CITY OF FORT COLLINS

UPPER COOPER SLOUGH BASIN

SELECTED PLAN OF IMPROVEMENTS

May 2021

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Section 1 – Introduction

1.1 Background and Objectives

The goal of this report is to prepare a selected plan of stormwater improvements for the Upper Cooper Slough Basin. This report follows a draft plan developed in 2017 by ICON Engineering, Inc. (ICON). Subsequent to the development of the 2017 plan, ongoing collaboration with development groups contributed to refinement of the proposed stormwater improvement concepts. This 2021 study reflects the results of collaboration with development groups including; the Montava, Sonders, and Country Club Reserve Developments. In addition, this plan was updated to further evaluate improvements required at, and downstream, of Mulberry Street through the Gateway at Prospect development corridor.

Prior to 2017, an alternative analysis was completed by ICON, (*Cooper Slough, Alternative Analysis Update, 2017*). The alternative analysis recommended drainage improvements and development criteria for the Upper Cooper Slough Basin. The 2017 draft Selected Plan report summarized recommendations in the alternative analysis study and updated information from past studies, including the most recent Selected Plan report prepared by Anderson Consulting Engineers, Inc. (ACE) in 2006. The improvements recommended in the 2006 Selected Plan were modified slightly in 2017, however, the main goals were not changed.

The 2021 Upper Cooper Slough Basin Selected Plan Improvements include:

1. North Poudre Reservoir No. 6 – Outlet Sill
2. Sonders and Sonders East Developments Selected Plan Improvements
3. Sod Farm
    - Sod Farm Detention Pond and No. 8 Outlet Ditch Spill
4. Montava Development Selected Plan Improvements:
    - Mountain Vista Diversion on No. 8 Outlet Ditch (to C&S Pond)
    - Removal of C&S RR Flow Split (C&S RR Railroad Diversion)
    - Crumb and C&S RR Regional Detention Pond
    - AB Detention Pond Improvements
    - On-site Detention Requirements
5. Improvements Downstream of Mulberry
    - Mulberry Street (SH-14) Crossing
    - Lake Canal Crossing
    - Gateway at Prospect Stream Improvements
    - Regional Pedestrian Trail Identification
6. Other Culvert Improvements
    - Vine Drive Crossing
    - Mountain Vista Culvert – West flow path
7. Bank and Habitat Improvements

In addition, site specific development criteria recommendations for Mountain Vista and Anheuser Busch locations have also been provided. A vicinity map of the Cooper Slough watershed is provided in **Figure 1.** The Mountain Vista and Anheuser Busch areas can be found on **Figure 2.**

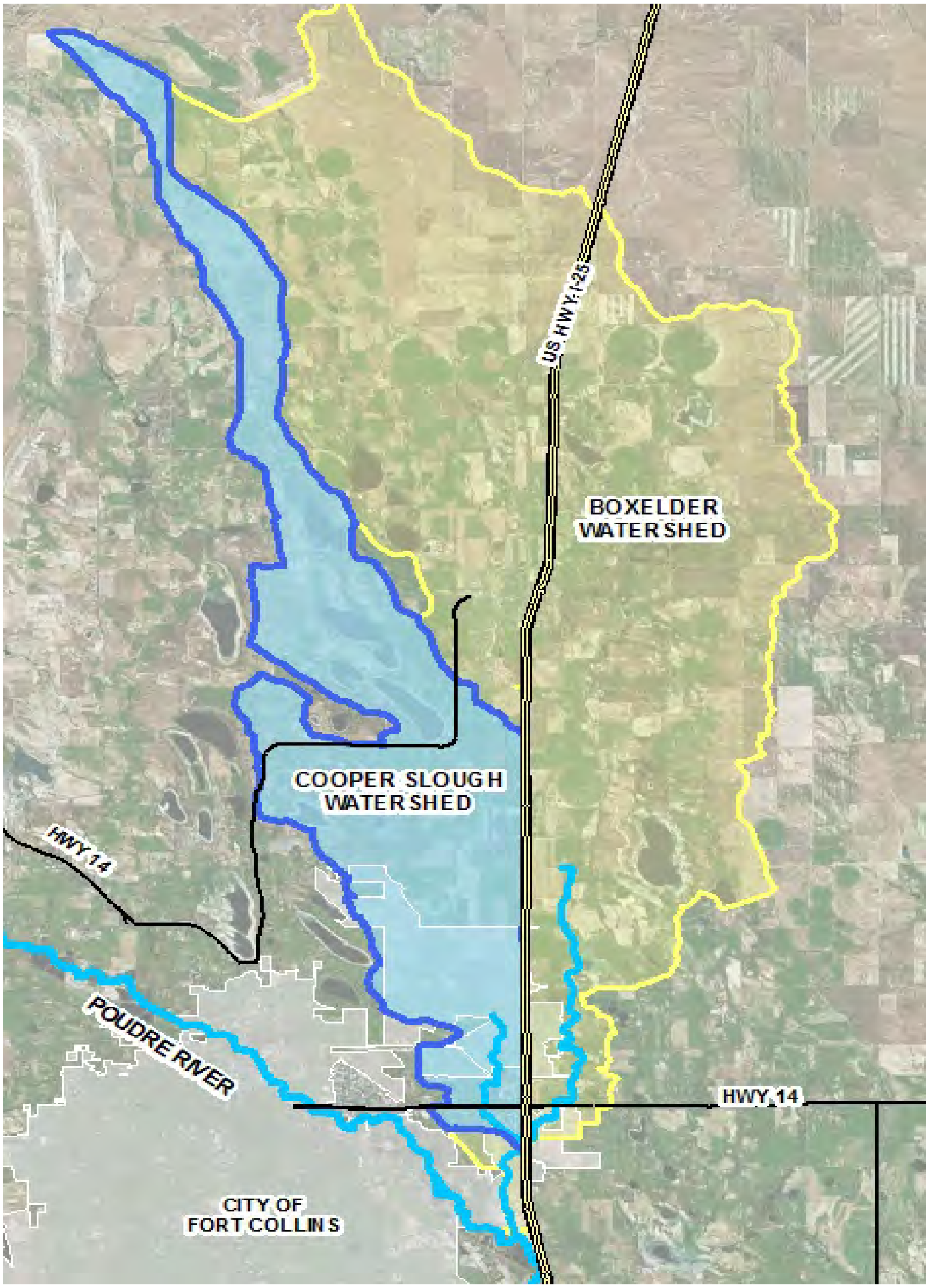


Figure 1: Cooper Slough Watershed Vicinity Map

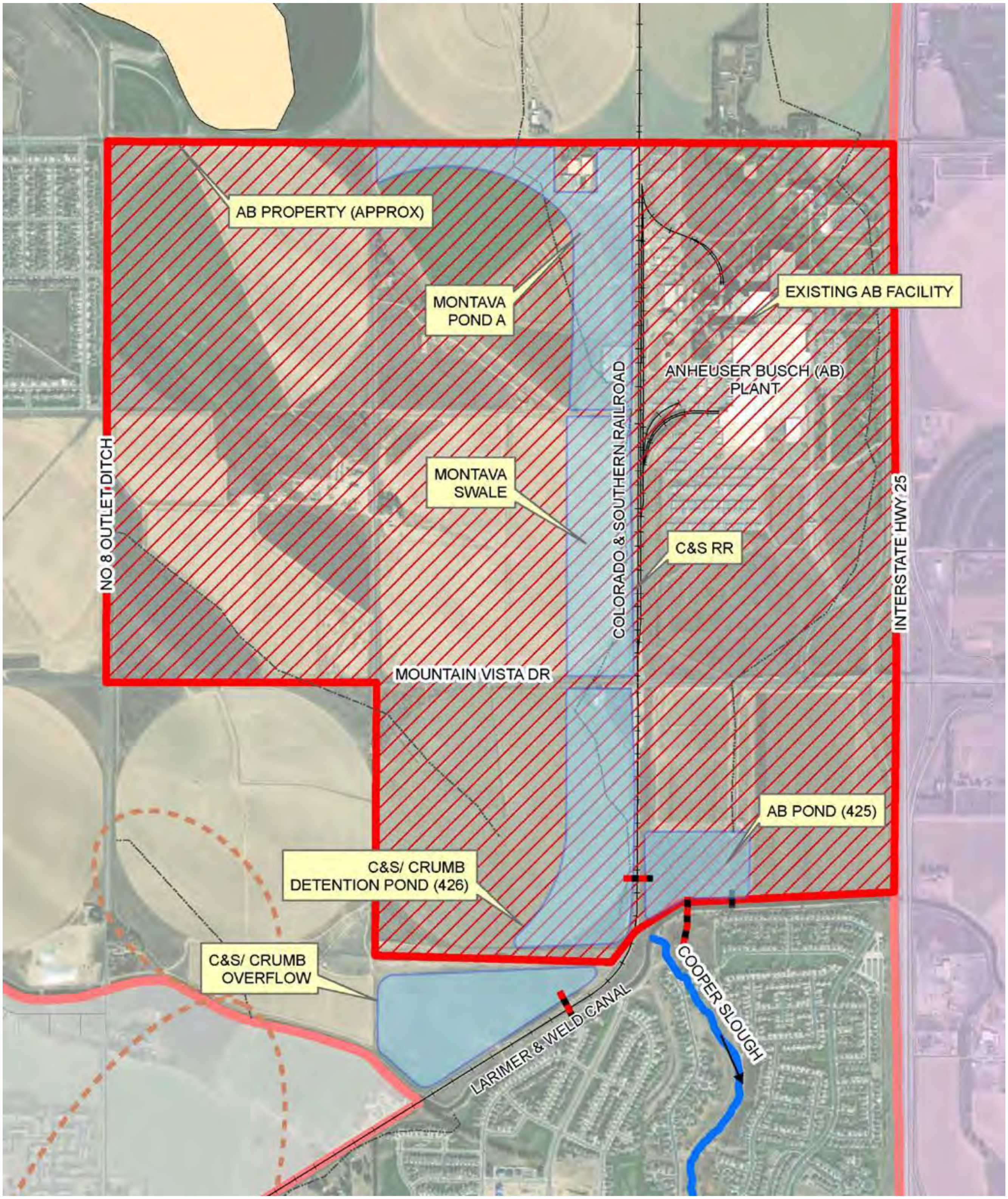


Figure 2: Mountain Vista and Anheuser Busch Property

1.2 Cooper Slough Basin Description

The Cooper Slough drainage basin resides in northeast Fort Collins and unincorporated Larimer County, Colorado. It is a long and slender watershed, flowing from north to south, comprising 28 square miles which are tributary to Box Elder Creek and the Cache la Poudre River. The watershed begins at the confluence with Box Elder Creek (about one-half mile south of Mulberry Street and slightly west of I-25) and proceeds north for 20-miles to Larimer County Road 80 at a location northwest of the Town of Wellington. The basin has a maximum width of 3.9-miles at a location just south of Wellington. Predominant land uses are characterized by farmland and open space, with development occurring mainly in the southern portion of the watershed, near northeast Fort Collins.

The Cooper Slough watershed can be divided into upper and lower portions by the Larimer & Weld Canal (L&W Canal) which transects the basin from west to east and intercepts natural and man-made drainages. Upper Cooper Slough is significantly larger than the Lower Cooper basin, at 26.4 sq.-miles and 2.3 sq.-miles respectively. There are three primary drainage paths in Upper Copper Slough, which flow from north to south. The western most flow path is the Number 8 Outlet Ditch (No. 8 Ditch) which carries both storm and irrigation flows. It has been noted in previous studies that the capacity of this ditch is "severely limited" (ACE 2006) and is in need of improvements which will be discussed later in this study. In addition to the irrigation and drainage ditches, four (4) significant irrigation reservoirs exist in the upper watershed. These include the North Poudre Reservoirs Nos. 2, 5, and 6 and the Windsor Reservoir No. 8.

Since the L&W Canal captures flows from the entire upper watershed there are multiple locations, in multiple watersheds, where storm flows will spill from the canal. In the Cooper Slough basin, the most notable spill is in the Waterglen Development area at the upper end of the historic Cooper Slough channel. Disconnecting some of the upper watershed inflows to this canal will be discussed later in this report. A vicinity map of the Cooper Slough watershed is provided in Figure 1.

1.3 Previous Studies

The following list presents major studies of the Box Elder/ Cooper Slough watersheds;

- "Upper Cooper Slough Selected Plan"; ICON, 2017
- "Upper Cooper Slough Alternative Analysis Update"; ICON, 2017
- "Upper Cooper Slough Basin Selected Plan of Improvements"; Anderson Consulting Engineers, Inc., 2006
- "Cooper Slough, Boxelder Creek Master Drainageway Planning Study"; SLA, August 1981;
- "Hydrology Report, Anheuser Busch Company, Inc."; Ayres Associates, January 2000;
- "Technical Documentation for the Hydrologic Modeling of the Boxelder Creek/ Cooper Slough Basin"; Anderson Consulting Engineers, Inc., January 2002;
- "Technical Documentation for the Alternatives Feasibility Analysis of the Boxelder Creek/ Cooper Slough Basin"; Anderson Consulting Engineers, Inc., December 2002;

- "Selected Plan of Improvements for the Boxelder Creek/ Cooper Slough Basin"; Anderson Consulting Engineers, Inc., April 2004;
- "Upper Cooper Slough Basin Selected Plan of Improvements"; Anderson Consulting Engineers, Inc., June 2006;
- "Box Elder Creek / Cooper Slough Hydrology Update"; ICON Engineering, Inc., April 2014;
- "Conditional Letter of Map Revision (CLOMR) for East Side Detention Facility (ESDF), Larimer & Weld Canal Crossing Structure (LWCCS), Opening Of I-25 Boxes, Siphon of Lake Canal, Prospect Road Bridge Replacement, Boxelder Creek Overflow. Also Known As (Boxelder 6)"; Ayres Associates, February 2015.
- "Boxelder and Cooper Slough Letter of Map Revision (LOMR) for Boxelder 6 Project East Side Detention Facility (ESDF), Larimer & Weld Canal Crossing Structure (LWCCS), Opening Of I-25 Boxes, Siphon of Lake Canal, Prospect Road Bridge Replacement, Boxelder Creek Overflow"; Ayres Associates, March 2018.

