supply
Areas 1-8: Conveyance Pathways
Miles
0
1
2

Recommended Project 8 (RP-8):

Yolo Bypass Wildlife Area Public and Operation & Maintenance Road Improvements

Location:

Yolo Bypass Wildlife Area south of I-80. (See Figure A-8 on reverse)

Recommendations:

Raise 6 miles of primary low lying public access road locations inundated during early stages of flooding (e.g. at the "Rice Corner" and the "Y"). Augment key O&M roads with gravel to make "all-weather" roads.

Road in YBWA. **See Figure A-8 on reverse.**

Description of Improvements and Potential Benefit:

Improvements include raising access roads and surfacing with "all-weather" materials as shown on Figure A-8. Benefits include improved public and operation and maintenance access.

Description of Problem:

The existing elevations along roadways at the "Rice Corner" and "Y" restrict public access during early stages of flooding (see Figure A-8 on reverse). These are important access points for public use and operation and maintenance of water supply and drainage structures. These roads flood as Toe Drain levels rise making the entire west side of the YBWA (4,600 acres) inaccessible for public use even during relatively small flood events. Not all existing operation and maintenance roads are gravel or all-weather roads that allow access immediately after a flooding event. Future increases in the duration and frequency of flooding will increase the need for maintenance of these roads as flood waters recede. The Discover the Flyway program for schools relies on access to the west side of the YBWA. The number of students served by the program decreases even during relatively small flood events. The impact will increase if the duration and frequency of flooding increases. Access to the west side of the YBWA is also important for other public uses, including hunting and wildlife viewing.

RECOMMENDED PROJECT #8	YBWA Public and O&M Road Improvements					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Improved O&M access to maintain agricultural operations.
Migratory waterfowl or shorebird habitat benefit				X		Improved O&M access to maintain managed wetland operations.
"Shovel readiness"				X		Relatively simple design plans required
Ease of permitting				X		This project would require CEQA compliance but may qualify for the Existing Facilities, the Replacement or Reconstruction, or the Minor Alterations to Land Categorical Exemptions (Class 1, 2 or 4 Exemptions). This project would also likely require an Encroachment Permit from the Central Valley Flood Protection Board.
Potential for local matching funding		X				Yolo Basin Foundation and farmers that lease land on the Yolo Bypass Wildlife area are the only potential sources of matching funds and probably do not have sufficient funds for a significant contribution.
Eligibility for grants				X		Given that the YBWA is state owned and managed and the multi-benefit aspects of the project, there is a good chance of receiving grants since there are listed plants, animals and invertebrates at the Tule Ranch. There are also multiple opportunities for partnerships with agencies and conservation organizations.
Estimated benefit acreage				X		Up to and potentially exceeding 17,000 acres (agricultural land/wetlands).
Cost estimate			X			6 miles of road, clean ditches, regrade: $700,000
Flood benefit	X					
Listed species benefit	X					
Public benefit (hunting, education, access, etc)				X		Improved public and O&M access.
Water quality benefit		X				Reduced runoff of fine sediment from access roads.
Other environmental benefit		X				Reduced vehicular impact to sensitive habitat areas.

Potential Benefit Region: Yolo Bypass Wildlife Area, including managed wetlands and farm and grazing leases.

Potential Partners: California Department of Fish and Wildlife, Los Rios Farms, Schene Cattle Company, DeWit Farms, California Waterfowl, Ducks Unlimited and Yolo Basin Foundation.

Potential Constraints: TBD.

Estimated Cost and Proposed Funding Source(s): $700,000

Potential Implementation Timeline: Moderate (3-5 years).

Other: This project could be combined with YBWA Dual Function Canal Reconfiguration (RP-7) and Local Agricultural Crossing Improvements (RP-10) to improve system wide operations for supply and drain efficiency.

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

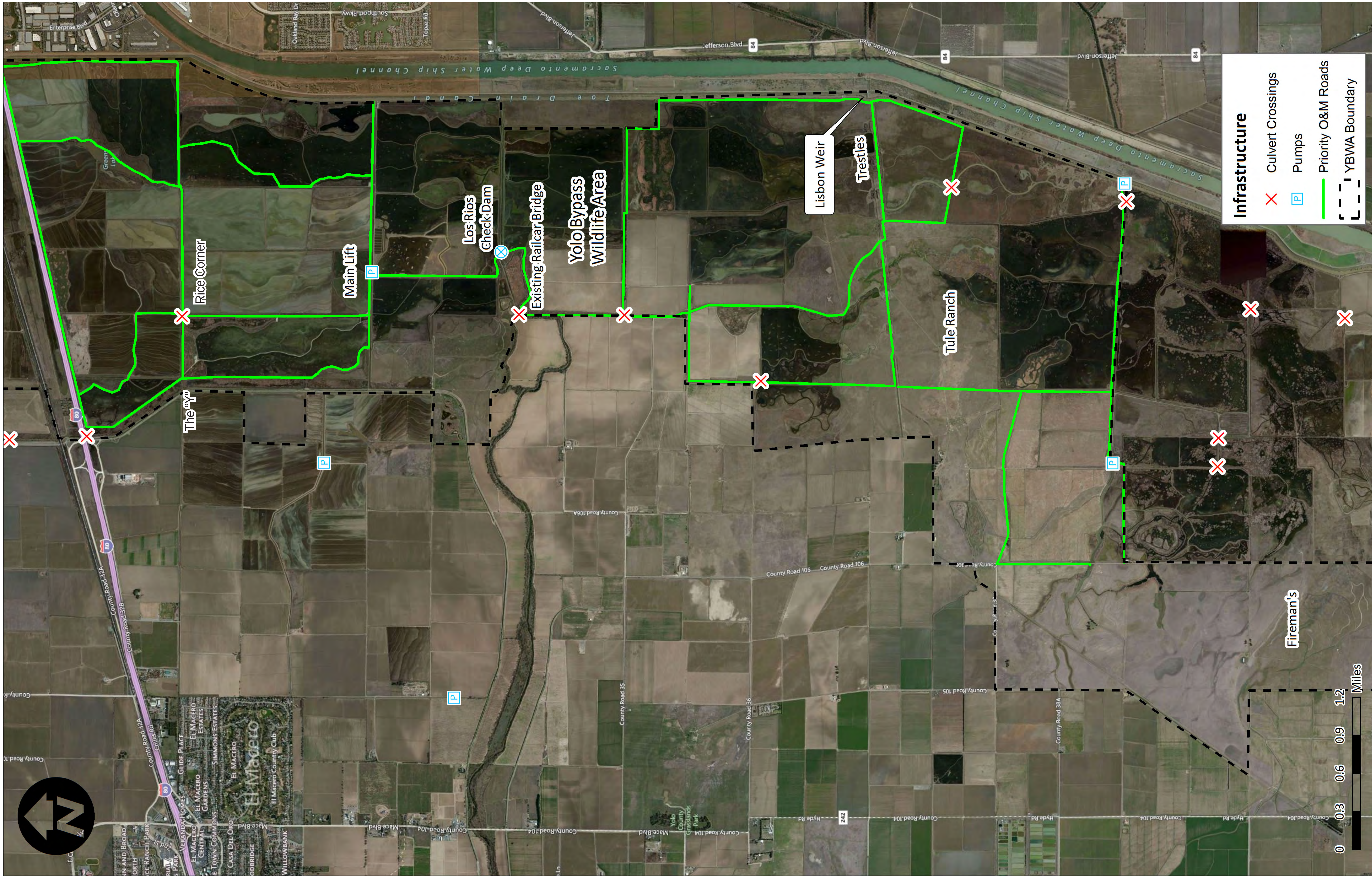
Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

cbec eco engineering

Figure A-8

BDCP1675



Recommended Project 9 (RP-9):

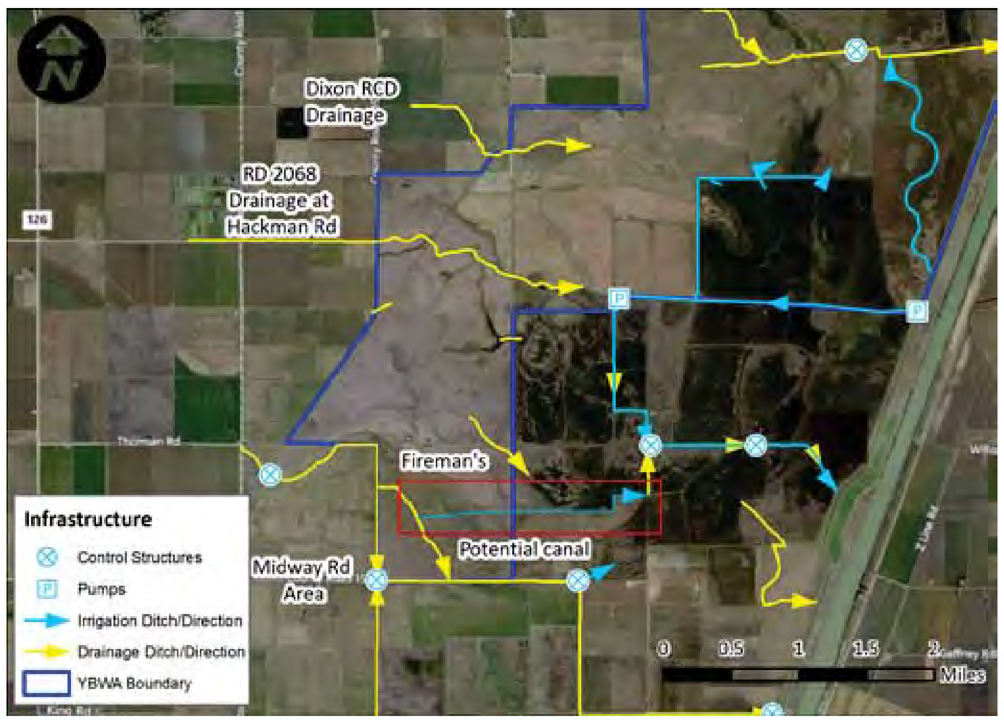
Stormwater and Summer Tailwater Re-Use and Supply

Location:

Near the RD 2068 delivery point at the east end of Midway Road.

Recommendations:

Re-use or divert excess winter runoff and/or agricultural tailwater near the Midway Road Area.

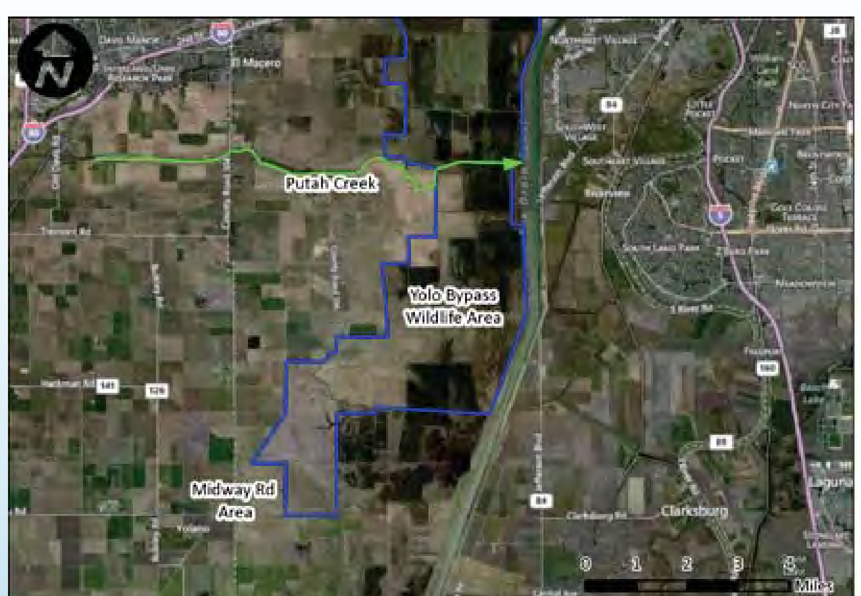


Description of Improvements and Potential Benefit:

Improvements include several control structure installations or upgrades, one pump station installation and one upgrade, as well as canal creation and improvements. Benefits include Improved summer and/or winter supply to potential contracted users, and potential habitat and water quality improvements.

Description of Problem:

Existing configuration of canals and pumps does not maximize water supply to potential contracted users when available as a result of winter storms or summer tailwater runoff since it is not possible to transfer, divert, or pump water efficiently to various ports of the system using the current infrastructure.



RECOMMENDED PROJECT #9	RD 2068 Stormwater and Summer Tailwater Re-Use and Supply					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit			X			Improved summer and/or winter supply.
Migratory waterfowl or shorebird habitat benefit			X			Improved summer and/or winter supply.
"Shovel readiness"		X				Relatively simple design plans required
Ease of permitting				X		This project would require CEQA compliance but may qualify for the Minor Alterations to Land Categorical Exemption (Class 4 Exemption). This project would also likely require a Streambed Alteration Agreement from the California Department of Fish and Wildlife, a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers, and an Encroachment Permit from the Central Valley Flood Protection Board.
Potential for local matching funding					X	To be determined.
Eligibility for grants					X	To be determined.
Estimated benefit acreage					X	Varies depending on location.
Cost estimate			X			$1,340,000
Listed species benefit	X					
Public benefit (hunting, education, access, etc)			X			Improved water level management during summer through late fall and winter waterfowl/shorebird/wetland habitat flooding on DFW and private lands
Water quality benefit	X					Could have a WQ benefit if tailwater is discharged through vegetated lands
Other environmental benefit	X					

Potential Benefit Region: Yolo Bypass Wildlife Area managed wetlands, Tule Ranch cattle grazing (below Lisbon Weir), duck clubs and other potential users.

Potential Partners: RD 2068, California Department of Fish and Wildlife, Yolo Basin Foundation, Yolo County, Solano County.

Potential Constraints: Modification to pumps and water control structures may require consideration of water rights. Easement modification may also be required to access new infrastructure.

Estimated Cost and Proposed Funding Source(s): $1,340,000.

Potential Implementation Timeline: Moderate (3-5 years).

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

Recommended Project 10 (RP-10):

Local Agricultural Crossing Improvements

Location:

Throughout the Yolo Bypass at localized crossings with and without water control structures as initially identified by management area or property. (See Figures A-10a and A-10b).

Recommendations:

Replace 28 agricultural crossings that do not require a control structure with railcar bridges with concrete abutments or similar upgrades. Upgrade priority water control structures to improve water supply function and drainage.

Railcar crossing without concrete abutments at the Island, YBWA. This crossing is recommended for replacement with concrete abutment railcar crossing. **(See Figures A-10a and A-10b).**

Description of Problem:

Existing local agricultural crossings consist of rudimentary culvert and fill materials that require persistent maintenance to minimize blockages due to beaver activity and invasive aquatic vegetation. Certain existing agricultural crossings experience access restrictions during flood events.

Description of Improvements and Potential Benefit:

Improvements to culvert crossings include replacing existing crossings with clear span decks consisting of either rail car bridges or other structural techniques. Benefits include reduced maintenance costs, improved water delivery, drainage for agriculture and managed wetlands, and improved conveyance during flooding and low water operations. Control of mosquito populations may also improve. Landowners and wetland managers indicated that rail car bridges generally are less likely to be blocked by beaver dams than culverts. Improvements to water control structures may consist of similar clear span decks with concrete abutments with the addition of sluice gates or flashboard riser combination gates. Those gates can be removed in the winter for improved drainage by creating a larger flow conveyance area.

RECOMMENDED PROJECT #10	Local Agricultural Crossing Improvements					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Reduced maintenance costs. Improved conveyance during flood and low water operations.
Migratory waterfowl or shorebird habitat benefit				X		Improved conveyance during flood and low water operations.
"Shovel readiness"			X			Relatively simple design plans required
Ease of permitting				X		These crossings would require CEQA compliance but would likely qualify for the Existing Facilities or the Replacement or Reconstruction Categorical Exemptions (Class 1 or 2 Exemptions). If the construction includes disturbance within the water course, they may require a Streambed Alteration Agreement from the California Department of Fish and Wildlife and a Clean Water Act Nationwide Permit from the U.S. Army Corps of Engineers. An Encroachment Permit from the Central Valley Flood Protection Board may also be required.
Potential for local matching funding			X			Landowners may be interested in contributing some matching funds to improve operations. Need to discuss with individual landowners. Grant money may be available for improved crossings when habitat is improved.
Eligibility for grants				X		Multi-benefit aspects of the project will increase eligibility for grants.
Estimated benefit acreage				X		Varies depending on location of crossing.
Cost estimate			X			Up to $70,000 per crossing, dependent on location
Flood benefit			X			Improved conveyance during flood and low water operations.
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved reliability of public access.
Water quality benefit	X					
Other environmental benefit	X					

Potential Benefit Region: Throughout the Yolo Bypass.

Potential Partners: California Department of Fish and Wildlife, Yolo Basin Foundation, California Waterfowl Association, and Ducks Unlimited.

Potential Constraints: TBD.

Estimated Cost and Proposed Funding Source(s): Up to $70,000 per crossing, dependent on location specific needs. Preliminary crossings identified for replacement as shown on Figures A-10a and A-10b.

Potential Implementation Timeline: Short (1-3 years).

Other: More study needed to further prioritize replacement locations based on conversations with landowners/farmers/managers.

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

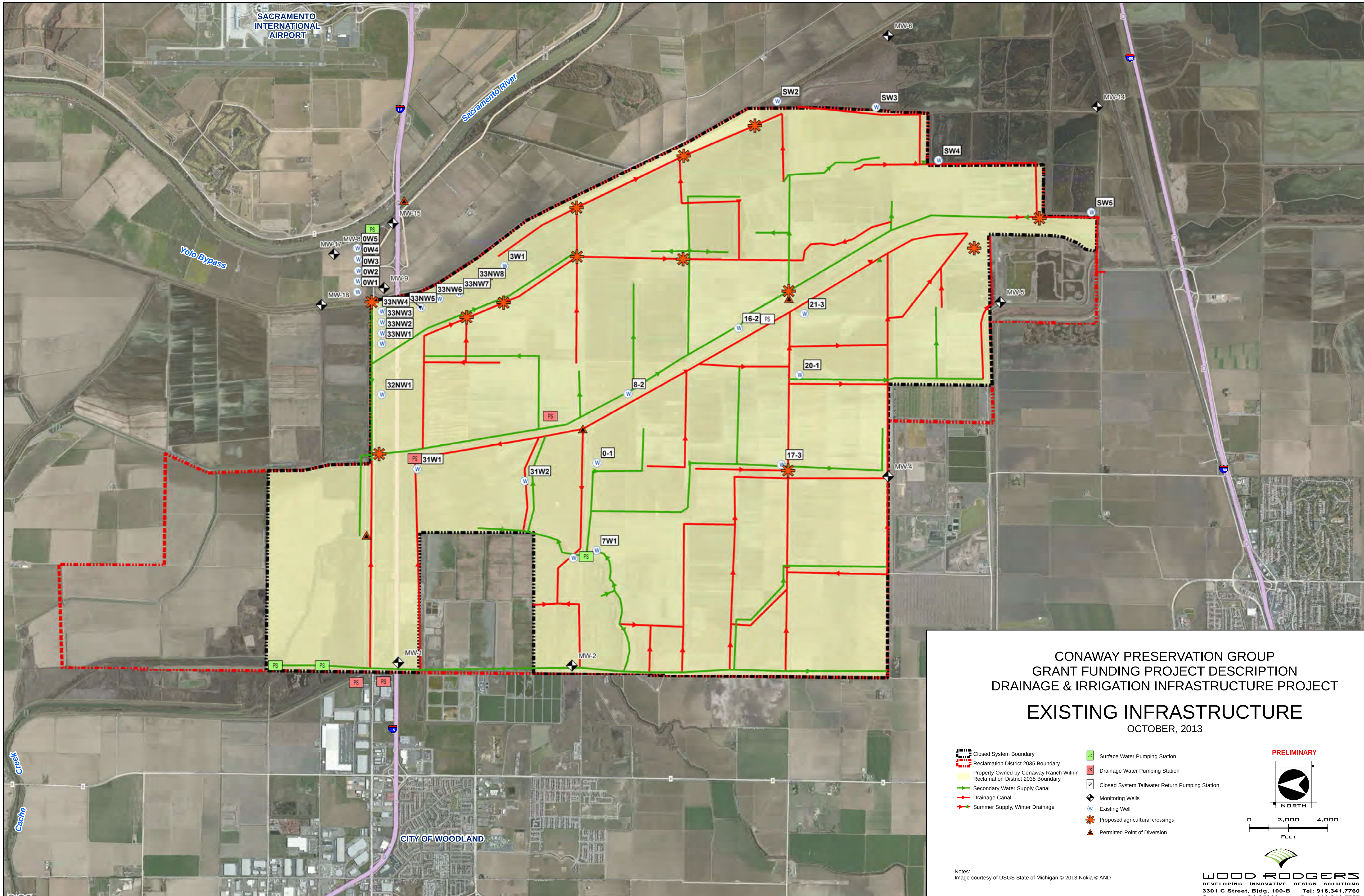
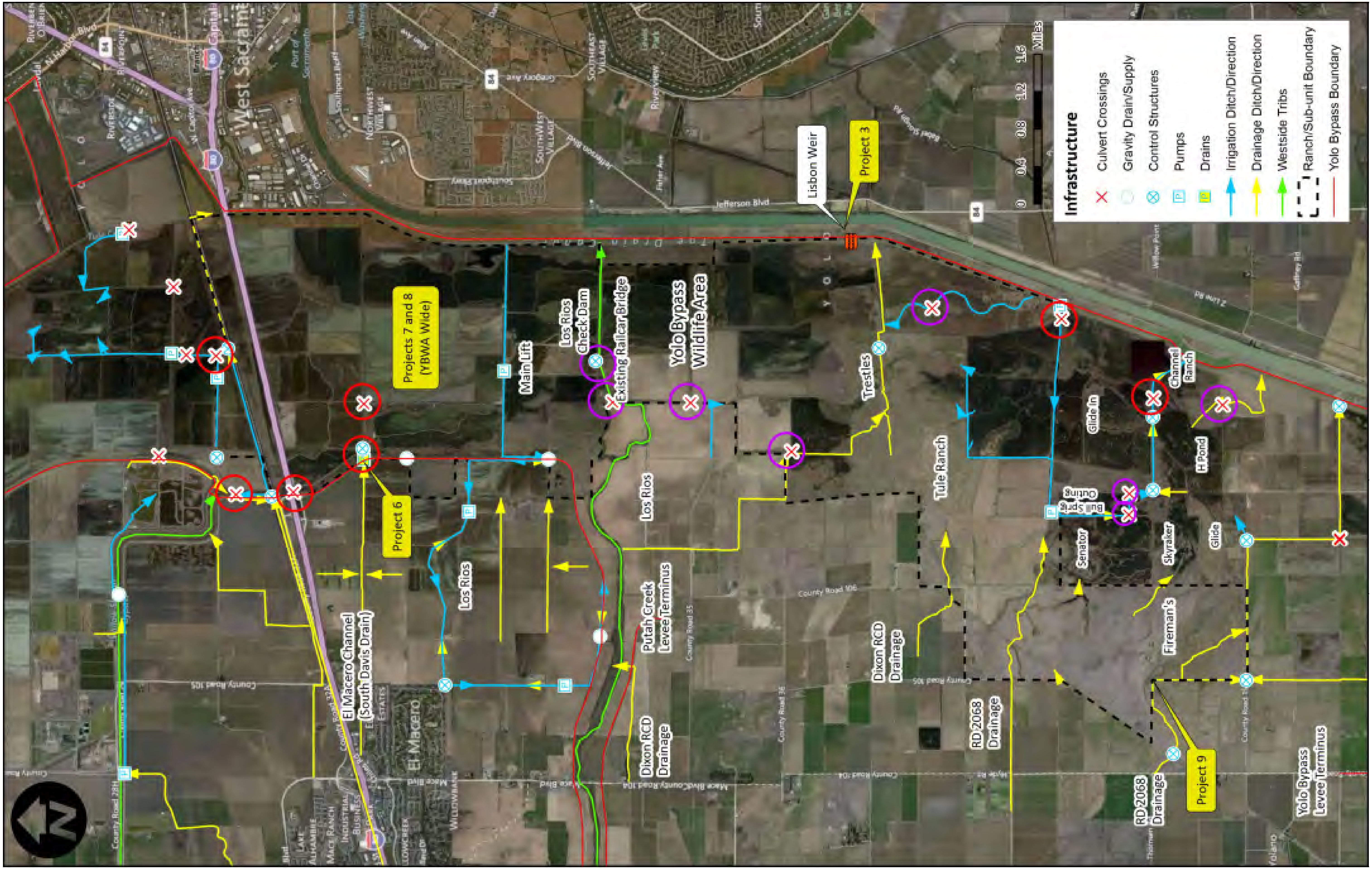

SACRAMENTO INTERNATIONAL AIRPORT
Sacramento River
Yolo Bypass
SW2
SW3
SW4
SW5
MW-6
MW-14
MW-15
MW-17
MW-8
MW-9
MW-18
MW-5
MW-4
MW-1
MW-2
0W5
0W4
0W3
0W2
0W1
3W1
33NW8
33NW7
33NW6
33NW5
33NW4
33NW3
33NW2
33NW1
32NW1
31W1
31W2
0-1
7W1
8-2
16-2
21-3
20-1
17-3
CITY OF WOODLAND
Cache Creek
CONAWAY PRESERVATION GROUP
GRANT FUNDING PROJECT DESCRIPTION
DRAINAGE & IRRIGATION INFRASTRUCTURE PROJECT
EXISTING INFRASTRUCTURE
OCTOBER, 2013
Closed System Boundary
Reclamation District 2035 Boundary
Property Owned by Conaway Ranch Within Reclamation District 2035 Boundary
Secondary Water Supply Canal
Drainage Canal
Summer Supply, Winter Drainage
Surface Water Pumping Station
Drainage Water Pumping Station
Closed System Tailwater Return Pumping Station
Monitoring Wells
Existing Well
Proposed agricultural crossings
Permitted Point of Diversion
PRELIMINARY
NORTH
0 2,000 4,000
FEET
Notes:
Image courtesy of USGS State of Michigan © 2013 Nokia © AND
WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Sacramento, CA 95816
Tel: 916.341.7760 Fax: 916.341.7767

Figure A-10b



Notes: Higher priority crossings for replacement/upgrade circled in red, lower priority in purple. Crossings not circled need to be assessed for priority by further conversations with managers.

Recommended Project 11 (RP-11):

Creation of Coordinated Maintenance and Improvement Reimbursement Program or Agency

cbec eco engineering

Location:

Throughout the Yolo Bypass.

Recommendations:

Develop a special district, possibly through an existing Resource Conservation District, to maintain irrigation and drainage canals and implement other system improvements.

Description of Problem:

Existing agricultural operations and wetland managers control vegetation and siltation in irrigation and drainage canals at landowners' expense even though the Yolo Bypass provides system wide benefits as part of the Sacramento River Flood Control Project. Existing agriculture and managed wetland canals, crossings, fields and pumps require frequent maintenance, including removal of silt, invasive aquatic vegetation, and beaver blockages. Removal of flood debris on bridges, crossings, streambanks, and fields is also necessary after large flood events. Future increased inundation and frequency of flooding could increase maintenance needs and costs incurred to landowners and managers.

Description of Improvements and Potential Benefit:

Landowners could participate in the maintenance and improvement program through a state funded reimbursement process or the state or special district could hire a dedicated labor force and purchasing equipment through grants or other funding sources. The program would need to be managed by one or two full time staff, probably a general manager, and a labor/engineering supervisor. If the program includes a dedicated labor force, operating costs could significantly increase. Alternatively, a Yolo Bypass "Keeper" approach could be adopted, similar to the Putah Creek Streamkeeper, a position created by the Putah Creek Accord in 2000. System wide benefits would include improved conveyance during flooding, improved water supply operations for proposed fish habitat management, improved drainage of lands on the receding limb of the hydrograph, and improved access during and after flood events. Public and private landowners in the Bypass would benefit from reduced maintenance costs and improved access.

RECOMMENDED PROJECT #11	Bypass Wide: Creation of Coordinated Maintenance and Reimbursement Program					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit				X		Improved supply and drainage operations due to more frequent vegetation and silt removal.
Migratory waterfowl or shorebird habitat benefit				X		Improved supply and drainage operations due to more frequent vegetation and silt removal.
"Shovel readiness"	X					Not applicable.
Ease of permitting						The establishment of a coordinated maintenance and improvement reimbursement program or agency would not require CEQA compliance and would not require any specific permits.
Potential for local matching funding		X		X		Local landowners and wetlands managers may be willing to contribute some funds on an annual basis based on existing costs to maintain canals, but local funding is currently insufficient for the need.
Eligibility for grants		X				Given the costs are ongoing and grants are usually for one-time projects, it will be difficult to identify grants for implementation. An ongoing funding source must be identified.
Estimated benefit acreage				X		Varies depending on jurisdiction of agency or program within Bypass.
Cost estimate			X			Costs could vary considerably. Approximately $150,000 to $200,000 for two staff, accommodation and administrative costs. Maintenance costs could vary considerably depending on coverage.
Flood benefit				X		Improved drainage and conveyance due to more frequent vegetation and silt removal.
Listed species benefit					X	
Public benefit (hunting, education, access, etc)				X		Improved reliability of access.
Water quality benefit					X	
Other environmental benefit		X				Environmental benefits could be realized through improved management of watercourses.

Potential Benefit Region: Throughout the Yolo Bypass.

Potential Partners: Dixon RCD, Yolo County RCD, California Department of Fish and Wildlife, California Department of Water Resources and Sacramento Yolo Mosquito and Vector Control District.

Potential Constraints: Difficult to secure ongoing funding sources, a governance system would need to be developed.

Estimated Cost and Proposed Funding Source(s): Staffing and accommodation costs could be up to $200,000 annually. Maintenance costs would vary depending on land coverage. Funding sources could potentially through a Public Benefit Fund, Mutual Water Company or Special District.

Potential Implementation Timeline: Long (5+ years).

Other:

- Example program at the Grasslands Water District in Los Banos, CA does vegetation removal for all duck clubs and agricultural canals that are part of the District. The District bought equipment and hired staff to do vegetation work on all of the canals.
- Sacramento-Yolo Mosquito and Vector Control District provides equipment and staffing to do vegetation removal and ditch maintenance in breeding problem areas.
- One group of private landowners in the Bypass is in the process of forming a Mutual Water Company, one purpose being the sharing of ditch and road maintenance expenses.

For more info about this project please contact:

Cindy Tuttle, Yolo County, 530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

yolo basin foundation

Recommended Project 12 (RP-12):

Westside Tributaries Monitoring


Photo © Dave Feliz

Location:

Knights Landing Ridge Cut, Cache Creek, Willow Slough Bypass, Putah Creek tributary inputs to Bypass.

Recommendations:

Various measures to improve, or introduce, flow gauging on tributary flow inputs to the Yolo Bypass.

Description of Problem:

Since westside tributary inflows play an important role in Bypass inundation, understanding the timing and magnitude of inflows is needed to determine their relative influence compared to larger inflows from the Fremont and Sacramento Weirs. Better data is needed to synthesize past and future hydrology datasets for the purposes of modeling existing conditions and future management scenarios. For example, discussion on future management scenarios has included the consideration of modifying the inundation regime for the Yolo Bypass during flood events. In terms of balancing habitat and agricultural objectives, the magnitude, frequency, duration, timing, depth, area, and rate of change of floodplain inundation are all critical parameters to understand thoroughly. The westside tributary inflows affect these parameters significantly. A brief summary of available data for each tributary is provided below:

- Flow estimates entering the Yolo Bypass at Knights Landing Ridge Cut (KLRC), were approximated prior to 2009 based on Colusa Drain flows at Highway 20, rough rainfall runoff estimates for the un-gauged portion of Colusa Basin, and flows to the Sacramento River via the Knights Landing Outfall Gates (Outfall Gates). This resulted in flow estimates with large uncertainty. In 2009, flow gauging on KLRC downstream of the Outfall Gates (CDEC ID RCS) was initiated by DWR North Central Region Office (NCRO).
- Flow estimates entering the Yolo Bypass at the Cache Creek Settling Basin have been based on USGS gauged flows on Cache Creek just downstream of I-5 since 1903 without any routing and attenuation (i.e. compensating for changes to the hydrograph shape due to channel geometry or storage in the Cache Creek Settling Basin). This resulted in flow estimates with large uncertainty. Beginning in 2009, the USGS gauged total outflows from the Settling Basin. Flow measurements for Cache Creek are based solely on the USGS gauge on Cache Creek where water enters the western side of the Bypass. These measurements do not account for storage or attenuation in the Settling Basin.
- Data for flows entering the Yolo Bypass via the Willow Slough Bypass are based on scaled Interdam Runoff estimates for Putah Creek since the Willow Slough Bypass has never been gauged.
- Flows entering the Yolo Bypass at Putah Creek are based on Putah Diversion Dam (PDD) total outflow (low flow plus flood flow releases) 20 miles upstream along with seepage loss estimates and conditional criteria when Monticello Dam is spilling. Only low flows (i.e., less than 100 cfs) are gauged on Putah Creek by Solano County Water Agency (SCWA) downstream of PDD at several locations.

Further details of this recommended project are provided in the accompanying report, Appendix B.