1.3.1 2006 Selected Plan

The 2006 Upper Cooper Slough Basin Selected Plan of Improvements report was developed by Anderson Consulting Engineers (ACE) in 2006 for the City of Fort Collins. The purpose of the 2006 selected plan was to address the recommendation in the Boxelder Creek/Cooper Slough Selected Plan report and to develop a regional drainage plan for the Upper Cooper Slough Basin, separately. The regional drainage plan was developed to formulate improvements that consider the rapid development with the basin as well as the AB Master Agreement with the City of Fort Collins. The intent of the 2006 Selected Plan was also to provide a framework for the regional drainage improvement plan for Cooper Slough. The improvements identified by the 2006 Selected Plan were conceptual and subject to revision during final design. This includes addressing issues such as; final improvement configuration, property acquisition, easements, water rights, etc.

With the highly variable development nature of the Upper Cooper Slough Basin, the regional master plan recommended flexibility with respect to the design/implementation of drainage improvements as long as the overall goals outlined in the 2006 Selected Plan were satisfied. The goals of the 2006 Selected Plan were to:

1) Limit the release (both peak discharge and volume) associated with future development within the Upper Cooper Slough Basin to the 100-year existing condition release rates into the lower Cooper Slough area;
2) Provide water quality enhancement commensurate with criteria identified in the Urban Storm Drainage Criteria Manual;
3) Identify dedicated outfall channels and detention facilities to safely convey stormwater flows generated with the basin; and

4) Limit the capture and uncontrolled spilling of stormwater runoff from the No. 8 Outlet Ditch and the L&W Canal.

To meet the above goals, the 2006 Selected Plan performed the following tasks:

a) Developed an existing condition hydrologic model that eliminated the influence of the stormwater conveyed by Boxelder Creek and captured by the L&W Canal.
b) Identified and developed alternative improvements that limited or eliminated uncontrolled spills from the existing irrigation canals within the basin.
c) Identified and analyzed regional detention alternatives.
d) Developed outfall channel alternatives for those areas of rapid development along the west side of the No. 8 Outlet Ditch.
e) Formulated a selected plan of improvements for the Upper Cooper Slough Basin.
f) Developed conceptual cost estimates.

The improvements recommended in the 2006 Selected Plan were updated based on current hydrology and project requirements with the 2017 alternative analysis. However, the overarching goals described above were unchanged.

As part of the 2006 master planning effort, several basin-wide alternatives were conceptually developed to alleviate potential flooding within the basin, to safely convey stormwater runoff associated with future development, and to meet the above goals. The alternatives focused primarily on the conveyance and detention of outfall runoff within the basin. Specific attention focused on development of outfall alternatives for the existing and future development areas along the west side of the No. 8 Ditch, south of County Road 54. The alternative analysis analyzed regional detention at eight potential locations, the mitigation of spills from the irrigation canals at several locations along the canals, outfall channels to convey the stormwater runoff to the major drainageways, and the enlargement of the C&S RR Detention Pond. All the alternatives included several underlying assumptions related to stormwater runoff with the Upper Cooper Slough Basin.

The 2017 alternative analysis refined several alternatives presented in the 2006 Selected Plan, and did not duplicate the alternative analysis that was performed in 2006.

1.3.2 2017 Alternative Analysis Update

Between 2002 and 2006, the City of Fort Collins (City) updated the hydrologic modeling for the Box Elder/Cooper Slough watershed as part of the Box Elder Creek Master Plan (Anderson Consulting Engineering, Inc. (ACE), 2006). Subsequently, this information was adopted by the Federal Emergency Management Agency (FEMA) for use in the floodplain analysis supporting revisions to the Digital Flood Insurance Rate Map (DFIRM). This hydrologic modeling was performed using the City's MODSWMM software.

In 2014, under contract with the City, ICON Engineering, Inc. (ICON) completed a conversion of the 2006 existing conditions MODSWMM model to the EPA SWMM (v. 5.0.22) hydrology model (ICON, 2014). Following this update, in 2015 Ayres Associates used this model to analyze and design the proposed East Side Detention Facility (ESDF) and other improvements in the Box Elder watershed, also known as 'Boxelder 6.' This project obtained a Conditional Letter of Map Revision (CLOMR) and has since been built. Consequently, the 2015 East Side Detention Facility CLOMR (Ayres 2015) hydrology model became the current existing conditions hydrology model for Boxelder and Cooper Slough watersheds used for the 2017 alternatives evaluations.

The alternative analysis update used the hydrologic model for the East Side Detention Facility (ESDF) CLOMR hydrology model as the Existing Conditions base model. The alternative analysis created a Selected Plan Hydrology model by adjusting the Existing Conditions base model to analyze the selected plan improvements. The Upper Cooper Slough Basin Alternative Analysis Update (2017, ICON) was completed prior to this report. The goals of the study were to:

a) Review the changes in hydrology along Cooper Slough, given the inclusion of past master planning solutions (2006 ACE) and future development potential;
b) Refine the grading concepts and positioning of the proposed C&S/ Crumb regional detention basin based on current development needs and State jurisdictional dam guidance;
c) Using the updated planning information, new bridge and culvert determination at Vine Drive, Mountain Vista, and Mulberry Street crossings.

1.3.3 2017 Draft Selected Plan Update

With the 2017 Draft Selected Plan, the 2006 Selected Plan was updated to reflect the 2017 Alternative Analysis that was performed by ICON. The improvements recommended in the 2006 Selected Plan were modified slightly to the recommendations in the 2017 alternative analysis update. However, the main goals were not changed. In addition to including the selected plan improvements, site specific development criteria for Mountain Vista and Anheuser Busch were recommended.

Section 2 – Selected Plan Improvements

The 2021 Selected Plan generally follows recommendations from past studies; however, site specific updates have been included based on further collaboration with ongoing property owners and development groups to ensure stormwater needs for the basin are being accommodated. Development groups with the watershed include; Montava, Sonders and Sonders East, Country Club Reserve, and Gateway at Prospect development locations.

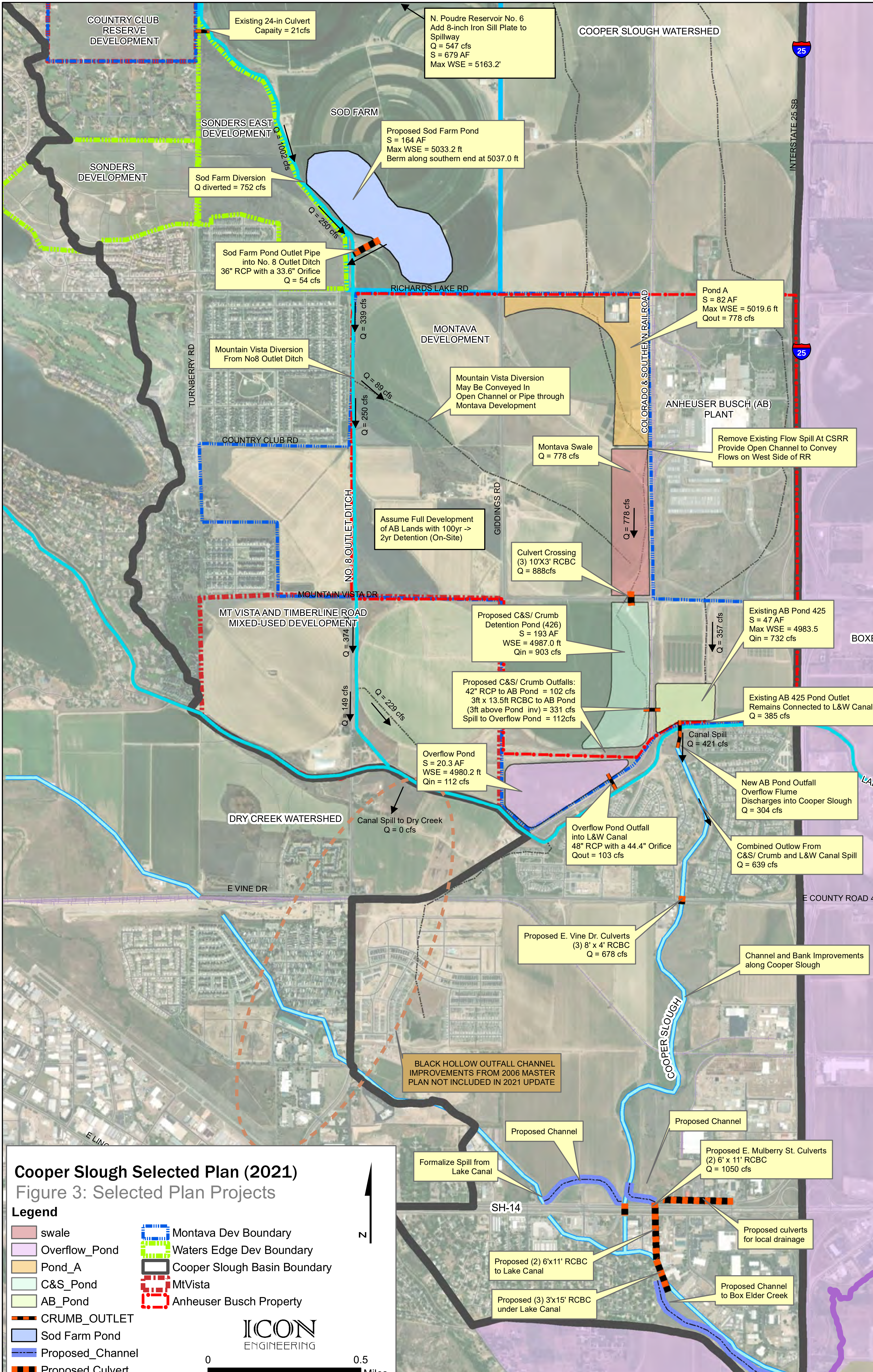
The main objectives from the past studies remained similar through addressing current and future drainage problems including:

- Preventing uncontrolled spills from the L&W Canal;
- Providing an outfall for stormwater flows within the eastern and western portions of the basin;
- Providing regional detention solutions for the basin; and
- Providing guidance for future development within the basin.

The Selected Plan improvement recommendations include:

1. North Poudre Reservoir No. 6 – Outlet Sill
2. Sonders and Sonders East Developments Selected Plan Improvements:
3. Sod Farm
    - Sod Farm Detention Pond and No. 8 Outlet Ditch Spill
4. Montava Development Selected Plan Improvements:
    - Mountain Vista Diversion on No. 8 Outlet Ditch (to C&S Pond)
    - Removal of C&S RR Flow Split (C&S RR Railroad Diversion)
    - Crumb and C&S RR Regional Detention Pond
    - AB Detention Pond Improvements
    - Mountain Vista Diversion on No. 8 Outlet Ditch (to C&S Pond)
    - On-site Detention Requirements
5. Improvements Downstream of Mulberry
    - Mulberry Street (SH-14) Crossing
    - Lake Canal Crossing
    - Gateway at Prospect Stream Improvements
    - Regional Pedestrian Trail Identification
6. Culvert Improvements
    - Vine Drive Crossing
    - Mountain Vista Culvert – West flow path
7. Bank and Habitat Improvements

Each of the improvements are summarized below. These improvements can be seen in **Figure 3.** It should be noted that due to changes in the Selected Plan and construction of ESDF, the Black Hollow Outfall Channel storm system improvements have been removed from the Selected Plan. As development occurs in the area, the need for a regional outfall system should continue to be considered with any regional stormwater needs for existing and proposed development within the western portion of the basin.



COUNTRY CLUB RESERVE DEVELOPMENT
Existing 24-in Culvert Capaity = 21cfs
N. Poudre Reservoir No. 6 Add 8-inch Iron Sill Plate to Spillway Q = 547 cfs S = 679 AF Max WSE = 5163.2'
COOPER SLOUGH WATERSHED
SOD FARM
SONDERS EAST DEVELOPMENT
Q = 1002 cfs
SONDERS DEVELOPMENT
Proposed Sod Farm Pond S = 164 AF Max WSE = 5033.2 ft Berm along southern end at 5037.0 ft
Sod Farm Diversion Q diverted = 752 cfs
Q = 250 cfs
INTERSTATE 25 SB
Sod Farm Pond Outlet Pipe into No. 8 Outlet Ditch 36" RCP with a 33.6" Orifice Q = 54 cfs
RICHARDS LAKE RD
Pond A S = 82 AF Max WSE = 5019.6 ft Qout = 778 cfs
Q = 339 cfs
MONTAVA DEVELOPMENT
COLORADO & SOUTHERN RAILROAD
Mountain Vista Diversion From No8 Outlet Ditch
Q = 89 cfs
Mountain Vista Diversion May Be Conveyed In Open Channel or Pipe through Montava Development
TURNBERRY RD
Q = 250 cfs
ANHEUSER BUSCH (AB) PLANT
COUNTRY CLUB RD
Montava Swale Q = 778 cfs
Remove Existing Flow Spill At CSRR Provide Open Channel to Convey Flows on West Side of RR
Q = 778 cfs
GIDDINGS RD
NO. 8 OUTLET DITCH
Assume Full Development of AB Lands with 100yr -> 2yr Detention (On-Site)
Culvert Crossing (3) 10'X3' RCBC Q = 888cfs
MOUNTAIN VISTA DR
MT VISTA AND TIMBERLINE ROAD MIXED-USED DEVELOPMENT
Proposed C&S/ Crumb Detention Pond (426) S = 193 AF WSE = 4987.0 ft Qin = 903 cfs
Existing AB Pond 425 S = 47 AF Max WSE = 4983.5 Qin = 732 cfs
Q = 357 cfs
BOXEL
Q = 374
Q = 149 cfs
Q = 229 cfs
Proposed C&S/ Crumb Outfalls: 42" RCP to AB Pond = 102 cfs 3ft x 13.5ft RCBC to AB Pond (3ft above Pond inv) = 331 cfs Spill to Overflow Pond = 112cfs
Existing AB 425 Pond Outlet Remains Connected to L&W Canal Q = 385 cfs
Canal Spill Q = 421 cfs
Overflow Pond S = 20.3 AF WSE = 4980.2 ft Qin = 112 cfs
LAR
New AB Pond Outfall Overflow Flume Discharges into Cooper Slough Q = 304 cfs
DRY CREEK WATERSHED
Canal Spill to Dry Creek Q = 0 cfs
Overflow Pond Outfall into L&W Canal 48" RCP with a 44.4" Orifice Qout = 103 cfs
Combined Outlow From C&S/ Crumb and L&W Canal Spill Q = 639 cfs
E VINE DR
E COUNTY ROAD 48
Proposed E. Vine Dr. Culverts (3) 8' x 4' RCBC Q = 678 cfs
Channel and Bank Improvements along Cooper Slough
COOPER SLOUGH
BLACK HOLLOW OUTFALL CHANNEL IMPROVEMENTS FROM 2006 MASTER PLAN NOT INCLUDED IN 2021 UPDATE
Proposed Channel
Proposed Channel
Proposed E. Mulberry St. Culverts (2) 6' x 11' RCBC Q = 1050 cfs
Formalize Spill from Lake Canal
SH-14
Proposed culverts for local drainage
Proposed (2) 6'x11' RCBC to Lake Canal
Proposed Channel to Box Elder Creek
Proposed (3) 3'x15' RCBC under Lake Canal
Cooper Slough Selected Plan (2021)
Figure 3: Selected Plan Projects
Legend
swale
Overflow_Pond
Pond_A
C&S_Pond
AB_Pond
CRUMB_OUTLET
Sod Farm Pond
Proposed_Channel
Proposed Culvert
Montava Dev Boundary
Waters Edge Dev Boundary
Cooper Slough Basin Boundary
MtVista
Anheuser Busch Property
N
ICON ENGINEERING
0 0.5 Miles

2.1 Hydrologic Modeling

Hydrologic modeling for the Selected Plan originated from the Boxelder 6 LOMR described in Section 1.3. Modeling for the Selected Plan of Improvements was performed in EPA SWMM version 5.1.015 using the kinematic wave method. Due to the complex interaction of the proposed pond system within the Montava Development (AB and C&S/Crumb detention ponds), a portion of the model was extracted from the kinematic model and converted to a dynamic wave model. The dynamic wave methodology more accurately accounts for channel storage, backwater, entrance/exit losses, flow reversal and pressurized flow within the stormwater systems. The following figure (**Figure 4**) shows the different models used. Inflow hydrographs were extracted from the upper kinematic model and input into the middle dynamic model. The middle model was then coded into the unsteady HEC-RAS model of the Larimer and Weld Canal as inflow hydrographs to the ditch. Spill hydrographs from the L&W HEC-RAS model were input back into the lower kinematic model as inflow hydrographs into the basin. This combination of models ensured accuracy for the function of the improvements, while also confirming downstream changes in flow within the designated floodplain corridors.

2.2 No. 8 Outlet Ditch and Larimer and Weld Canal Decreed Flows

After the development of the 2017 Selected Plan, through discussions with the Larimer and Weld Irrigation Company (LWIC), recommended maximum and decreed flow values for the No. 8 Outlet Ditch and the Larimer and Weld Canal changed. The following two scenarios were used for developing the selected plan.

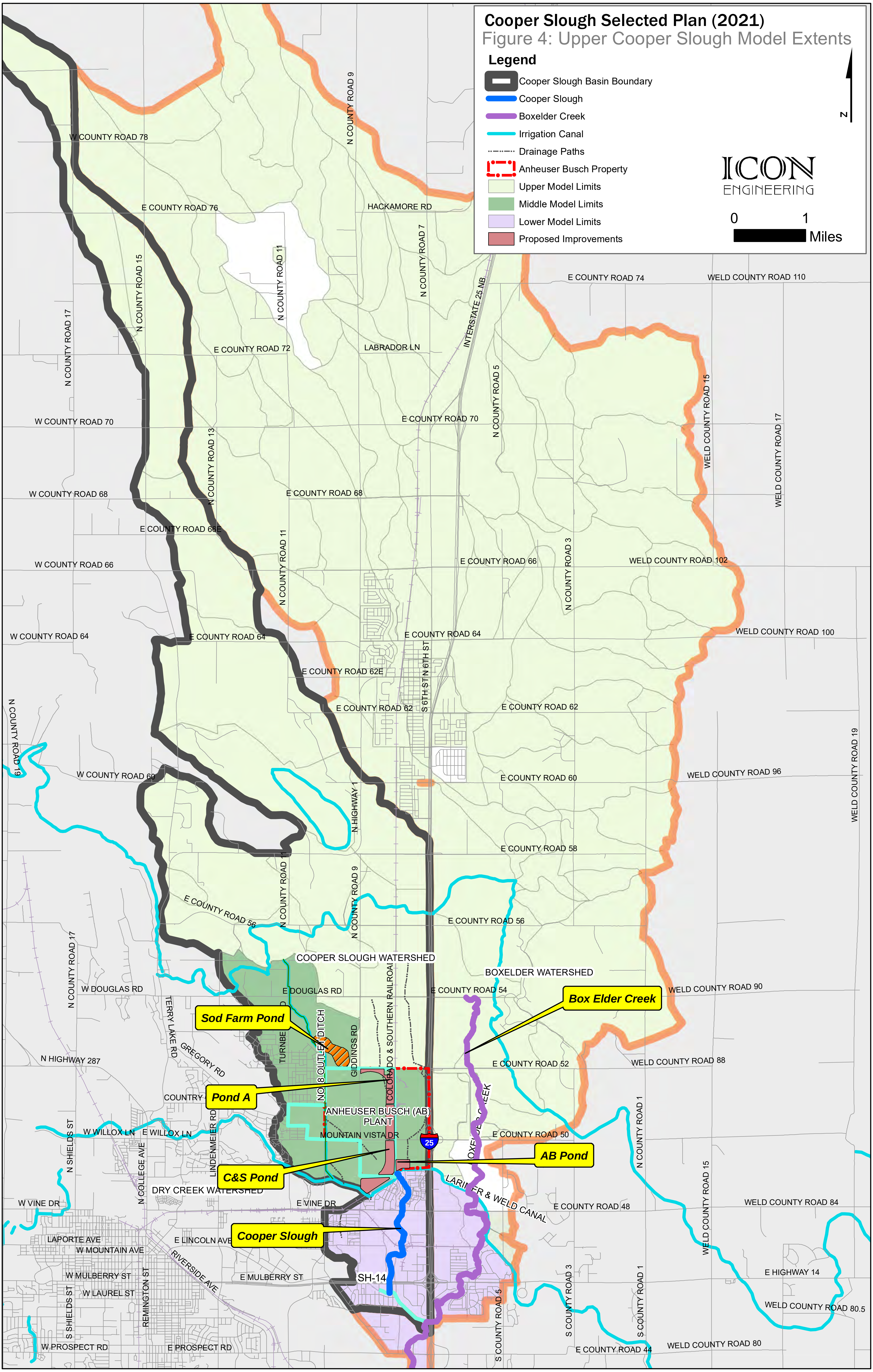
1) No.8 Outlet Ditch conveying a maximum flow of 250 cfs with the Larimer and Weld Canal conveying a decreed flow of 675cfs.
2) Larimer and Weld Canal conveying a maximum flow of 800 cfs with the No. 8 Outlet Ditch conveying no flow.

In general, it was observed that the proposed improvements upstream of the Larimer and Weld Canal were impacted greater by the 250 cfs flow in the No. 8 Outlet Ditch (Scenario 1) then when the No. 8 was running dry. This generally increased the size of the proposed Sod Farm Detention Pond, increased discharges at proposed spills from the No. 8, and increased the overall size of the proposed C&S / Crumb Detention Pond from what was shown by previous studies.

In contrast, the determined spills from the Larimer and Weld Canal were greater under Scenario 2, with the maximum flow of 800cfs in the canal and without any additional flow in the No. 8. Therefore, the improvements downstream of the Larimer and Weld Canal were analyzed and sized under this scenario.

2.3 North Poudre Reservoir No. 6 – Outlet Sill

Consistent with the 2006 Master Plan, the North Poudre Reservoir No. 6 (EPA SWMM node 476, Upper Model) was modified to include an 8-inch iron weir plate on the existing spillway. This effectively adds 307-AF of flood storage on top of the existing irrigation reservoir. Peak outflow from the reservoir was


Cooper Slough Selected Plan (2021)
Figure 4: Upper Cooper Slough Model Extents
Legend
Cooper Slough Basin Boundary
Cooper Slough
Boxelder Creek
Irrigation Canal
Drainage Paths
Anheuser Busch Property
Upper Model Limits
Middle Model Limits
Lower Model Limits
Proposed Improvements
N
ICON ENGINEERING
0
1
Miles
Sod Farm Pond
Pond A
C&S Pond
AB Pond
Cooper Slough
Box Elder Creek
ANHEUSER BUSCH (AB) PLANT
COOPER SLOUGH WATERSHED
BOXELDER WATERSHED
DRY CREEK WATERSHED
LARIMER & WELD CANAL
INTERSTATE 25 NB
W COUNTY ROAD 78
E COUNTY ROAD 76
HACKAMORE RD
E COUNTY ROAD 74
WELD COUNTY ROAD 110
E COUNTY ROAD 72
LABRADOR LN
W COUNTY ROAD 70
E COUNTY ROAD 70
W COUNTY ROAD 68
E COUNTY ROAD 68
E COUNTY ROAD 66E
W COUNTY ROAD 66
E COUNTY ROAD 66
WELD COUNTY ROAD 102
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WELD COUNTY ROAD 90
E COUNTY ROAD 52
WELD COUNTY ROAD 88
E COUNTY ROAD 50
E COUNTY ROAD 48
WELD COUNTY ROAD 84
E HIGHWAY 14
WELD COUNTY ROAD 80.5
E COUNTY ROAD 44
WELD COUNTY ROAD 80
N COUNTY ROAD 9
N COUNTY ROAD 7
N COUNTY ROAD 11
N COUNTY ROAD 15
N COUNTY ROAD 17
N COUNTY ROAD 13
N COUNTY ROAD 5
N COUNTY ROAD 3
N COUNTY ROAD 1
N COUNTY ROAD 19
WELD COUNTY ROAD 15
WELD COUNTY ROAD 17
WELD COUNTY ROAD 19
S 6TH ST
N 6TH ST
N HIGHWAY 1
W DOUGLAS RD
E DOUGLAS RD
TERRY LAKE RD
GREGORY RD
N HIGHWAY 287
NO 8 OUTLET DITCH
GIDDINGS RD
COLORADO & SOUTHERN RAILROAD
MOUNTAIN VISTA DR
W WILLOX LN
E WILLOX LN
LINDENMEIER RD
N SHIELDS ST
N COLLEGE AVE
W VINE DR
E VINE DR
LAPORTE AVE
E LINCOLN AVE
W MOUNTAIN AVE
RIVERSIDE AVE
W MULBERRY ST
E MULBERRY ST
W LAUREL ST
SH-14
REMINGTON ST
S SHIELDS ST
W PROSPECT RD
E PROSPECT RD
S COUNTY ROAD 5
S COUNTY ROAD 3
S COUNTY ROAD 1
25

reduced to 547 cfs from 754 cfs. The North Poudre Reservoir No. 6 improvements were analyzed in the Upper EPA SWMM model using the kinematic method. The improvements have a significant impact to the detention volume required in the Montava Development. The No. 6 Reservoir improvements have the potential to reduce the volume required in the Montava Development by approximately 215 ac-ft, from a total volume of 557 ac-ft (interim condition without upstream selected plan improvement in place) to 342 ac-ft after implementation of all selected plan improvements.

2.4 Selected Plan of Improvements Associated with the Sonders and Sonders East Developments

The Sonders and Sonders East developments are located adjacent to the existing Sod Farm sump. The drainage design was not provided for this location. Therefore, the proposed Selected Plan improvements were based on analysis included in the original selected plan model.

The developments are located west of the No. 8 Outlet Ditch and therefore must also incorporate on-site detention by detaining the 100-year storm event to 2-yr historic flow rate levels. The projected future stormwater releases for the developments were incorporated into the study using the Middle EPA SWMM model and dynamic wave methods.