Description of Improvements and Potential Benefit:

- **Knights Landing Ridge Cut:** DWR NCRO should continue the RCS monitoring program, continue to refine the low flow rating curve, and extend the rating curve for flows above 1,600 cfs. Future funding for continued monitoring at this location needs to be confirmed with DWR. In addition, a more reliable and accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- **Cache Creek:** In addition to operating the USGS gauging station just downstream of I5, the USGS should continue monitoring the total outflow from the Cache Creek Settling Basin. Future funding for continued monitoring at this location should be confirmed with the USGS. In addition, a more reliable and accurate method for approximating inflows into the Yolo Bypass prior to 2009 needs to be performed via desktop analysis.
- **Willow Slough Bypass:** The main recommendation here is to install flow and stage monitoring stations along the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy using scaled Interdam Runoff can be validated and potentially modified.
- **Putah Creek:** The US Bureau of Reclamation and Solano Irrigation District (SID) Putah Diversion Office (PDO) have been monitoring and recording flows on Putah Creek between Monticello Dam and Lake Solano. More recently, SCWA has been monitoring low flows (i.e., less than 100 cfs) and stages at eight stations along Putah Creek from the PDD to Los Rios Check Dam primarily during the growing season to verify fish pulse flows. Locations within the Yolo Bypass are not suitable for flow rating above 100 cfs due to backwater conditions from the Toe Drain. It is recommended that SCWA continue their monitoring efforts and expand their efforts at the I-80 station by rating it for higher flows for historical verification and for use in future modeling efforts. It is also recommended that the outflows to Putah Creek (i.e., releases and flood flows) be reported and archived on a subdaily time step rather than just daily. Further validation of the Interdam Runoff (between Monticello Dam and Putah Diversion Dam) is also recommended.

The tributary inflows to the Bypass are extremely important elements of any future studies. Inflows for all these tributaries are currently estimates at best. West side tributary inflows play a major part in inundation of the Bypass prior to the Fremont Weir spilling and it is therefore critical to better understand their relative contribution to Bypass inundation, particularly for future monitoring studies.

RECOMMENDED PROJECT #12	Bypass Wide: West Side Tributaries Monitoring					
Project Metric	No	Yes			Un-known	Comments
		Low	Med	High		
Agricultural benefit		X				Improved understanding of inundation regime in Bypass.
Migratory waterfowl or shorebird habitat benefit		X				Improved understanding of inundation regime in Bypass.
"Shovel readiness"			X			Relatively simple design plans.
Ease of permitting				X		The proposed monitoring would require CEQA compliance but would likely qualify for the Information Collection Categorical Exemption (Class 6 Exemption). No other permitting would be necessary.
Potential for local matching funding		X				
Eligibility for grants				X		DWR.
Estimated benefit acreage				X		Whole Bypass.
Cost estimate			X			$160,000 to $500,000 depending on estimation/gauging method and duration of monitoring.
Flood benefit					X	Improved understanding of inundation regime in Bypass.
Listed species benefit					X	
Public benefit (hunting, education, access, etc)					X	
Water quality benefit					X	Water quality, particularly methyl mercury regime related to inundation regime.
Other environmental benefit					X	

Potential Benefit Region: Improved prediction of the influence of west side tributary inflows on timing and duration of Bypass inundation.

Potential Partners: USGS, DWR, USBR, SCWA, SID.

Potential Constraints: Initial costs to set up gauging sites and on-going maintenance.

Estimated Cost and Proposed Funding Source(s): KLRC – up to $50,000 for desktop studies. Cache Creek – up to $50,000 for desktop studies. Willow Slough Bypass - $30,000 to establish flow gauging station, $5,000 per year for on-going maintenance and data processing. Putah Creek - $30,000 to establish flow gauging station, $5,000 per year for on-going maintenance and data processing.

Potential Implementation Timeline: Moderate (3-5 years).

For more info about this project please contact:

Cindy Tuttle, Yolo County
530-666-8061

Robin Kulakow, Yolo Basin Foundation
530-756-7248

cbec eco engineering

yolo basin foundation

APPENDIX B

WESTSIDE TRIBUTARY INFLOWS

1 WESTSIDE TRIBUTARY INFLOWS

The Yolo Bypass receives rainfall runoff, agricultural tailwater drainage, bypass flood flows, stormwater and wastewater effluent from several locations, primarily originating from the west. Four main tributaries, hereafter referred to as the Westside tributaries, convey variable amounts of runoff, stormwater and flood flows: the Knights Landing Ridge Cut Canal, Cache Creek, Willow Slough via the Willow Slough Bypass, and Putah Creek. The following sections summarize existing knowledge about the Westside tributaries, describe the low flow hydrology as estimated or described by the Yolo Bypass Management Strategy (herein, Management Strategy) (Jones & Stokes, 2001), and provide recommendations for validating these estimation equations or for future data collection.

Previous Yolo Bypass modeling efforts (e.g. cbec MIKE21 modeling) used the Management Strategy estimations as these represented the best available data at that time. cbec and others have previously noted potential improvements to modeling input data with more detailed information regarding Westside tributary flow characteristics and inflow locations (cbec, 2012; Northwest Hydraulics et al., 2012). A major recommendation from the present study is to implement a focused data collection and validation effort of hydrologic data for the Westside tributaries. The main recommendations include:

- **Knights Landing Ridge Cut:** Refine the rainfall trigger value at Colusa, or the value of rainfall in inches per day that must be exceeded to justify a “significant” amount of precipitation for a calculation of flow in the Knights Landing Ridge Cut. The Management Strategy cites 0.3 inches per day at Colusa as the condition determining KLRC inflow to the Yolo Bypass.
- **Cache Creek:** In addition to continuing Cache Creek data collection at the USGS gauges immediately entering the western edge of the Bypass near the Overflow Weir, historical gauged flows near Interstate 5 can be transformed with basic routing to account for storage and attenuation in the Settling Basin, especially during low flows.
- **Willow Slough Bypass:** The main recommendation here is to install flow and stage monitoring stations in the Willow Slough Bypass. Once data has been collected for several years, the assumptions from the Management Strategy can be validated and potentially modified.
- **Putah Creek:** SCWA has been monitoring low flows (i.e. less than approximately 100 cfs) at eight stations along Putah Creek from the Putah Diversion Dam to Los Rios Check Dam (available online at http://www.grabdata.com/solano_putahcreek.htm). It is recommended that these stations be rated for higher flows for historical verification and for use in future modeling efforts. Validation of the Interdam Reach (between Monticello Dam and Putah Diversion Dam) is also recommended.

The historical daily inflow hydrology to the Yolo Bypass was developed as part of the Yolo Bypass Management Strategy, Chapter 2 – Existing Conditions in the Yolo Bypass, (Jones & Stokes, 2001) for these four tributaries for the period of 1968 to 1998. cbec recently updated this hydrologic dataset through 2011 for a DWR modeling effort (cbec, 2012). During the period from 1968 to 2011, or 44 years, Fremont Weir spilled 29 of those years or 2 out of 3 years (66% of years) according to the updated hydrology dataset. The “Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals” Final Report evaluated a shorter timeframe of 26 years (1984 and 2009), during which the Fremont Weir spilled 15 of those years or 58% of years. In years when Fremont Weir did not spill, Cache Creek and the Knights Landing Ridge Cut generally supplied the majority of peak flows into the Yolo Bypass, followed by Willow Slough Bypass and Putah Creek (Figure B-1). These datasets are based primarily on estimation assumptions discussed in the following subsections.

1.1.1 KNIGHTS LANDING RIDGE CUT CANAL

1.1.1.1 Existing Configuration

The Knights Landing Ridge Cut Canal (herein, KLRC) originates at the Colusa Basin Drain near Knights Landing. It was designed to convey Colusa Basin flood flows as an alternative to discharging to the Sacramento River. The KLRC, completed in 1915, is approximately 400 feet wide with two channels excavated by dredger and borrowed to construct the bounding levees. A mid channel island also runs the midline of the KLRC due to dredger arm constraints (H.T. Harvey, 2008). The original design capacity was 15,000 to 20,000 cfs, with a 1983 preliminary current meter measurement and calculation estimating the maximum capacity at 15,700 cfs (DWR, 1990).

Upstream inflows originate from the Glenn-Colusa Irrigation District (GCID) in the form of winter runoff and summer agricultural tailwater runoff. The GCID replaced Davis Weir along the Colusa Drain near Williams with an Obermeyer bladder dam in 2010 (GCID, 2010). A set of flap gates, the Knights Landing Outfall Gates (KLOG), at the Sacramento River control winter flood flow conveyance down the KLRC, such that when river stage exceeds 25 feet USED (United States Engineering Datum, formerly United States Army Corps of Engineers Datum) or 24.2 feet NAVD88 (North American Vertical Datum of 1988) the flap gates close and all GCID runoff is conveyed into the Yolo Bypass (H.T. Harvey, 2008). The Wallace Weir, owned and operated by Knaggs Ranch, located on the KLRC at the western side of the Yolo Bypass (Figure B-2), is an earthen berm approximately 450 feet long with a permanent box culvert 28 feet wide at the northeastern end. The earthen berm is required to be removed on December 1 of each year to facilitate the flood conveyance function, and replaced in April or May. The maintainers sometimes leave the berm in place longer when it appears there is a low probability of early high flows from the Colusa Basin Drain. Depending on water year, timing of spring runoff event conditions and upstream users, runoff is impounded at Wallace Weir for use within and across the Yolo Bypass in Reclamation District 1600 (RD 1600). During the August to September drain period largely associate with rice production, a majority of tailwater runoff proceeds to the Sacramento River and in the winter and spring months when the river exceed 24.2 ft NAVD88, all water enters the Yolo Bypass.

1.1.1.2 Historical Hydrology and Recommendations

The main recommendation here is to refine the rainfall trigger value at Colusa, or the value of rainfall in inches per day that must be exceeded to justify a “significant” amount of precipitation for a calculation of flow in the KLRC. The Management Strategy cites 0.3 inches per day at Colusa as the condition determining KLRC inflow to the Yolo Bypass. Additionally, continued long term monitoring of flow and stage data at CDEC station ID RCS (Figure B-2) is highly encouraged to further verify the estimation assumptions or for future modeling efforts. Reviewed flow data for RCS at Knights Landing is available with DWR starting December 7, 2006.

To summarize Chapter 2 of the Management Strategy, daily inflow hydrology to the Yolo Bypass from KLRC was estimated by subtracting gauged outflows to the Sacramento River past the Knights Landing Outfall Gates (KLOG) from gauged flow at DWR's Colusa Basin Drain at Highway 20 station (CDEC ID: CDR) extrapolated to the entire watershed area (see Figure B-2 for gauging station locations and Jones & Stokes (2001) for detailed assumptions). This daily calculation is only performed if rainfall rates at Colusa exceed 0.3 inches per day, otherwise the estimated inflow value falls to zero (Jones & Stokes, 2001). To validate this estimation, it was compared to gauged flow in the Ridge Cut (CDEC ID: RCS) for one week in January 2010. In January 2010, a relatively minor storm event passed through the region, causing four non-consecutive days of Fremont Weir overtopping (Jan. 23, Jan. 24, Jan. 28 and Jan. 29), with flow in the Toe Drain near Interstate 5 (CDEC ID: YBY) ranging from 5,290 cfs and 7,170 cfs (Table 1). Rainfall at Colusa equaled or exceeded 0.3 inches per day on 2 of 7 days while flow at Highway 20 was relatively high exceeding 11,000 cfs. Because Sacramento River stage at Knights Landing exceeded 24.2 feet NAVD88, no outflow was conveyed from the Drain to the river. These conditions led to only two of seven days being included in the calculation. See the last two columns of Table B-1 comparing the Management Strategy estimate versus observed flow at CDEC station ID RCS (Figure B-2) in the KLRC and note the rainfall trigger and that the inflow estimate as compared to gauged flow.

A comparison of the January 2010 event to the March 2011 event shows large variation in the gauged data as well. While the January 2010 event gauged flow at CDEC Station ID CDR (Figure B-2) near Highway 20 reported higher magnitude than in the KLRC, the opposite occurred in March 2011 event likely due to ungauged overflows over the KLOG from the river to the Drain as stage in the Sacramento River exceeded the flood stage (37 feet USED or 36.2 feet NAVD88) (Figure B-3). A comparison of the two small spikes before and after the March 2011 event, in January and June 2011 respectively, show a closer match between CDR near Highway 20 and the Ridge Cut, as well as a better estimation of KLRC inflows.

Table B-1. Validation of Knights Landing Ridge Cut inflow hydrology estimate for a small flood event[1]

Location	Fremont Weir Spill	Toe Drain at I-5	Precipitation at Colusa	Colusa Basin Drain at Highway 20	Colusa Drain Outflow to Sacramento River	Sacramento River at Knights Landing	*KLRC*	Ridge Cut Slough at Co Hwy E8
Date	**FRE (cfs)**	**YBY (cfs)**	**CIMIS (in)**	**CDR (cfs)**	**A02945 (cfs)**	**KNL (ft, NAVD88)**	***KLRC Inflow Estimate (cfs)***	**RCS (cfs)**
1/23/2010	5,465	5,390	0.19	8,661	0	35.2	*0*	2,225
1/24/2010	3,317	5810	0.3	8,209	0	35.4	*9940*	2,457
1/25/2010	--[2]	5,290	1.4	7,633	0	34.4	*9242*	2,754
1/26/2010	--[2]	5,600	0.06	9,354	0	33.7	*0*	3,105

1/27/2010	--[2]	7,170	0	11,319	0	34.2	*0*	3,555
1/28/2010	3,707	6,300	0	10,847	0	35.0	*0*	3,909
1/29/2010	2,129	5,950	0.06	8,788	0	35.0	*0*	4,144

[1]All data is observed gauge data except the KLRC inflow estimate.

[2]No spill over Fremont Weir.

Since historical diversions and overflow at the KLOG are not gauged, updating the equation to account for these year to year variations is infeasible. Thus, the main recommendation here is to refine the rainfall trigger value of 0.3 inches per day. Additionally, continued long term monitoring of flow and stage data at RCS is highly encouraged to further verify the estimation assumptions or for subsequent modeling efforts.

1.1.2 Cache Creek

1.1.2.1 Existing Configuration

Cache Creek inflows to the Bypass proceed from the Cache Creek Settling Basin either over the Cache Creek Overflow Weir, with a design capacity of 30,000 cfs or through a low flow outlet at the southern extent of the settling basin. FloodSAFE Yolo identified the Cache Creek Settling Basin for modification to improve flooding conditions in the region in a 2009 presentation (FloodSAFE Yolo, 2009). Potential changes in the region should be considered for Yolo Bypass management as well (CVFPP, 2011). Additionally, the Central Valley Flood Protection Board recently requested approval of a letter to United States Army Corps of Engineers requesting a reconnaissance study to determine federal interest in the modification project (CVFPB, 2013).

1.1.2.2 Historical Hydrology and Recommendations

In addition to continuing Cache Creek data collection at the USGS gauges immediately entering the western edge of the Bypass, the key recommendation here is to consider transforming CCY historical gauged flows with basic routing to account for storage and attenuation in the Settling Basin, especially during low flows.

As described in the Yolo Bypass Management Strategy (Jones & Stokes, 2001), inflows to the Yolo Bypass from Cache Creek are gauged by the United States Geological Service (USGS), with a long term gauging record (USGS ID: 11452500; CDEC ID: CCY on Figure B-2). While the Management Strategy notes that no significant tributaries or diversions exist downstream of this gauge, the timing and magnitude of inflows at the inlet to the Yolo Bypass are likely affected by storage in the Cache Creek Settling Basin located adjacent to the western edge of the Yolo Bypass. A comparison between CCY and recent total flow (overflow weir plus outflow) data collection as part of a Cache Creek Settling Basin Study at USGS station 11452901 (location shown in B- 2) for the 2010 and 2011 storm events shows that small peaks events at CCY are attenuated in the Settling Basin (Figure B-4). Additionally, for larger events, as in March 2011, the timing and magnitude of total peak inflow to the Bypass may be delayed.

1.1.3 Willow Slough Bypass

1.1.3.1 Existing Configuration

Willow Slough originates from a small unregulated watershed between Cache Creek and Putah Creek with historically intermittent swales and sloughs draining to the Yolo Basin (CDFW, 2008). The Willow Slough Bypass has a design capacity of 6,000 cfs and is maintained by DWR (CVFMP, 2010). The Davis Wastewater Treatment Plant discharge location releases effluent to the Willow Slough Bypass (see Figure B-2). In addition, the Davis Wetlands border the Willow Slough Bypass and discharge treated water into the Yolo Bypass. As part of the State Plan for Flood Control, Willow Slough was rerouted from its historic northward route toward the Yolo Bypass to its current configuration within the Willow Slough Bypass with a diversion weir (Merritt Diversion Dam) at the bifurcation point just downstream of a railroad bridge near the County Road 29 and 101A (F Street) intersection (CVFMP, 2010).

1.1.3.2 Historical Hydrology and Recommendations

The main recommendation here is to install flow and stage monitoring stations in the Willow Slough Bypass, preferably upstream and downstream of the diversion dam that sits at the upstream end of the Willow Slough Bypass floodway. Once data has been collected for several years, the assumptions from the Management Strategy can be validated and potentially modified.

As described in the Management Strategy (Jones & Stokes, 2001), Willow Slough has not been gauged during the historical record. Instead historical hydrology was estimated by inferring Willow Slough flow from gauged runoff in the Interdam Reach (between Lake Berryessa and Lake Solano) of Putah Creek adjusted by drainage area for the Interdam Reach compared to Willow Slough. See the Management Strategy for more details on these assumptions. As Willow Slough is unregulated, small peak runoff events are common (CDFW, 2008). Compared to Putah Creek from recent water years 2005 to 2011, Willow Slough flows are similar in pattern with slightly higher magnitude peaks due to estimation assumptions scaling up drainage area, except when Berryessa spills as in 2006 (Figure B-5).

1.1.4 Putah Creek

1.1.4.1 Existing Configuration

Putah Creek is regulated by Monticello Dam at Lake Berryessa, and the Putah Diversion Dam near Winters and the Los Rios Check Dam in the YBWA. Putah Creek below the Diversion Dam serves as a diversion point for irrigation and discharge along its length and also as a flood control channel maintained by DWR in the leveed portion from 1 mile upstream of Interstate 80 to the Yolo Bypass (CVFPB, 2010). The Los Rios Check Dam is a 12 foot high, by 25 foot wide concrete structure with removable timber stop logs, which are in place from April/May through December 1st to impound water for agriculture and wetland management. During the remaining months, the stop logs are removed to assist fall-run Chinook migration in Putah Creek when Solano County Water Agency (SCWA) is releasing water from Putah Diversion Dam to fulfill the requirements of the Putah Creek Accord (CDFW, 2008).

The Putah Creek Accord was signed in May 2000 to provide minimum flows and pulse flows for the benefit of fish and wildlife.

Lower Putah Creek is also undergoing a study funded through an Ecosystem Restoration Program Grant to consider realignment of the channel within the YBWA, improve fish passage and meet other Ecosystem Restoration Project Goals (Yolo Basin Foundation, 2010b). As part of that, stage and flow monitoring (at locations noted in Figure B-2) was conducted between November 2012 and June 2013, which confirmed that the conveyance capacity of the creek within the YBWA before it begins to spill onto its floodplain is approximately 1,000 cfs.

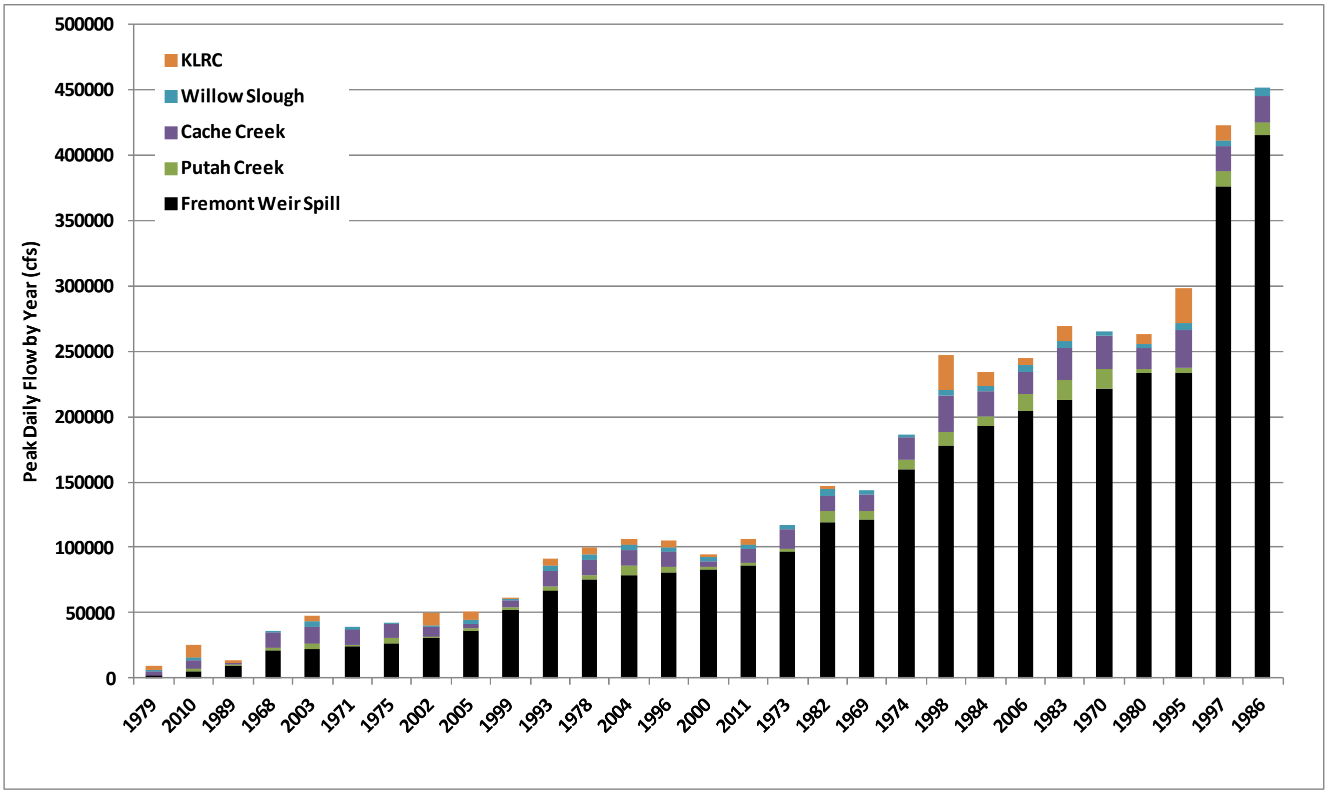
In addition, the UC Davis Wastewater Treatment Plant discharges into Putah Creek at Old Davis Road (see Figure B-2).

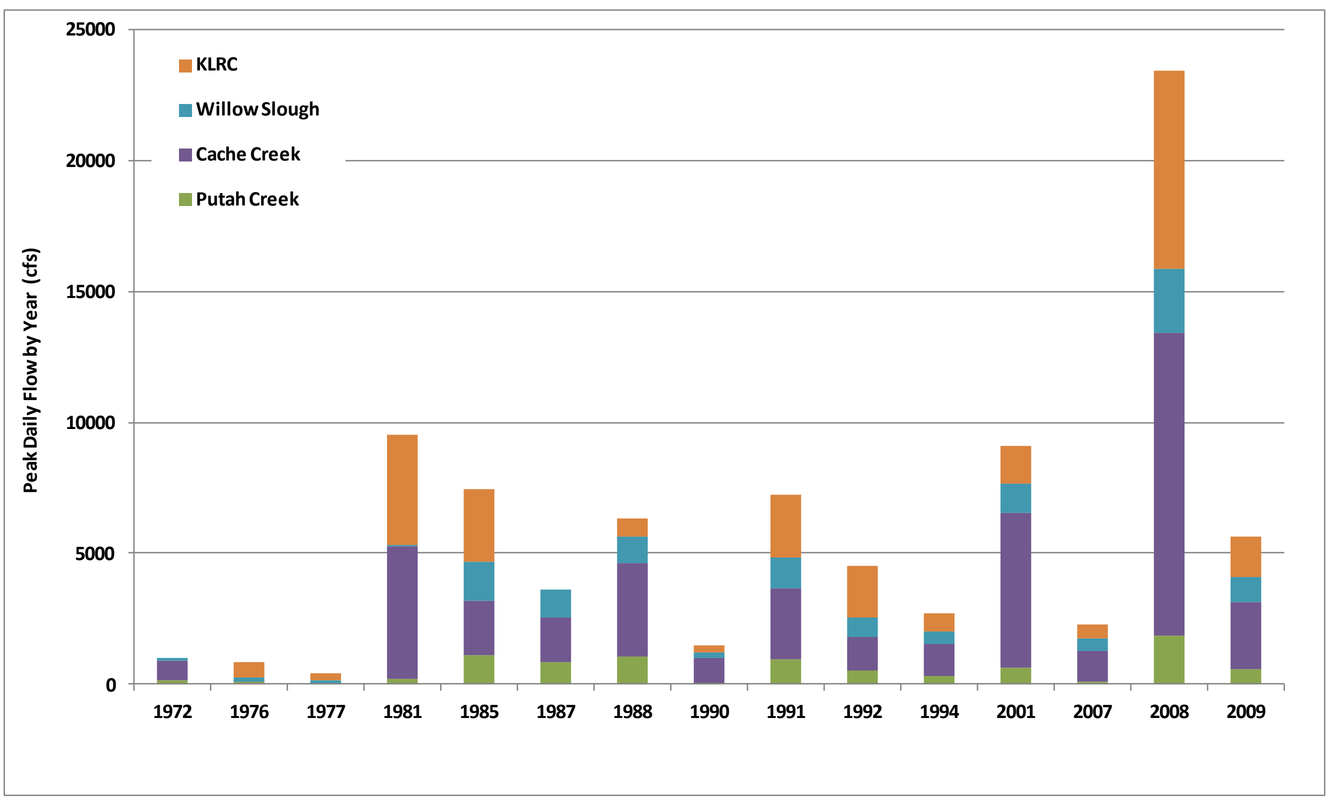
1.1.4.2 Historical Hydrology and Recommendations

SCWA has been monitoring low flows (i.e. less than approximately 100 cfs) data collection at eight stations along Putah Creek from the Putah Diversion Dam to Los Rios Check Dam (available online at http://www.grabdata.com/solano_putahcreek.htm). We recommend that these stations be rated for higher flows for historical verification and for use in future modeling efforts.

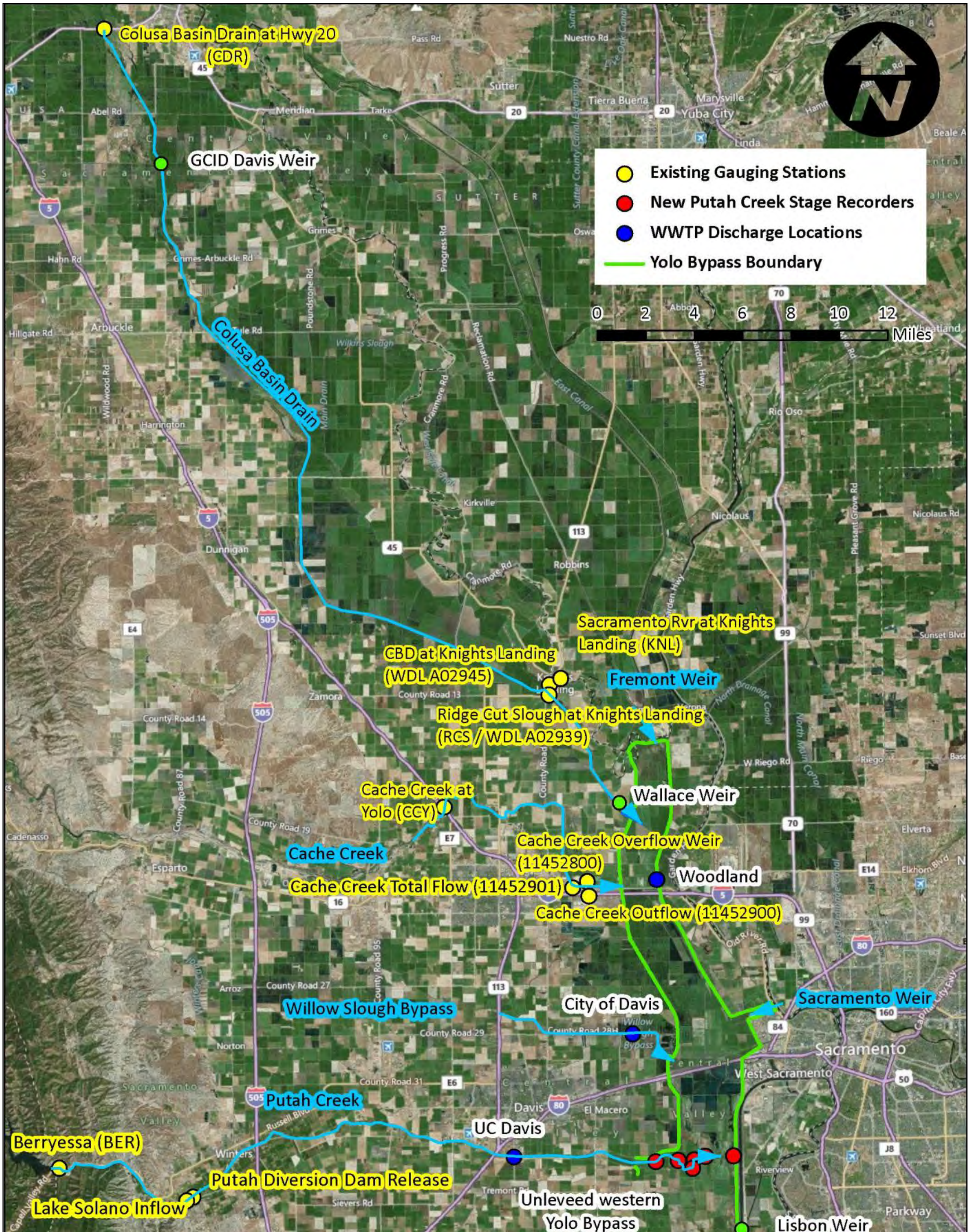
The Management Strategy estimated inflows to the Yolo Bypass from Putah Creek based on release and spill at Monticello Dam and Putah Diversion Dam. During times with no active rainfall-runoff (Condition 1) or if Monticello Dam is spilling (Condition 3), inflow to the Yolo Bypass equals Putah Diversion Dam releases minus 30 cfs seepage and evapotranspiration losses. If there is active rainfall runoff (Condition 2), defined as Interdam Runoff in excess of 100 cfs, then inflow to the Yolo Bypass equals two times the Putah Diversion Dam releases minus 30 cfs for losses. See the Management Strategy (Jones & Stokes, 2001) for more detail regarding these assumptions.

Interdam Runoff is defined as the difference between (a) Berryessa release plus spill and (b) Putah Diversion Dam release after diversion to the Putah South Canal. To better estimate Interdam runoff, total flow through the Putah Diversion Dam (i.e., release plus spill) including diversions to the Putah South Canal could be added to part (b) in this equation.





Notes: Years with Fremont Spill (top) and without (bottom)	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **Relative tributary yearly maximum flow**		
		Project No. 12-1039	Created By: AMS	**Figure B-1**



Notes: Image courtesy of BingMaps (2009).	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **Tributary gauging stations**	
		Project No. 12-1039	Created By: AMS	**Figure B-2**

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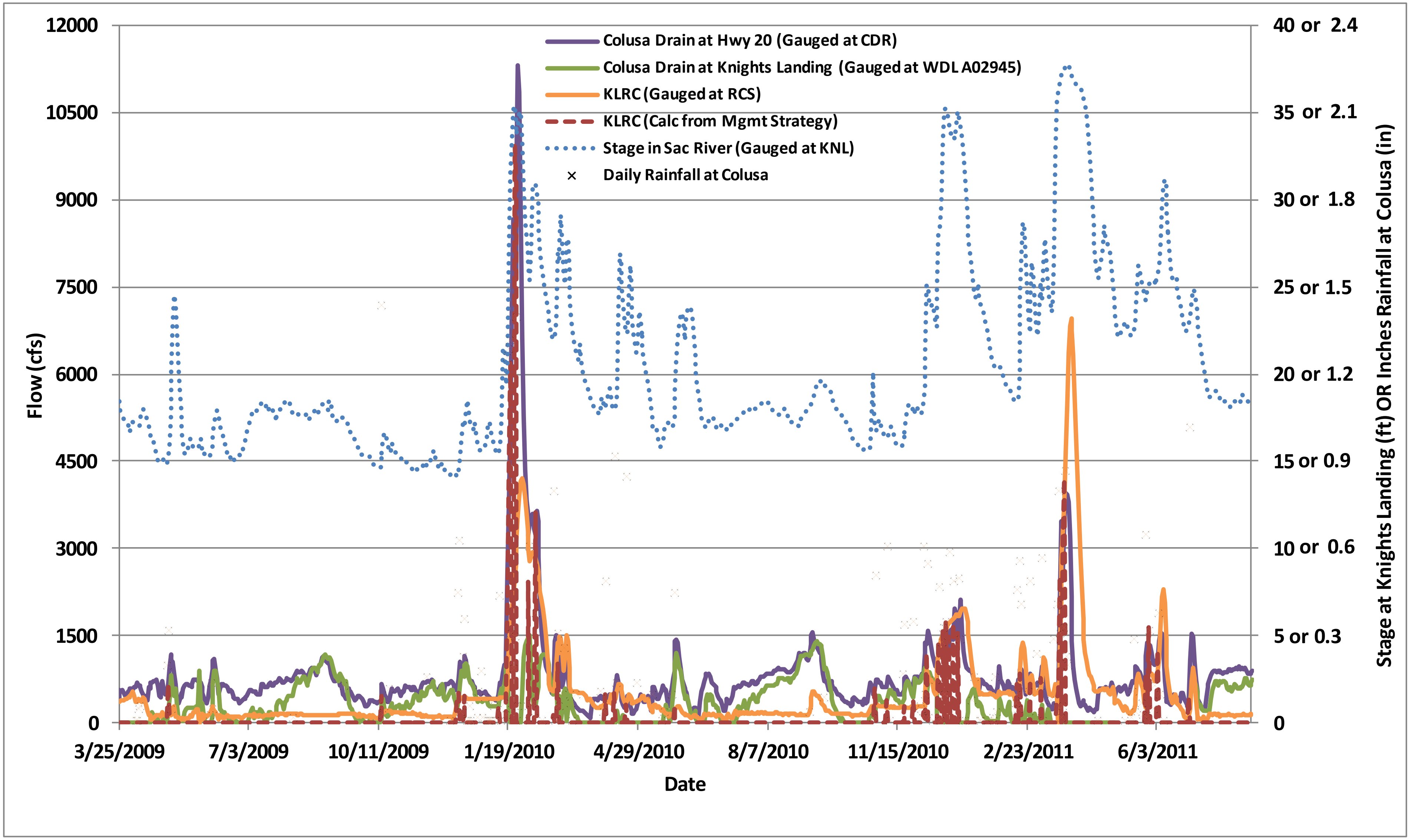
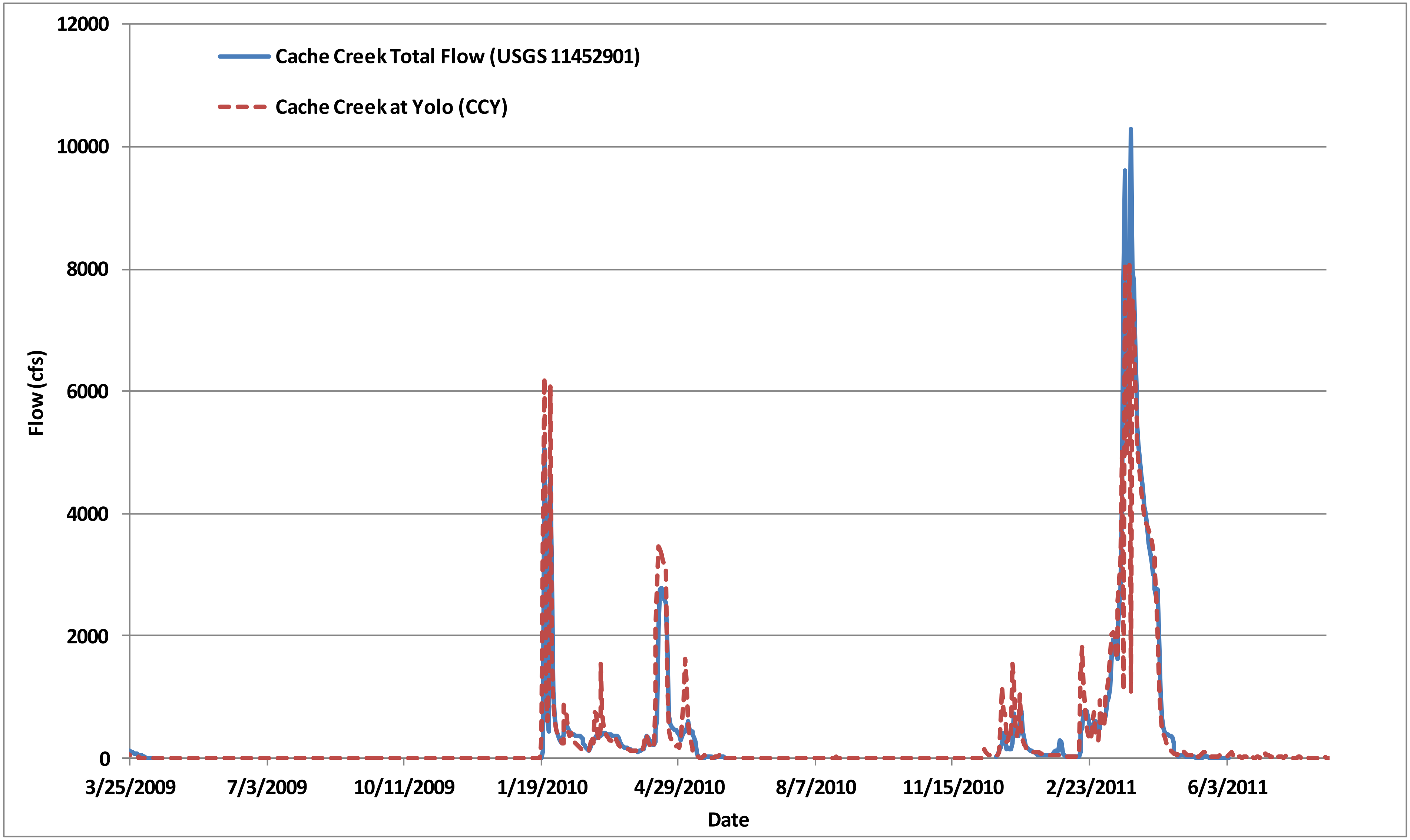
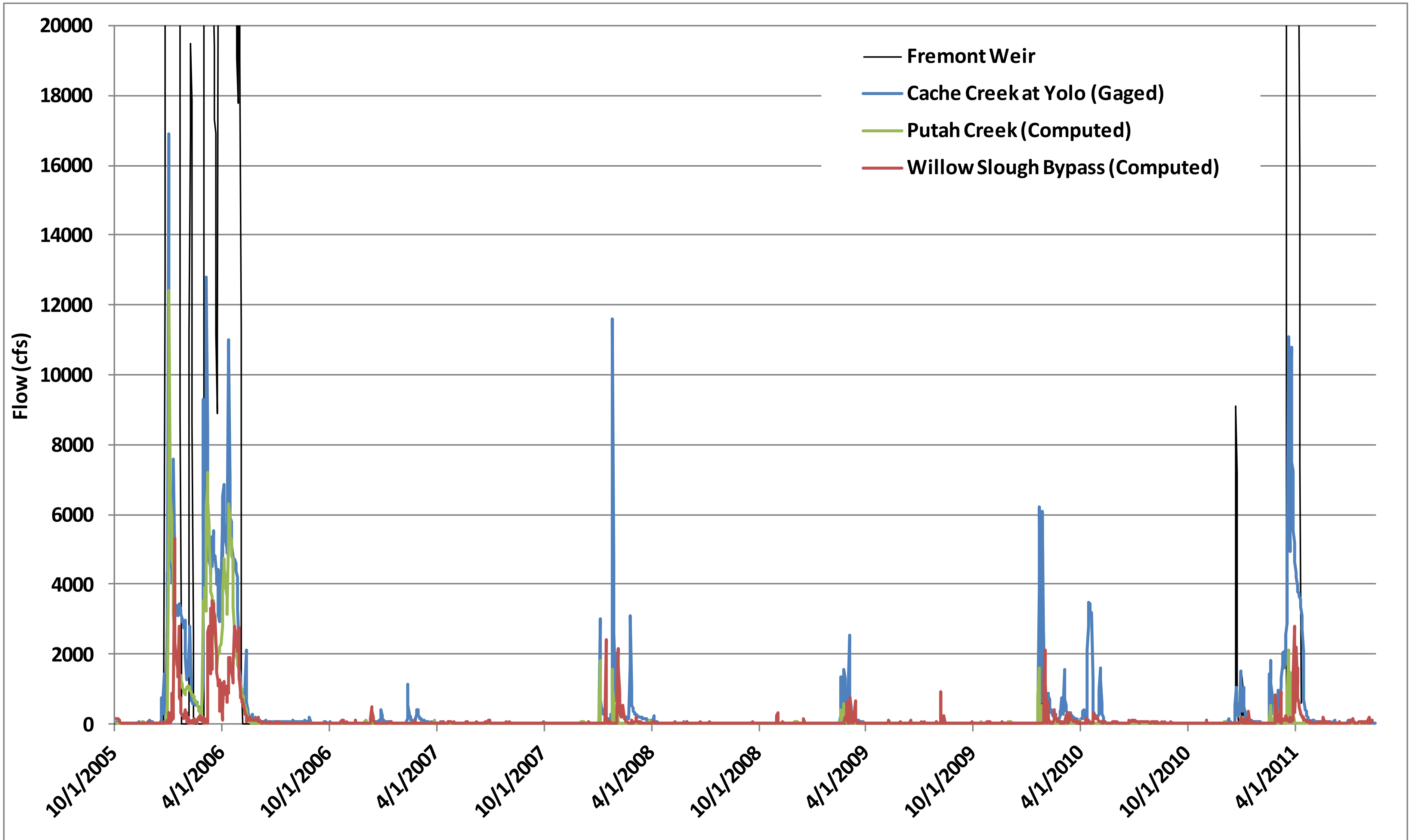
1/4/2014



Notes: Daily flow and stage data.	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **KLRC estimation validation**	
		Project No. 12-1039	Created By: AMS	**Figure B-3**



Notes: CCY is gauged daily flow at I-5 upstream of the Settling Basin, Cache Creek Total Flow is the composite of the overflow weir and low flow channel gauged data at 11452800 and 11452900 respectively. Note small peak attenuation and differences in event peak magnitude.	cbec eco engineering	*Yolo Bypass Drainage and Water Infrastructure Improvement Study* **Cache Creek inflow to Yolo Bypass** Project No. 12-1039 | Created By: AMS | **Figure B-4**



Notes: Recent hydrologic datasets for tributaries by Yolo Bypass Management Strategy (Yolo Basin Foundation, 2001) rationale. Note relative increase in Putah Creek relative to Willow Slough when Berryessa spills.

cbec eco engineering

Yolo Bypass Drainage and Water Infrastructure Improvement Study

Recent Cache, Putah and Willow Slough comparison

Project No. 12-1039	Created By: AMS	**Figure B-5**

Hydrology | Hydraulics | Geomorphology | Design | Field Services

cbec, inc., eco-engineering
2544 Industrial Blvd.
West Sacramento, CA 95691
USA

T 916.231.6052 X220 F 916.669.8886
cbecoeng.com

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EXHIBIT F

Yolo Bypass MIKE-21 Model Review: Strengths, Limitations and Recommendations for Refinement

By

Northwest Hydraulic Consultants (NHC)

With

Yolo County and cbec eco engineering

September 20, 2012

FREMONT WEIR AT HEAD OF YOLO BYPASS, MAY 2008 (LEFT) AND JANUARY 28 2010 (RIGHT) - NHC PHOTOS

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YOLO BYPASS MIKE-21 MODEL REVIEW: STRENGTHS, LIMITATIONS AND RECOMMENDATIONS FOR REFINEMENT

PURPOSE

This report summarizes the strengths and limitations of the MIKE-21 Yolo Bypass model prepared by cbec eco engineering (cbec), identifies areas requiring further model review, and identifies recommended model refinements.

BACKGROUND

The state and federal government are developing the Bay Delta Conservation Plan (BDCP) to improve water supply reliability and restore ecosystem functions within the Sacramento-San Joaquin Delta. A central BDCP component includes the implementation of various conservation measures that are intended to improve habitat for sensitive fish species. BDCP has identified Conservation Measure #2 within the Yolo Bypass, which includes the construction of a notch in the Fremont Weir and the installation of operable gates to lower the height at which Sacramento River water can flow into the Bypass. Conservation Measure #2 will increase the frequency and duration of flooding of the Yolo Bypass which is intended to improve fish habitat.

To estimate the “footprint” (i.e. location of inundated acreage) of additional flooding from an operable gate in the Fremont Weir, Metropolitan Water District of Southern California (MWD) and the Department of Water Resources (DWR) separately contracted with cbec to develop a two-dimensional, flexible mesh MIKE-21 hydrodynamic simulation model for the Yolo Bypass (cbec’s MIKE-21 Yolo Bypass Model). This model has been used to develop approximate extents and depths of inundation in the Bypass for several assumed steady state flow release scenarios and historical flood events at the Fremont Weir. Graphical displays of the MIKE-21 Model results provided to DWR and others visually display the inundation that might occur within the Yolo Bypass associated with different steady state and unsteady, historical flow release scenarios at the Fremont Weir. Given the importance of accurately estimating the approximate extents and depths of inundation because of the potential impact of flooding on existing land uses, Yolo County contracted with Northwest Hydraulic Consultants (NHC) to review the underlying assumptions in the MIKE-21 Model and to describe its current strengths, limitations and recommendations for refinement.

MIKE-21 is a modeling tool which uses numerical algorithms to approximate flow properties under user-specified conditions. The level of accuracy of the results provided by MIKE-21 is strongly dependent upon the level of accuracy of the user-specified information. Such information includes the bathymetric and topographic data used to create the computational grid, the refinement of the grid itself, channel and floodplain roughness values used within the model, and the correct flow boundary conditions located at the correct locations throughout the model. NHC’s review was founded on the understanding that the reliability of two-dimensional numerical models, such as MIKE-21, greatly depends on how well the user-specified information reflects the intended application of the model. The purpose of the model and the specific hydraulic questions the model is intended to address defines the necessary detail for various scalar and temporal components of a model's structure, its boundary conditions and key operational parameters. Determination of the flood conveyance capacity of the Yolo Bypass and water levels that may occur during a 100 or 200-year flood, for example, relies on data with significantly different levels of detail compared to much lower flow conditions associated with releases through an operable gate at the Fremont Weir. A numerical model is considered to be ready to produce reliable results only if the questions and problems to be addressed by the model are properly defined, all of the key input data have been thoroughly checked, and if model sensitivity, calibration and verification analyses have been carefully completed.

The following discussion provides a brief summary of NHC's findings regarding the cbec Yolo Bypass MIKE-21 Model. These findings are based on the information that has been received to date (see references). Further reporting regarding the ecological modeling analysis and results has been completed by cbec and is currently being reviewed by DWR. DWR has indicated that this additional reporting will become available this summer.

STRENGTHS OF CBEC'S YOLO BYPASS MIKE-21 MODEL

MIKE-21 is a depth-averaged two-dimensional (2-D) numerical modeling tool designed to simulate water levels and flows in rivers, estuaries, bays and coastal areas. It can simulate both steady-state (constant) flow conditions or unsteady (time varying) flow conditions in the two horizontal dimensions. This proprietary modeling tool was developed by and can be obtained from DHI Water & Environment (DHI) in Denmark.

Unlike one-dimensional models, two-dimensional models are intended to simulate more complex flow conditions (flow direction, depth and average velocity), which may vary laterally across the width of flow or include flows with variable directions. These models require the user to input a network of ground elevation points throughout the entire area to be modeled, not just at widely spaced cross sections. A network of computational cells (triangles or quadrilaterals) containing this information is then used by the model to determine the water surface elevation, average flow velocity, flow depth and flow direction at each computational point in the network of cells. There can be hundreds of thousands of computational points in a detailed 2-D model, depending on the level of detail required to address a particular flow scenario.

The cbec MIKE-21 Model uses a "flexible mesh" version, which allows the user to specify small, closely spaced computational cells in areas where greater detail is needed to capture complex flow conditions. A typical application of a two-dimensional model would be to resolve complex flow conditions at a confluence of two rivers where pockets of high velocities may form with large recirculating eddies across the channel. Another application includes flows that occur in river and floodplain areas where a single-channel or multiple-channel river spreads laterally out onto a complex floodplain with variable flow directions, depths and velocities (e.g., similar to how the toe drain and Yolo Bypass fill and empty during floods). To help accomplish this for the Yolo Bypass, cbec used available LiDAR data (DWR, 2005) for Yolo Bypass floodplains and collected additional bathymetric data along the Tule canal/toe drain in 2009-2010 and measurements of the I-80 and I-5 causeway abutments and railroad trestle features in the Bypass. Cbec subsequently informed us that some of these data were reviewed, checked and summarized through the following methods and documents:

- 2009 Toe Drain surveys by Environmental Data Solutions (EDS) were undertaken to USACE approved QA/QC protocols.
- 2010 Toe Drain/Tule Canal surveys by cbec included reporting of QA/QC performed (cbec 2012).

These documents were not available or reviewed by NHC during the preparation of this report.

MIKE-21 is a highly respected modeling tool that comes with all of the standard hydrodynamic modeling capabilities needed to assess frequency and duration of flooding questions in the Yolo Bypass. It is well documented and comes with detailed users manuals. DHI provides limited technical support to licensed users of the model. However, as with all numerical models MIKE-21 is strongly dependant on user specified information including: inflow boundary conditions, tides, channel and floodplain roughness (including ground surface conditions, vegetation, cropping, cultivation patterns), floodplain topographic details, channel bathymetry, characteristics of flow obstructions and other required model parameters such as eddy viscosity and bed friction.

LIMITATIONS OF CBEC'S YOLO BYPASS MIKE-21 MODEL

Beginning in 2008, several different numerical models (one-dimensional and two-dimensional models) were developed by different groups for different purposes, using different assumptions and data to assess a variety of BDCP questions and issues. Currently available reports describing the development, application and results from cbec's MIKE-21 model of the Yolo Bypass do not provide sufficient details regarding the MIKE-21 model's purpose, its development and testing, sources and reliability of input data used to define key boundary conditions, modeling parameters and modeling assumptions. This lack of reporting detail regarding cbec's Yolo Bypass MIKE-21 model, and similarly several of the other models, makes review and comparison of current modeling results difficult for Yolo County resource managers. Based on a review of readily available reporting and discussions with DWR and cbec modelers, the following is a list of limitations associated with the current version of cbec's Yolo Bypass MIKE-21 model. The review included information provided in a recent memo from cbec dated June 18, 2012 entitled *MIKE 21 2D Yolo Bypass Model Strengths and Limitations* (cbec 2012b).

1. Limitations related to Topography and Bathymetry

cbec (June 2012) state that "the accuracy of the Bypass model results are controlled by the accuracy of the topography and bathymetric data sources; the mesh size and resolution; the accuracy and reliability of the boundary conditions (inflow hydrographs); the spatial, temporal and depth-dependent hydraulic roughness conditions; and the stability of the numerical (computational) scheme and its ability to handle wetting and drying." The reviewers agree that these model development considerations control the accuracy of the MIKE-21 model and other models being applied to the Yolo Bypass. Based on this understanding, the following are specific MIKE-21 modeling limitations and concerns.

A. **Some topographic data are inaccurate.** cbec describes inherent topographic inaccuracies due to LiDAR information affected by returns off ponded water, floating vegetation and dense riparian corridors, LiDAR flight timing, and because there are missing portions of the West Side LiDAR coverage in the non-leveed portion of the Bypass. The steps necessary to check and correct these potential inaccuracies need to be identified, but they will generally include additional detailed surveys. Similarly, low profile topographic features such as agricultural roads, berms, swales, graded break lines, rice checks, rice check gates and culverts, and irrigation and drainage ditches may not be discernable in the current LiDAR data (see discussion below), which is equally important when modeling field-to-field flooding and draining processes during low to medium flow conditions in the Bypass.

B. **Some topographic detail is insufficient.** The topographic detail may be insufficient in low areas adjacent to the Toe Drain and Tule Canal to accurately depict where and when lateral breakout flows leave the canal and spread out onto the floodplain. Inaccuracies in these areas could also affect how return flows drain back into the Toe Drain (draining and drying of the floodplain). cbec further identified large areas where insufficient topographic detail is available to accurately describe how flows discharging from west side tributaries (i.e., Knights Landing Ridge Cut, portions of Willow Slough outlet, and Putah Creek) spread out and eventually discharge into the Toe Drain or Tule Canal. An accurate depiction of shallow flooding processes in the tributary inflow areas is very important to determine the existing impact of flooding on agricultural land uses. The lack of topographic detail on a field-by-field basis is a significant limitation of the current model. However, it should be noted that modeling on a field-by-field basis will be challenging due to the numerous rice checks/culverts that change on a yearly basis. Additional ground surveys, as discussed in 1C below, will be needed to refine the MIKE-21 model in order to address this issue.

C. **Need additional ground surveys.** cbec identified areas where additional ground surveys were conducted to provide greater detail near water control features and grade breaks. Additional detail is still needed in other areas, especially where agricultural impacts need to be assessed at an individual field level. This may require collecting additional information to better understand the effects of rice check culverts on the shallow flooding characteristics of individual fields. These checks may be opened or closed, depending on the water management needs of individual field managers. Field-by-field berms with holes in them may be less of a concern.

2. Limitations related to Hydrology and Flow Boundary Conditions

A. **Reliability of west side tributary flows is questionable.** The reliability of the currently prescribed west side tributary flows from the Knights Land Ridge Cut, Cache Creek, Willow Slough and Putah Creek is questionable. Hydrologic information included in the MIKE-21 model for the west side tributary flows originated from preliminary estimates produced during an initial planning-level study completed in 2001 by Jones and Stokes (Yates, 2012). Based on the documents reviewed by NHC for the MIKE-21model review, the preliminary hydrologic estimates have not been checked, verified or updated since 2001. Cbec has indicated that the preliminary estimates have been updated as part of their work for DWR (cbec March 2012), which has not yet been released or peer reviewed. In addition, the inflow locations of some of the west side tributary inflows are not accurately specified in the model at this time. The model needs to have sufficient detail to accurately define inflow locations of all west side tributary inflows and how those flows will spread out onto the Bypass. It is very important to evaluate and, if necessary, update the west side tributary hydrologic data prior to continuing further modeling assessments.

B. **Fremont Weir inflow boundary conditions have not been verified.** Preliminary inflow boundary conditions at the Fremont Weir (for weir overtopping spills and for an assumed gated slot in the weir) were developed in 2009 by DWR and may not have been fully tested or verified. A letter from DWR also refers to errors in a logic statement and a datum associated error that resulted in overestimation of the notch flow period and underestimation of historical periods of Fremont

Weir overflows (DWR, June 2011). Therefore, important flow boundary conditions being used in the MIKE-21 model may need to be carefully checked or verified. DWR also explains that there are three different ways inflows into the Yolo Bypass over the Fremont Weir have been computed for the BDCP. cbec used constant steady flows over the Fremont Weir without inflows from the West Side tributaries for their work for MWD. For DWR, cbec used constant notch flows at the Fremont Weir with assumed steady (constant) flows entering the bypass from each of the west side tributaries. The notch flows were derived from the Draft Technical Memorandum for Technical Study #2: Evaluation of North Delta Migration Corridors: Yolo Bypass (BDCP April, 2009). Their estimated West Side tributary flows were derived in collaboration with DWR based on average conditions assumed to be coincident with notch flow activation as described in cbec November, 2010.

C. **Need to further assess and document effects of system-wide filling and draining processes.** DWR mentioned (Kirkland, 2011a, 2011b) that ". . . flooding and draining in the Yolo Bypass varies with system-wide conditions as well as with Fremont (Weir) inflows." Therefore, results from previous studies of the Yolo Bypass could be quite different depending on how explicitly the system-wide filling and draining processes are specified in the MIKE-21 model or other models used to assess Conservation Measure #2. We agree that understanding how these processes work and how they are currently being depicted in Yolo Bypass models is very important and warrants further assessment and documentation.

D. **Need to complete additional model sensitivity and calibration analyses.** Floodplain storage and drainage, and the effects of bi-directional flows caused by diurnal tides greatly complicate the hydraulics and water levels in the southern portion of the Yolo Bypass and 2-D model during frequent floods and pulse flows. Additional model sensitivity testing and calibration analyses should be completed to ensure that the daily influences of changing tide levels are being modeled properly for Conservation Measure # 2 flow conditions and that the current downstream model boundary is in a reliable location.

E. **Need to check simplifying assumptions.** Simplifying assumptions necessary to develop and run the MIKE-21 model such as floodplain roughness have not been checked or verified. The model currently includes the primary control structures within the Toe Drain, such as the Lisbon Weir; however, tide gates and checks located away from the Toe Drain within the Bypass (e.g., Los Rios dam) are not included in the model. Inclusion of these types of floodplain water control features would require additional surveys to be conducted. The effects of these features could affect modeled Conservation Measure #2 flow results.

F. **Need to clarify inclusion of waterfowl habitat in model assumptions.** The model assumptions do not clarify whether areas within the Bypass that are currently managed to provide waterfowl habitat through the winter and early spring are included in the current models or how those managed wildlife areas affect flooding on adjacent agriculture lands. It is unclear whether flooded fields are included or not. Based on discussions with cbec, details regarding management of water fowl areas are not included in the model. Collection of data needed to assess such areas could be somewhat cumbersome due to year-to-year changes in management practices. However, the effects associated with the wetland areas being full or empty during modeled flood events should be accounted for at a reasonable level due to their associated effects on Conservation Measure #2's flow results.

3. Limitations related to Model Structure and Computational Assumptions

A. **Need to validate wetting and drying assumptions.** Accurate simulation of wetting and drying processes on individual agricultural fields is one of most sensitive, yet important physical processes to be tested and verified within the MIKE-21 model. Accurate information regarding timing, depth, spatial extent and duration of inundation within the Bypass is required for the agricultural impact assessments. It is important to test and document how the currently prescribed internal boundary conditions are being used for wetting and drying in individual cells.

The importance and sensitivity of these internal floodplain wetting and drying assumptions are amplified by the cell size (dimensions) and ground slope within the cell. How the model simulates these processes needs to be tested and better understood and documented to determine how sensitive and reliable model results are to those assumptions.

B. **Need to refine model to address questions related to impacts of flooding.** Current cell sizes used to represent major portions of the floodplain west of the toe drain are much larger than those along the toe drain. Therefore, cbec (June 2012) recently stated that, "While it is possible to use the model to predict floodplain inundation extents over discrete sub-reaches of the Bypass, the model is not currently appropriate for predicting floodplain inundation on a field-by-field basis. There is no model currently available that can do this type of analysis in the Bypass." Significantly smaller mesh sizes, but more importantly, increased spatial details to facilitate the use of smaller mesh sizes are needed in order to assess field-by-field depth, duration, lateral extent of flooding and hydraulic wetting and drying processes required for agricultural impact assessments. Such model refinements would require careful assessment of current LiDAR data, reconstruction of portions of the floodplain model and the inclusion of local land form details such as roads, ditches, berms, rice checks, swales, drainage control structures, etc. Additional ground surveys may be required to provide these details. Model sensitivity analyses need to be conducted to determine where and to what levels of precision new topographic data are required. If new topographic and bathymetric data were collected the model would need to be updated, tested and recalibrated. Results from a future refined model may be measurably different from the present coarse-grid model. Model refinements and their effects on prior results need to be thoroughly reported.

4. Model Testing, Calibration and Verification

A. **Need additional sensitivity analyses.** Further model testing is essential given that there is only limited model calibration data available. Therefore, additional model sensitivity analyses should be conducted as stated in the sections above, including detailed model sensitivity analyses to test the effects that small changes in topographic detail, or assumed floodplain roughness (Manning's "n"), or computational mesh size (and spatial details), or the effects that a time varying tide may have on computed results. The current Yolo Bypass MIKE-21 model was calibrated to flow conditions measured in the Tule Canal and Toe Drain during an approximately bank-full flow period in February and March of 2010. No floodplain data are available for calibrating or verifying water levels or shallow flooding processes in the floodplain areas. Therefore, the accuracy of computed wetting and drying and shallow overland flow processes (depths and velocities) in floodplain areas has not yet been determined, which would first require additional ground surveys and further model testing and refinements to rectify known inadequacies in the topographic source data. Additional analyses should be conducted to determine which modeling parameters and data requirements the model is most sensitive to.

Test results will likely indicate which types of model input data may require improved precision and refinement.

B. **Need to validate model.** cbec recently stated (June 2012) that the Bypass Model has not been validated. cbec has informed us that they collected additional data during the April 2011 flood that could be used for validation but they have not been contracted to use these data. In addition, DWR should check with their monitoring and modeling groups as well as the Corps of Engineers to determine if model validation data are available. Perhaps implementation of simplified winter flow and water level monitoring activities should be considered in order to provide needed calibration and validation data?

5. MIKE-21 Model Availability

A. **MIKE-21 is a proprietary model.** MIKE-21 is a proprietary model and a model license must be purchased from DHI Water & Environment along with annual user support fees if one elects to receive annual technical support and model updates. Interested users can perform limited reviews (view only) of results files produced by cbec without a model license; however, a model license is required for users to develop input files and to open and work with output files to prepare graphics or perform additional model simulations. Therefore, independent evaluation of MIKE-21 modeling results by stakeholders may be difficult without owning a licensing agreement with DHI. Costs to purchase a license and pay for annual support fees can be significant.

RECOMMENDED NEXT STEPS

The following is a list of recommended next steps:

1. **Clearly define Yolo Bypass modeling questions.** Beginning in 2008, several different numerical models (one-dimensional and two-dimensional models) were developed by different agencies and groups for different purposes, using different assumptions and data to assess a variety of BDCP questions and issues. It is likely that many of the models evolved without the benefits of having a mutually-agreed-upon Model Development Program to provide stakeholders such as Yolo County the opportunity to define their most important key questions and physical processes to be modeled prior to model development. Therefore, key Yolo Bypass questions to be addressed by the MIKE-21 model need to be clearly defined along with specification of all the essential information needed to develop a reliable MIKE-21 model of the Yolo Bypass (i.e., geometry, hydraulic boundary conditions, hydraulic parameters, key modeling assumptions, and water control features). This is also true for any of the Yolo Bypass models (e.g., HEC-RAS, RMA-2).

2. **Clearly document MIKE-21 modeling information.** The current modeling information needs to be clearly documented and validated to ensure the model results accurately represent the expected inundation scenarios associated with Conservation Measure #2. Therefore, the model's purpose, procedures used for development and testing the model, sources and reliability of input data used to define key boundary conditions, modeling parameters and modeling assumptions need to be fully described and reported. Out-of-date, untested, or unverified data and inflow boundary condition assumptions need to be updated prior to refining and recalibrating the model.

3. **Collect missing data and perform sensitivity analysis.** Missing or inaccurate topographic data need to be collected and integrated into the model, as feasible. Also, sensitivity analyses need to be conducted on the model's base assumptions to identify and prioritize where and what additional model refinements and improvements are necessary. The preliminary West Side tributary flow information (Jones and Stokes, 2001), for example, needs to be extended to include recent flow records. More detailed information regarding the West Side tributary flow characteristics, inflow locations, and boundary condition assumptions needs to be developed and integrated into the model.

4. **Develop a public domain model.** Given the need to use the Yolo Bypass model in the future to address many different types of questions and flow scenarios, there should be a strategy for making the MIKE-21 model and/or its result files available to stakeholders or there should be consideration of possibly using a different "open source" model that is publicly available. For example, the Sacramento District of the USACE completed the development and testing of multi-dimensional hydrodynamic simulation models (ADH and EFDC). These models geographically cover the entire Sacramento-San Joaquin River Delta, the Yolo Bypass, Fremont Weir and the Sacramento, Sutter Bypass, Feather River confluence area adjacent to the Fremont Weir. These models have been under development and testing for the past 3-4 years primarily to assess high flow conditions in the Bypass in relation to the Delta. Therefore, the resolution of the Corps of Engineers models is not currently of sufficient detail to answer the agricultural impact questions being posed by Yolo County. Further investigations and discussions with the Corps should be conducted to identify whether these USACE models (ADH/EFDC) could be refined to address low flow hydrodynamic flooding and draining conditions in the Yolo Bypass or whether other publically available models should be developed.

The MIKE-21 model software is not a public domain model, meaning that it is not freely available for download from the internet. A software license must be purchased from the developer, DHI, Inc to run simulations. However, a MIKE-21 model viewer can be used to view results files but not to make changes to the model input files. MIKE-21 is widely owned by consultants active in the field locally, and is approved by the USACE and FEMA.

The US Army Corps of Engineers (USACE) developed a public domain RMA2 model of the Yolo Bypass in 2007 that is widely used by consultants and agencies and is mandated by the Central Valley Flood Protection Board (CVFPB) for addressing impacts to flood conveyance in the Yolo Bypass. However, this is a steady state 2-dimensional model and therefore can only be used to model impacts to peak flood events. It cannot be used to model hydrographs and unsteady flow conditions, such as the tidal boundary at the lower extents of the Yolo Bypass. This is one of the reasons the MIKE-21 model was developed.

DWR has recently updated an historically available 1-dimensional, hydrodynamic HEC-RAS model for the Yolo Bypass. We understand that this model is being updated for the recently collected data provided by DWR and MWD, such as the toe drain bathymetry. While this model is appropriate for analyzing system-wide issues, it is not appropriate for analyzing detailed shallow floodplain inundation and interactions with distributary channels, such as the toe drain, in the Yolo Bypass

The data used to develop the MIKE-21 model input files, such as LiDAR data, toe drain bathymetric surveys, and input boundary hydrology has been disseminated by DWR and MWD. These data can be used for development of other models for the Yolo Bypass for other objectives. The MIKE-21 model input files cannot be used in the development of other models.