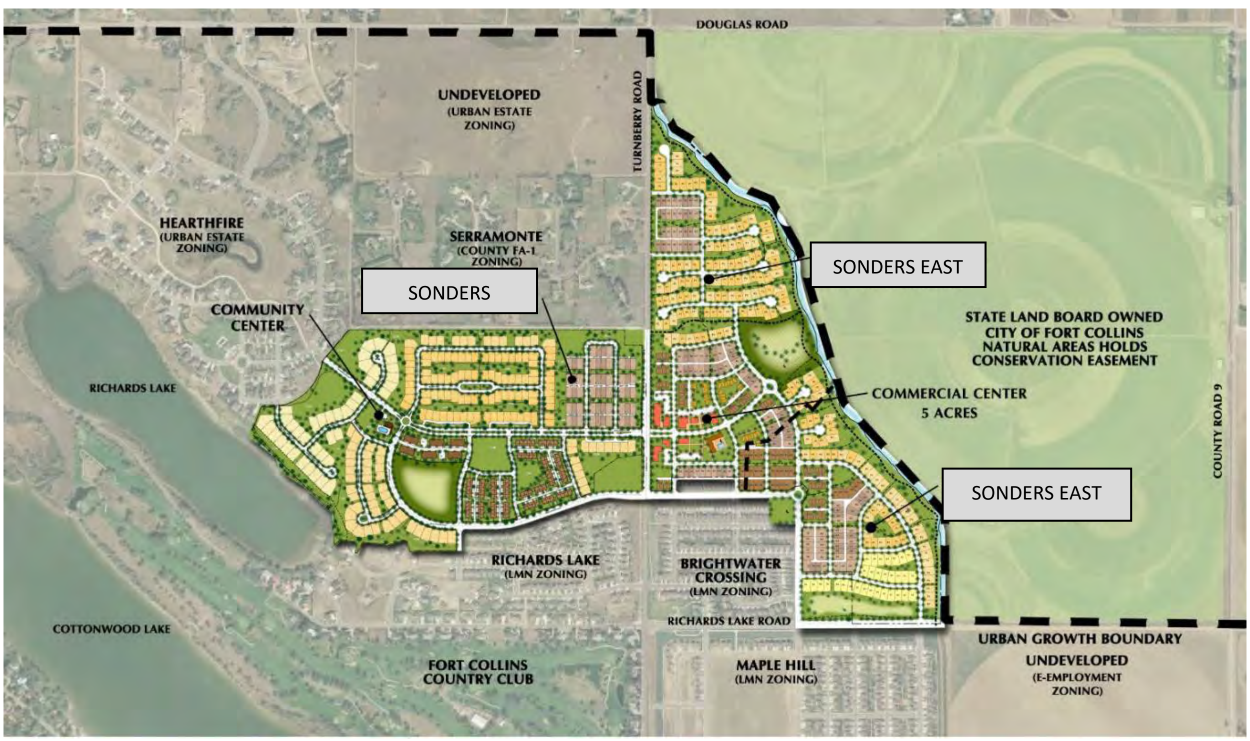


Figure 5: Sonders and Sonders East Preliminary Design

2.5 Sod Farm Detention Pond and No. 8 Outlet Ditch Spill

The Selected Plan of improvements formalizes the inadvertent detention at the Sod Farm while also detaining flows diverted from the No. 8 Outlet Ditch. The existing Sod Farm detention area (EPA SWMM node 438, Middle Model) was improved to receive and detain all flows in excess of the 250 cfs irrigation flow in the No. 8 Outlet Ditch. The 2006 Master Plan proposed stormwater storage of 198 ac-ft with a peak release rate of 78 cfs. The updated plan proposes 164 ac-ft of storage with a peak release of 54 cfs. As with the original plan, detained flows are proposed to be returned to the No. 8 through a proposed 36-inch pipe, including a 34 inch-diameter orifice control. The Sod Farm Detention Pond will require modifications to the existing perimeter berm to increasing detention capacity. It should be noted that due to the pond size, the pond could be considered jurisdictional and the State Engineer's office should be consulted for confirmation of any additional design requirements.

The existing flow split (EPA SWMM divider 842, Middle Model) from the No. 8 Outlet Ditch near the Sod Farm will become a formalized flow control split. This proposed structure will limit the flows in the No. 8 Ditch to the maximum flow of 250 cfs and spill the remaining flows into the Sod Farm detention area. The peak spill flow into Sod Farm is proposed to increase from 617 cfs to 991 cfs. **Figure 6** presents the proposed Sod Farm improvements location and flow patterns.

As discussed above, the size requirements for the Sod Farm improvements are controlled by the maximum flow of 250 cfs in the No.8. Therefore, these improvements were modeled using the first ditch flow scenario. The following summarizes the stormwater flows and volumes for the Sod Farm improvements:

- Effective Inadvertent Detention
    - Volume = 138.4 ac-ft
    - Flow In = 617 cfs (from the No. 8 Ditch via unformalized spill)
    - Flow Out = 0 cfs
- Selected Plan Detention Volume
    - Volume = 164.1 ac-ft
    - Flow In = 991 cfs (735cfs from the No. 8 Ditch via formalized spill structure)
    - Flow Out = 54 cfs (via 36-inch pipe)

Hydrologic modeling notes that the Sod Farm detention has minimal impact to the overall size of the detention ponds further downstream in Montava, but would influence the sizing of conveyance channels and diversion systems downstream. The phasing of improvements between Sonders and Montava should review any interim impacts on the combined drainage systems.

2.6 Country Club Reserve Development

The Country Club Reserve Development is located west of the Sod Farm, west of Turnberry Road and south of East Douglas Road. Adjustments to the hydrologic model were made to incorporate future stormwater changes from the development. Specifically, Basin SB46 was adjusted to discharge into a future detention pond with an outlet capacity of the existing 24" culvert (link 246, Middle Model).

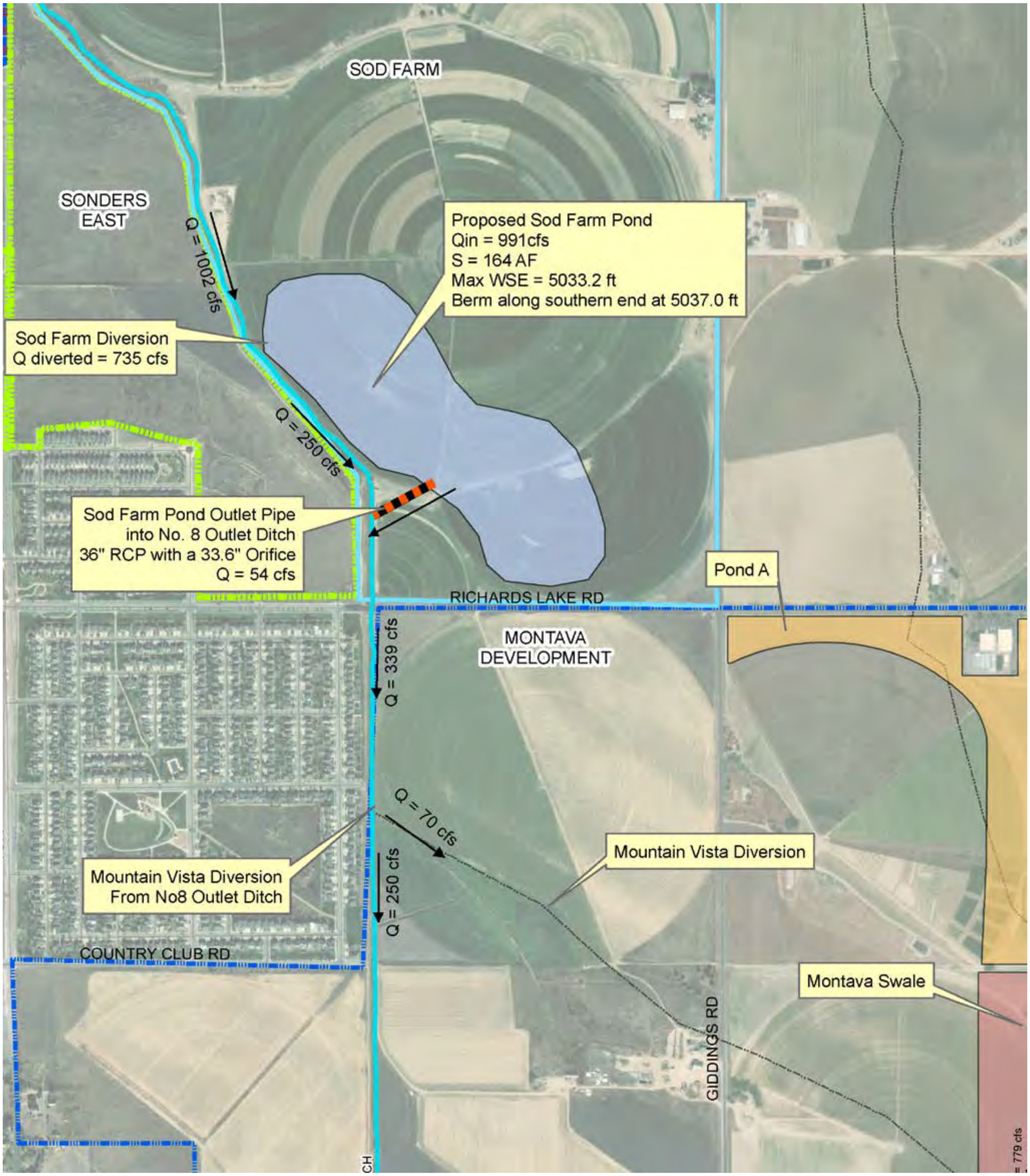


Figure 6: Sod Farm Diversion and Detention Improvements

Figure 7: Country Club Reserve Development Proposed Conceptual Plan

Figure 8: Country Club Reserve Proposed Improvements

2.7 Selected Plan Improvements Associated with Montava Development

The Montava development is generally located north of the Larimer and Weld Canal (LWC), west of the Colorado and Southern Railroad (CSRR), south of Richards Lake Road, and east of the No. 8 Outlet Ditch. There is also a small piece of the development that is located at the northwest corner of Mountain Vista and Timberline Road, west of the No. 8. The project site is located in and around several Selected Plan improvements for the Cooper Slough Basin. The conceptual design of the site has been prepared by Martin and Martin, Inc. The design incorporates several onsite detention ponds with three large regional detention ponds (Pond A, C&S/Crumb Pond and the AB Pond). The development group has been working closely with the City of Fort Collins and ICON to refine stormwater concepts consistent with these Selected Plan recommendations. The improvements associated with the Montava Development were analyzed using the middle EPA SWMM model and dynamic wave methodology.

In addition to managing offsite storm flows, the Montava Development also incorporates on-site detention, reducing proposed 100-year discharges to 100-yr historic levels. In general, the detention is accommodated in both local and regional pond facilities. The effects of this detention have been incorporated in the Selected Plan EPA SWMM models. The Anheuser-Busch (AB) areas located to the east of the CSRR, between the current brewery and the L&W drain to the proposed AB Regional Pond, designated at the current time to manage existing stormwater interception. It is assumed that future development within AB will manage stormwater changes on-site. Should Montava develop prior to the implementation of other selected plan improvements, the development would need to detain flows accordingly to avoid increases in discharges downstream on Cooper Slough. This may result in oversizing detention on-site until other upstream improvements are implemented. As noted in Section 2.3 these ponds could potentially be reduced in size after the other improvements are constructed.

The design of the Montava Development, as well as any development to the North of the L&W Canal, generally are based on the irrigation flow scenario with the No. 8 Outlet Ditch conveying a maximum flow of 250 cfs, however with its proximity to the L&W Canal, the development also needs to ensure that the flows south of the canal are not exceed for both ditch flow scenarios.

2.7.1 Removal of C&S RR Flow Split (C&S RR Railroad Diversion)

Under existing conditions, a flow split of approximately 459 cfs (west to east) currently occurs across the Colorado and Southern (C&S) railroad. The 2017 Selected Plan proposed a diversion channel along the west side of the railroad tracks to eliminate this split. The proposed channel conveyed the stormwater south, ultimately to the proposed C&S / Crumb Detention Pond. This modification increased the overall peak flows along the west side of the CSRR from 1335 cfs to 1504 cfs.

The Montava development plans propose to eliminate this spill through a series of detention and stormwater improvements. The Proposed Montava Pond A, combined with the offsite improvements to the No. 6 Reservoir, will decrease flow from 1504 cfs to 778 cfs. Outflow from the pond is proposed to be conveyed through the Montava Development in a proposed swale to the proposed C&S/Crumb Pond. Detention Pond A is approximately 82 ac-ft in volume with a maximum depth of 10 ft.

2.7.2 Crumb and C&S RR Regional Detention Pond

The proposed C&S / Crumb detention facility (EPA SWMM node 426) is situated on a dry drainage channel located approximately three-quarters of a mile southwest of the existing AB facilities and immediately upstream (northwest) of the CSRR and L&W Canal. **Figure 9** shows the location of the proposed C&S/ Crumb detention pond.