5. **Develop a strategy to address recommendations in this report.** Yolo County proposes to work collaboratively with DWR and cbec to determine what modeling refinements are most essential for evaluation of the Bypass and the best approach for implementing the recommendations described above. Adopted next steps must ensure that any model refinements accurately reflect the model's purpose and clearly address Yolo County's questions regarding Conservation Measure #2's long-term effects on land uses within the Yolo Bypass. We recommend developing a strategy to implement the recommendations in this report before major decisions are made related to Conservation Measure #2.

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EXHIBIT G

FINAL REPORT

Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals

PREPARED FOR: Yolo County

PREPARED BY: Richard Howitt[1], Duncan MacEwan[1], Cloe Garnache[1], Josue Medellin Azuara[1], Petrea Marchand[2], Doug Brown[3], Johan Six[1], and Juhwan Lee[1]

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Great egret in a harvested rice field. Photo courtesy of Dave Feliz

[1] University of California, Davis
[2] County of Yolo
[3] Douglas Environmental

Executive Summary

The California Natural Resources Agency and the U.S. Department of the Interior propose to increase the frequency and duration of flooding in the Yolo Bypass for seasonal fish rearing habitat, both as a major component of the Bay Delta Conservation Plan (BDCP) and also as a Reasonable and Prudent Alternative (RPA) in the federal National Marine Fisheries Service's Biological Opinion on the Coordinated Long Term Water Operations of the Central Valley Plan and State Water Plan for winter run salmon, spring run salmon, and Central Valley steelhead. While the state and federal government have not yet fully defined proposals to flood the Bypass for juvenile salmon, the project will have broader support and cost less if state and federal agencies minimize effects on existing land uses such as flood protection, migratory waterfowl and other terrestrial species habitat, and agriculture.

This report provides a quantitative framework for assessment of agricultural impacts of flooding in the Yolo Bypass consistent with initial proposals in the Biological Opinion RPA and BDCP Conservation Measure 2 (CM2). Since the RPA and CM2 are not fully developed, this report evaluates 12 possible scenarios and describes a range of possible impacts on agriculture and the Yolo County economy. Of the 12 scenarios evaluated, 10 scenarios assume annual inundation through a specified date (RPA scenarios) and 2 scenarios assume opportunistic inundation associated with natural overtopping of the Fremont Weir (CM2 scenarios). The modeling framework developed for this report can be used to evaluate any future proposal, and therefore is a useful tool for ongoing discussions regarding project design.

Background

The 57,000-acre Yolo Bypass is first and foremost one of the primary means of providing flood protection to the Sacramento region. Yolo Bypass agriculture also provides significant benefits to the local economy, migratory waterfowl, and the flood protection system. The Bypass can carry on average four times the flow of the Sacramento River or approximately 420,000 cfs. Yolo Bypass agriculture helps to maintain this flood capacity by controlling vegetation, thereby reducing the state's responsibility for vegetation removal. Yolo Bypass rice fields also provide habitat and food for migratory waterfowl when flooded for straw decomposition during the winter months.

"Natural" flooding in the Yolo Bypass can occur at any time from the Sacramento River overtopping the Fremont Weir and/or from tributary flows entering the Bypass from the west during storm events. Farmers have adapted to these conditions and landowners have lowered their lease rates to some extent to reflect the risk. Natural flooding delays planting times and reduces crop yields in the Bypass – or even prevents planting. Late season flood events may reduce crop yields through short-duration flooding, even if farmers prepare fields early in the season. As such, increased frequency and duration of inundation within the Bypass for fish habitat may translate into financial losses for farmers and the regional economy.

Scenarios

CM2, as described in the February 2012 BDCP draft, would lower a portion of the Fremont Weir to an elevation of 17.5 feet, from its current elevation of 32.8 feet, and construct an operable gate to allow Sacramento River water to flow into the Yolo Bypass (BDCP 2012). CM2 also includes a number of other actions within the Yolo Bypass including construction of fish passage improvements at the Fremont Weir. CM2 actions are designed to reduce migratory delays and loss of adult salmon, steelhead, and sturgeon, enhance rearing habitat for juvenile Sacramento River Basin salmonids, enhance spawning and rearing habitat for Sacramento splittail, and improve food sources for delta smelt downstream of the Bypass. Since CM2 is not fully developed, the authors created a "low-impact" scenario that is consistent with the 2012 draft. This scenario suggests supplemental flooding of up to 6,000 cubic feet per second (cfs) for 30 to 45 days in years when flooding occurs naturally in the Yolo Bypass.[4] This scenario provides a low estimate of CM2 impacts to demonstrate the potential to develop a project that minimizes impacts on agriculture. This scenario should not be used as a proxy for actual CM2 agricultural impacts since CM2 is not fully developed. If the BDCP proposes flooding in years the Fremont Weir does not overtop, agricultural impacts will increase significantly relative to this scenario.

The RPA, in Actions I.6 and I.7, requires the U.S. Bureau of Reclamation and the California Department of Water Resources to evaluate modification of operations at the Fremont Weir to increase rearing habitat for juvenile salmon. Similar to BDCP, the Bureau of Reclamation plans to evaluate lowering a portion of the Fremont Weir and constructing an operable gate to allow Sacramento River water to flow into the Yolo Bypass. The RPA requires additional rearing habitat for juvenile winter run, spring run, and Central Valley steelhead from "December through April" in the "lower Sacramento River basin." The RPA further identifies "an initial performance measure" of 17,000 to 20,000 acres with "appropriate frequency and duration." Since Reclamation has not fully developed actions to implement the RPA, the authors created scenarios that are consistent with the existing language in Actions I.6 and I.7. These scenarios cover proposed annual flooding between 3,000 cfs and 6,000 cfs and end dates varying from February 15th to May 15th. These scenarios provide a range of possible RPA impacts, but should not be used as a proxy for actual RPA impacts since the RPA is not fully developed.

Flooding at the proposed volumes of 3,000 and 6,000 cfs would inundate[5] between 12,200 and 25,000 total[6] acres, assuming no flooding from creeks on the west side of the Yolo Bypass. An increase in flooding could result in economic losses to farmers and the local economy, dependent on timing, frequency, volume, and duration. In addition, flooding may increase the costs of late season rains which could affect land values, lending, and farming in the Yolo Bypass.

This study estimates the expected losses of total agricultural revenue, total Yolo County revenue (value added), tax revenue, and jobs for the twelve policy scenarios listed in Table 1.

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[4] See Table 3.4-3 of the February 2012 BDCP Draft Report.

[5] This study is an agricultural impact analysis and, as such, areas of inundation include the literal flooding "footprint" plus fields that are partially inundated, discussed in Section 2.2.

[6] 12,200 total acres includes 4,500 acres of wetlands and Liberty Island, and 25,000 total acres includes 9,200 acres of wetlands and Liberty Island. Thus, flooding will affect between 7,700 and 15,800 acres of land used for agricultural production.This footprint does not include any land in Solano County.

Table 1. Inundation Scenarios

3,000 cfs	6,000 cfs
Feb 15 (Annual)	Feb 15 (Annual)
Mar 24 (Annual)	Mar 24 (Annual)
Apr 10 (Annual)	Apr 10 (Annual)
Apr 30 (Annual)	Apr 30 (Annual)
May 15 (Annual)	May 15 (Annual)
Low-impact CM2 Scenario	Low-impact CM2 Scenario

Results

Table 2 identifies the expected total annual losses to the Yolo County economy (also known as value added losses) associated with the inundation scenarios evaluated in the study. The fundamental driving factors in the analysis are total acres inundated, reduced crop yields, and increased land fallowing. As the last day of flooding through the proposed gate in the Fremont Weir increases, farmers would delay field preparation and planting, resulting in reduced crop yields and increased land fallowing. Agricultural revenues would fall, translating into losses in the Yolo County economy and employment in the region.

Under the RPA scenarios, the effect of increased flooding early in the season would be small, less than $0.25 million with 6,000 cfs flow. Flooding through May 15 significantly increases effects, with total losses to Yolo County economy of $3.8 million and $8.9 million under 3,000 cfs and 6,000 cfs, respectively. Under the low-impact CM2 scenario, in which flooding only occurs as an extension to natural flooding, expected annual losses would range from $0.63 to $1.5 million under 3,000 and 6,000 cfs, respectively.

Table 2. Expected Total Annual Loss to Yolo County Economy (Value Added) (Thousands of 2008 dollars)

Inundation Scenario	3,000 cfs	6,000 cfs
February 15	148	241
March 24	931	1,744
April 10	2,337	5,015
April 30	3,371	7,735
May 15	3,886	8,889
Low-impact CM2 Scenario	625	1,468

Assumptions

This analysis relies on assumptions that may increase or decrease the estimates of impacts if changed. The analysis does not explicitly consider, for example, changes in late season rains and management and associated operation difficulties that may affect drainage and field preparation times. Consideration of these impacts would increase the estimates of actual expected annual losses to the economy from the scenarios modeled in this analysis. In addition, the areas of assumed inundation under different flooding scenarios might change if different hydrologic models are used to estimate the footprint and the models are further developed to allow evaluation of tributary flows. Depending on the size of the footprint, impacts could increase or decrease. Impacts could also change if the expected crop price changes. This study uses an expected crop price that is representative of an average over recent years and neither relies on recent boom price levels nor on earlier depressed agricultural conditions. Finally, river levels may not be high enough in all years to allow flooding in the Yolo Bypass through an operable gate. If the Yolo Bypass gate cannot be used every year, the estimates of flooding for each inundation end date (with the exception of the low-impact CM2 scenario) would also decrease.

Recommended Additional Research

In addition to evaluating additional inundation scenarios as more information becomes available, the authors also recommend the following actions:

- Create inundation scenarios that include the west side tributaries to the Bypass once existing models are adequately reviewed.
- Create inundation scenarios that reflect potential constrained project footprints of 7,000 to 10,000 acres, since the current analysis only models unconstrained flooding and therefore includes acres that do not directly benefit fish.
- Analyze the effect of crop insurance on farmer responses to likely inundation proposals.
- Analyze the response of agricultural lending institutions to likely inundation proposals.
- Evaluate proposed inundation scenarios under a range of expected future crop prices.
- Compare the predicted area of inundation under the MIKE21 and HEC-RAS models.
- Analyze potential economic benefits to Yolo County from increased recreation opportunities (e.g. short-term construction benefits or additional recreational opportunities).
- Analyze potential benefits to farmers of increased groundwater recharge resulting from more frequent flooding of the Bypass.

Acknowledgements

The authors thank Yolo County, the State and Federal Contractors Water Agency (SFCWA), and the Conaway Preservation Group for the funding and support necessary to prepare this study.

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1 Introduction

The California Natural Resources Agency and the U.S. Department of the Interior propose to increase the frequency and duration of flooding in the Yolo Bypass for fish habitat, both as a major component of the Bay Delta Conservation Plan (BDCP) and also as a Reasonable and Prudent Alternative (RPA) in the federal National Marine Fisheries Service's Biological Opinion on the Coordinated Long Term Water Operations of the Central Valley Plan and the State Water Plan for winter run salmon, spring run salmon, and Central Valley steelhead. Under both alternatives, the project will have broader support and cost less if impacts on existing land uses – such as flood protection, migratory waterfowl and other terrestrial species, and agriculture – are minimized. Since the RPA and BDCP's Conservation Measure #2 (CM2) are not fully developed, this report evaluates 12 possible scenarios and describes a range of possible impacts on agriculture and the Yolo County economy with the goal of informing future decisions about project design. The modeling framework developed for this report also can be used to evaluate future proposals.

CM2, as described in the February 2012 BDCP draft, would lower a portion of the Fremont Weir to an elevation of 17.5 feet, from its current elevation of 32.8 feet, and construct an operable gate to allow Sacramento River water to flow into the Yolo Bypass (BDCP 2012). CM2 also includes a number of other actions within the Yolo Bypass including construction of fish passage improvements at the Fremont Weir. CM2 actions are designed to reduce migratory delays and loss of adult salmon, steelhead, and sturgeon, enhance rearing habitat for Sacramento River Basin salmonids, enhance spawning and rearing habitat for Sacramento splittail, and improve food sources for delta smelt downstream of the Bypass. Since CM2 is not fully developed, the authors created a "low-impact" scenario that is consistent with the 2012 draft. This scenario suggests supplemental flooding of up to 6,000 cubic feet per second (cfs) for 30 to 45 days in years when flooding occurs naturally in the Yolo Bypass.[7] This scenario provides a low estimate of CM2 impacts to demonstrate the potential to develop a project that minimizes impacts on agriculture.

The RPA, as described in Actions I.6 and I.7, requires the Bureau of Reclamation and the California Department of Water Resources to evaluate modification of operations at the Fremont Weir to increase rearing habitat for juvenile salmon. Similar to BDCP, the Bureau of Reclamation plans to evaluate lowering a portion of the Fremont Weir and constructing an operable gate to allow Sacramento River water to flow into the Yolo Bypass. The RPA requires additional rearing habitat for juvenile winter run, spring run, and Central Valley steelhead from "December through April" in the "lower Sacramento River basin." The RPA further identifies "an initial performance measure" of 17,000 to 20,000 acres with "appropriate frequency and duration." Since Reclamation has not fully developed actions to implement the RPA, the authors developed scenarios to evaluate possible options for annual flooding between 3,000 cfs and 6,000 cfs and end dates varying from February 15th to May 15th. These scenarios are modeled to provide a range of possible RPA impacts.

This study estimates the extent of inundation, crop yield loss, and effects on the agricultural economy from increasing the frequency and duration of flooding in the Yolo Bypass, either as a

[7] See Table 3.4-3 of the February 2012 BDCP Draft Report.

result of CM2 or the RPA. Of the 12 scenarios evaluated, 10 scenarios assume annual inundation through a specified date (RPA scenarios) and 2 scenarios assume opportunistic inundation associated with natural overtopping of the Fremont Weir (CM2 scenarios). All estimates include the direct economic effects associated with reduced agricultural production, as well as multiplier (direct and induced) effects associated with upstream and downstream changes to the regional economy. The authors used the HEC-RAS hydrologic model and the DAYCENT agronomic model to estimate the extent of inundation and change in crop yield, respectively, for each of the 12 scenarios. The authors estimated the effect on agricultural production using the Bypass Production Model (BPM), developed specifically for the Yolo Bypass. The BPM estimates the change in crop mix, agricultural revenues, and other factors due to crop yield loss (DAYCENT model) and the number of acres affected (HEC-RAS and MIKE-21 models) in the Yolo Bypass. Results from the BPM are linked to the IMPLAN regional input-output model to estimate total output, value-added, and employment losses within the Yolo Bypass and the Yolo County economy.

1.1 Scope of Analysis and Caveats

This report presents model results of the impacts of increased flooding on Yolo Bypass agriculture and the Yolo County economy. Thus, the geographic scope of the analysis is Yolo County and, in particular, the Yolo Bypass. The study does not consider crop production shifts out of the region. This would require, in part, an analysis of the rice mills in West Sacramento and Woodland to determine the proportion of business from Bypass production in addition to other regional economic effects. Additionally, whether rice production would shift out of the Bypass is an agronomic question since specific soil and climate data is required. The modeling approach also is sensitive to several parameters that are clearly described in the report. In addition, the authors conducted sensitivity analysis of key parameters. This report provides information about these important parameters in this section and reviews them throughout the text. Section 5 provides sensitivity analysis.

Subbing: Increased flooding in the Bypass may raise the groundwater table in regions out of the Bypass. This may restrict farming and/or reduce yields in affected areas, thereby increasing economic losses. We do not account for subbing in this analysis.

Late Rains: We provide expected annual loss estimates by using a time series of hydrologic conditions in the Bypass. However, late season rains may have additional costs that we have not captured. For example, if farmers begin field preparation late due to flooding for fish habitat and late rains occur, this may delay planting further and increase economic losses.

Prices: Expected future crop prices are uncertain. We use 2009-2010 average prices which do not reflect recent booms or historic depressed levels. We analyze the sensitivity of impact estimates to price changes in Section 5.

Lending and Insurance: We do not evaluate the effect of increased flooding on lending and insurance for farmers in the Bypass. This is related to late season rains and other management difficulties Bypass farmers may face with extended flooding.

Drought or Less Frequent Inundation: For the RPA scenarios, we have implicitly assumed water will be available for increases in the duration and frequency of Bypass flooding for fish habitat in every year. We recognize that RPA Action 1.6.1 only requires an increase in the acreage of seasonal floodplain rearing habitat and allows that water may not be available for flooding in every year. In addition, extended drought may lower the river level below the range of the operable gate at Fremont Weir, which may decrease expected losses since flooding will not occur in these years.

1.2 Inundation Scenarios

We consider five inundation dates and two different flow rates associated with possible RPA implementation. Additionally, we consider one low-impact CM2 scenario under the same flow rates, for a total of twelve policy scenarios (see Table 1). The inundation dates correspond to the last day of Sacramento River water releases through operable gates in the Fremont Weir: February 15th, March 24th, April 10th, April 30th, and May 15th. The two flow rates are 3,000 cfs and 6,000 cfs, which correspond to the flows recommended for fish in *Technical Study #2: Evaluation of North Delta Migration Corridors: Yolo Bypass* prepared for the BDCP Integration Team in April 2009. As discussed in the Executive Summary and the Introduction, the authors created these inundation scenarios because the RPA and BDCP alternatives are not yet fully developed. This framework used to evaluate these scenarios can be used for evaluate other scenarios as the RPA and BDCP alternatives evolve.

We identified the five end dates to represent a range of outcomes from RPA alternatives to flooding for fish habitat in the Yolo Bypass. The RPA only includes flooding through April, but we include a May 15th date to inform discussions related to potential flooding for splittail. The 2010 BDCP draft proposes flooding for splittail every 7 years if flooding does not occur naturally, although the acres of splittail flooding are not specified. Once acreage targets are more fully refined, the model framework can be used to develop loss estimates specific to proposed flooding scenarios.

The low-impact CM2 scenario, as described in the introduction, corresponds to supplemental flooding in years with natural overtopping at Fremont Weir. As such, the end date in this scenario is variable and depends on the specific water year. In Section 3.3 we describe the time series of hydrologic conditions used to generate annual expected losses in the low-impact CM2 scenario.

Fields in the Bypass must drain before farmers can begin preparation for planting. Agricultural fields located along the east side of the Bypass adjacent to the Tule Canal/Toe Drain tend to drain more slowly than higher elevation fields to the west. According to author interviews with land managers and farmers, slower drainage on the east side delays planting and tends to lower crop yields. On average, it takes two weeks for fields to drain on the west side of the Bypass and four weeks on the east side of the Bypass. Field preparation takes an additional four weeks. Thus, the authors assumed a delay of six to eight weeks between the last day water is released through a Fremont Weir gate and planting, depending on the location of the field.

February 15th. February 15th represents an end date to Fremont Weir flooding when agriculture is largely unaffected. Farmers have an adequate buffer for unforeseen circumstances, such as rain or cool conditions that lengthen the time needed for field drainage. Farmers state they prefer to start ground preparation by March 15th to allow adequate time for field work and planting. It takes approximately 4 weeks from the date a farmer can start field work to the date of planting, so an end date of February 15th would typically result in early April planting on the west side of the Bypass and mid-April planting on the east side.

March 24th. The March 24th end date translates into planting by late May on the east side of the Bypass and mid-May on the west side of the Bypass. This inundation end date represents a scenario in which growers are expected to experience yield losses (see Section 3), but are still able to plant their crops. We anticipate some land fallowing and shift in crop mix but in general crop yields are high enough to cover variable costs.

April 10th. The April 10th end date translates into planting by early June on the east side of the Bypass and late May on the west side of the Bypass. According to farmers interviewed, in an average year, June 10th is the last possible date to plant. As such, significant yield losses and land fallowing are expected in this scenario. If any unforeseen circumstances occur in this scenario, there is a high risk that planting will not occur.

April 30th. The April 30th end date translates into planting in late June on the east side of the Bypass and mid-June for the west side of the Bypass. It corresponds to the latest flood date under the RPA. According to farmers interviewed, in an average year, June 10th is the last possible date to plant. As such, significant yield losses and land fallowing are expected in this scenario. In this scenario, planting may not occur at all on the east side of the Bypass and there is a high risk that planting will not occur on the west side.

May 15th. The May 15th end date for water releases represents a date when farmers state they will not plant crops, as it corresponds with a plant date of mid-July on the east side of the Bypass and early July on the west side of the Bypass. This date is frequently referred to in public forums as important for splittail habitat. Yield response functions from the DAYCENT model confirm that crop yields are not high enough to cover variable operation costs if the flooding through the operable gate in the Fremont Weir continues through May 15th. Consequently, significant land fallowing would occur. Contracts and other fixed costs may induce farmers to plant late in the season, however.

Low-impact CM2 scenario. The low-impact CM2 scenario is consistent with the description of CM2 in the BDCP February 2012 draft, but represents a scenario in which the impacts would be significantly lower than other potential scenarios. The actual proposal may differ significantly from this scenario, depending on future policy decisions. In this scenario, flooding is extended by 30 days in years with natural flooding in the Bypass to augment habitat and there is no flooding in dry years. We use a 26-year hydrologic time series, described in Section 3.3, to simulate this proposal. For example, with natural flooding until February 1 the CM2 proposal extends flooding by 30 days, through March 1. If CM2 proposed flooding during years in which natural flooding does not occur, impacts will increase significantly.

2 Data Overview

We collected extensive data for the Yolo Bypass to facilitate an empirical analysis of the proposed inundation scenarios. These include the following: (i) field-level geo-referenced crop data and agricultural region definitions, (ii) crop yields and yield change based on planting date, (iii) crop prices, (iv) costs of production, and (v) area inundated under proposed flow volumes. We review these data in the following section.

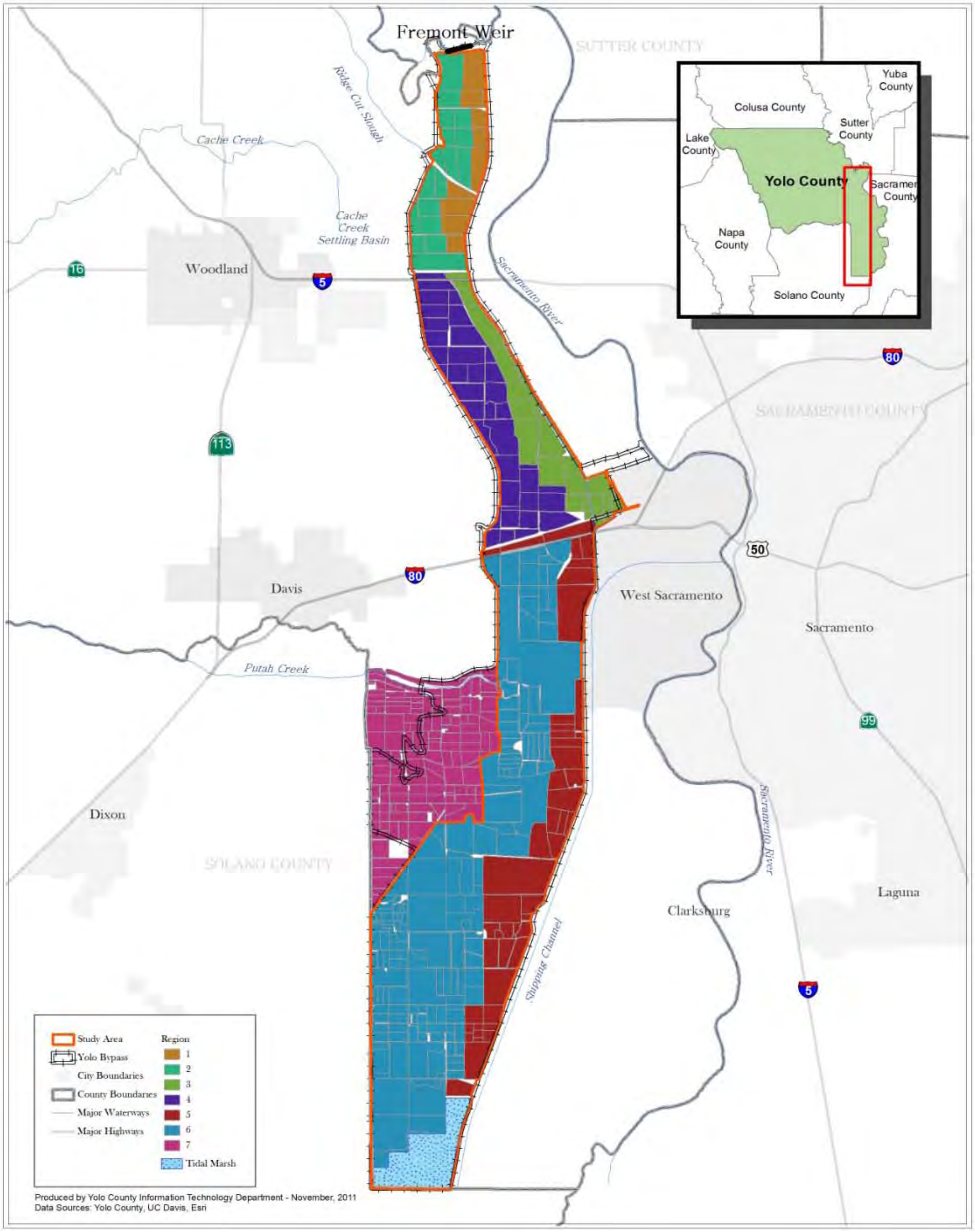
2.1 Agricultural Sub-regions

The Yolo Bypass slopes gradually downward from west to east and north to south. Temperatures are generally lower in the southern end of the Bypass. Consequently, there are heterogeneous production conditions across the region and natural differences in both yield and drainage times. We identified 7 homogenous agricultural sub-regions in the Yolo Bypass which represent these production conditions and, as such, form the basis of the BPM. We used soil and climate data, in addition to interviews with Bypass farmers, to develop homogenous agricultural sub-regions. The regions are illustrated in Figure 1.

Note that the BPM, as with the majority of agricultural production models, is a regional economic model, defined over the 7 regions illustrated in Figure 1. Field-level yield and production data are available for a subset of fields in the Bypass (discussed below), and these data are used in the DAYCENT agronomic model. We discuss this point again in Section 2.3 and again in Section 3, but want to raise the point here so the reader is not confused about the use of field-level data versus agricultural sub-regions in the model.

As shown in Figure 1, Regions 1 and 2 are located north of Interstate 5, Regions 3 and 4 are located between Interstate 5 and Interstate 80, and Regions 5, 6 and 7 are located south of Interstate 80. The area south of Interstate 80 is divided into three regions due to its relatively large width and the row crop region located in the western portion, which distinguishes it from the managed wetlands and grazing lands located to the east. CM2 and the RPA will most likely not affect Region 7, as this region is located outside of the flood inundation footprint. This region is therefore not discussed in further detail in this report or considered in the analysis.

Figure 1. Yolo Bypass Sub-regions



2.2 Field Level Crop Data and Flood Footprint

We compiled detailed land use data for 2005-2009 from Pesticide Use Reports, the Yolo Natural Heritage Program, the Sacramento-Yolo Mosquito and Vector Control District, the Yolo Basin Foundation, and individual farmers. As a result of the extent of data collected, and verification with key stakeholders, the database for this study is the most comprehensive and detailed information on Yolo Bypass land use available.[8]

Table 3 identifies major land uses in the area of the Bypass affected by each of the respective flow volumes (identified by the HEC-RAS hydrologic model, discussed in Section 2.6) over the five years of data collected for the study. Agricultural land constitutes the majority of the area within the Bypass, followed by wetland and fallow land. The main crops in the affected area of the Yolo Bypass are rice, irrigated pasture, processing tomato, vine seed, safflower, wild rice, corn, and sunflowers.

We model 3,000 cfs and 6,000 cfs scenarios in this report which correspond to different total affected acres, as estimated by the HEC-RAS model. An important consideration for the agricultural impacts analysis is that in any flooding scenario, a sub set of fields will be partially innundated. In other words, the HEC-RAS model estimates a “literal” footprint of affected acres dependent on the flow volume, but this does not account for partial flooding of existing agricultural fields. Cultivation of proportions of these partially-flooded fields is costly and, in many cases, impossible. Partial innundation makes it difficult or impossible to use machinery to begin field preparation and, as such, the field is effectively entirely inundated. It is essential to account for the difference between the literal footprint from hydrologic modeling and the effective footprint, the latter is relevant for agricultural impact analysis.

To incorporate the effective flood footprint, we conducted a series of interviews with Bypass farmers and extension specialists to determine the proportion of a field flooded at which farmers cannot begin preparation. Farmers interviewed report the decision to prepare a partially inundated field is different between rice and other field crops and depends on a number of factors including relative prices, weather, and costs. We determined when 20 percent of a rice field is flooded farmers will not begin preparation. For all other crops, 30 percent is the relevant proportion. Fields partially inundated according to the above proportions are modeled as completely flooded and consequently included in the estimates of affected acres.

Note that preparation of a partially inundated field includes installation of checks to control existing flooding and other potentially costly management alternatives. We do not include these production costs in the analysis, thus our estimates are lower than they would be if we included these costs in the analysis.

[8] DWR developed 2008 crop data for Yolo County, including the Yolo Bypass, that slightly differs from the 2008 data used for this dataset. The differences are small and do not affect the outcome of the study. Specifically, the BPM calibrates to a 5 year average (2005-2009), thus small changes to acreage in one year do not have a significant effect on model results.

Table 3. Major land uses in areas affected by increased inundation in the Yolo Bypass (acres)

Crop and Flow Volume	2005	2006	2007	2008	2009
Fallow					
3,000 cfs	3,220	3,606	1,702	1,514	984
6,000 cfs	6,640	6,860	2,858	3,526	2,297
Liberty Island					
3,000 cfs	2,071	2,071	2,071	2,071	2,071
6,000 cfs	2,071	2,071	2,071	2,071	2,071
Vine					
3,000 cfs	245	0	0	0	72
6,000 cfs	245	104	0	0	238
Pasture					
3,000 cfs	2,026	2,026	2,026	2,026	2,284
6,000 cfs	3,890	3,890	3,987	3,890	5,166
Rice					
3,000 cfs	765	173	931	968	1,531
6,000 cfs	2,358	1,254	2,920	2,409	4,263
Safflower					
3,000 cfs	606	657	519	770	499
6,000 cfs	1,450	1,545	1,616	1,840	1,273
Sunflower					
3,000 cfs	138	0	0	0	0
6,000 cfs	138	0	0	0	0
Processing Tomatoes					
3,000 cfs	662	867	721	930	1,047
6,000 cfs	1,285	1,285	1,370	1,829	1,779
Wetland					
3,000 cfs	2,501	2,502	2,503	2,504	2,505
6,000 cfs	7,076	7,076	7,076	7,076	7,076
Wild Rice					
3,000 cfs	0	195	427	494	494
6,000 cfs	0	928	2,292	2,303	2,393
Corn					
3,000 cfs	0	138	584	208	0
6,000 cfs	0	138	925	208	0

We identified 9 major crop groups in areas affected by flooding in the Bypass, which we use for the subsequent analysis. The 9 crops include corn, irrigated pasture, non-irrigated pasture, rice, wild rice, safflower, sunflower, processing tomatoes, vines (melons). Fallow land is an implicit tenth group. Approximately 100 acres of crops did not fit into these categories directly, including dry beans and organic rice. We determined the number of acres was not sufficient to require an additional crop group and these acres were included in the crop group with the most similar cost, return, and production characteristics. Specifically, organic rice acres were added to the rice crop group and dry bean acres were added to the corn crop group.

Figures 2-6 illustrate the distribution of land use across the entire Yolo Bypass, by field, for the years 2005 through 2009. These data show typical crop rotations across the sub-regions. In the southern end of the Bypass, the crops are predominately pasture and in the northern sub-regions the crops are predominately rice. The eastern sub-regions include a mix of pasture, rice, corn, and processing tomatoes.

Crop acreage increased during the dry years of 2007 through 2009 and fallow land decreased. In 2008 and 2009, high agricultural commodity prices potentially resulted in planting of larger acreages than average, in particular for corn and wheat. Rice prices spiked in 2008, which partially explains the increase in rice acreage in the Yolo Bypass. Water year type also affects production. The California Department of Water Resources classified 2005 as an above normal hydrologic year type, 2006 as wet, and 2007 through 2009 as dry years. The Fremont Weir overtopped through May 3rd in 2006, overtopped for three days in May of 2005 (resulting in a couple of weeks of inundation), and did not overtop in 2007 through 2009.

Figure 2. Agricultural Land Use, Yolo Bypass 2005

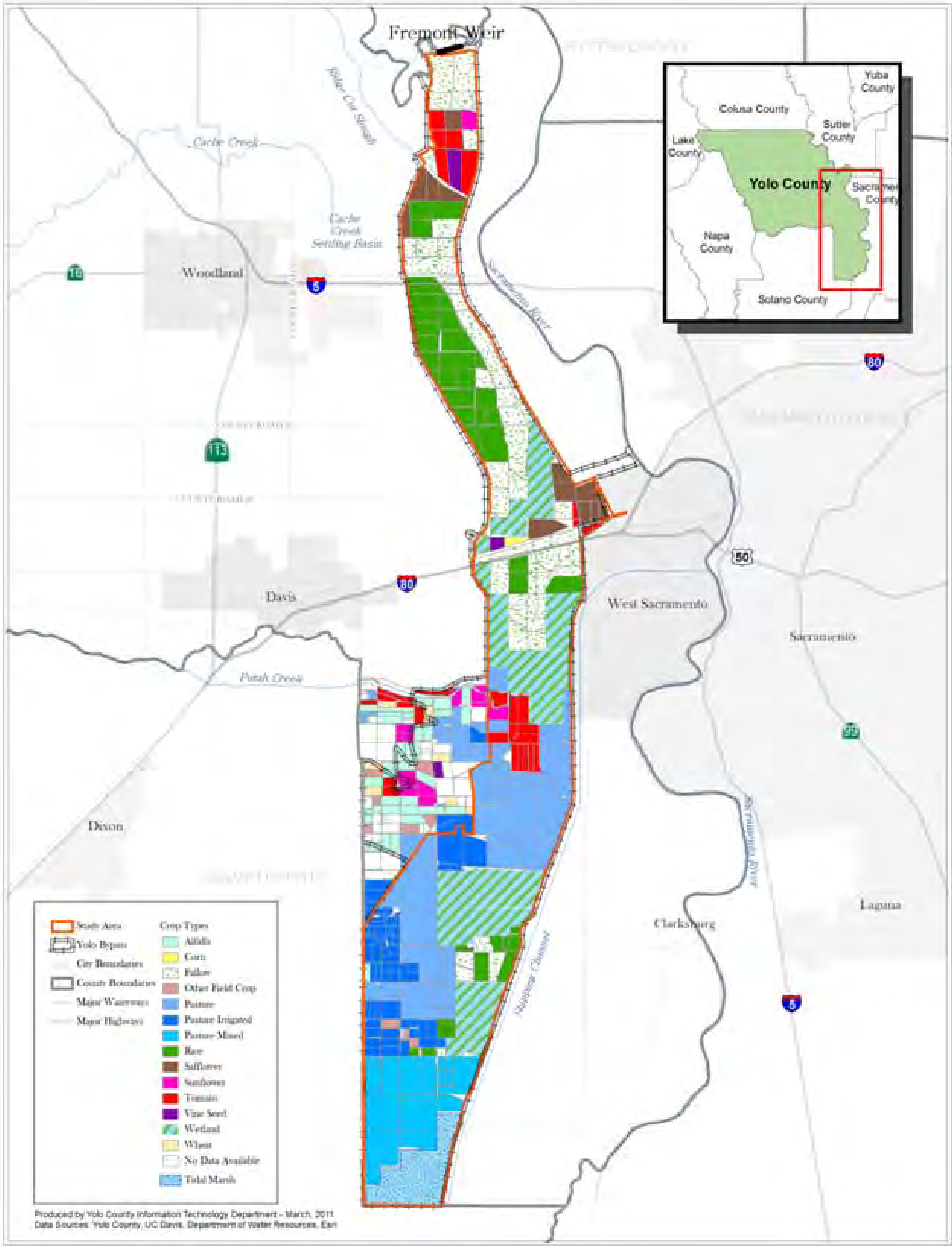


Figure 3. Agricultural Land Use, Yolo Bypass 2006

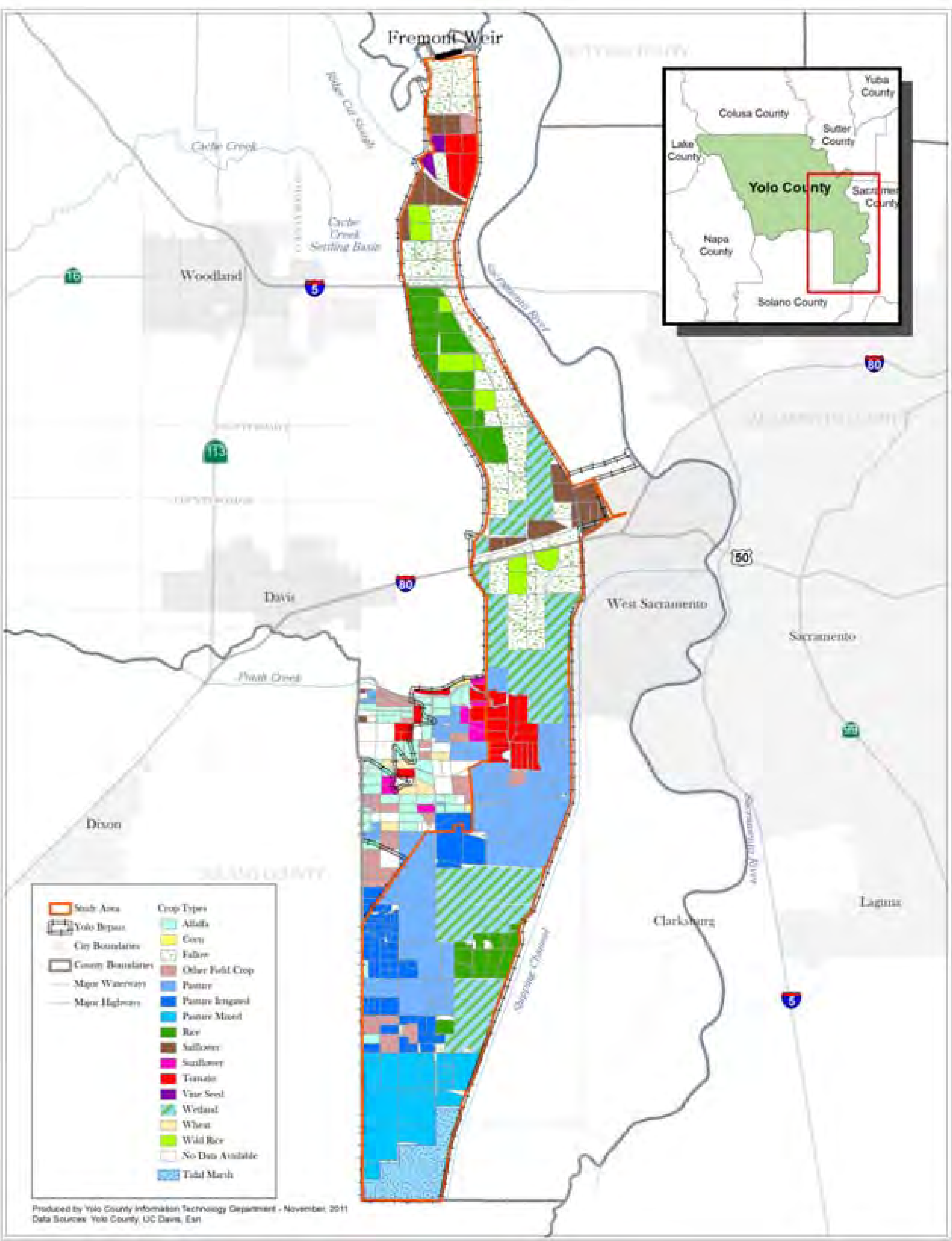


Figure 4. Agricultural Land Use, Yolo Bypass 2007

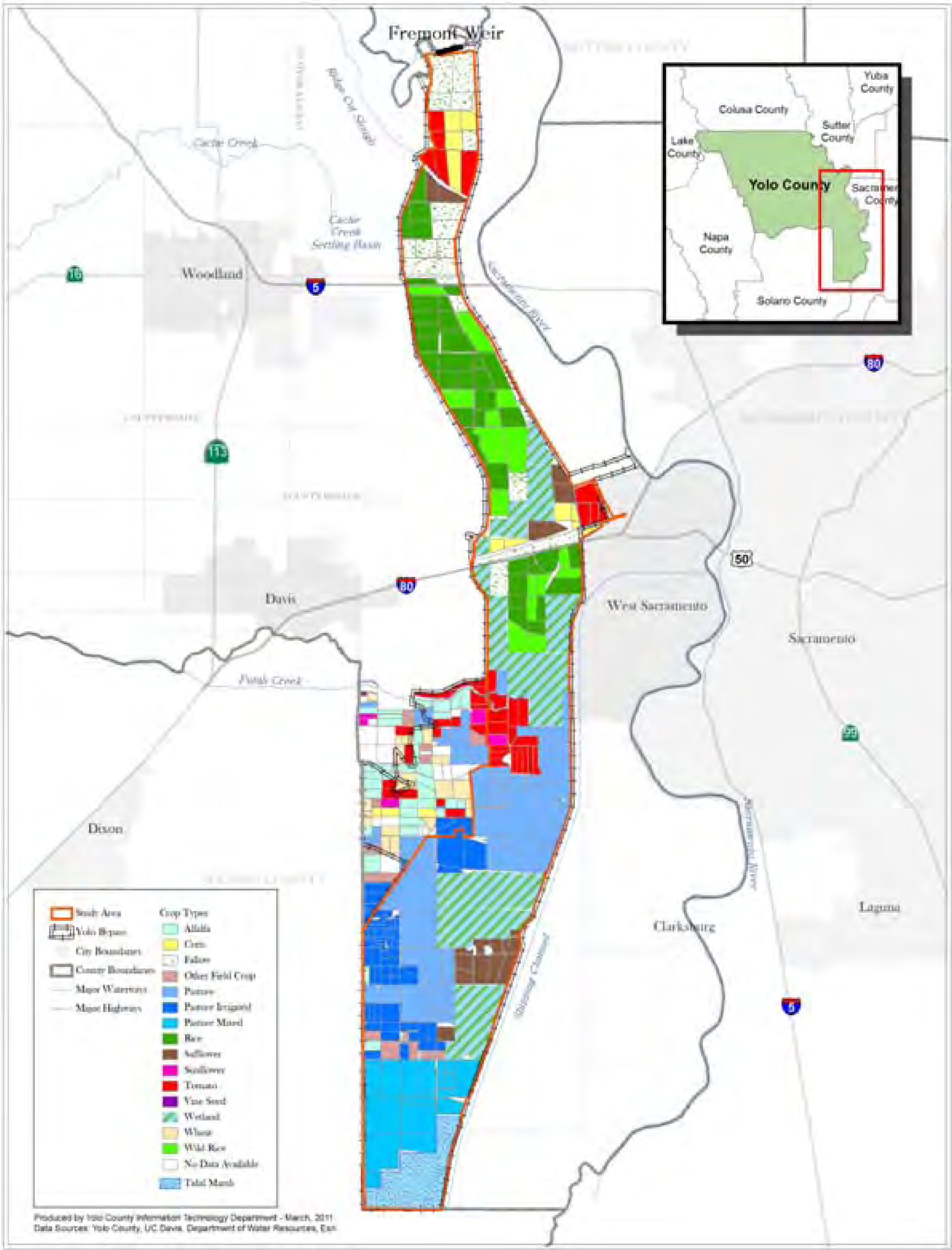


Figure 5. Agricultural Land Use, Yolo Bypass 2008

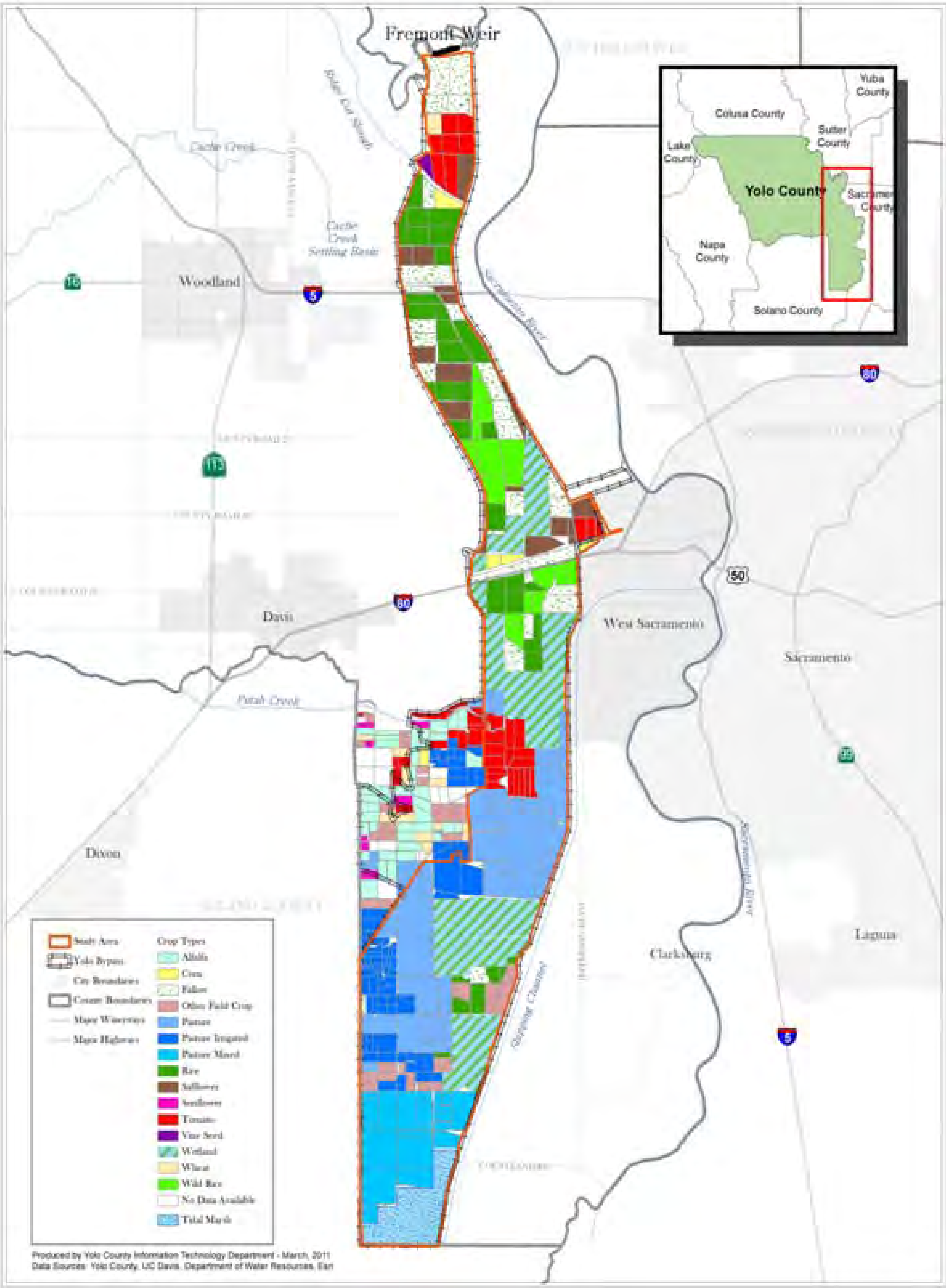
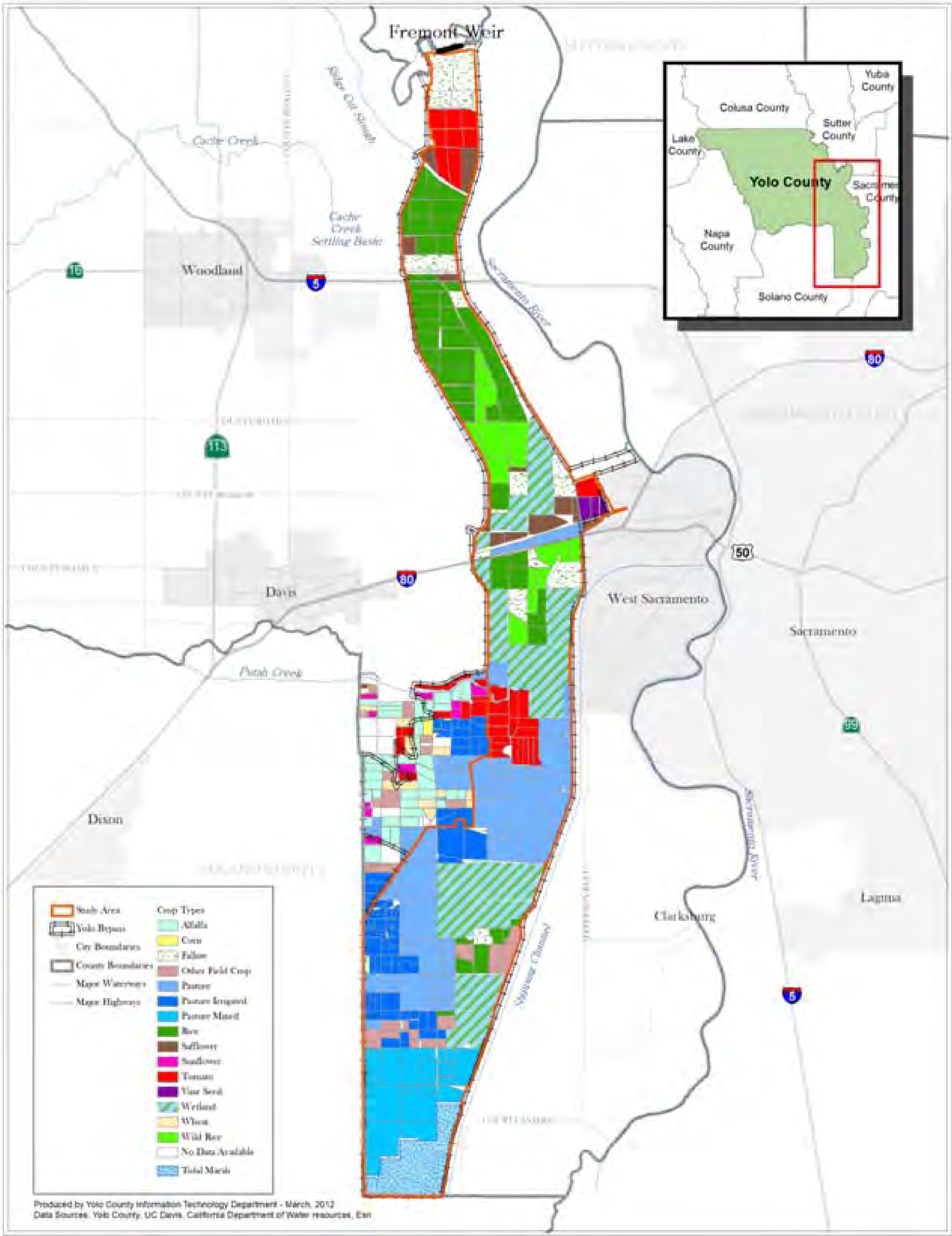


Figure 6. Agricultural Land Use, Yolo Bypass 2009



2.3 Crop Yields

Holding total area inundated constant, crop yields are the fundamental driving factor for agricultural revenue losses due to flooding in the Yolo Bypass. We use two sources of information on crop yields in this analysis. This procedure is outlined here, explained again in Section 3, and all the technical details and equations are contained in Appendix A.

We observe field-level yield data and other micro-production characteristics (soil, climate, etc.) for a subset of fields in the Bypass. These fields are used to calibrate the DAYCENT agronomic model. The DAYCENT model estimates the yield on any given field taking into account all production conditions, including climate and date the crop was planted. We then use the calibrated DAYCENT model to estimate crop yields on a subset of fields in each of the 6 regions of the BPM. We control for all other factors and allow the planting date to vary, thus the DAYCENT model generates a series of data points, for each crop and region, which tells us the expected yield conditional on the crop planting date.

We use the data points from the DAYCENT results to estimate a single yield function, for each crop and region. We fit this function using non-linear regression analysis (discussed in Section 3 and Appendix A). The result is a single function, for each crop and region in the Bypass, which relates crop yield to the planting date. These functions are included in the BPM, discussed in Section 3.

In summary, we use field-level production observations to calibrate a field-level agronomic model. We use the model to simulate the yield on a subset of fields for each crop and region as a function of planting date. Finally, we fit a non-linear function to these data for each crop and region. Thus, we are able to determine crop yields for each region as a function of the planting date.

Note that consistent data on the yields, prices and costs of growing melons for vine seed were unavailable. Instead, we use economic information for melons grown for fruit, accordingly crop yields and budgets are expressed in terms of melons grown for fruit. This is not a critical assumption since melon acreage in the affected area averages less than 200 acres per year (between 2005 and 2009).

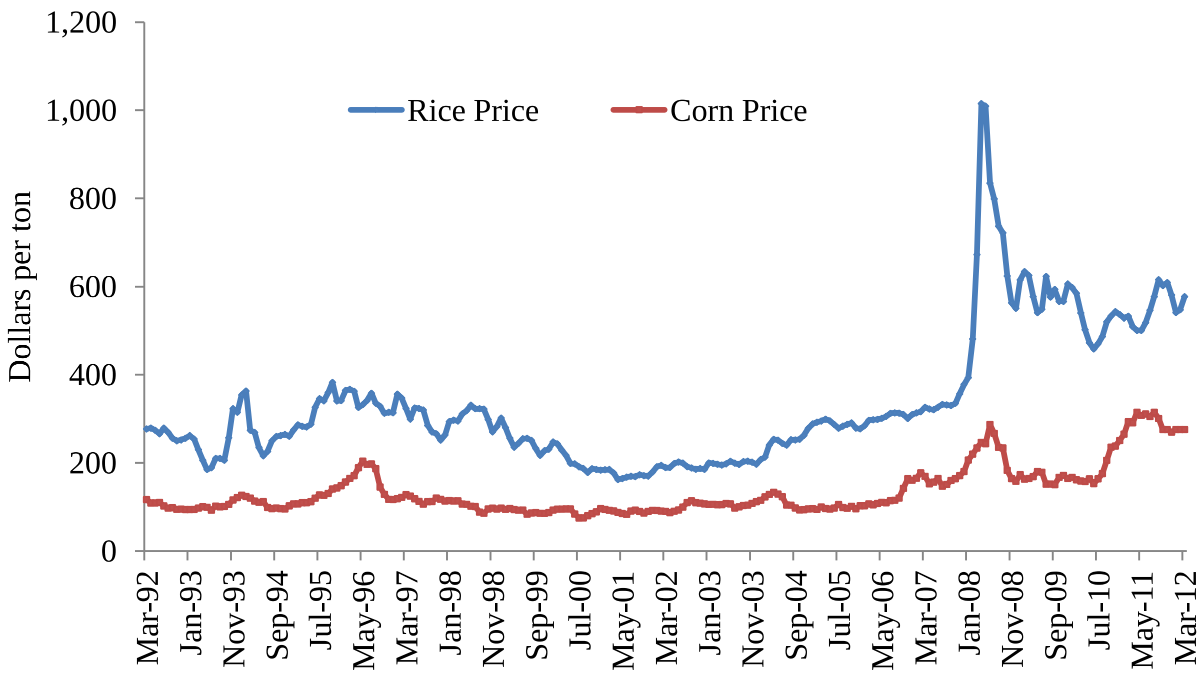
2.4 Crop Prices

We obtained crop prices for the 9 crops considered in the analysis from the Yolo County Agricultural Commissioner reports (Agricultural Commissioners Reports, 2012). No price data per animal unit month (AUM) or hay production was available for pasture, thus we used the price estimate per AUM per acre provided in the Cost and Returns study for flood irrigated pasture grown in the Sacramento Valley (UC Cooperative Extension, 2003). Additionally, sunflower prices are only available for 2007 and 2008 in the Agricultural Commissioner's data. Therefore, we used data reported by the National Agricultural Statistics Service (NASS). We also use NASS data for wild rice because no price data are available prior to 2006.

One of the key components of this analysis is expected crop prices. Higher crop prices translate into larger losses per acre and induce farmers to plant later in the season, thereby reducing fallow land. The results of this study are sensitive to the choice of expected future crop prices.

Unfortunately, there is no general consensus for future expected crop prices. The commodity price spike of 2007/2008 was unprecedented and followed decades of declining real commodity prices. Prices have since declined but remain higher than pre-spike levels and appear to have stabilized on a higher trend. Figure 7 illustrates the 20 year trend in corn and rice prices and highlights the difficulty of selecting representative prices to use in this analysis.

Figure 7. Commodity Price Trends, Monthly Prices from 1992 - 2012[9] in Constant 2010 dollars



The impact analysis in this report uses a two-year average (2009-2010) of crop prices for each of the crop groups. There are two main reasons for this: (i) these years are representative of historical average prices in Yolo County and, (ii) 2009 and 2010 crop prices exclude the price spikes in 2008 and again in 2011.

Table 4 summarizes the average crop price[10] (dollars per ton) for each of the crop groups included in the analysis. Column two shows the prices used (2009-2010 average) and column three shows the 10 year average crop price. Related to point (i) above, Table 4 shows that 2009-2010 average crop prices are representative of the recent history (2000 - 2009 average). Namely, rice and corn prices are slightly higher than the 10 year average but other crops are generally lower. Column four reports 2008 prices for each of the crops. With the exception of corn and safflower, all crop prices were significantly inflated in 2008. In summary, 2009 and 2010 average prices are representative of recent prices in Yolo County and, more importantly, omit the recent price spikes which would upward bias our economic impact estimates.

[9] Data compiled from http://www.indexmundi.com/

[10] Rice prices do not include direct payments, counter-cyclical program payments, or marketing loan payments. Where applicable, these are included in the data used for the analysis.

Table 4. Crop Prices, 2009-2010 average and 2000-2009 average (2008 dollars per ton)

Crop Group	2009-2010 Average	2000-2009 Average	2008
Corn	172.69	124.31	152.20
Irrigated Pasture	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)
Non-Irrigated Pasture	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)
Rice	397.89	251.36	513.10
Wild Rice	961.85	1,275.30	1,684.20
Safflower	351.18	319.79	432.62
Sunflower	1,196.15	1,781.47	1,092.32
Processing Tomatoes	78.81	59.15	68.81
Vine Seed (Melon Proxy)	303.00	292.9	296.10

2.5 Costs of Production

In this report, we use Cost and Return studies developed by the UC Cooperative Extension (UCCE) to determine crop costs of production. These studies provide production costs for representative farmers in the Sacramento Valley and, as such, are representative of Bypass farming. Crop budgets are prepared for various years, thus we use the NASS prices paid indices for specific item categories to express each item cost in constant 2008 dollars.

Given the variety of lease arrangements and ownership structures among Bypass farm operators, we did not include an annual land cost in the net return calculation maximized by the BPM model. Thus the model optimizes the net returns to land and management. This is common in PMP models. The technical discussion of this issue is in Appendix A. Note that PMP captures implicit land costs through the calibration routine, thus these costs are not “omitted” from the model. Table 5 summarizes the variable costs of production for each crop.

Table 5. Variable Production Costs per acre (in 2008 dollars)

Crop Group	Cost
Corn	$607
Melons	$4,110
Pasture irrigated	$269
Pasture dry	$118
Rice	$898
Safflower	$239
Sunflower	$553
Tomato, processing	$1,838
Wild rice	$502

2.6 Areas of Inundation

The second key driving factor in this analysis is the total number of affected acres under proposed flow volumes from Fremont Weir water releases through an operable gate. We consider two flow volumes (3,000 and 6,000 cfs) in this report.

We estimate the number of affected acres using the one-dimensional HEC-RAS hydrologic hydraulic simulation model. We use the HEC-RAS model for two reasons including, (i) the National Marine Fisheries Service used the HEC-RAS model to estimate innundated acreage for the Biological Opinion, and (ii) Yolo County recently completed an independent review of the MIKE-21 model that indicates additional data and improvements to the model are needed before it can used for policy decisions related to Yolo Bypass flooding. An initial comparison of the MIKE-21 and HEC-RAS footprints for 3,000 cfs and 6,000 cfs indicate the difference is relatively small.

Given the potential interest in this issue, some additional information is necessary to justify the decision to rely on HEC-RAS. Both one-dimensional (1-D) and two-dimensional (2-D) models are useful tools in hydraulic engineering and water resource planning studies. The accuracy of both 1-D and 2-D models is strongly dependent upon the quality of information specified by the user as input into the model and on the boundary conditions (flow, initial water level and channel roughness) the user must also specify. It can therefore be difficult to compare results without understanding how each model was developed, including how bed roughness, inflow and stage boundary conditions were specified, and other how other assumptions and constraints were entered as user-specified inputs to each model. Once the MIKE-21 or other model is improved as specified in the 2012 model review, MIKE-21 or another model can be used for making policy decisions related to Bypass flooding.

Figures 8 and 9 identify the fields inundated under the 3,000 and 6,000 cfs flow rates. We consider a field, in terms of restricting farm operations, to be effectively inundated if 30 percent or more of the field was inundated for field crops and 20 percent or more for rice crops. As discussed in Section 2.2, this reflects input received from Bypass farmers indicating that they would not typically initiate field preparation efforts if a portion of their field is still partially inundated. The blue areas in these figures identify the predicted flood inundation area. The red and yellow areas identify the contiguous fields that would be affected at 20% and 30%, respectively. Note that as the flow rate increases, the number of affected acres increases. Consequently, planting dates are delayed on more fields and farm revenue losses are expected to increase.

Figure 8. Agricultural Land Flooded under 3,000 cfs flow rates.

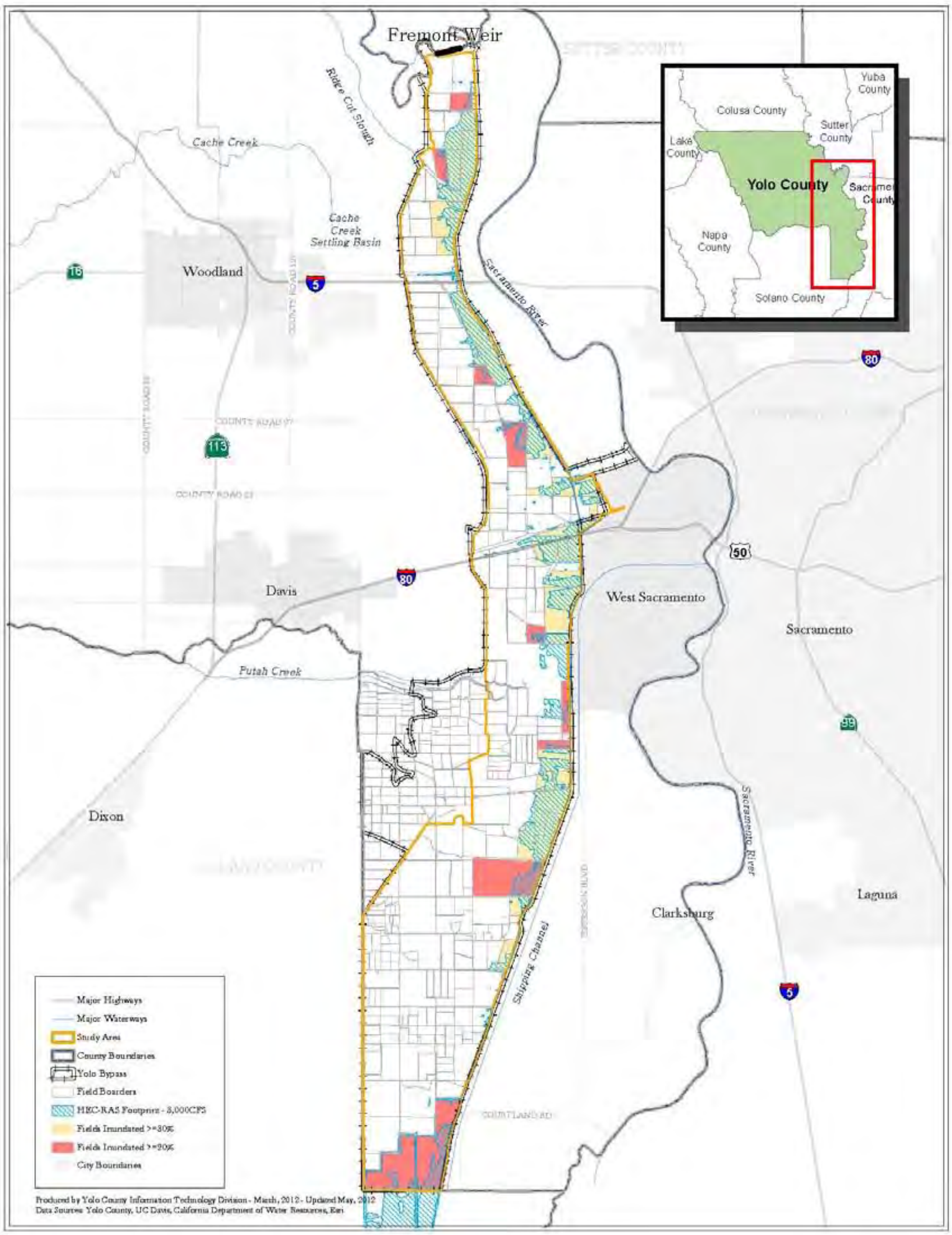
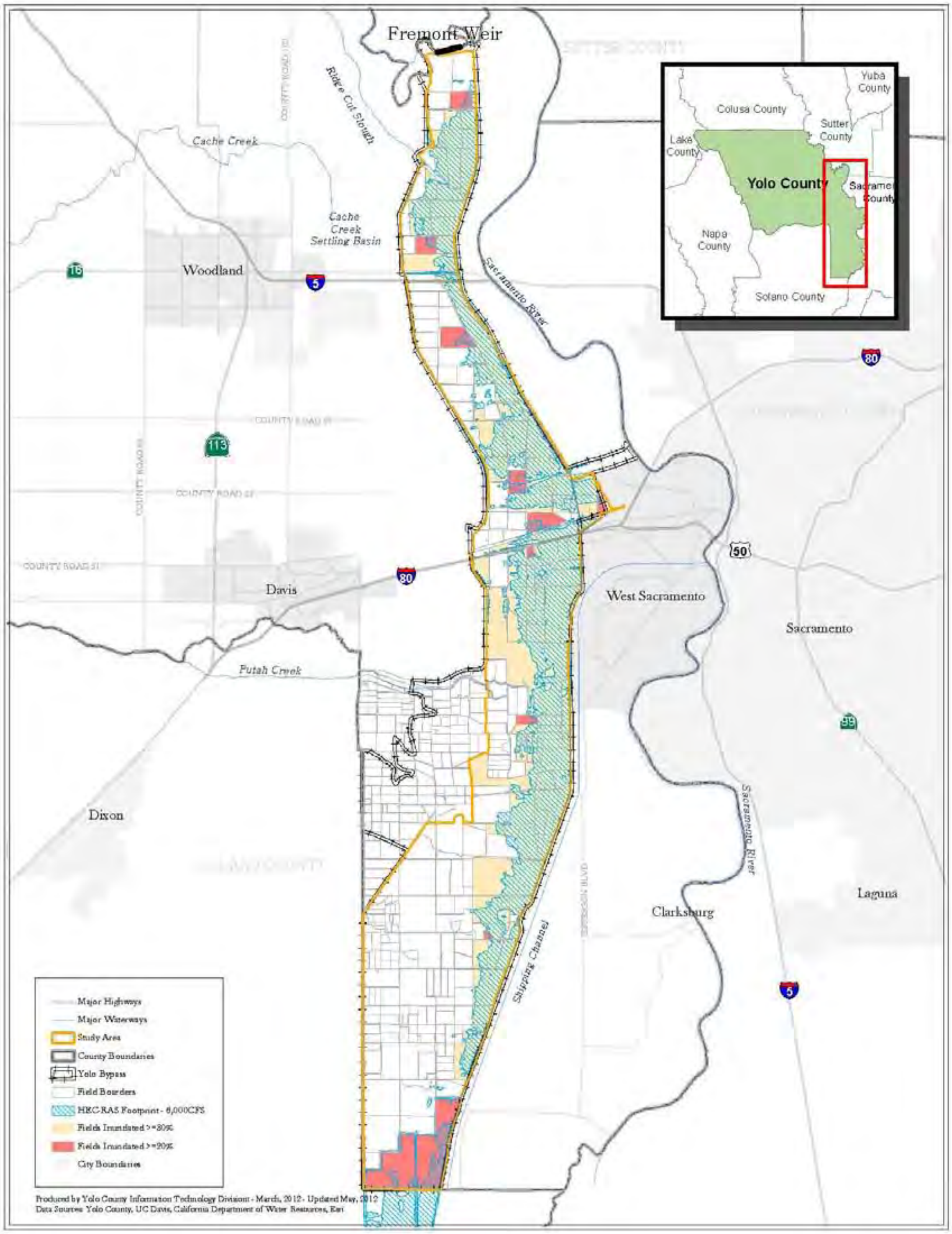


Figure 9. Agricultural Land Flooded under 6,000 cfs flow rates.