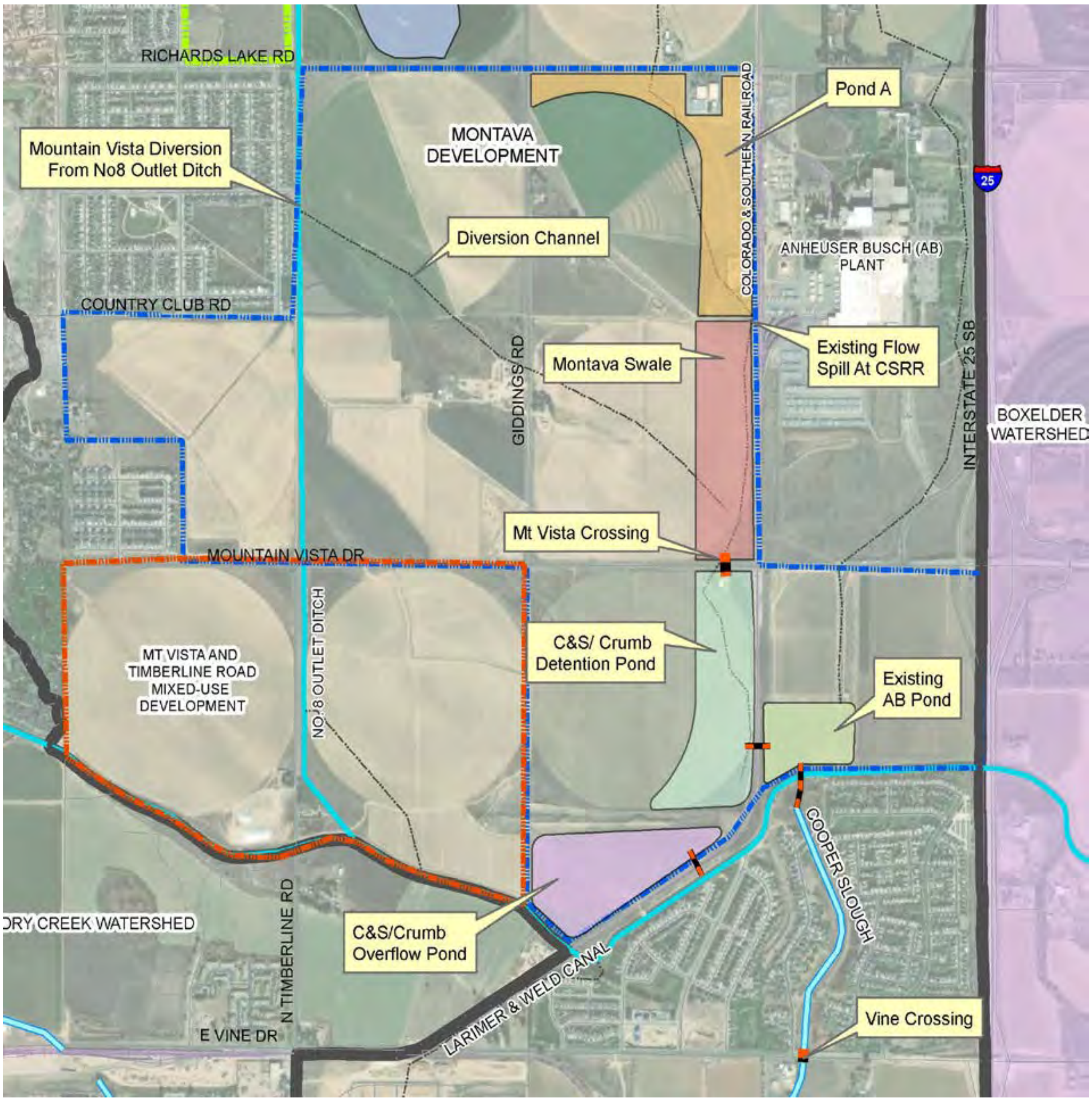


Figure 9: Montava Development Vicinity Map with Proposed Improvements

The proposed C&S/Crumb detention pond will improve and formalize the existing inadvertent stormwater detention at this location. The conceptual design proposed in the 2017 Selected Plan proposed a formal detention area excavated below natural ground with an outlet pipe to bypass flows up to the 100-year event under the CSRR and L&W Canal. The proposed pipe would restore the direct hydrologic connection to the lower Cooper Slough drainage channel. The 2017 plan also proposed to lower the 100-year water surface by up to seven (7) feet, removing the ponded water surface from the railroad embankment. The pond configuration was chosen with input from the State Engineer's Office, Dam Safety Branch and City's input regarding the desire for non-jurisdiction as a state dam.

In consultation with the City and Montava development group, this stormwater improvement has been updated. The proposed C&S/Crumb detention pond incorporates a dual staged outlet, including a 42-inch culvert at the pond invert and a 3ft x 13.5ft box culvert located approximately 3 feet above the bottom of the pond. This staged pond outlet adjusts the timing of the flows to minimize the

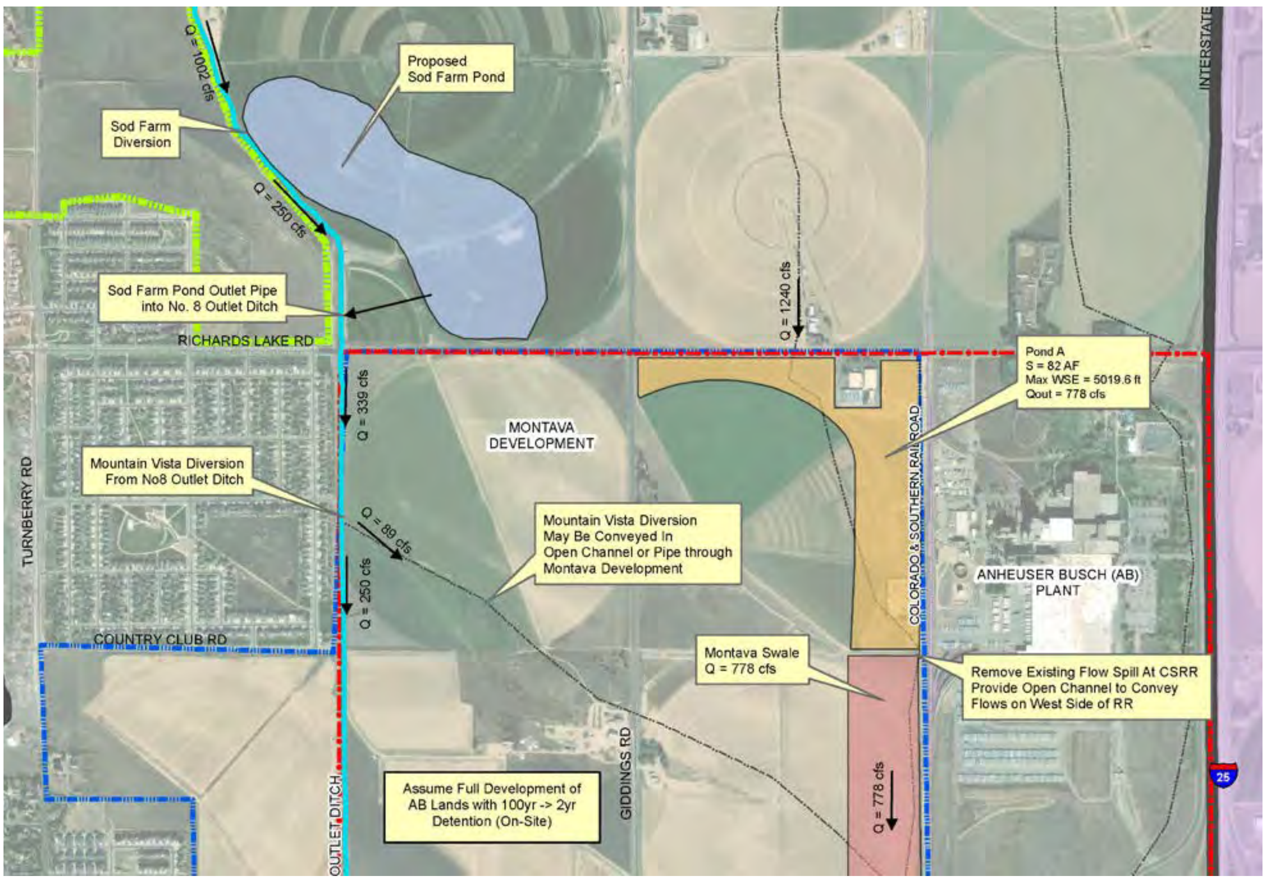


Figure 10: Detention Pond A Improvements

peaks, while also minimizing the required pond volume. Both outlet structures are proposed to discharge directly into the proposed AB Detention Pond. The C&S/Crumb Pond also includes an overflow spill, south into the C&S/Crumb Overflow Pond.

The revised configuration provides 193 ac-ft of storage at a maximum depth of 7ft. This pond also provides onsite detention for a portion of the development directly draining to the pond.

There are several potential utility conflicts which will require further evaluation during design of the pond, these include (but are not limited to):

- AB 30-in waterline
- AB sanitary sewer force main,
- Platte River Power Authority electric line, and
- Overhead high voltage electric transmission line.

2.7.3 Crumb and C&S RR Overflow Pond

The proposed C&S/ Crumb Detention Pond is located within the Montava Development. A City owned parcel is located South of the facility. This area was previously proposed to be used as part of the 2017 Selected Plan design for the C&S/Crumb Pond. Due to site constraints and existing utilities, the C&S/Crumb Pond was split into two ponds, the C&S/Crumb Pond and the Overflow Pond, with the city owned portion encompassing the overflow pond. The C&S/Crumb Pond will pond 3 feet before overtopping to the south, into the overflow pond. The Overflow Pond then is proposed to discharge into the Larimer and Weld Canal through a 48-inch culvert. This culvert is restricted to 103 cfs by a proposed 44-inch diameter orifice plate. Overall, the Crumb and C&S RR Overflow Pond is proposed to be approximately 20 ac-ft in volume and 5.2 feet deep.

2.7.4 AB Detention Pond Improvements

The AB Detention Pond (EPA SWMM node 425) is an existing detention pond located south of the main AB brewery, adjacent to the L&W Canal. The Montava Development recommends minor modifications to the existing facility to accommodate site stormwater. The existing outlet structure is proposed to remain as is and will continue to discharge directly into the Larimer and Weld Canal. An additional flume overflow is also proposed to be added to the pond. Ponding water in excess of 3.2 feet in depth will be conveyed over the canal in a flume, and discharge into Cooper Slough south of the canal. During a 100-year event, the proposed pond will release 385 cfs into the Larimer and Weld Canal and will release 304 cfs to Cooper Slough from the flume crossing. **Figure 12** shows the location of proposed AB Detention Pond and spillway.

2.7.5 Mountain Vista Diversion on No. 8 Outlet Ditch (to C&S Pond)

An existing spill occurs from the No. 8 Outlet Ditch approximately 1500 feet north of Mountain Vista Drive. The Selected Plan proposed to formalize this spill and to remove the storm flows from the ditch, leaving only the maximum flow of 250 cfs. The formalized flow spill will divert up to 89 cfs from