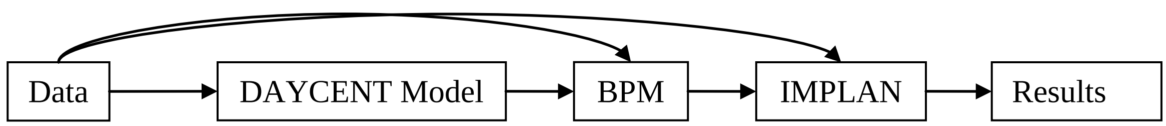


3 Overview of the Modeling Approach

We estimate the effect of the twelve proposed scenarios on Bypass agriculture based on the data summarized in Section 2 and a series of empirical models, summarized in this section. This section briefly reviews the modeling approach and policy scenarios evaluated. A detailed technical overview of the modeling approach is included in Appendix A.

Figure 10 provides an overview of the key steps in our analysis. Starting with input data described in the previous section, we use a series of linked models to estimate the effects on agriculture. The DAYCENT model is an agronomic model used to estimate field-level yields, as a function of planting date, for subsets of fields in each region of the Bypass. Regression analysis on the DAYCENT model output and additional input data are used to calibrate the BPM. Output from the BPM and other input data are used as inputs to the IMPLAN model. The fundamental results include direct, indirect, and induced (the sum of which is total) expected effects on total agricultural output (revenues), value added, agricultural employment, and statewide taxes.

Figure 10. Illustration of the Fundamental Modeling Approach



We briefly preview the five steps outlined in Figure 10, and provide more details in the subsequent sections.

Data: Input data were described in Section 2. In summary, we compiled a comprehensive economic, agronomic, and geo-referenced dataset of agricultural production in the Yolo Bypass between 2005 and 2009.

DAYCENT Model: Field-level data were used to calibrate the agronomic DAYCENT model (DeGryze et al 2009). We use the DAYCENT model to estimate crop yields as a function of various agronomic conditions, including planting date. We use non-linear regression analysis to fit a series of crop yield functions for each crop and region in the Bypass. Technical details are provided in Appendix A.

BPM: We use the crop yield functions estimated from the DAYCENT model, plus additional economic data, to calibrate the BPM. The BPM is the fundamental model of this analysis. The BPM relates changes in crop yield and total affected acres to changes in agricultural production and, fundamentally, changes in agricultural revenues. The BPM is a Positive Mathematical Programming (PMP after Howitt, 1995) model of agriculture in the 6 regions of the Yolo Bypass. PMP models calibrate exactly to an observed base year of production conditions and grower decisions and have been used extensively for water and agriculture policy analysis in

California and around the world. Appendix A reviews the technical details of the BPM and PMP calibration procedure.

IMPLAN: The IMPLAN model estimates regional economic losses. Expected revenue losses from the BPM analysis represent direct economic effects. Upstream and downstream industries will be affected, however, and some agricultural workers will lose their jobs when production in the Bypass decreases. We use the IMPLAN regional Input-Output (IO) model to estimate the direct, indirect, and induced effects of the 12 scenarios. The sum of these components represents the total impact of the scenarios.

The key result from this overview is that all of the analysis in this report is driven by observed data and observed grower decisions in the Bypass. We use a sequence of linked models to estimate the total (direct, indirect, and induced) effects of flood date and flow volume on agriculture in the Yolo Bypass. These effects are defined and described in detail in Section 4 and Appendix A.

3.1 Estimating Crop Yields (DAYCENT Model)

Crop yields are the fundamental driving factor for agricultural revenue losses due to flooding in the Yolo Bypass. As farmers delay planting, crop yields decline which in turn leads to lower revenues and land fallowing. We estimate crop yield, and variation based on planting date, using the DAYCENT agronomic model and non-linear regression analysis on output data.

We can summarize the procedure as two steps, (i) estimate field-specific yields using the DAYCENT model and, (ii) use the DAYCENT model output to perform regression analysis and estimate crop and region-specific yield functions. These functions relate crop yield to the planting date and are directly incorporated into the BPM. More information about this process is available in Appendix A.

Table 6 presents the results (after both steps are completed) from the yield data analysis by sub-region. Yields vary across regions and by planting date. Recall that after the last day of water releases through the Fremont Weir gate, there is a 6-8 week delay before planting occurs. This assumption is implicitly built into the yield data summarized in Table 6.

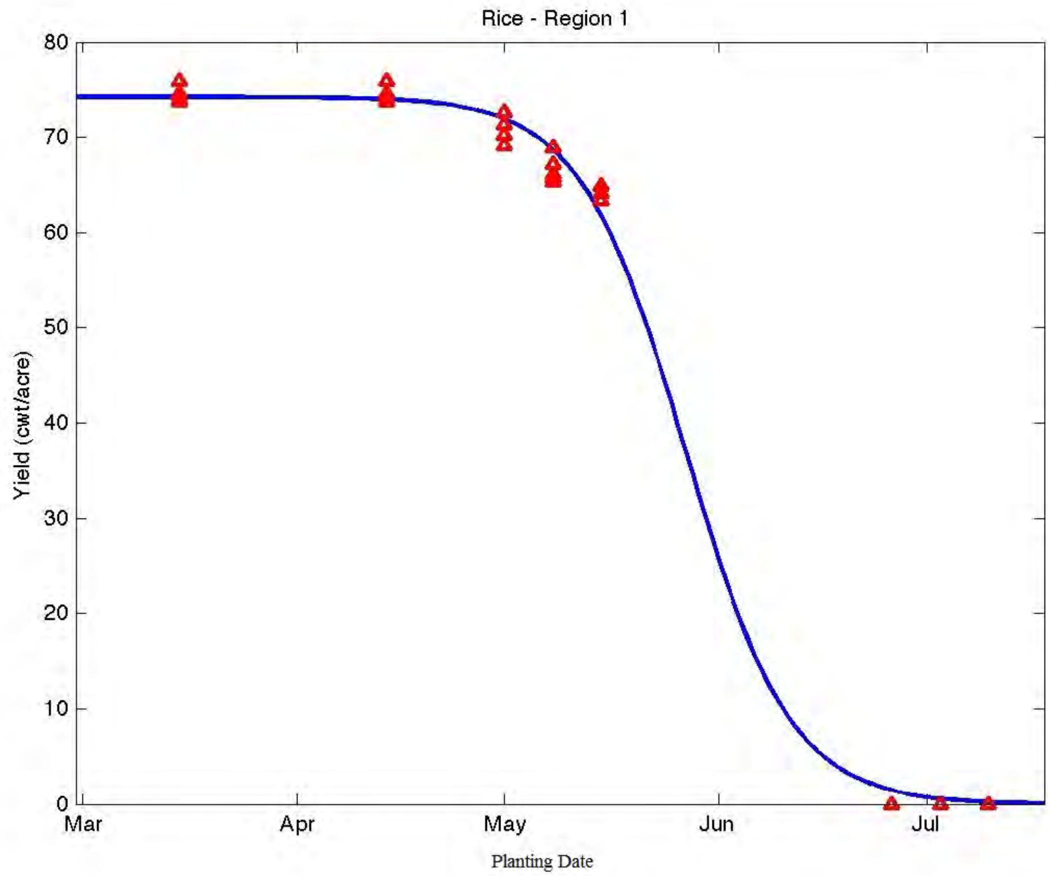
There are crop and region specific functions underlying all of the data summarized in Table 6. Figure 11 summarizes this function for an example crop of rice in Region 1. Yield functions for all the crops can be found in Appendix A. The vertical axis identifies the expected yield, the horizontal axis identifies the date, red triangles are output data from the DAYCENT field-level model, and the blue line represents the results of the fitted non-linear yield function.

There are several things to note from the example in Figure 11. First, one of these functions (the blue line) exists for every crop in every region. This governs the relationship between crop yield and planting date and, in part, drives the results of the economic (BPM) model. Second, note that the relationship is non-linear, as expected. Over some range early in the season, farmers will realize only a slight yield decline from a small delay in planting date. Substantial delays cause yields to decline rapidly.

Table 6. Estimated yield by planting date (last day of water releases) (tons/ac)

Yield (ton/acre)	Region	Last day of water releases at Fremont Weir			
		Feb 15th	March 24th	April 10th	May 15th
Corn	1	5.84	4.72	0.51	0.00
Corn	2	5.90	5.84	4.05	0.01
Corn	3	5.88	4.76	0.59	0.00
Corn	4	5.73	5.48	3.09	0.02
Pasture - dry (AUM/acre)	5	0.45	0.29	0.25	0.21
Pasture - dry (AUM/acre)	6	0.55	0.33	0.28	0.22
Pasture - irrigated (AUM/acre)	5	2.23	1.44	1.26	1.05
Pasture - irrigated (AUM/acre)	6	2.77	1.64	1.38	1.10
Rice	1	4.14	3.19	1.08	0.01
Rice	2	4.15	3.98	2.88	0.09
Rice	3	4.15	3.20	1.09	0.01
Rice	4	4.12	3.92	2.76	0.09
Rice	5	3.66	2.50	1.14	0.07
Rice	6	3.74	3.42	2.41	0.21
Safflower	1	1.07	0.51	0.29	0.07
Safflower	2	1.19	1.01	0.76	0.21
Safflower	3	1.09	0.51	0.29	0.08
Safflower	4	1.09	0.74	0.48	0.14
Safflower	5	0.98	0.41	0.21	0.04
Safflower	6	1.10	0.70	0.43	0.12
Sunflower	1	0.64	0.56	0.52	0.45
Sunflower	6	0.63	0.60	0.56	0.46
Processing Tomato	1	38.57	34.60	28.79	10.35
Processing Tomato	2	38.76	37.25	33.98	17.59
Processing Tomato	3	38.99	35.06	29.18	10.29
Processing Tomato	6	38.36	36.23	32.48	17.74
Melons	2	7.52	7.52	6.55	3.55
Melons	3	6.80	6.20	4.84	2.10
Melons	4	6.65	6.65	5.77	2.97
Wild rice	1	0.92	0.71	0.24	0.00
Wild rice	2	0.92	0.88	0.64	0.02
Wild rice	3	0.92	0.71	0.24	0.00
Wild rice	4	0.92	0.87	0.61	0.02
Wild rice	5	0.81	0.56	0.25	0.02
Wild rice	6	0.83	0.76	0.54	0.05

Figure 11. Example Expected Average Yield Function, Rice in Region 1



3.2 Bypass Production Model

The Bypass Production Model (BPM) combines the HEC-RAS data, DAYCENT yield functions, and other economic data into a Positive Mathematical Programming (PMP) agricultural production model of the Yolo Bypass. The model calibrates exactly to an observed base year of input and output data which, in our analysis, is 2005 - 2009 average land use. In other words, the model exactly replicates observed farmer behavior, in terms of input use and outputs, over this period. Once the model calibrates, and a series of economic and numerical checks are satisfied (see Howitt et al. 2012), we use the BPM to simulate changes in agricultural production under the twelve proposed policy scenarios. We review the basics of the BPM in this section. The interested reader can find technical details in Appendix A.

The BPM estimates the change in crop mix, agricultural revenues, and other factors due to crop yield loss (DAYCENT model) and the number of acres affected (HEC-RAS model) in the Yolo Bypass. The BPM calibrates to an average of 2005-2009 land use input data (summarized in Section 2). All dollars are expressed in 2008 real terms. Crop prices for calibration are an average of 2005-2007 prices in Yolo County. The 2005-2007 average prices were determined to be representative of conditions farmers in the Yolo Bypass faced, on average, when making planting decisions between 2005 and 2009. Input costs are expressed in 2008 dollars, from the UCCE budgets. Policy simulations use 2009-2010 average crop prices, as discussed previously.

Technical details of the PMP calibration procedure and functional forms in the model are left to Appendix A. We briefly review the estimation procedure in this section. The BPM estimation procedure can be summarized as a series of five steps:

Step 1: Calibrate the BPM to base data (2005 - 2009, as discussed previously). Perform a series of checks to ensure economic and numerical conditions are satisfied.

Step 2: Run the BPM for a season with *known* overtopping dates at Fremont Weir, and flooding in the Yolo Bypass. This represents the base condition (e.g. natural flooding) for agriculture in the Bypass in the absence of the proposed policy flooding scenarios (for that year). Repeat Step 2 for a series of known years. There are 26 known overtopping dates in the analysis which are discussed in more detail in the following section.

Step 3: Over the same series of years as step two, run the BPM and impose (sequentially - one at a time) the twelve proposed policy flooding scenarios. This represents what *would have* happened to Bypass agriculture *if* the flooding policy was implemented in that year. Repeat Step 3 for all of the same years as Step 2.

Step 4: For each year simulated in Steps 2 and 3, calculate the difference in agricultural revenues (and other outputs). Record the result for negative changes in revenue. Intuitively, for policy evaluation we are interested in negative changes in revenue because a positive change in revenue implies that the policy was “better” than nature. For example, if natural flooding occurred in the Bypass until April 30th, imposing a policy which stops water releases from a Fremont Weir gate on April 10th would not be possible (i.e. it would increase revenues).

Step 5: Calculate the average loss of revenue (and other changes) across all of the years simulated in Steps 2 - 4. This represents the expected effects due to the proposed flooding scenarios, and is the fundamental output of the BPM.

The fundamental procedure of the BPM is to generate an *expected* effect on agriculture by using the calibrated model to estimate what would have happened under natural flooding, and then asking what would have happened if a specific policy (last day of water releases) was in place. This procedure allows us to generate an expected effect because we control for the expected natural flood events in the Bypass. The following section illustrates this point.

3.3 Adjustments for Natural Flooding

In many years flooding occurs naturally in the Yolo Bypass and, in some years, flooding may occur late in the season. Estimates of agricultural losses need to account for the fact that natural conditions may result in flooding beyond the proposed policy date. We use a 26 year (1984-2009) time-series of hydrologic conditions in the Bypass to estimate expected future revenue losses in the Bypass. The implicit assumption is that the previous 26 years are representative of expectations for natural flooding in the near future. The implications of this assumption and details on the procedure used in the BPM are described in more detail in Appendix A.

Given the 26 year time-series, estimates represent expected annual losses due to flooding for fish habitat in the Bypass. There are two reasons these 26 years of data were identified as reasonable, including (i) detailed flow information over the Fremont Weir was available for these years, and (ii) it is representative of current hydrologic conditions in the Sacramento Valley watershed. Older hydrologic information less accurately represents current conditions because it does not account for changes in urban development and reservoir operations that have altered flows in the Sacramento River over time.

Table 7 summarizes the observed last day of overtopping and provides some notes about the nature of flooding in key years. During the 26 years, there are five years (1989, 1996, 1998, 2003 and 2005) in which flooding events in the Yolo Bypass did not occur consecutively. In these years, except for 2003, an early dry period enabled farmers to proceed with their land preparation, but planting was delayed or significantly affected by late floods. To account for this in the analysis, 28 days (the amount of time needed for field preparation) was credited to the planting date in these years. This assumes that farmers had to wait for the fields to drain in these years, but required minimal field preparation effort since this was completed earlier in the season.

Table 7. Fremont Weir Overtopping End Dates

Year	End Date	Important Notes and Adjustments
1984	11-Jan	
1985	-	
1986	25-Mar	
1987	-	
1988	-	
1989	14-Mar	Early dry year, followed by late flooding, farmers able to prepare fields early reducing the effect of late flooding
1990	-	
1991	-	
1992	-	
1993	6-Apr	
1994	-	
1995	13-May	
1996	24-May	Early dry year, followed by late flooding, farmers able to prepare fields early reducing the effect of late flooding
1997	13-Feb	
1998	8-Jun	Early dry year, followed by late flooding, farmers able to prepare fields early reducing the effect of late flooding
1999	14-Mar	
2000	17-Mar	
2001	-	
2002	10-Jan	
2003	7-May	Flooding confined to the Toe Drain; minimal effect on agriculture
2004	10-Mar	
2005	24-May	Early dry year, followed by late flooding, farmers able to prepare fields early reducing the effect of late flooding
2006	5-May	
2007	-	
2008	-	
2009	-	

3.4 IMPLAN

We use the Impact Analysis for Planning model (IMPLAN) Professional Version 3 and a 2009 database for Yolo County. We link the IMPLAN model to results from the BPM, in order to estimate changes in total output value, value added, employment, and tax revenues as a result of the proposed flood policies. IMPLAN is an input-output model which accounts for relationships between sectors of the economy in order to estimate the effects of a change (e.g. reduced agricultural output) in another sector of the economy. IMPLAN is widely used by State and Federal agencies including the California Department of Water Resources, the California Regional Water Quality Control Boards, the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the U.S. Bureau of Economic Analysis, and the U.S. Bureau of Land Management.

We summarize four key outputs for this analysis: changes in total output value, changes in "value added", changes in employment, and changes in statewide tax receipts. For each output we report direct, indirect, and induced effects, the sum of which is the total effect. We define these components below, further technical details can be found in Appendix A.

Total Output Value (e.g. Gross Revenues): The gross value of agricultural production in the Yolo Bypass to the "global" economy. For example, this is price multiplied by yield/acre multiplied by the total number of acres.

Total Value Added: The net value of agricultural production in the Yolo Bypass to the Yolo County economy. This measure recognizes that many inputs/outputs are produced or consumed outside of Yolo County and, as such, are not relevant effects for the flood policy analysis. For example, food production is exported out of the county, state, or country for many crops. Similarly, tractors are produced outside of the county, fertilizers are produced in another state, etc. The measure of value added controls for these effects. Total value added includes compensation for employees, income to business and landowners, and other business, specific to Yolo County.

Total Employment: The change in agricultural employment in Yolo County due to changes in agricultural production in the Yolo Bypass. Specifically, this includes NAICS classification system sector 111 - agricultural employment.

Total Statewide Tax Revenue: The change in tax receipts due to reduced output in the Yolo Bypass.

Each of these components has a direct, indirect, and induced effect on the Yolo County economy. The sum of the three is the total effect and sometimes the indirect and induced effects are jointly referred to as "multiplier" effects. We define these terms below.

Direct: Immediate effects on the relevant agricultural economy. For example, gross farm revenue losses due to reduced yields in the Bypass.

Indirect: Changes in related sectors as a result of direct changes to production in the Bypass. For example, reduced production in the Bypass will cause farmers to purchase fewer inputs, this is an indirect effect.

Induced: Changes in all other sectors of the economy as a result of the direct changes to production in the Bypass. For example, reduced production in the Bypass will lead to reduced hours for farm workers who will, in turn, purchase fewer goods and services from other industries in the region.

Total: Direct + Indirect + Induced

4 Results

We summarize the results of the analysis in this section. Results correspond to each of the 12 policy scenarios (water release end date and flow volume) for the four measures detailed in Section 3.4. First, we summarize changes in acreage across the Bypass.

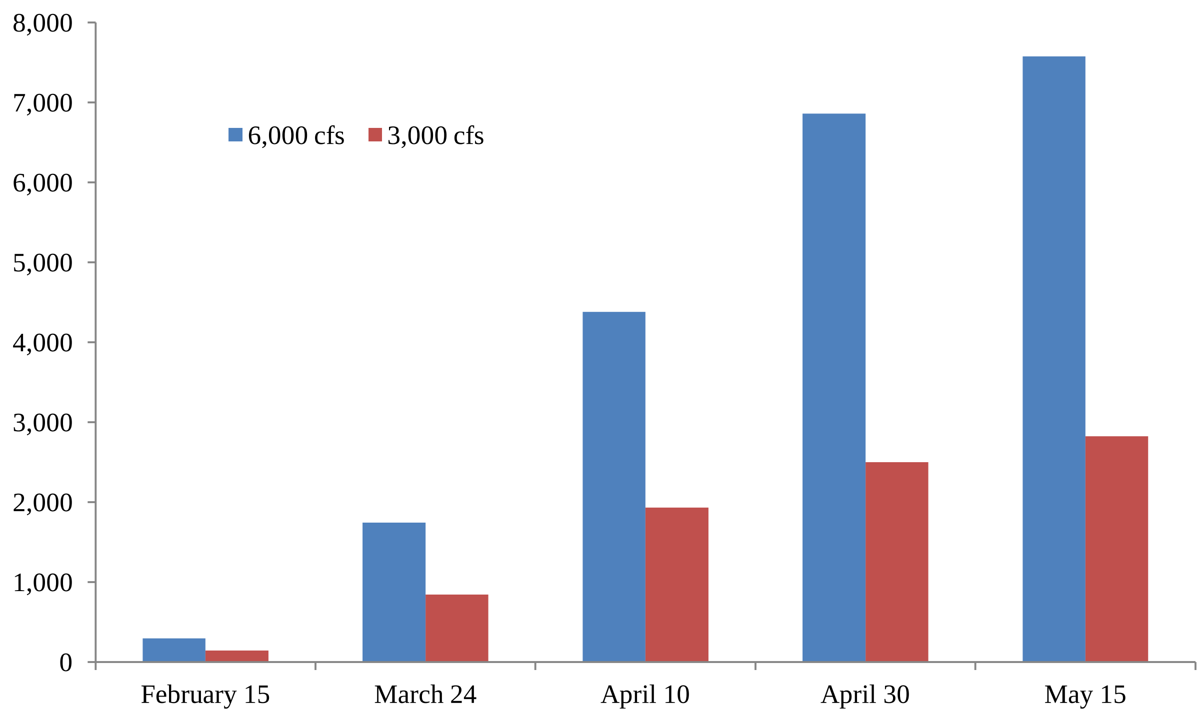
Results are annual expected losses, reported in constant 2008 dollars.

4.1 Acreage Change Summary

Farmers may fallow land or shift small amounts of land to alternative crops in response to delayed planting due to flooding. Figure 12 illustrates the expected annual acreage loss due to Bypass inundation policies. Specifically, this figure represents the average annual loss of acres across all crops, where the average is taken over the 26 year hydrologic time series. Flooding later in the season delays field preparation; this decreases crop yields and increases land fallowing. All else constant, the 3,000 cfs scenario affects fewer acres and results in less fallowing than the 6,000 cfs scenario.

There is a base level of average fallow acres in any given year within each of the affected 3,000 and 6,000 cfs flood areas. Specifically, in the 3,000 cfs flood region, the 2005 through 2009 base (calibration) data shows that an average of 2,200 acres are fallow in any given year. Similarly, in the 6,000 cfs flood region, 4,400 acres are fallow in any given year. These additional fallow acres are typically for rotation purposes and are not included in Figure 12.

Figure 12. Expected Annual Loss of Acres (26 year average), by Overtopping End Date.



We also evaluated a low-impact CM2 scenario where water flows through an operable gate at Fremont Weir are only imposed for an additional 30 days in years when there is natural flooding. As expected, the losses under this proposal are minimal. An average of 460 acres are expected to be fallowed under the 3,000 cfs low-impact CM2 scenario. This increases to 1,200 acres under the 6,000 cfs low-impact CM2 scenario.

4.2 Revenue Losses Summary

We summarize the expected agricultural revenue losses for each flow rate and last day of water releases from the Fremont Weir gate in Table 8. As shown, total output value (gross farm revenue) expected losses range from $0.28 to $17.3 million per year in the RPA scenarios, depending on the last day of water releases from the Fremont Weir gate and the flow rate. As expected, a later water release date delays planting and, consequently, reduces crop yields and increases farm revenue losses. Similarly, higher flow rates affect more fields and increase farm revenue losses.

Losses for the RPA scenarios should be interpreted as annual expected losses from continuous flooding up to the identified end date.

Table 8. Expected Annual Total Revenue Loss (2008 dollars), RPA Scenarios

Expected Total Revenue Loss (Output Value) ($2008)		
	3,000 cfs	6,000 cfs
February 15		
Direct	172,278	280,530
Indirect+Induced	116,463	189,826
Total	**288,741**	**470,356**
March 24		
Direct	1,081,960	2,026,110
Indirect+Induced	731,777	1,370,310
Total	**1,813,737**	**3,396,420**
April 10		
Direct	2,713,780	5,823,400
Indirect+Induced	1,835,472	3,938,499
Total	**4,549,252**	**9,761,899**
April 30		
Direct	3,915,080	8,981,760
Indirect+Induced	2,647,896	6,074,741
Total	**6,562,976**	**15,056,501**
May 15		
Direct	4,512,650	10,333,200
Indirect+Induced	3,052,140	6,988,682
Total	**7,564,790**	**17,321,882**

Expected losses for the low-impact CM2 scenario range between $1.2 to $2.8 million per year. The low-impact CM2 scenario corresponds to supplemental releases only in years where natural flooding occurs. As such, loss estimates are much lower, between $1.2 and $2.8 million per year. Note that in some years losses are zero (when there is no natural flooding) and in other years losses are substantial (when there is late natural flooding). These loss estimates correspond to expected annual losses, summarized in Table 9.

Table 9. Expected Annual Total Revenue Loss (2008 dollars), Low-impact CM2 Scenario

Expected Total Revenue Loss (Output Value) ($2008)		
	3,000 cfs	6,000 cfs
Low-impact CM2 Scenario		
Direct	725,930	1,704,640
Indirect+Induced	490,987	1,152,982
Total	**1,216,917**	**2,857,622**

A proportion of Yolo Bypass production and crop consumption occurs within Yolo County. As such, losses to Yolo County are expected to be less than total revenue losses. The proper measure of the effect on the Yolo County economy is change in “value added” (defined in section 3.4). Table 10 summarizes the change in value added under the proposed flooding policies. In the RPA scenarios expected losses in value added range from $0.14 to $8.9 million per year.

Table 10. Expected Annual Value Added Loss (2008 dollars), RPA scenarios

Expected Total Yolo County Revenue Loss (Value Added) ($2008)		
	3,000 cfs	6,000 cfs
February 15		
Direct	74,648	121,954
Indirect+Induced	73,568	119,914
Total	**148,216**	**241,868**
March 24		
Direct	469,589	879,285
Indirect+Induced	462,261	865,620
Total	**931,850**	**1,744,905**
April 10		
Direct	1,177,877	2,527,185
Indirect+Induced	1,159,463	2,487,936
Total	**2,337,340**	**5,015,121**
April 30		
Direct	1,699,112	3,898,193
Indirect+Induced	1,672,667	3,837,395
Total	**3,371,779**	**7,735,587**
May 15		
Direct	1,958,644	4,484,527
Indirect+Induced	1,928,028	4,414,727
Total	**3,886,672**	**8,899,254**

Comparable to the output value losses, value added losses in the low-impact CM2 scenario are lower than many of the RPA scenarios. Table 11 summarizes the CM2 results. Expected annual losses to value added range from $0.63 to $1.5 million per year.

Table 11. Expected Annual Value Added Loss (2008 dollars), Low-impact CM2 scenario

Expected Total Yolo County Revenue Loss (Value Added) ($2008)		
	3,000 cfs	6,000 cfs
Low-impact CM2 Scenario		
Direct	315,084	739,971
Indirect+Induced	310,155	728,336
Total	**625,239**	**1,468,307**

4.3 Employment Losses Summary

Table 12 summarizes the corresponding expected annual agricultural job losses under the proposed flooding policies. Employment effects are generally small, ranging from no effect to 130 jobs lost.

Table 12. Expected Annual Agricultural Jobs Loss, RPA scenarios

Expected Total Employment Loss		
	3,000 cfs	6,000 cfs
February 15		
Direct	1	2
Indirect+Induced	1	2
Total	**2**	**4**
March 24		
Direct	7	13
Indirect+Induced	7	12
Total	**13**	**25**
April 10		
Direct	17	37
Indirect+Induced	16	35
Total	**34**	**73**
April 30		
Direct	25	58
Indirect+Induced	24	55
Total	**49**	**112**
May 15		
Direct	29	66
Indirect+Induced	27	63
Total	**56**	**129**

Table 13 summarizes the low-impact CM2 scenario employment losses. Direct expected gross revenue losses are less than $1.5 million per year and the corresponding job losses are small.

Table 13. Expected Annual Agricultural Jobs Loss, CM2 Scenario

Expected Total Employment Loss		
	3,000 cfs	6,000 cfs
Low-impact CM2 Scenario		
Direct	5	11
Indirect+Induced	4	10
Total	**9**	**21**

4.4 Tax Losses Summary

Table 14 summarizes the total expected annual losses in tax revenues to the state under the proposed flooding scenarios in the RPA. Annual tax revenue losses can be as high as $0.82 million under the 6,000 cfs flow scenario that extends flooding as late as May 15. For the 3,000 cfs flow regime scenario, annual tax revenue losses are less than $0.36 million.

Table 14. Expected Annual Total Statewide Tax Revenue Losses (2008 dollars), RPA Scenarios

Expected State and Local Tax Revenue Loss ($2008)		
	3,000 cfs	6,000 cfs
February 15	13,604	22,193
March 24	85,515	160,130
April 10	214,496	460,241
April 30	309,428	709,892
May 15	356,677	816,686

Table 15 summarizes the expected annual tax revenue losses to the state for the low-impact CM2 scenario.

Table 15. Expected Annual Total Statewide Tax Revenue Losses (2008 dollars), Low-impact CM2 Scenario

Expected State and Local Tax Revenue Loss ($2008)		
	3,000 cfs	6,000 cfs
Low-impact CM2 scenario	57,377	134,744

5 Sensitivity Analysis

Results of the analysis are sensitive to parameters and assumptions listed in Section 1.1. Some overstate and others understate expected losses. We believe our estimates are generally conservative. Nonetheless, some sensitivity analysis is warranted.

Expected loss estimates are most sensitive to changes in area inundated, yield loss, and crop prices. Area inundated is driven by HEC-RAS model results that are based on RPA and low-impact CM2 scenarios. As such, we don't have a basis to vary the number of affected acres. Similarly, yield loss is a function of planting date that is driven by agronomic data and non-linear regression analysis. As such, we do not have a justifiable basis to vary this relationship. Prices, as discussed in Section 2.2, are uncertain and we perform sensitivity analysis on these parameters.

We select 2005-2006 average prices to represent a "low" price scenario and 2008 prices to represent a "high" price scenario. Note that some crop prices are actually higher (lower) than the base scenario for the lower (higher) sensitivity analysis scenarios. This is expected since some crop prices are correlated and we typically don't expect to observe all prices trending in the same direction. In other words, a sensitivity analysis where all crop prices are 10 percent higher is not relevant sensitivity analysis. Table 16 summarizes the low and high prices used for sensitivity analysis, in addition to the base (2009-2010) prices used in the analysis. Note that the largest uncertainty occurs with the price of rice, which experienced a large spike in 2008 following years of lower prices.

Table 16. Price Sensitivity Analysis Range (2008 dollars), All Scenarios

Crop Group	2005-2006 Average (LOW)	2009-2010 Average (BASE)	2008 (HIGH)
Corn	141.00	172.69	152.20
Irrigated Pasture	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)
Non-Irrigated Pasture	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)	49.20 (based on $35 per AUM)
Rice	274.80	397.89	513.10
Wild Rice	1,469.30	961.85	1,684.20
Safflower	314.80	351.18	432.62
Sunflower	1,056.10	1,196.15	1,092.32
Processing Tomatoes	67.75	78.81	68.81
Vine Seed (Melon Proxy)	349.80	303.00	296.10

Figure 13 summarizes the results of the price sensitivity analysis for the 3,000 cfs scenarios. Sensitivity analysis corresponds to the output of the BPM model, gross agricultural revenues (gross output value), or the direct effects listed in Table 8. The base estimate has been normalized to 1, thus the bars show the percentage deviation due to prices. For example, in the April 10 RPA scenario low prices reduce losses by 24 percent (0.76) and high prices increase losses by 23 percent (1.23).

Figure 13. Price Sensitivity Analysis for Gross Output Value under 3,000 cfs, All Scenarios.

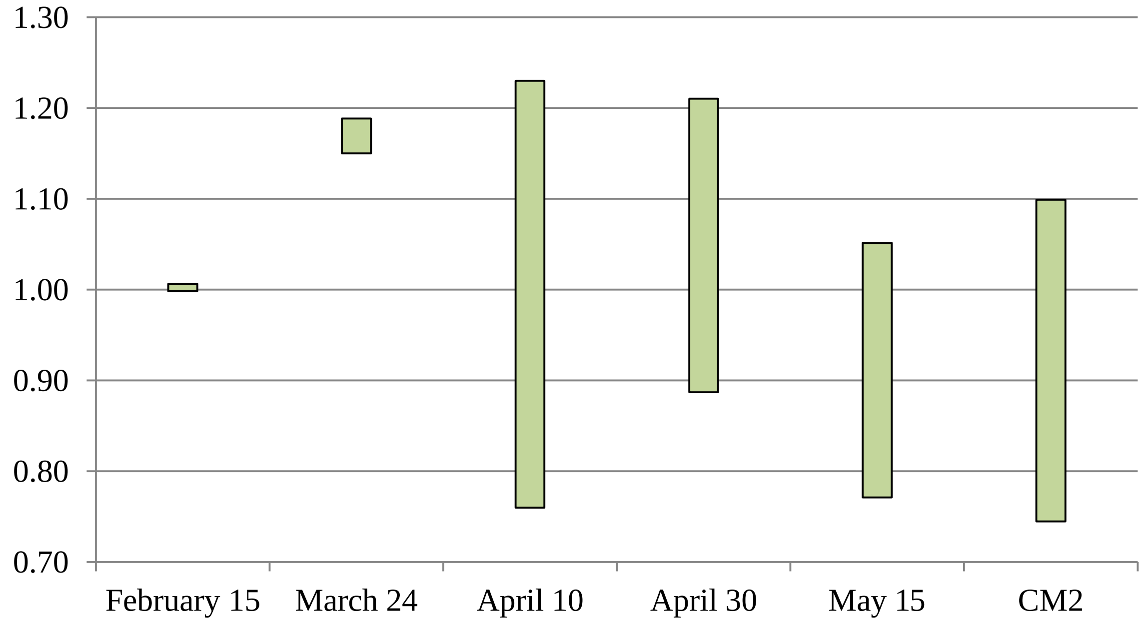
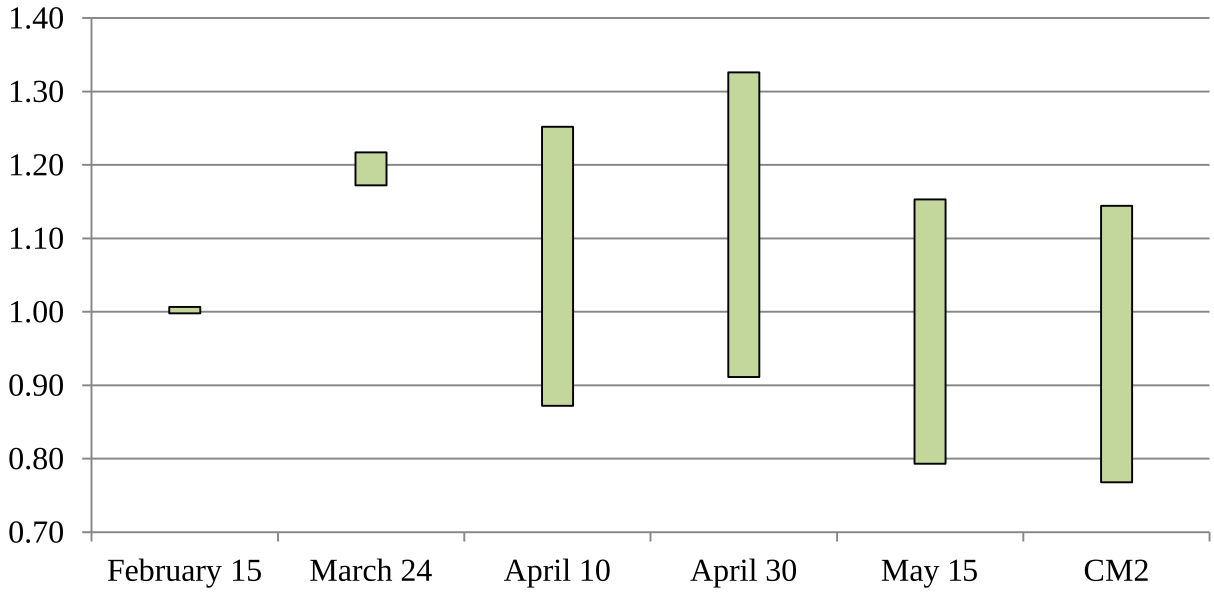


Figure 14 summarizes the results of the price sensitivity analysis for the 6,000 cfs scenarios. Again, sensitivity analysis corresponds to the output of the BPM model, gross agricultural revenues (gross output value), or the direct effects listed in Table 8. The base estimate has been normalized to 1, thus the bars show the percentage deviation due to prices. For example, in the April 10 RPA scenario low prices reduce losses by 13 percent (0.87) and high prices increase losses by 25 percent (1.25). Figures 13 and 14 indicate that results are slightly sensitive to crop prices, as expected. Our estimates based on 2009-2010 average prices are generally conservative since the deviation from the base is generally above 1.

Figure 14. Price Sensitivity Analysis for Gross output Value under 6,000 cfs, All Scenarios.



Other areas where we are unable to perform sensitivity analysis include weather shocks and changes in the cost of production. The latter raises an important point, namely we have implicitly assumed that the costs of production in the Bypass remain constant even with late flooding. However, if production costs go up, for example due to overtime labor or increased preparation costs, loss estimates will increase.

6 Conclusion

This study has assembled extensive data on cropping, water use, and the economics of the agricultural industry in the Yolo Bypass. We then use these data to calibrate and link four models. Namely, an engineering model of field flood inundation (HEC-RAS), an agronomic model of yield loss due to shorter growing seasons (DAYCENT), an economic production model of farm crop decisions in the Yolo bypass (BPM), and finally a regional economic model of the Yolo County economy (IMPLAN). The net economic results from these four models are measured as a set of output values for twelve alternative flood scenarios that cover two different volumes of flooding and five different ending dates for the RPA, plus an evaluation of the CM2 proposal. The five overtopping dates analyzed were selected to span the full range from no effect on cropping, to the cost of flooding that prevents any cropping, and intermediate values.

For each of the twelve scenarios the net dollar effect on the Yolo County economy is measured in terms of value-added. The loss in employment is measured in terms of full-time equivalent jobs, and the effect on the State tax receipts. The expected economic value added losses range widely from $0.15 to $8.9 million per year. The effect on job losses and tax receipts also varies widely, depending on the scenario.

Despite our efforts to assemble the very best data set, we would like to stress that the model results are sensitive to several assumptions. In particular, we would like to note that the areas of inundation under different flooding scenarios may well change with different engineering models and better data. In addition, we have attempted to use a weighted price for future crops that is representative of an average over recent years and neither relies on recent boom price levels or earlier depressed agricultural conditions.

We would also like to emphasize that this study is only able to measure the expected cost to the Yolo County economy, and is not able to account for changes in risk, management difficulties, and other factors facing the county and the agricultural industry in the Bypass.

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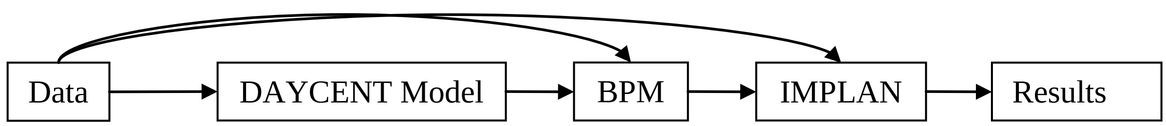
0 Technical Appendix: Overview of the Modeling Approach

Evaluation of agricultural policies requires a modeling framework which can be used to simulate losses and estimate costs. In this report, we adopt a modeling framework driven entirely by a rich, empirical dataset, highlighted by Figure A1. We estimate the effect of 12 proposed policies of flood level and date for fish habitat on Bypass agriculture. The scenarios include flow rates of 3,000 and 6,000 cfs from the Sacramento River passing through an operable gate in the Fremont Weir. The last day of overtopping at Fremont Weir occurs on February 15, March 24, April 10, April 30 or May 15. Additionally, we evaluate the CM2 proposal which does not correspond to a specific end date.

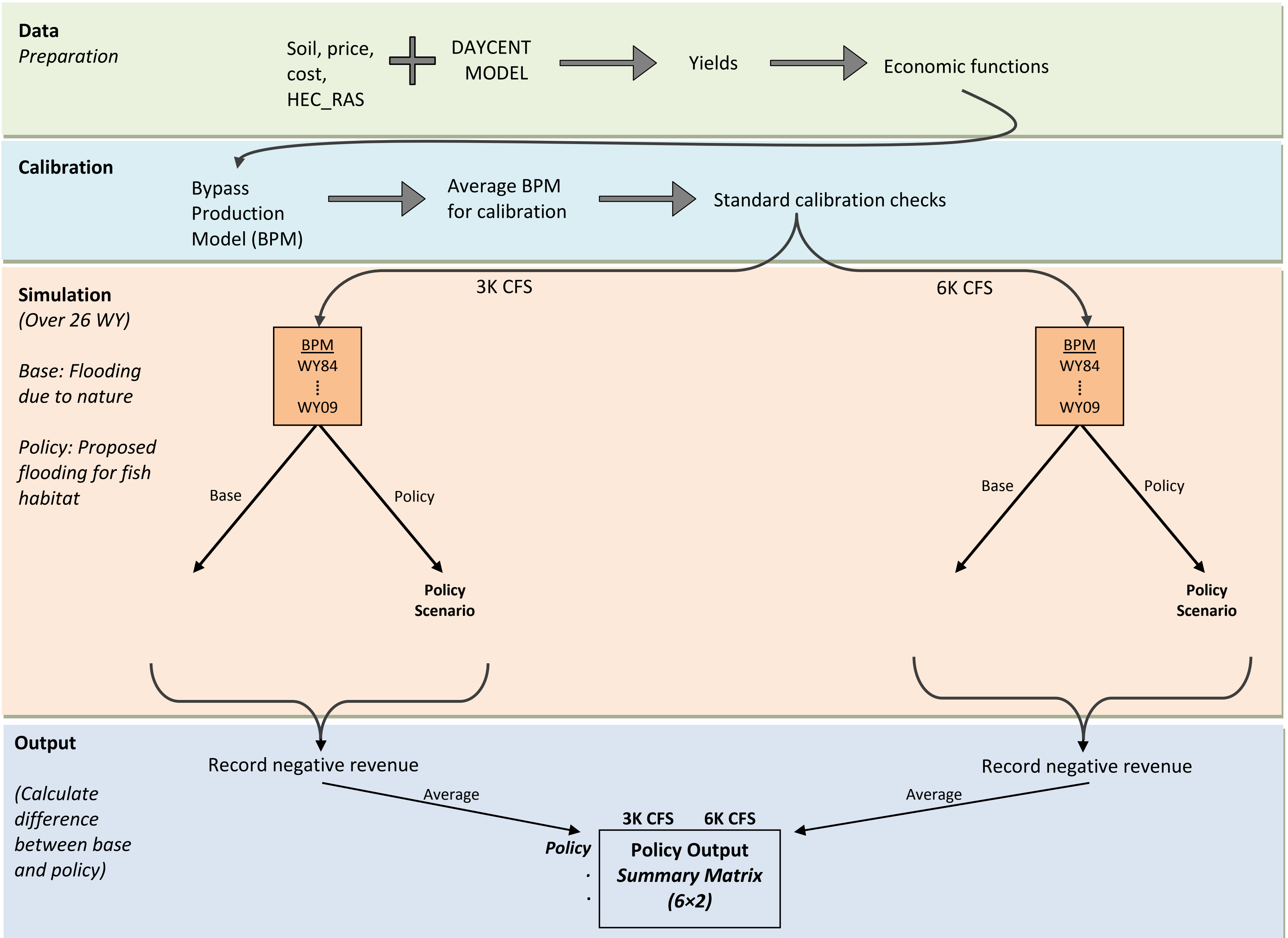
Figure A1 provides a simple illustration of the key steps in the analysis. Starting with input data (including the HEC-RAS model), we use a series of linked models to estimate the impacts to agriculture. The DAYCENT model is an agronomic model used to estimate field-level yields, as a function of planting date, for subsets of fields in each region of the Bypass. Regression analysis on the DAYCENT model output and additional input data are used to calibrate the BPM. Output from the BPM and other input data are used as inputs to the IMPLAN model.

Figure A1. Illustration of the Fundamental Modeling Approach



Production and geo-referenced land use data, HEC-RAS output, DAYCENT simulations, and regression analysis are used as inputs to the Bypass Production Model (BPM). The BPM is the fundamental economic model in the analysis. The technical details of the analysis can be summarized in four phases including, (i) data preparation, (ii) calibration, (iii) estimation, and (iv) output. The flow chart in Figure A2 illustrates this process, which we review in detail in this technical appendix.

Data preparation involves the compilation and synthesis of model data, including geo-referenced land use data, production data, and HEC-RAS model output. This stage additionally includes field-level simulations with the DAYCENT model and regression analysis. Model calibration includes development of the Bypass Production Model (BPM) and exact calibration, through Positive Mathematical Programming, in inputs and outputs to a known base year. Estimation involves simulation of the calibrated BPM over a series of known water years (nature) and sequentially imposing the 12 proposed policies on the model. The difference between the base and policy simulations is recorded for all years with revenue losses. The output phase estimates losses from the BPM and generates expected annual gross revenue losses. Output from the BPM are input to the IMPLAN model to estimate Yolo County direct, indirect, and induced economic effects.


Data
Preparation
Soil, price, cost, HEC_RAS
DAYCENT MODEL
Yields
Economic functions
Calibration
Bypass Production Model (BPM)
Average BPM for calibration
Standard calibration checks
Simulation
(Over 26 WY)
Base: Flooding due to nature
Policy: Proposed flooding for fish habitat
3K CFS
6K CFS
BPM
WY84
WY09
Base
Policy
Policy Scenario
BPM
WY84
WY09
Base
Policy
Policy Scenario
Output
(Calculate difference between base and policy)
Record negative revenue
Average
Record negative revenue
Average
3K CFS
6K CFS
Policy
Policy Output
Summary Matrix
(6×2)

1 Data Preparation

We collected extensive data for the Yolo Bypass in order to conduct an empirical analysis of the proposed inundation scenarios. These include the following: (i)field-level geo-referenced crop data and region definitions, (ii) crop yields and yield change based on planting date, (iii) crop prices, (iv) costs of production, and (v) area inundated under 3,000 and 6,000 cfs flow volumes. We review these data in the following section.

1.1 Land Use and Production Data

Production and land use data are summarized in the main text of this report, we provide a brief summary in this section. Land use data are from a series of years, 2005-2009, of land use for major crops, fallow land, and wetland in the Yolo Bypass. We identified 6 agricultural sub-regions in the Yolo Bypass which represent homogeneous production conditions and form the basis of the BPM. We used soil and climate data, in addition to interviews with Bypass farmers, to develop homogenous agricultural sub-regions.

1.2 The DAYCENT Model

The DAYCENT model (DeGryze et al. 2009) is an agronomic model of field-level yields for specific agricultural production regions. Johan Six and Juhwan Lee in the Plant Sciences Department at UC Davis were responsible for model analysis and simulations.

The DAYCENT model calibrates to observed production conditions on a sub-set of fields in the Yolo Bypass. The sub-set of fields is selected to represent heterogeneous production conditions in the Bypass. The model is calibrated against data for corn, rice, safflower, sunflower, processing tomato, alfalfa and mixed melons. The model does not explicitly simulate pasture so we use alfalfa grown on a yearly rotation to proxy for irrigated pasture. Based on interviews with farmers we determined that the yearly yield of dry pasture in AUM/acre is a fifth that of irrigated pasture. The model does not simulate vine seed so we use the yield for mixed melons (honeydew and watermelon) as a proxy for vine seed.

The DAYCENT model estimates the yield on any given field taking into account all production conditions, including climate and date the crop was planted. We use the calibrated DAYCENT model to estimate crop yields on a subset of fields in each of the 6 regions of the BPM. We control for all other factors and allow the planting date to vary, thus the DAYCENT model generates a series of data points, for each crop and region, of the expected yield given the crop planting date.

1.3 Yield Functions Regression Analysis

We use the data points from the DAYCENT model results to estimate a single yield function, for each crop and region. We fit this function using non-linear regression analysis which results in a single function, for each crop and region in the Bypass, which relates crop yield to the planting date. The yield response functions are included in the BPM.

We control for all other factors and specify yield as a function of the planting date. We estimate the yield function by pooling all field observations, from the DAYCENT model, in each region for the years 2005-2009. This is because we want to estimate the average yield response to the planting date over a range of years rather than capturing yearly weather effects. The objective of this study is to estimate the expected effects on agriculture due to increased flooding for fish habitat and, as such, we do not want to capture weather or other effects in the yield response functions.

For each crop i and region g, define $y_{i,g}$ as crop yield and $d_{i,g}$ as the planting date. Note that the planting date is the last day of over-topping plus region-specific drainage and preparation times. Model parameters include $\alpha_{i,g}$, $\beta^0_{i,g}$, and $\beta^1_{i,g}$. The estimated model for all crops except pasture is defined as

$$y_{i,g} = \frac{\alpha_{i,g}}{1+e^{\beta_{0i,g}+\beta_{1i,g}d_{i,g}}}. \tag{1.1}$$

Pasture exhibits a different response than the other crops due to its resistance to delayed planting date. We define the yield response function for pasture as

$$y_{i,g} = \frac{\alpha_{i,g}}{1+e^{\beta_{1i,g}d_{i,g}}}. \tag{1.2}$$

We experimented with a series of functional forms for the yield response functions and determined that the exponential provided the best fit of the data. Specifically, the AIC (and, AIC-corrected for small sample sizes) indicated that the models in Equations 1.1 and 1.2 were the best fit for the data.

We perform nonlinear regression analysis in Stata to generate parameter estimates. Not all crops are gown in all regions, thus yield functions only apply to regions where crops are grown. Dry and irrigated pasture have the same yield functions. Rice and wild rice have the same yield functions. These simplifications are made because there is limited data availability for these crops. The following tables summarize the parameter estimates and standard errors.

Table A1. Pasture Yield Function Parameter Estimates (standard errors in parentheses)

Pasture in Region	Alpha	Beta-0	Beta-1	Observations
5	0.900	2.784	-0.024	35
	(0.350)	(0.597)	(0.009)	
6	0.886	2.803	-0.025	35
	(0.350)	(0.602)	(0.009)	

Table A2. Corn Yield Function Parameter Estimates (standard errors in parentheses)

Corn in Region	Alpha	Beta-0	Beta-1	Observations
1	5.837	-32.354	0.222	43
	(0.037)	(12.347)	(0.092)	
2	5.905	-31.547	0.217	45
	(0.031)	(9.015)	(0.067)	
3	5.885	-31.247	0.214	45
	(0.038)	(10.278)	(0.076)	
4	5.731	-24.544	0.172	46
	(0.081)	(9.789)	(0.073)	

Table A3. Vine Seed (Melons) Yield Function Parameter Estimates (standard errors in parentheses)

Vine Seed in Region	Alpha	Beta-0	Beta-1	Observations
2	10.907	-5.012	0.032	37
	(1.786)	(1.197)	(0.006)	
3	8.871	-6.218	0.039	37
	(1.811)	(2.107)	(0.010)	
4	9.327	-5.544	0.036	37
	(1.801)	(1.576)	(0.008)	

Table A4. Rice Yield Function Parameter Estimates (standard errors in parentheses)

Rice in Region	Alpha	Beta-0	Beta-1	Observations
1	4.157	-19.492	0.132	54
	(0.014)	(1.065)	(0.007)	
2	4.160	-19.616	0.132	53
	(0.015)	(1.125)	(0.008)	
3	4.162	-19.571	0.132	53
	(0.015)	(1.111)	(0.008)	
4	4.140	-18.971	0.129	54
	(0.016)	(1.139)	(0.008)	
5	3.768	-22.392	0.154	47
	(0.009)	(1.614)	(0.012)	
6	3.821	-21.303	0.145	49
	(0.008)	(1.053)	(0.007)	

Table A5. Safflower Yield Function Parameter Estimates (standard errors in parentheses)

Safflower in Region	Alpha	Beta-0	Beta-1	Observations
1	1.472	-5.498	0.044	51
	(0.244)	(1.364)	(0.008)	
2	1.256	-8.812	0.059	51
	(0.073)	(1.501)	(0.009)	
3	1.531	-5.350	0.044	51
	(0.272)	(1.369)	(0.008)	
4	1.391	-5.830	0.046	51
	(0.200)	(1.360)	(0.008)	
5	1.278	-6.526	0.052	51
	(0.311)	(2.606)	(0.016)	
6	1.521	-5.429	0.045	51
	(0.294)	(1.487)	(0.008)	

Table A6. Sunflower Yield Function Parameter Estimates (standard errors in parentheses)

Sunflower in Region	Alpha	Beta-0	Beta-1	Observations
1	1.816	0.000	0.006	55
	(0.077)	(0)	(0.000)	
6	0.676	-5.104	0.025	55
	(0.054)	(1.968)	(0.010)	

Table A7. Processing Tomatoes Yield Function Parameter Estimates (standard errors in parentheses)

Processing Tomatoes in Region	Alpha	Beta-0	Beta-1	Observations
1	39.29	-10.09	0.06	55
	(0.536)	(0.720)	(0.004)	
2	39.49	-10.09	0.06	55
	(0.568)	(0.756)	(0.004)	
3	39.68	-10.25	0.06	55
	(0.557)	(0.762)	(0.004)	
6	39.76	-8.44	0.05	55
	(0.638)	(0.592)	(0.003)	

Equations (1.1) and (1.2), and the parameter estimates in Tables A1-A7, show that the best fit of the DAYCENT yield data is with a logistic-type functional form. Over a small range of planting delay there is a small effect on yields. Yields decline at an increasing rate over some intermediate range and, at some point, asymptote towards zero. Figures A3-A9 illustrate the yield functions for each crop in an example region. Data points are in red, fitted functions in blue.

Figure A3. Fitted Yield Function for Corn in Region 1

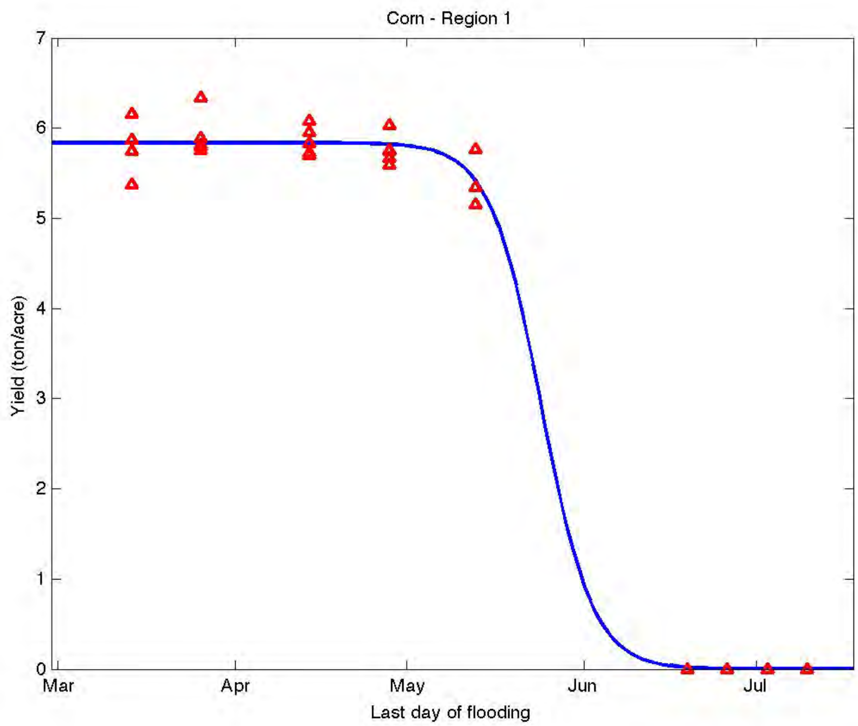


Figure A4. Fitted Yield Function for Pasture in Region 6

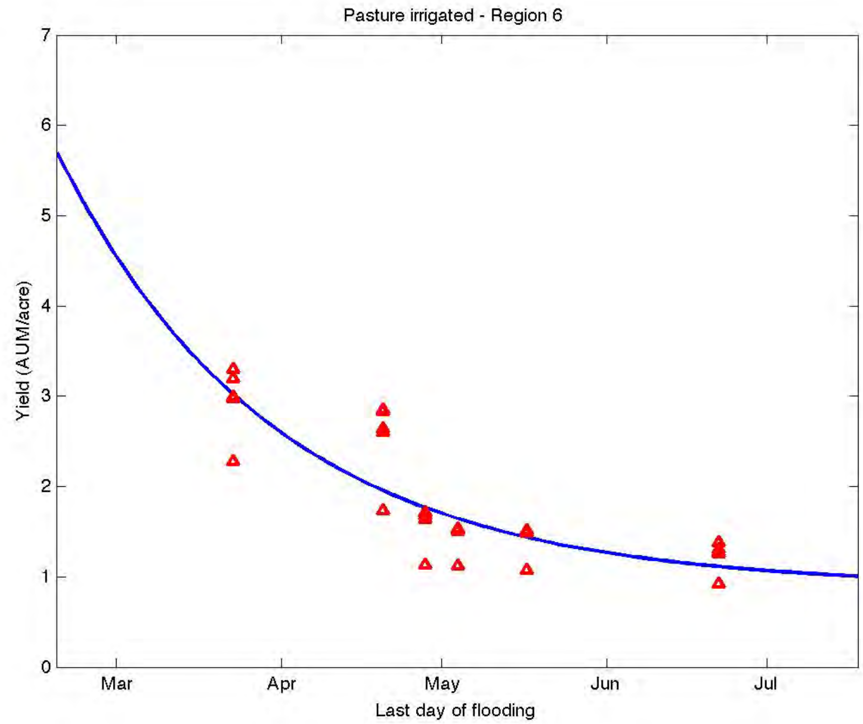


Figure A5. Fitted Yield Function for Rice in Region 2

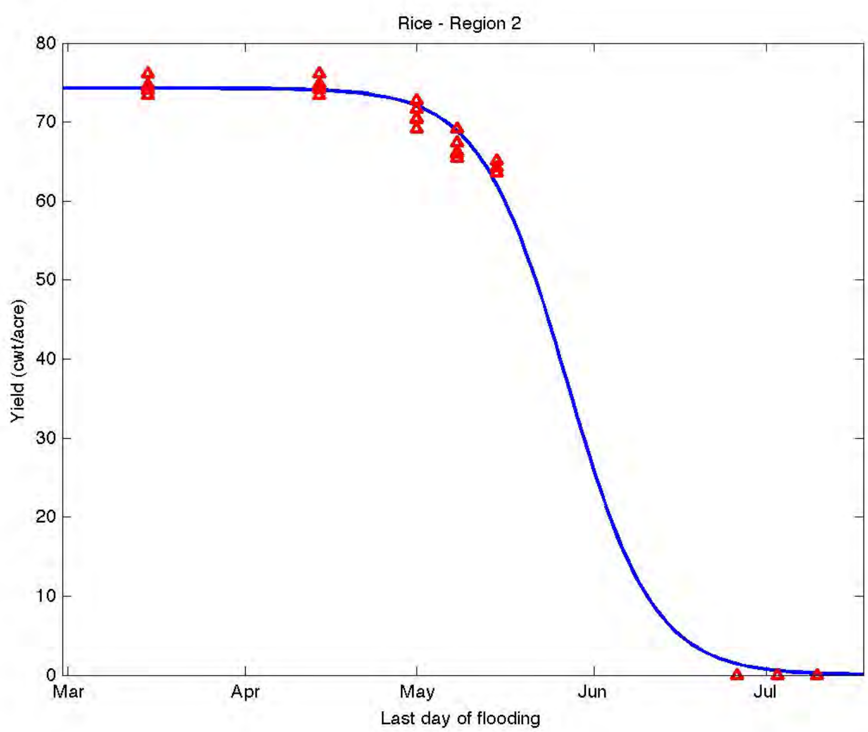


Figure A6. Fitted Yield Function for Safflower in Region 1

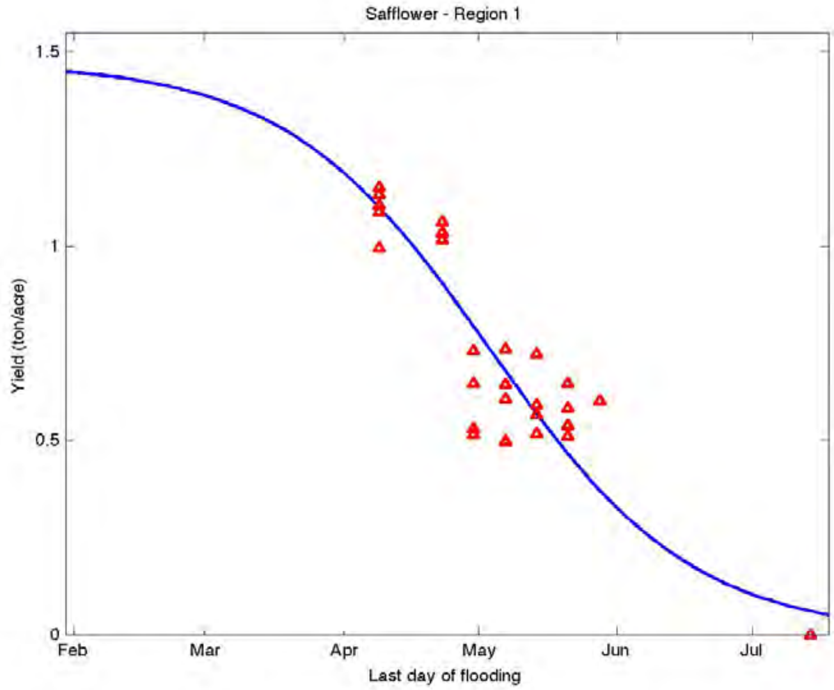


Figure A7. Fitted Yield Function for Sunflower in Region 1

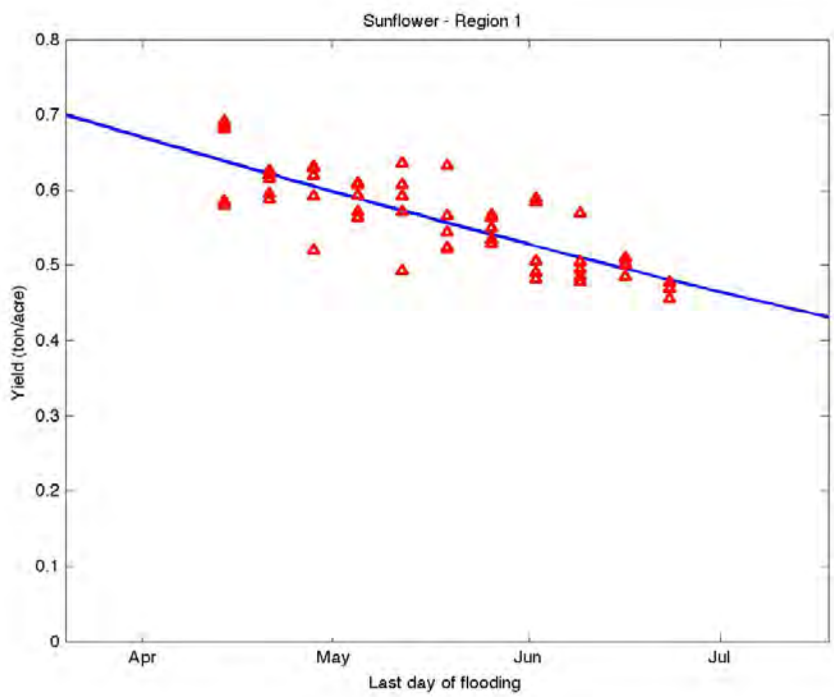


Figure A8. Fitted Yield Function for Processing Tomatoes in Region 3

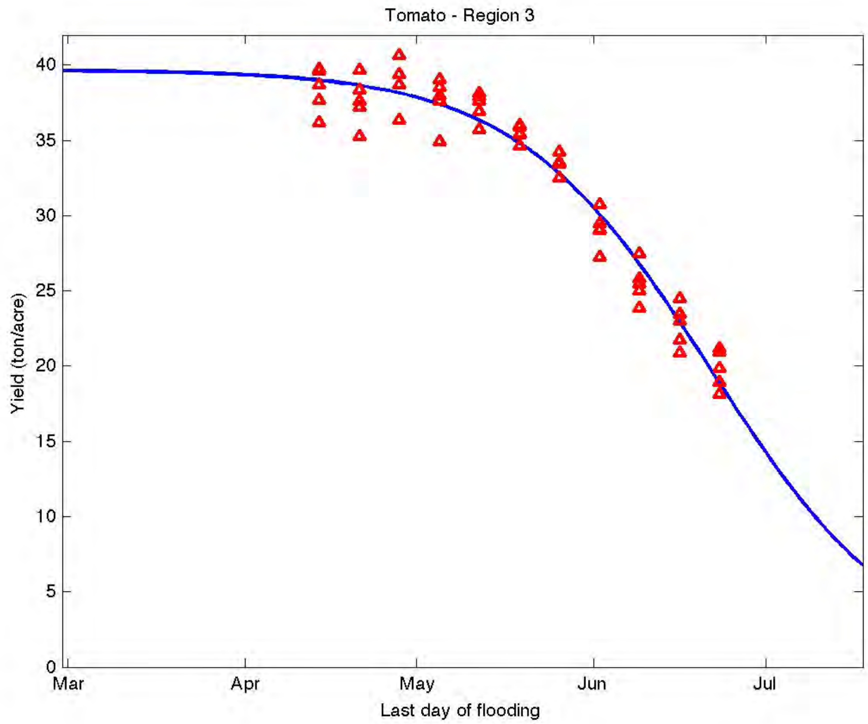
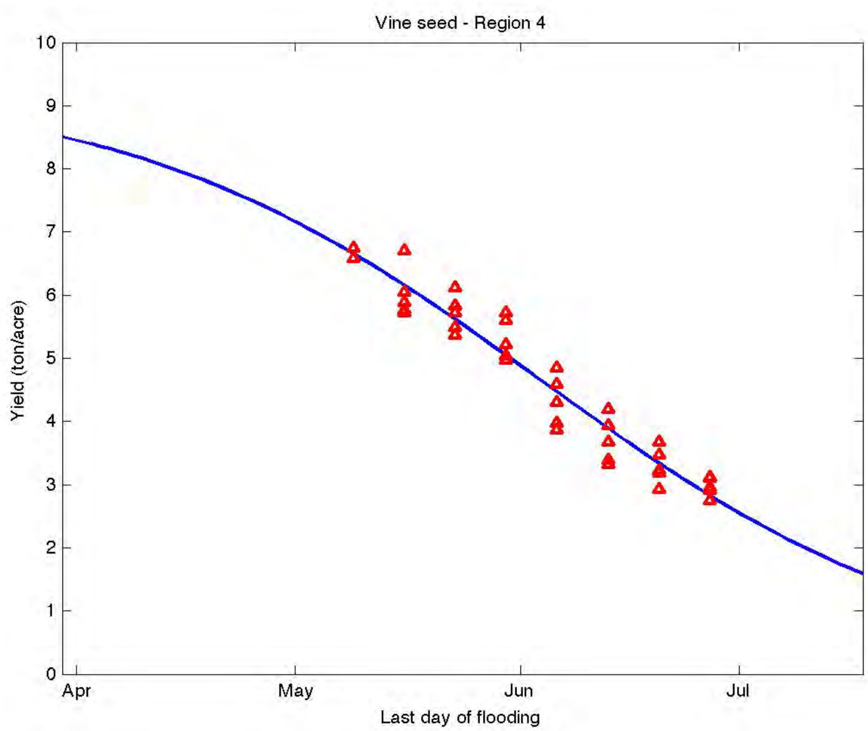