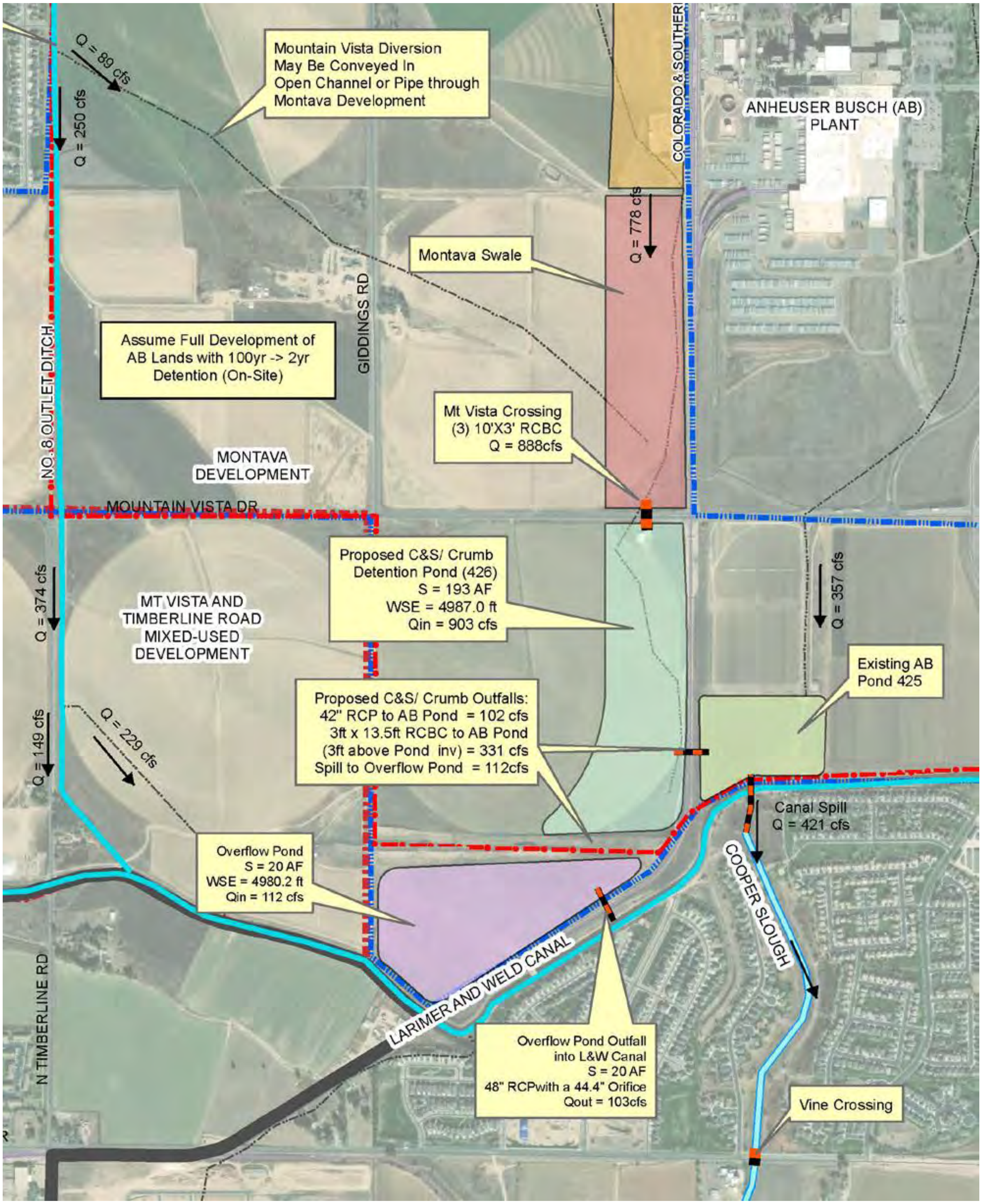


Figure 11: C&S/Crumb Detention Pond and Overflow Pond Improvements

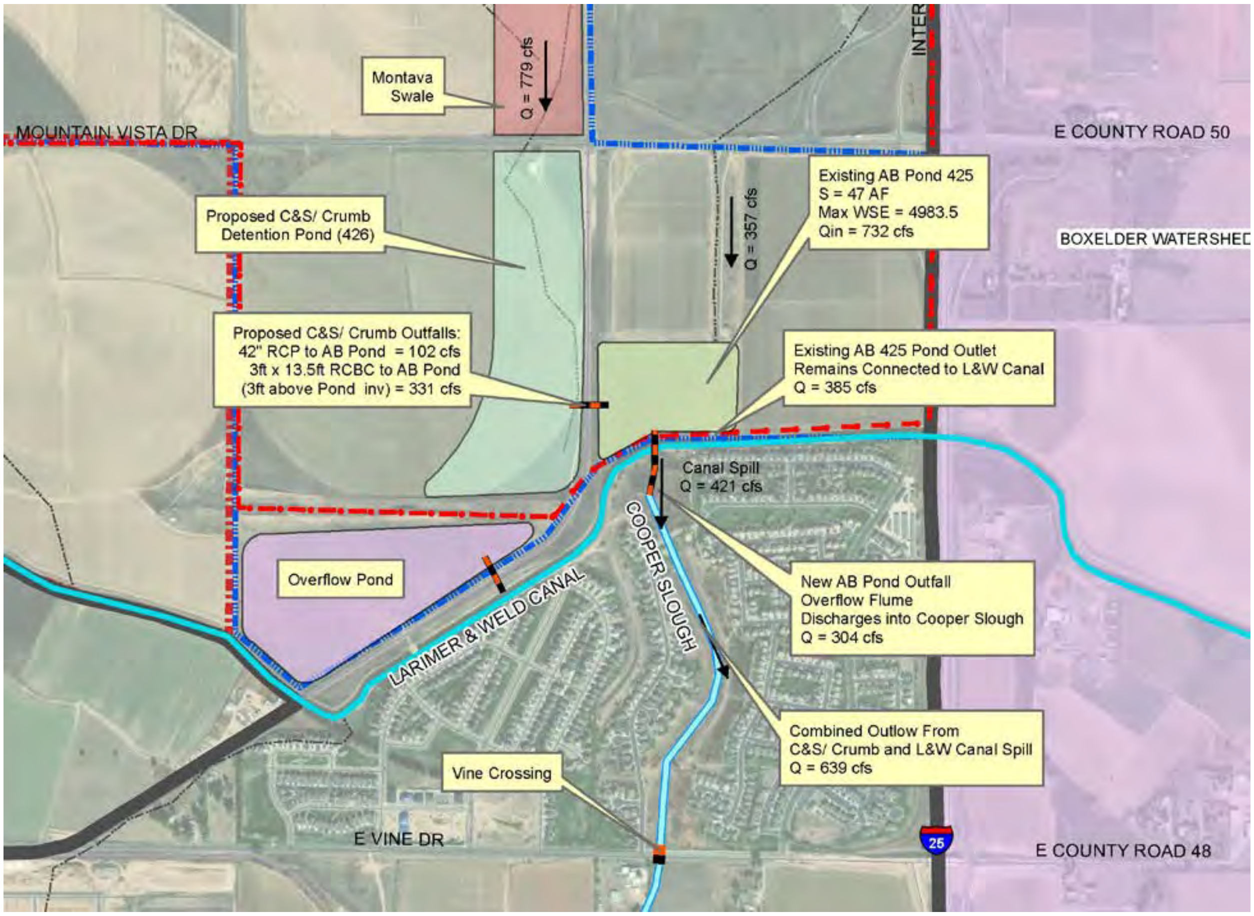


Figure 12: AB Detention Pond Improvements

the ditch and to the proposed C&S/ Crumb Detention Pond. The development should anticipate a conveyance path and culverts for flow at existing and future road crossings. **Figure 13** displays the configuration of the proposed Mountain Vista Diversion Improvements.

2.7.6 Onsite Detention

The Montava development area is required to provide several onsite detention ponds per their preliminary modeling, prior to discharging to the C&S/Crumb, AB and A Ponds. Theses on-site ponds are required to replicate the existing inadvertent detention through the site. The ponds total an on-site volume of 35.6 ac-ft. This includes an on-site detention pond located on Anheuser-Busch property, north of E County Road 50. This pond will detain flows from Basin SB29 from 1000 cfs down to 285 cfs. This pond ultimately discharges into the AB Pond. This pond was intended to reduce the AB site runoff to historic 100-year rates in support of meeting ultimate existing conditions discharges to the L&W/Cooper Slough for the Montava interim condition.

2.8 Mountain Vista Drive and Timberline Road Mixed-Use Development

The Mountain Vista Drive and Timberline Road Mixed Use development is located downstream near the Larimer and Weld Canal, south of Mountain Vista Drive. The No. 8 Ditch currently splits flow through the center of the development. The EPA SWMM model was adjusted to incorporate a future development at this location.

Similar to other locations, onsite detention will be required for the Mountain Vista Drive and Timberline Road Mixed-Use Development. The detention releases future flow into the Larimer and Weld Canal at the 2-year historic rate.

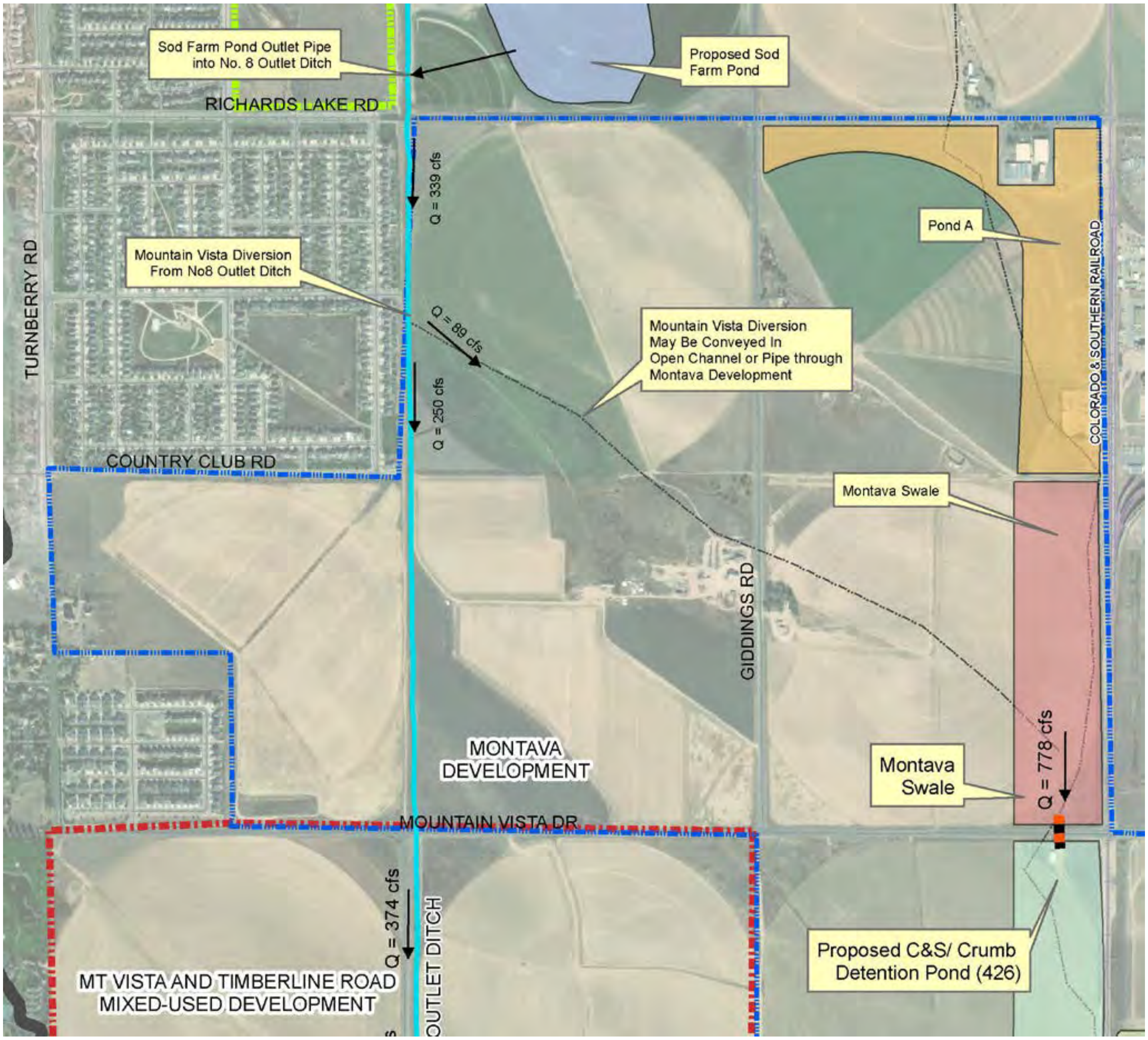


Figure 13: Mountain Vista Diversion Improvements

Figure 14: Mountain Vista and Timberline Road Mixed-Use Development

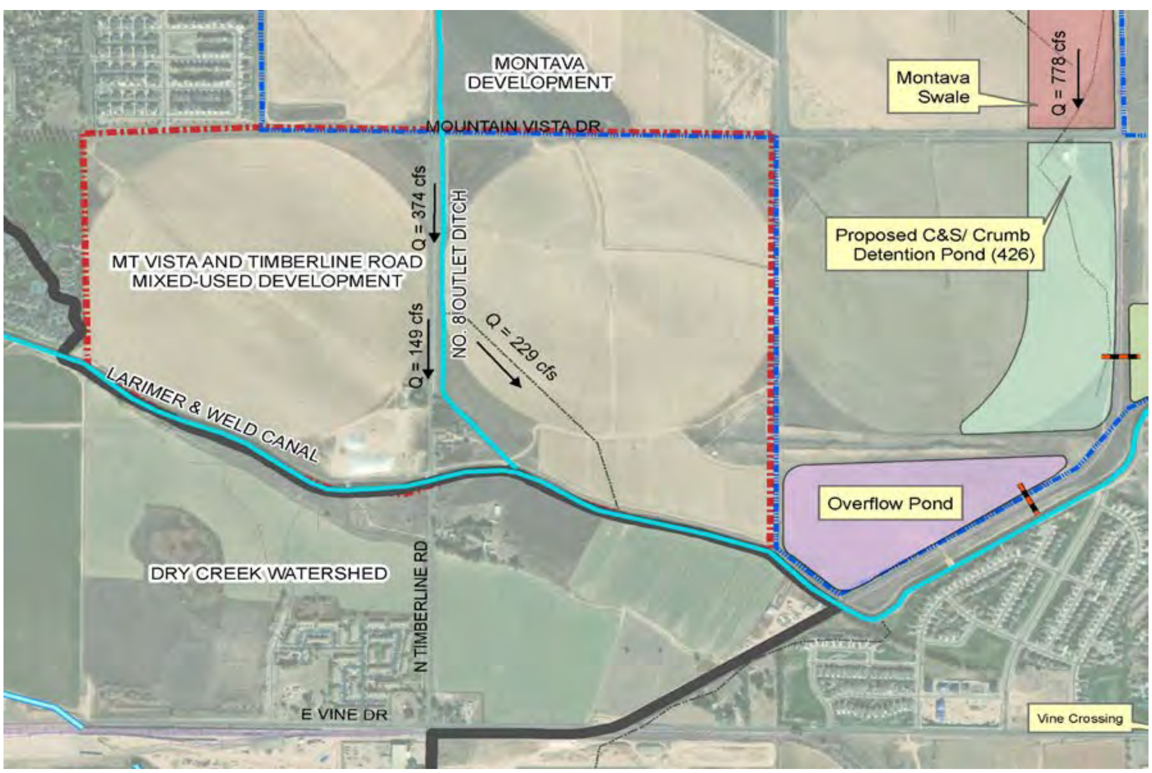


Figure 15: Mountain Vista and Timberline Road Mixed-Use Development

2.9 Improvements South of Mulberry Street (SH-14)

Approximately 1050 cfs flows south along Cooper Slough to Mulberry Street. There, the flow is currently conveyed under Mulberry Street (SH-14) through dual 48-inch diameter culverts with approximately 200 cfs capacity. All flow in excess of this 200 cfs backs up and overtops the roadway. Commercial development upstream and downstream of Mulberry are at risk of flooding as a result. Floodwater overtopping Mulberry ultimately enters and spills from the Lake Canal prior to reaching Boxelder Creek. The following improvements are proposed to convey the 100-year storm event from Mulberry Street to Boxelder Creek.

2.9.1 Mulberry Street (SH-14) Crossing

At Mulberry Street (EPA SWMM node 406. Lower Model), dual (2) 6ft high by 11ft wide RCBCs are proposed to convey the 1050 cfs discharge without overtopping. The installation of these culverts will remove the existing Cooper Slough split flow path to the east of the crossing location.

The water can be conveyed to the Lake Canal through either an open channel or culvert system. The Cooper Slough channel improvements would consist of a channel 6 feet deep, with a bottom width of 13 feet. The channel would contain a low flow channel in the bottom to convey the base flows. Due to the size of the channel, and land acquisition required, the extension of the dual (2) 6ft high by 11ft wide box culverts have been proposed for the Selected Plan. The box culverts also provide more flexibility around the existing 60-inch waterline currently paralleling the culvert alignment between Mulberry and the Lake Canal.

In the case that these culvert improvements are installed before the downstream culvert or channel improvements are in-place, interim conditions must preserve the existing flow split so that downstream properties are not adversely impacted by increased flows in the main channel. For this interim condition, the new culverts would be mostly or entirely blocked up to the existing flow split amounts (approximately 200-cfs) depending on the configuration of the existing 48-inch culverts as described below.

From that perspective, it may also be necessary to continue to utilize all, or a portion, of the capacity of the existing 48-inch pipes based on water rights for downstream users of the Lake Canal. Adjudicated water rights may need to be investigated further with final design. The capacity of the Lake Canal was not analyzed with this study. Therefore, the proposed box culverts were analyzed assuming the existing culverts are removed and the proposed culverts convey the entire flow.

2.9.2 Lake Canal Crossing

Cooper Slough is proposed to be conveyed below the Lake Canal in triple (3) 3ft high x 15ft wide box culverts. A shallow culvert crossing is required at this location due to the elevations of the canal in comparison with elevations at the confluence with Boxelder Creek.

2.9.3 Gateway at Prospect Stream Improvements

Downstream of Lake Canal, the flow is proposed to be conveyed in a drainage channel. The proposed channel is estimated to be 6ft deep, with a bottom width of 13ft. The channel is anticipated to be multi-staged, and high functioning, low maintenance with respect to balancing stormwater and ecological function. This channel will be designed in detail with the proposed development and coordinated with the City of Fort Collins.

It should be noted that the large water line described above is also present through this stream corridor. Coordination will need to be made with the utility owner to protect the water line, as well as other utility that may also exist or be proposed for the future.

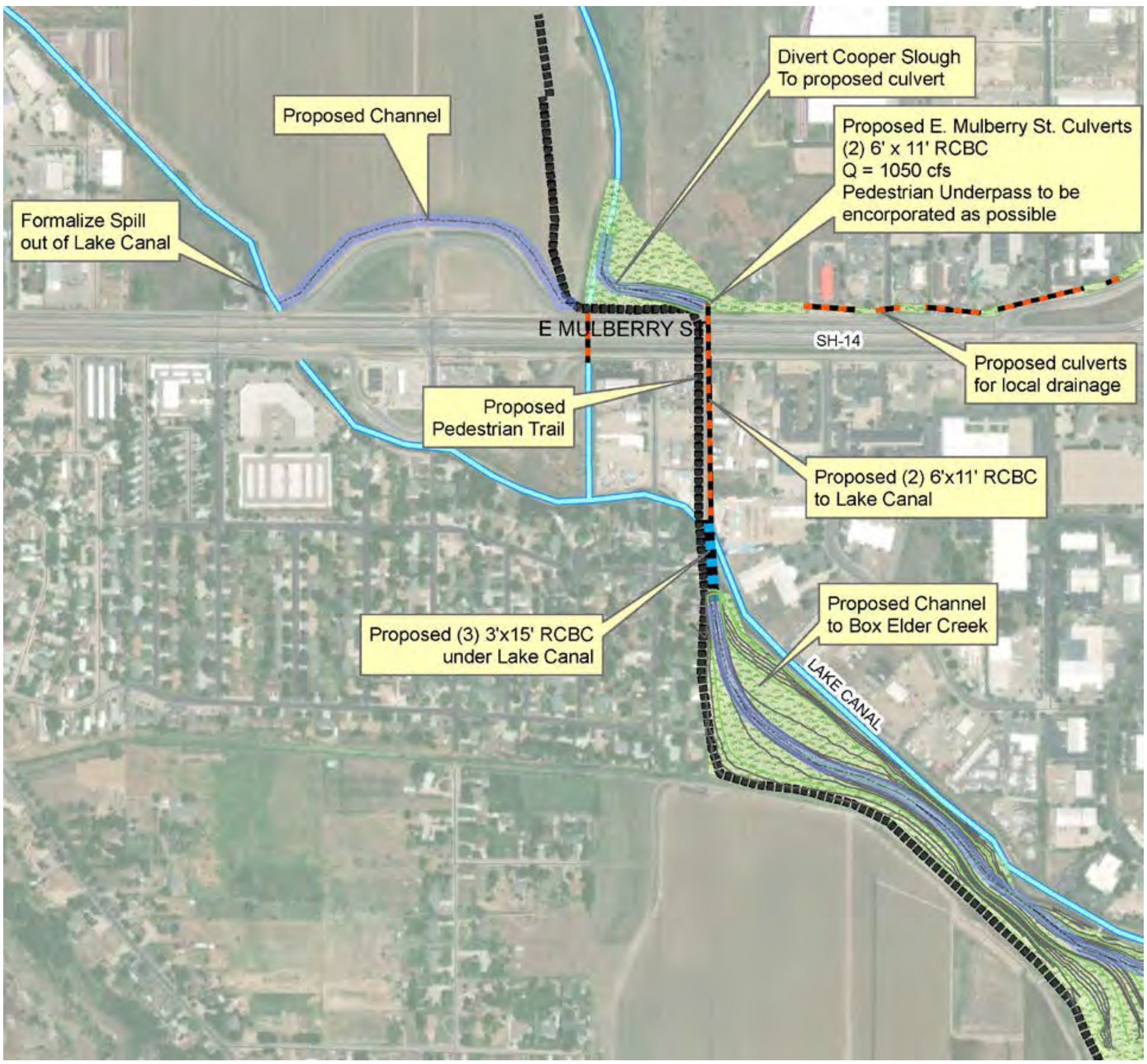


Figure 16: Improvements South of Mulberry Street

2.9.4 Proposed Regional Pedestrian Trail

The proposed regional trail parallels I-25 from the Poudre Trail to Vine Drive, and will roughly parallel the Cooper Slough from Vine south to the confluence with the Box Elder Creek. The trail is proposed to be a 10-ft multi-use trail. The trail south of Mulberry will be located within a 30-ft easement located adjacent to the ditch access road and will be incorporated within the Gateway at Prospect development. The trail is outside of the ditch easement. The trail will follow the proposed box culvert over the Lake Canal and north above of the proposed box culvert between Mulberry and the Lake Canal. The proposed trail will cross under Mulberry in a proposed underpass, separate from the stormwater improvements.

2.9.5 Business Park Drainage Improvements Upstream of Mulberry

The peak flow to the culverts at Mulberry is controlled by the local basin immediately upstream. The basin includes 148 acres of commercial development generating a peak flow of 974 cfs during a 100-year event. Flow travels south where it overtops Mulberry and floods the commercial development to the south. A stormwater collection system is proposed to collect water upstream of Mulberry. Two alternatives were reviewed.

The first alternative consists of a combination of swales and culverts located along the southern boundary of the development, north of Mulberry. The swales collect water and convey it west to the proposed culvert system described above. Large 6ft high x 11ft wide box culverts would be required to convey the water under the commercial building entrances. The crossings would be designed so that the majority of the flows will be conveyed under the road with exception to the major floods where water would also overtop business accesses roads.

The second alternative proposes to purchase undeveloped area within the business park, located approximately 500 feet north of Mulberry, and constructing a detention pond. This pond would outfall along Weicker Drive, to the west and to Cooper Slough. The pond and outlet pipe would collect the majority of the basin runoff before it reaches Mulberry. Improvements would be required along the north side of Mulberry to ensure that the remaining flow does not overtop to the south.

Costs for the above-mentioned improvements range from $20.5 million to $26.5 million, with an assumed $1.2 million for property acquisition associated with the second alternative. A future subarea plan may be required to review stormwater options for this business park in detail.

2.9.6 Formalize Spill from Lake Canal

Upstream of Mulberry Street it is proposed to spill all the storm flows in excess of the decreed flow in the Lake Canal. The proposed spill of 255 cfs will travel along the north side of Mulberry Street and discharge into the proposed culverts at Mulberry Street.

2.10 Other Culvert Improvements

Other culvert crossings sizes were determined for this Selected Plan at E. Vine Drive and two locations on Mountain Vista Drive.

2.10.1 Vine Drive Crossing

At E. Vine Drive (EPA SWMM node 866), triple (3) 8 x 4-foot reinforced concrete box culverts (RCBCs) with 678 cfs capacity are proposed to replace the existing twin 42-inch diameter culverts having 189 cfs capacity. Channel improvements will be needed for 50 to 100-feet downstream to reduce tail water on the proposed culverts.

2.10.2 Mountain Vista Culvert – East flow path

There is a main flow path south of the Anheuser Busch (AB) Plant that crosses Mountain Vista Drive (EPA SWMM node 829) prior to entering into the AB Detention Pond. The existing condition flow at this location is 890 cfs. With the proposed development on the AB property, and the removal of the split flow path, the flow decreases to 357 cfs. Currently triple 3ftH x 6ft W RCBCs exists under the Mountain Vista Drive crossing. These culverts have capacity to convey approximately 479 cfs prior to overtopping the road.

2.11 Bank and Habitat Improvements along Cooper Slough

Bank and habitat improvements are recommended downstream of Vine Drive. The needs for these improvements are discussed more in subsequent report sections.

Section 3 –Results for Selected Plan

3.1 Discharge Comparison at Key Points

Table 1 presents peak discharge results at selected key locations throughout the Cooper Slough watershed. This table compares the results of the 2006 Upper Cooper Slough Master Plan (ACE 2006), the 2018 Boxelder 6 LOMR (Ayres), and the 2021 Upper Cooper Slough Selected Plan Update.

Table 1: Peak Discharge Results at Selected Key Locations

SWMM ID	Location	Peak Discharge (cfs)		
		2006 Master Plan (Proposed Conditions)	**ESDF LOMR (Current Conditions)**	**2021 Selected Plan Update (Proposed Conditions)**
476_Out	North Poudre Reservoir Number 6 Outflow	671	754	547
438_OUT	Sod Farm Detention Pond	78	0	54
426	Inflow to the C&S Detention Pond	2580	1408	903
426_OUT	Outflow from C&S Detention Pond	550	662	544
425	Inflow to the AB Regional Detention Pond	1801	920	732
425_OUT	Outflow from the AB Regional Detention Pond	392	565	689
909	Cooper Slough south of L&W Canal[1]	923	740	639
866	Cooper Slough at Vine Drive	970	777	678
7417	Cooper Slough at the CSRR (South of Vine)	997	767	678
406	Cooper Slough at Mulberry Street (SH-14)	1047	961	1048
850	No.8 Ditch at CR54 [2]	512	503	638
842	No. 8 Ditch at Sod Farm Spill [2]	824	1000	1002
843	Spill to Sod Farm from No. 8 Ditch	699	617	735
841	No. 8 Ditch at CR 52 [2]	205	408	346
828	No. 8 Ditch at Mountain Vista Drive Spill [2]	297	522	339
830	Spill to Mountain Vista Area from No. 8 Ditch	0 [3]	12	89
822	No. 8 Ditch at Mountain Vista Drive [2]	297	512	375
901	No. 8 Ditch at L&W Canal [2]	307	278	149

Notes:

[1] 2006 ACE Master Plan assumed no inflows from Boxelder Creek (via the L&W Canal).

[2] No 8. Ditch Locations Include 125cfs of Irrigation Flows.

[3] From the 2006 Master Plan, the "Revised Optional Selected Plan" included a 304cfs diversion from the No. 8 Outlet Ditch at the Mountain Vista Spill location.

3.2 Detention Pond Results

Table 2 provides results of the four proposed or improved detention ponds as part of the Upper Cooper Slough Selected Plan. This includes improving and formalizing detention at the Sod Farm location, improvements to the existing AB Regional Detention Pond, improving and formalizing the inadvertent C&S/ Crumb detention, and adding flood storage above the existing North Poudre irrigation Reservoir No. 6. In Table 2, the 'existing condition' references the ESDF LOMR modeling.

Table 2: Detention Pond Results

Location	SWMM Node	Existing/ Proposed	Peak Discharge (cfs)		Storage (AF)	Depth Above Spillway (ft)	Invert	Max WSE
			Inflow	Outflow				
Sod Farm Pond	438	Ex	856.1	0.0	112.5	3.29	5029	5032.29
		Pr	990.7	53.7	164.1	4.20	5029	5033.20
AB 425	425	Ex	920.1	565.0	85.4	5.00	4979	4984.00
		Pr	731.9	688.6	47.2	4.48	4979	4983.48
C&S/ Crumb	426	Ex	1408.4	661.6	240.0	8.44	4981	4989.44
		Pr	902.6	543.6	193.1	6.96	4980.0	4986.96
Pond A	A	Ex	---	---	---	---	---	---
		Pr	1459.1	778.1	82.2	10.6	5009.0	5019.6
N. Poudre Res. No. 6	476	Ex	6534.2	753.9	371.1	0.72	5162	5162.72
		Pr	6534.2	546.7	678.5	1.22	5162	5163.22

Notes:

EX = ESDF LOMR (Existing conditions)

Pr = 2021 Selected Plan Update (Proposed Conditions)

[1] The N. Poudre Res. No. 6 "invert" elevation of 5162 is the crest of the irrigation reservoir spillway; all flood storage is above this elevation.

The "Existing Condition" is the East Side Detention Facility LOMR.

3.3 Diversion Element Results

Table 3 shows the results at the three revised diversions in the Upper Cooper Slough Selected Plan.

Table 3: Diversion Element Results

Location	SWMM Node	Existing/ Proposed	Peak Inflow (cfs)	Peak Outflow (cfs)	
				Main Stem Link	Diverted Link
Sod Farm	842	Ex	1000	384	617
		Pr	1002	250	735
Mountain Vista	833	Ex	522	510	12
		Pr	339	250	89
C&S RR - Diversion Removal	940	Ex	1794	1335	459
		Pr	991	991	0

Notes :

EX = ESDF LOMR (Existing Conditions)

Pr = 2021 Selected Plan Update (Proposed Conditions)

Section 4 - Prioritization of Selected Plan Components

in general, much of this master plan can be constructed as the needs develop. The sequences of construction for the below groupings may be altered if opportunities arise to construct these improvements in conjunction with other projects such as proposed development, new roads, reservoir projects, etc. In these instances, where Selected Plan components are constructed in an order different from that shown in the Selected Plan prioritization, care should be taken to ensure that these constructed improvements do not adversely impact downstream properties through an increase in stormwater discharges, and that the design of the constructed facilities considers the effects of other Selected Plan components that may be constructed later.