Figure A9. Fitted Yield Function for Melons (Vine Seed) in Region 4



2 The Bypass Production Model (BPM) Calibration

We use the crop yield functions estimated from the DAYCENT model, plus additional economic data, to calibrate the BPM. The BPM is the fundamental model of the analysis. The BPM relates changes in crop yield and total affected acres to changes in agricultural production and, fundamentally, changes in agricultural revenues. The BPM is a Positive Mathematical Programming (PMP after Howitt, 1995) model of agriculture in the 6 regions of the Yolo Bypass.

Note that a model is, by definition, a simplified representation of a real system. In the process of abstracting and simplifying a real system a model loses some information; thus even with theoretically consistent structure it is highly unlikely that a model will calibrate closely to observed (base year) data. The problem is well documented in the agricultural production modelling literature (Hazell and Norton 1986, Kasnakoglu 1990). One solution is to use observed farmer behavior, in the form of observed land use patterns, and additional exogenous information in order to calibrate the parameters of the structural model that exactly reproduce observed base-year conditions. The method of Positive Mathematical Programming is a common calibration method for structural agricultural production models (Howitt 1995), which we use in the BPM.

2.1 Positive mathematical programming (PMP)

The BPM self-calibrates using a three-step procedure based on Positive Mathematical Programming (PMP) (Howitt 1995) and the assumption that farmers behave as profit-maximizing agents. A traditional optimization model would have a tendency for overspecialization in production activities relative to what is observed empirically. PMP incorporates information on the marginal production conditions that farmers face, allowing the model to exactly replicate a base year of observed input use and output. Marginal conditions may include inter-temporal effects of crop rotation, proximity to processing facilities, management skills, farm-level effects such as risk and input smoothing, and heterogeneity in soil and other physical capital. In the BPM, PMP is used to translate these unobservable marginal conditions, in addition to observed average conditions, into region and crop-specific exponential cost functions.

Calibrating production models using PMP has been reviewed extensively in the recent literature. Buyssee et al. (2007) and Heckelei and Wolff (2003) argue that shadow values from calibration and/or resource constraints are an arbitrary source of information for model calibration. Subsequent research suggests using exogenous information such as land rents instead of shadow values (Heckelei and Britz 2005, Kanellopoulos et al. 2010). When multiple years of observations are available Heckelei and Britz (2005) propose a generalized maximum entropy formulation to estimate resource and calibration constraint shadow values. Merel and Bucaram (2010) and Merel et al. (2011) propose calibration against exogenous supply elasticity estimates. The BPM model is calibrated using traditional PMP with exogenous supply (acreage response) elasticity information.

2.2 Model Calibration

PMP is fundamentally a three-step procedure for model calibration that assumes farmers optimize input use for maximization of profits. In the first step a linear profit-maximization program is solved. In addition to basic resource availability and non-negativity constraints, a set of calibration constraints is added to restrict land use to observed values. In the second step, the dual (shadow) values from the calibration and resource constraints are used to derive the parameters for an exponential "PMP" cost function. In the third step, the calibrated model is combined into a full profit maximization program. The exponential PMP cost function captures the marginal decisions of farmers through the increasing cost of bringing additional land into production (e.g. through decreasing quality).

The BPM framework requires that additional land brought into production faces an increasing marginal cost of production. The most fertile land is cultivated first, additional land brought into production is of lower "quality" because of poorer soil quality, drainage or other water quality issues, or other factors that cause it to be more costly to farm. This is captured through an exponential land cost function (PMP cost function) for each crop and region. The exponential function is advantageous because it is always positive and strictly increasing, consistent with the hypothesis of increasing land costs. The PMP cost function is both region and crop specific, reflecting differences in production across crops and heterogeneity across regions. Functions are calibrated using information from acreage response elasticities and shadow values of calibration and resource constraints. The information is incorporated in such a way that the average cost data (known data) are unaffected.

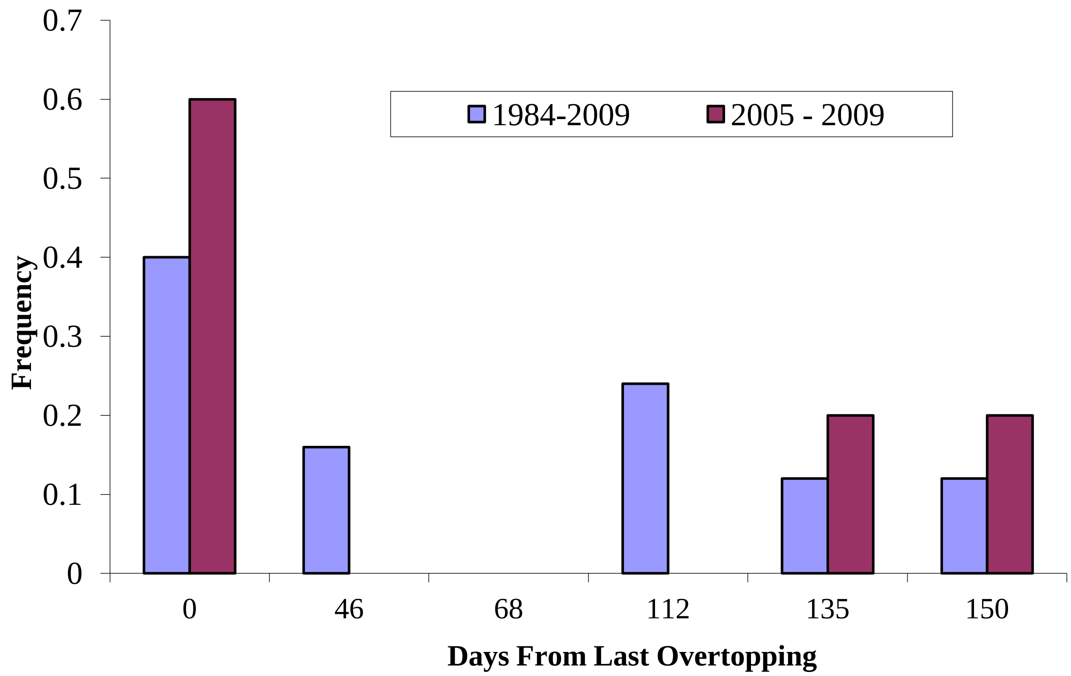
Formally, the exponential PMP cost functions are, for each crop i and region g, defined as

$$C_{gi}(x_{gi}) = \phi_{gi} e^{\gamma_{gi} x_{gi}}, \tag{1.3}$$

where ϕ_{gi} and γ_{gi} are parameters estimated by the PMP calibration routine described above and x_{gi} are total acres observed in production during the calibration base years.

The BPM calibrates to average observed land use between 2005 and 2009. We determined that 2005-2009 are representative of the full dataset (1984-2009) in terms of flood occurrence in the Yolo Bypass and, as such, are representative of land use in 3,000 and 6,000 cfs affected areas of the Bypass. Furthermore, detailed geo-referenced land use data were only available for 2005-2009 in the Yolo Bypass. The histogram in Figure A10 shows that the sub-set of years which we use for calibration (2005-2009) is representative of all years in the data (1984-2009) and, as such, represents a reasonable set of years to use for model calibration. While the data do omit some years of intermediate flood dates, Figure A10 shows that we capture the lower and upper bounds of inundation reasonably well. As such, we feel that calibration to average 2005-2009 land use accurately reflects base conditions in the Bypass.

Figure A10. Histogram of Overtopping Date Frequencies (84-09 and 05-09)



Standard calibration checks follow model calibration (see Howitt et al. 2012). These checks verify that the base year of observed data is reproduced by the calibrated model and that economic optimization requirements are satisfied.

We use a three year average of prices in the BPM, 2005-2007. These prices were determined to be representative of the average production conditions between 2005 and 2009 and, as such, are representative of the calibration data used in the model.

2.3 Profit Maximization Program Definition

The BPM solves for the cropping pattern that maximizes the agricultural profit across all regions subject to regional land constraints and yield functions estimated from the DAYCENT data. Data are as described previously. We assume the flood agency announces the policy it chooses for that year (or series of years) before farmers make their planting decisions. Therefore, farmers know the last day of overtopping for that year (with the exception of years where nature results in overtopping past the policy date) and the yields associated with that planting date. The objective function for the profit maximization program in the BPM is

$$\max_{x_{ig}} \sum_g \sum_i p_i \cdot y_{ig} \cdot x_{ig} - \sum_g \sum_i \phi_{ig} e^{\gamma_{ig} x_{ig}} - \sum_g \sum_i vc_{ig} x_{ig}, \qquad (1.4)$$

where subscripts and variables are as previously defined, p_i are individual crop prices, and vc_{ig} are region and crop-specific variable costs of production per acre. Yields (y_{ig}) vary by planting date, as defined above, according to the yield functions estimated with DAYCENT model output as,

$$y_{i,g} = \frac{\alpha_{i,g}}{1 + e^{\beta_{0i,g} + \beta_{1i,g} d_{i,g}}}, \quad \forall \, \text{i} \neq \text{pasture}, \tag{1.5}$$

and

$$y_{ig} = \alpha_{ig} + e^{\beta_{0ig} + \beta_{1ig} d_{ig}}, \ \text{for} \ \text{i} = \text{pasture}, \tag{1.6}$$

where subscripts, variables, and parameters are as previously defined. Finally, land constraints in each region are defined as

$$\sum_i x_{ig} \leq b_g, \ \ \forall \, g, \tag{1.7}$$

where b_g is the total number of acres (crop acres plus fallow) observed in each region.

In summary the procedure in the calibrated BPM model is to maximize Equation (1.4) subject to Equations (1.5) - (1.7) by selecting the optimal crop mix, x_{ig}. Simulating the model over the base calibration data reproduces the observed base allocation.

3 BPM Simulation

BPM model simulations proceed for two flow volumes separately: 3k CFS and 6k CFS, given the calibrated model defined in Equations (1.4) - (1.7). we defined the simulation procedure in the main text of the report, and repeat here for completeness.

Step 1: Run the BPM for a season with *known* overtopping dates at Fremont Weir, and flooding in the Yolo Bypass. This represents the base condition (e.g. natural flooding) for agriculture in the Bypass in the absence of the proposed policy flooding scenarios (for that year). Repeat Step 1 for a series of known years, there are 26 total.

Step 2: Over the same series of years as step two, run the BPM and impose (sequentially - one at a time) the 12 proposed policy flooding scenarios. This represents what *would have* happened to Bypass agriculture *if* the flooding policy was implemented in that year. Repeat Step 2 for the all of the same years as Step 1.

Step 3: For each year simulated in Steps 1 and 2, calculate the difference in agricultural revenues (and other outputs). Record the result for negative changes in revenue. Intuitively, we only want negative changes in revenue because a positive change in revenue implies that the policy was “better” than nature. For example, if natural flooding occurred in the Bypass until April 30th then imposing a policy which stops overtopping at Fremont Weir on April 10th would not be possible (i.e. it would increase revenues).

Step 4: Calculate the average loss of revenue (and other changes) across all of the years simulated in Steps 1 - 3. This represents the expected impacts to agriculture due to the proposed flooding scenarios, and is the fundamental output of the BPM.

The fundamental procedure of the BPM is to generate *expected* losses to agriculture by using the calibrated model to estimate what would have happened under natural flooding, and then asking what would have happened if a specific policy (last day of overtopping) was in place. This procedure allows us to generate expected losses because we control for the expected natural flood events in the Bypass. The following section illustrates this point.

4 BPM Output and Expected Losses

The final phase in the analysis is to use the BPM simulations to estimate the change in agricultural gross revenues and acreage as a result of each of the policies (last overtopping date for RPA, or low-impact CM2 scenario) under both flow volumes (3k and 6k CFS). We estimate regional economic effects (jobs and income) using the IMPLAN model.

Economic losses are interpreted as expected annual losses in our analysis. The key assumption is that the previous 26 year hydrology in the Yolo Bypass is representative of expected future conditions. Specifically, natural overtopping at Fremont Weir will occur with the same expected frequency, duration, and volume. There are two reasons these 26 years of data were identified as reasonable, including (i) detailed flow information over the Fremont Weir was available for these years, and (ii) it is representative of current hydrologic conditions in the Sacramento Valley watershed. Older hydrologic information less accurately represents current conditions because it does not account for changes in urban development and reservoir operations that have altered flows in the Sacramento River over time. If better data become available we can revisit this assumption.

The policy analysis output in the report is the average, over 26 years, of annual losses as estimated by the individual policy scenarios in the BPM.

4.1 IMPLAN

The IMPLAN model estimates regional economic changes in production, value added, employment, and tax receipts. Expected revenue losses from the BPM analysis represent direct economic effects. However, upstream and downstream industries will be affected and some agricultural workers will lose their jobs when production in the Bypass decreases. We use the IMPLAN regional Input-Output model to estimate the direct, indirect, and induced effects of the 12 policy scenarios. The sum of these components represents the total effect of the policies.

IMPLAN is a multiplier model, which accounts for interrelationships among sectors and institutions in the regional economy. The input-output representation of the economy was first proposed by Leontief (1941). Production in this setting is assumed to occur by using fixed proportions of factors, such that the same amount of a production input.

Coverage if the IMPLAN area for this study is exclusive to Yolo County. We used the NAICS classification system and groped agricultural production into a single sector, NAICS 111. We employed IMPLAN Professional Version 3 and a 2009 database for Yolo County.

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EXHIBIT H

COUNTY OF YOLO

Board of Supervisors

District 1, **Michael H. McGowan**
District 2, **Don Saylor**
District 3, **Matt Rexroad**
District 4, **Jim Provenza**
District 5, **Duane Chamberlain**

625 Court Street, Room 204 ▪ Woodland, CA 95695
(530) 666-8195 ▪ FAX (530) 666-8193
www.yolocounty.org

County Administrator, **Patrick S. Blacklock**
Deputy Clerk of the Board, **Julie Dachtler**

September 5, 2013

Secretary Jewell
United States Department of the Interior
Bureau of Reclamation
Mid-Pacific Region, Bay-Delta Office
801 I Street, Suite 140
Sacramento, CA 95814-2536

Secretary John Laird
California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

Re: Comments on the Revised Administrative Draft of the Bay Delta Conservation Plan

Dear Secretary Jewell and Secretary Laird:

This letter communicates comments from the County of Yolo (County) on the administrative draft of the Bay Delta Conservation Plan (BDCP). The County's comments on specific text in the administrative BDCP should be read to apply to all substantially similar text appearing in the document. The County also reserves the right to provide additional comments on BDCP--including detailed legal and technical comments--as work on the BDCP continues.

1. **The BDCP Conservation Measure 2 ("CM2") Biological Objectives Undermine Existing Collaboration and Limit Adaptive Management.**

CM2 still does not include a balanced approach to habitat restoration that places adequate weight on existing land uses, including agriculture, recreation, and waterfowl habitat. While CM2 has changed in some respects over time, it continues to entail flooding a large area of the Yolo Bypass on a frequent basis for an amount of time that may significantly impact agriculture and other existing land uses, all without a sound scientific basis for concluding that the hypothesized fish benefits will ever materialize. The County has long offered alternative approaches that would minimize or avoid adverse effects while restoring substantial floodplain habitat in the Yolo Bypass, but the administrative draft does not yet reflect Yolo County's efforts.

Specifically, Yolo County strongly objects to the use of the criteria that flooding should be achieved in 70% of all years, as well as the specific acreage criteria, in the CM2 biological objectives. Based on the County's understanding of biological objectives, including such specific criteria in the biological objectives will limit options to minimize impacts of the proposal. The biological objectives are especially egregious considering it is the County's understanding that the fish benefits associated with such broad objectives are still uncertain. The BDCP should start with biological objectives that minimize impacts, as well as take into account the scientific uncertainty associated with fish benefits, and then use adaptive management to increase the percent of years inundation occurs and acreage of inundation, if necessary. The biological objectives, as currently written, will undermine the ongoing collaborative process between the County and the BDCP because they lock in critical parameters of the proposed project.

In addition to creating specific acreage targets in the CM2 biological objectives, the County believes a fundamental problem with the BDCP and EIR/EIS is that both rely on a published paper (Sommer et al. 2007) to state the Yolo Bypass floods in 70 percent of all years. The statistic is used as the basis for at least three biological objectives in Chapter 3 of the BDCP (Objectives FRCS1.2, STHD1.2, and WRCS1.2) that are central to certain actions proposed in CM2. There are at least two problems with this statistic, however, which are problems also described in the County's comments on the EIR/EIS. First, this statistic is potentially inaccurate. Before it is used as the basis for a biological objective or the EIR/EIS baseline, this statistic must be thoroughly evaluated for accuracy. Second, even if accurate, the statistic does not define the extent of Bypass flooding. It likely includes very small overtopping events that caused only localized inundation within the Bypass. This statistic thus cannot be used to define current or "natural" conditions that have any significant bearing on appropriate restoration strategies. Its use in CM2 and the above-referenced objectives is scientifically questionable in the absence of any apparent connection to research regarding the appropriate frequency of inundation for covered aquatic species.

The County urges the state and federal government to revise the biological objectives to allow the state and federal government to incorporate the results of the ongoing collaborative process in the BDCP, rather than predetermining the outcome by adopting restrictive biological objectives. The County further urges the BDCP to create a Yolo Bypass governance structure, as discussed by Yolo County with Deputy Secretary Jerry Meral and other parties that will apply to the planning, as well as the implementation process for CM2.

2. CM2 is Mitigation for Adverse Effects, but Taxpayers are Paying for CM2.

The state and federal government have already identified increased inundation of the Yolo Bypass floodplain as mitigation for operation of the existing water supply system as part of the Bureau of Reclamation's Yolo Bypass Salmonid and Habitat Restoration Project, proposed to comply with a federal Biological Opinion. In addition, CM2 is referenced as sufficient to avoid the need to mitigate for CM1 *Water Facilities and Operation* ("CM1") impacts throughout the BDCP administrative draft. Yolo Bypass inundation is, consequently, documented as mitigation for both CM1 and existing water supply operations. The state and federal water contractors are paying for construction of CM1 (including mitigation), but the taxpayers are paying for CM2. There is no funding, for example, allocated to the contractors in the draft BDCP, as indicated in Table 8.50 (Ch8, p94-96). This is of utmost importance to Yolo County because the costs of the project include compensation for impacts to Yolo County from CM2. As the County has demonstrated through multiple studies, CM2 could potentially have significant impacts on agriculture, waterfowl habitat, and other existing land uses. In addition, there are potentially significant local economic impacts from CM2. The beneficiaries of CM1 must fully pay for CM2 if BDCP uses CM2 to avoid mitigation for CM1 impacts, including compensation for local economic impacts. Yolo County, as well as the taxpayers at large, should not be shouldering the financial burden for a project that benefits other parts of the state.

It is clear from language in the BDCP draft that BDCP uses benefits of CM2 as a means to avoid implementing specific mitigation measures (and associated costs) for the impacts of CM1. Chapter 5 of the BDCP administrative draft describes in detail the anticipated benefits of CM2 to covered fish species. Specifically, CM2 "will improve passage and habitat conditions for Sacramento splittail, Chinook salmon, green and white sturgeon, lamprey, and possibly steelhead (Ch5, p19, lines 16-17)… *CM2 Yolo Bypass Fisheries Enhancement* is expected to improve spawning, substrate, rearing habitat, and food production benefits to covered fish species" (Ch5, p115, lines 21-22). The following are examples of using CM2 for "mitigation avoidance":

- **Juvenile winter-run Chinook salmon impacts.** The north Delta intakes may have near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects on juvenile winter-run Chinook salmon. "The *CM2 Yolo Bypass Fisheries Enhancement* will enhance conditions in the Yolo Bypass, which has been shown to be a highly beneficial habitat for juvenile salmonids (Sommer et al. 2001a)" (Ch5, p256, lines 13-15). These positive effects outweigh the negative effects for a net result of a "low beneficial effect" (Ch5, p256, line 16).

- **Spring-run Chinook salmon impacts.** The adverse effects for Chinook salmon, central valley spring-run evolutionarily significant unit (ESU) include the north Delta intakes may have near-field (screen contact/impingement and predation) and far-field (reduced flow-related survival) effects on juvenile winter-run Chinook salmon, and exposure to increased contaminants. These adverse effects are outweighed by CM2 enhanced conditions in the Yolo Bypass, "which has been shown to be a highly beneficial habitat for juvenile salmonids (Sommer et al. 2001a) " (Ch5, p278, lines 15-16). for a net result of a "modest beneficial effect" (Ch5, p278, lines 17).

- **Steelhead impacts.** The same adverse effects are posed for steelhead, central valley distinct population segment (DPS). The adverse effects are again, outweighed by CM2 by increasing food resources and providing a greater use of an alternative, relatively high-survival migration pathway. The BDCP calculates a net result as a "beneficial effect" (Ch5, p342, lines 35).

- **Splittail impacts.** The adverse effects for Sacramento splittail are the greater exposure to contaminants and In-Water and Maintenance Activities. CM2 will have a "large positive effect" (Ch5, p358, line 19) on splittail spawning and rearing habitat availability. "*CM2 Yolo Bypass Fisheries Enhancement* is also expected to reduce the per capita risk of stranding in the Yolo Bypass" (Ch5, p358, lines 25-26). The BDCP concludes "the overall effect of the BDCP on splittail will be to increase the abundance, productivity, and diversity of the species and improve the species' chances for survival. The BDCP will adequately mitigate the impacts of the covered activities and conserve the species in the Plan Area." (Ch5, p369, lines 18-21).

- **White and green sturgeon impacts.** The adverse effects to white and green sturgeon include the increased exposure to contaminants and reduced transport or migration flows. The beneficial effects provided by CM2 are expected to reduce the illegal harvest of green and white sturgeon, improve passage, and provide food that contributes to increased productivity and higher abundance. The BDCP concludes "the positive effects of the BDCP are expected to outweigh the adverse effects." (Ch5, p382, line 35).

- **Pacific and river lamprey impacts.** The adverse effects for Pacific and River Lamprey are increased predation and take. The beneficial effects of CM2 are expected to reduce impediments to passage and stranding. Due to this offset, it is found that BDCP will provide a small net benefit to both Pacific and river lamprey.

The state and federal government need to ensure the BDCP financing chapter includes strategies that ensure the beneficiaries of the BDCP pay for its implementation, rather than state taxpayers and Yolo County.

3. **Insufficient Budget for Necessary Methylmercury and other Contaminant Monitoring and Mitigation.**

The BDCP needs to state clearly how it intends to measure and mitigate for the increased loading, concentrations, and bioavailability of methylmercury in the aquatic system in the Yolo Bypass and areas downstream, as well as other contaminants. The BDCP also need to assure that the state and federal contractors will fully fund such mitigation. The current BDCP draft does not meet either of these goals for methylmercury or other contaminants.

Based on Table 8.50, the state and federal contractors have budgeted no funding for CM12-Methylmercury Management. Appendix 5.D, Section 5D.4, however, states the covered activities for the Yolo Bypass have the potential to increase the loading, concentrations, and bioavailability of methylmercury in the aquatic system in the Yolo Bypass. "Currently, the methylmercury in water discharging from the Yolo Bypass to the Sacramento River is 0.27 ng/L (annual average) (Foe et al. 2008). This concentration likely will increase under the BDCP, but may be mitigated to some extent by CM12 (Ch8, p36, lines 15-18). Chapter 8 states "more detailed mercury surveys may be required for designing specific restoration plans…project design surveys for mercury will be conducted for approximately 40,400 acres of restoration area at one sample per 50 acres and will include collection and analysis of composite samples representing the 0- to 12-inch depth interval and, on a more limited basis, the 12-inch to 14- or 16-inch depth interval."(Ch8, p45, lines11-13) The "estimated cost for methylmercury site characterization and project design surveys is $1.7 million in undiscounted 2012 dollars[1]." (Ch8, p45, lines14-15) Given the Central Valley Regional Water Quality Control Board's Delta Total Maximum Daily

Load for methylmercury and the unknown impacts of CM2 on Yolo Bypass and Delta methylmercury levels, providing funding for monitoring of methylmercury is essential. [1]

With regard to other contaminants, the BDCP draft states in multiple places that CM2 could increase the loading of contaminants in important waterways and affect fish species. In Chapter 5, for example, the draft states "The BDCP could adversely affect winter- run Chinook salmon life stages occurring in the Plan through changes in contaminants as a result of changes in water operations (*CM1 Water Facilities and Operation, CM2 Yolo Bypass Fisheries Enhancement*) and habitat restoration (principally, *CM4 Tidal Natural Communities Restoration*)." (CH5, p248, lines10-13). Yet it dose not appear that the BDCP budgeted sufficient funding budgeted to monitoring changes in contaminants resulting from these changes in water operations. The BDCP should provide adequate funding for this monitoring in the financing chapter.

4. **Adaptive Management Process' Nine-Step Plan Does Not State Goals Clearly or Ensure Mitigation for Impacts.**

Before adaptive management can be instated, the methodology for collecting baseline and post construction measurements needs to be clearly outlined with an appropriate timeline. Additionally, BDCP must state, for each of the potentially adverse actions, what the acceptable variance is between pre and post construction measurements and how significant differences will be calculated.

Figure 3.6-1 illustrates the adaptive management process through the "Nine-Step Plan." This circular diagram returns to Step 1, 2, 3 or 4 after Step 9, implying that adaptive management will be a constant process. Generally, the adverse effects described in the BDCP have quantitative outcomes (e.g. population counts, entrainment numbers, MeHg concentrations). This general, non-scientific Nine-Step Plan does not specify the statistical difference at which mitigation is necessary or how BDCP will mitigate for identified significant adverse effects. It is imperative the BDCP details the acceptable variation from baseline data, what methodology they will use for creating the baseline and measuring significant differences, and which management techniques will be implemented to ameliorate any problems that arise. Without such information, it is impossible to evaluate the BDCP's adaptive management approach whether it could lead to additional environmental, economic, or other impacts during the term of BDCP. The state and federal government must address these critical issues prior to BDCP approval.

5. **The BDCP Needs to Improve Coordination with the Yolo Natural Heritage Program**

The County recognizes the Yolo County HCP/NCCP Joint Powers Agency (JPA) released the first administrative draft of the Yolo Natural Heritage Program after the BDCP draft was

[1]To collect, analyze, and provide a report for 808 sites (40,400 acres/ one sample per 50 acres) and to sample at surface and depth at each site is a total of 1,616 samples. These calculations use a conservative estimate of $500/sample (see values stated on Ch8, p45, lines 5-6). The $1.7 million budget will cover baseline sampling and only one sampling effort during the fifty years post construction.

released. The JPA is currently working on the second administrative draft. Given the extent of the terrestrial species impacts identified in the draft plan and the EIR/EIS, the County encourages close coordination with the BDCP in the months ahead to ensure accurate information is included in the public draft of the BDCP and implementation of the BDCP does not affect implementation of the Yolo Natural Heritage Program.

The BDCP plan section 1.5.5 also incorrectly states that the Yolo Natural Heritage Program provides habitat for 28 sensitive species and 21 of these species are in common with the BDCP. The Yolo Natural Heritage Program provides habitat for *32* sensitive species and *20* of these species are in common with the BDCP. The Yolo Natural Heritage Program does not cover the California red-legged frog (*Rana draytonii*).

The County appreciates this opportunity to comment on the Administrative Draft of the BDCP. We look forward to hearing from you with respect to the issues raised in this letter.

Very truly yours,

Duane Chamberlain

Duane Chamberlain,
Chair, Yolo County Board of Supervisors

cc: Yolo County Board of Supervisors
Rep. Doris Matsui
Rep. John Garamendi
Senator Dianne Feinstein
Senator Barbara Boxer
Senator Lois Wolk
Assemblymember Mariko Yamada
Assemblymember Roger Dickinson

BDCP1675

From: Petrea Marchand <petrea@conserosolutions.com>
Sent: Tuesday, July 29, 2014 4:27 PM
To: bdcp.comments@noaa.gov
Cc: Patrick Blacklock; Phil Pogledich; Jim Provenza; Oscar Villegas; Cindy Tuttle; Alexander Tengolics; Dirk Brazil; Robin Kulakow
Subject: Yolo County comments on the Public Draft BDCP and EIR EIS
Attachments: 2014 0729 Final Yolo County Letter on BDCP EIR EIS and Attachments.pdf; 2014 0729 Final Yolo County BDCP Comment Letter and Attachments.pdf

Mr. Wulff:

Attached are Yolo County's comments on the Public Draft BDCP and EIR EIS.

Thank you!

Petrea Marchand
Consero Solutions
www.conserosolutions.com
719 2nd Street, Suite 13
Davis, CA 95616
o: 530-746-2083
c: 916-505-7191
f: 916-290-0319