The primary sequential requirement of the Selected Plan is to construct the diversion from the No. 8 Outlet Ditch diversion (Group 4) following the construction of the C&S / Crumb regional detention pond (Group 3). Other prioritization recommendations within each designated group are discussed below.

The Groups are shown on the Prioritization of Selected Plan (**Figure 17**) on the following page.

Group 1: Mulberry Street to Boxelder Creek

Table 4: Mulberry Street to Boxelder Creek Selected Plan Prioritization

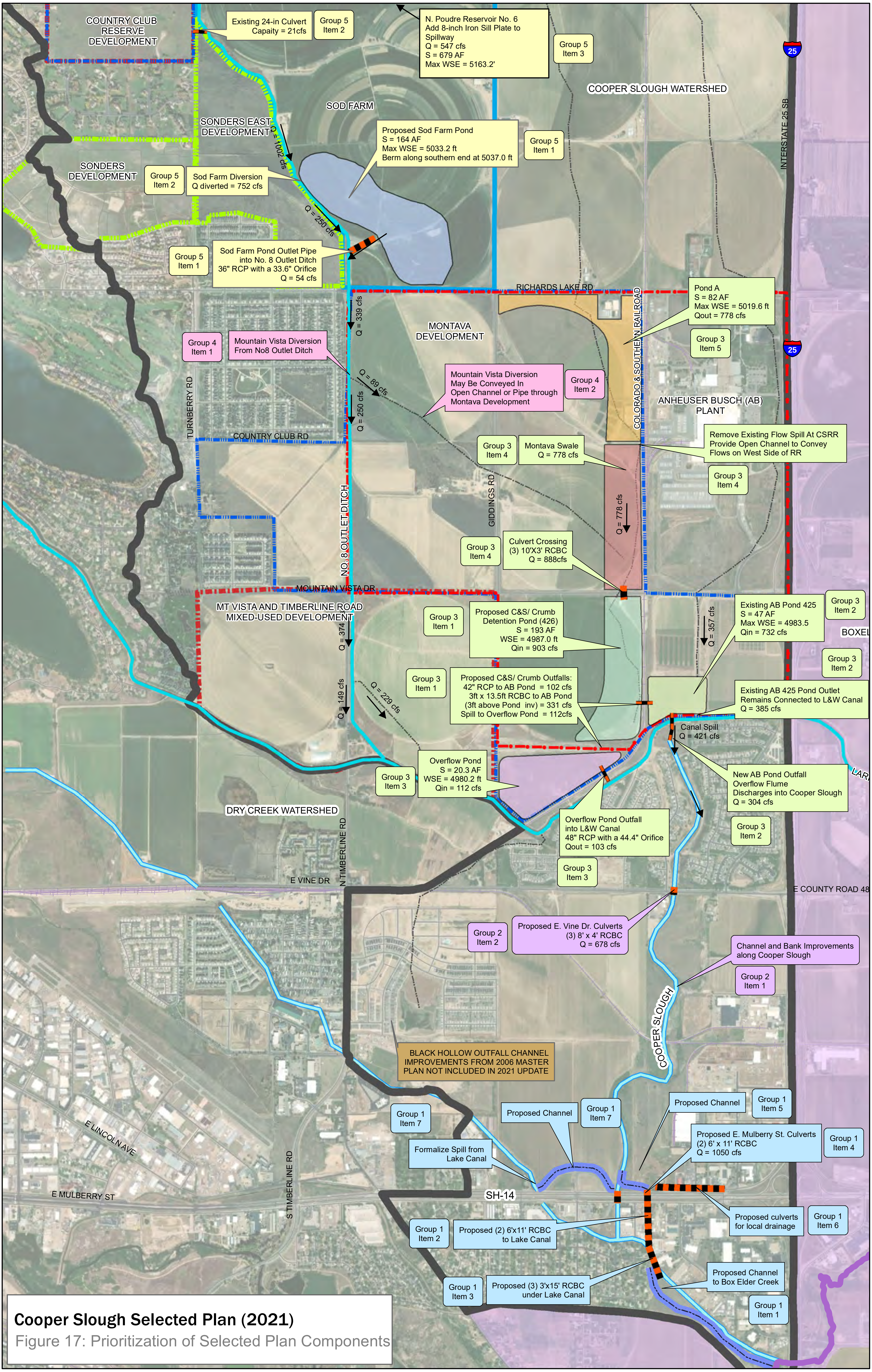
Order of Construction	Mulberry Street to Boxelder Creek Selected Plan Components
1	Cooper Slough Channel Improvements from Lake Canal to Boxelder Creek
2	Cooper Slough Outfall from State Highway 14 (Mulberry Street) to the Lake Canal Crossing
3	Lake Canal Crossing (3) 15'Wx6'H RCBCs
4	Mulberry Street Culverts (2) 11'Wx6'H RCBCs
5	Cooper Slough Channel Improvements upstream of Mulberry St to Mulberry Culverts
6	Outfall system for the business park located at the northwest corner of I-25 and State Highway 14.
7	Construction of the Lake Canal side-flow spillway and conveyance channel, upstream of State Highway 14.

This group components are shown in light blue in the exhibit.

These improvements are necessary to:

- Prevent overtopping of State Highway 14 (Mulberry Street),
- Prevent flooding within the business park northeast of SH 14 and I-25 (caused by the backing up of the culverts under SH 14),
- Prevent flooding within the industrial park south of SH 14 (caused by the overtopping of SH14), and
- Prevent spills from the Lake Canal as stormwater flows are conveyed to Boxelder Creek.

In the case that the culvert improvement under Mulberry (item 3) are installed before the downstream channel improvements (items 1 and 2), an interim condition will be created that must preserve the existing flow split so that downstream properties are not adversely impacted by increased flows in the main channel. For this interim condition, the new culverts should be mostly blocked to preserve the existing flow split amounts, approximately 200 cfs.



Cooper Slough Selected Plan (2021)

Figure 17: Prioritization of Selected Plan Components

The improvements in Group 1 may be implemented independent of upstream improvements in the remaining project groups. The construction of the C&S RR/Crumb Pond (Group 3) will release storm flows into Cooper Slough at a more constant rate than what the channel currently experiences. The impact of the more frequent storm flows on Cooper Slough should be evaluated prior to the construction of Group 3 improvements. Based on the results of the analysis, the culvert and channel improvements in Group 1 may need to be constructed prior to the Group 3 improvements to ensure that the increase in more frequent flows in Cooper Slough can be conveyed to Box Elder Creek and will not have a negative impact on the surrounding area.

Group 2: Cooper Slough Improvements Vine Drive & Downstream

Table 5: Vine Drive and Downstream Selected Plan Prioritization

Order of Construction	Cooper Slough at Vine Drive and Downstream Selected Plan Components
1	Bank and channel improvements along Cooper Slough waterway, below the L&W Canal.
2	Improvements to the Vine Drive culverts at Cooper Slough.

This group components are shown in light purple in the exhibit.

These improvements are necessary to:

- Eliminate overtopping of Vine Drive,
- Prevent flooding within the development north of Vine (caused by the backing up of the culverts under Vine), and to
- Stabilize portions of the Cooper Slough waterway in anticipation of more frequent flows that will be released directly to Cooper Slough from the Group 3 improvements to the C&S RR/Crumb Detention Pond.

These improvements can be implemented independent of the other selected plan improvements. The construction of the C&S RR/Crumb Pond (Group 3) will release storm flows into Cooper Slough at a more constant rate than what the channel currently experiences. The impact of the more frequent storm flows on Cooper Slough should be evaluated prior to the construction of Group 3 improvements. Based on the results of the analysis, the restoration improvements in Group 3 may be recommended to be constructed prior to the Group 3 improvements. Reconstruction at Vine Drive could occur independently as the peak flow have not increased.

Group 3: Montava Regional Improvements

Table 6: Montava Regional Improvement Prioritization

Order of Construction	Montava Selected Plan Components
1	Improvements to the C&S /Crumb Detention Pond & Outfall to AB Pond
2	Improvements to the AB Detention Pond & Overflow Flume
3	Construction of C&S / Crumb Overflow Pond & Outfall to L&W Canal
4	Montava Swale Construction
5	Montava Pond A Construction

This group components are shown in light purple in the exhibit.

These improvements are necessary to:

- Accommodate future detention needs within the Mountain Vista Subarea Plan boundary;
- Significantly reduce the peak flow and volume that enters the C&S RR/Crumb Detention Pond,
- Reduce the flows entering the L&W Canal
- Eliminates the C&S Railroad flow split.
- Accommodates diversion and flow changes from Group 4 improvements.

Improvements within Group 3 will progress with the Montava Development. In general, improvements shall progress from downstream to upstream, but also consider changes in imperviousness with the development and on-site detention requirements in addition to regional detention needs. Work within the Montava site should be phased to avoid increases in peak flows along Cooper Slough downstream of the L&W Canal. With this, it may be necessary to construct the flume over the L&W Canal from the AB Detention Pond after all other upstream improvements are in place.

Group 3 should be constructed prior to the onsite No. 8 Outlet Ditch diversion, upstream of Mountain Vista Drive, as well as the Mountain Vista Drive east culvert improvements. As noted previously, after the improvements are made to the North Poudre Reservoir No. 6 Spillway, the overall volume at the C&S / Crumb Detention Pond may be able to be reduced by approximately 215 ac-ft.

Group 4: No. 8 Outlet Ditch Improvements

Table 7: No. 8 Outlet Ditch Selected Plan Prioritization

Order of Construction	No. 8 Outlet Ditch Selected Plan Components
1	Mountain Vista Diversion from the No 8 to C&S/Crumb Detention Pond
2	Channel or storm conveyance from the diversion to the detention pond

This group components are shown in green in the exhibit.

These improvements are necessary to:

- Convey stormwater flows that will be diverted from the No. 8 Ditch to the C&S/Crumb Pond,
- Storm flows within the No. 8 Outlet Ditch will be significantly reduced,

Implementation of the Group 4 improvements will divert flow from the No. 8 Canal to the C&S RR/Crumb Detention Pond, and therefore as a direct impact on the required size of the pond. The improvements in Group 4 should not be completed until the improvements in Group 3 (the construction of the C&S/Crumb Detention Pond that the diversion will discharge into) are complete.

Group 5: North Poudre Reservoir and Sod Farm Improvements

Table 8: North Poudre Reservoir and Sod Farm Selected Plan Prioritization

Order of Construction	North Poudre Reservoir and Sod Farm Selected Plan Components
1	Construction of the Sod Farm Improvements
2	Construction of the Sod Farm Diversion off the No. 8.
3	Improvements to the North Poudre Reservoir No. 6 Spillway.

This group components are shown in blue in the exhibit.

These Improvements are necessary to:

- Decreases the stormwater flows within the No. 8 Ditch downstream of Richards Lake Road.
- Decreases stormwater volume required at the C&S / Crumb Detention Pond

This group must be implemented alongside development adjacent to the Sod Farm and funding availability for the No. 6 Spillway improvements. As noted, after the improvements are made to the No. 6 Spillway, the overall volume at the C&S / Crumb Detention Pond may be able to be reduced.

Section 5 –Development Criteria and Water Quality

5.1 General Basin Criteria

Development criteria within the Upper Cooper Slough Basin was established as part of the previous studies. The mitigation of flooding hazards in the Upper Cooper Slough Basin were evaluated based on existing conditions. Therefore, it is imperative that new development does not cause an increase in stormwater runoff peak discharged that may in turn increase the potential for flooding.

5.1.1 On-site Detention Requirement

The following on-site detention criteria are required for new development within the Upper Cooper Slough Basin to offset the impacts of increased discharge peaks and volumes and decreased travel times:

- Land that develops west of the No. 8 Outlet Ditch will incorporate on-site detention, detaining the 100-year storm event and releasing at the 2-year historic flow rate.
- Anheuser-Busch areas west of the Colorado and Southern Railroad (CSRR), south to the L&W Canal, are not required to provide detention and will drain to the proposed C&S RR/Crumb Pond other than an on-site pond located north of CR50. This pond will detain basin SB29 from 1000cfs down to 285cfs.
- Anheuser-Busch areas east of the CSRR, south to the L&W Canal, will drain to the proposed AB Regional Detention Pond through a series of swales and onsite detention ponds. The on-site ponds are required to replicate the existing inadvertent detention through the site. See the discussion in Section 2.7 for more detail.
- Off-site flows entering the site must be routed safely through the site.
- Detention facilities shall have overflow provisions (emergency spillways).

5.1.2 Extended Detention for Water Quality

All new development will be required to provide water quality extended detention treatment. The water quality detention requirements are per the “Urban Storm Drainage Criteria Manual, Volume 3”, by the Mile High Flood District.

5.1.3 Storm Drainage Design Standards

The “Fort Collins Stormwater Criteria Manual”, December 2018, shall be the basis of stormwater design. In addition:

- Runoff from new development shall be conveyed into historic and natural drainageways and be released from the site per the detention requirements above;
- Open channels shall be designed to encourage a natural channel approach, and grade control/drop structures shall generally follow the typical structures in the “Urban Storm Drainage Criteria Manual, Volume 2”, by Mile High Flood District;
- Channel gradient shall be designed to equal the equilibrium slope, unless an analysis is performed to substantiate an alternate slope.

5.1.4 Floodplain Regulations

The existing development within the basin has, in general, maintained the natural conveyance and storage functions of the floodplain. Regulation of the floodplain is considered a major component of this master plan.

The 100-year floodplains have been delineated based on existing conditions. There is a FEMA designated floodplain for Cooper Slough, south of the Larimer and Weld Canal. The floodplain can be found on FEMA floodplain panels 08069C0982F and 08069C0984H. Floodplains within the Upper Cooper Slough basin are regulated by FEMA, City of Fort Collins and Larimer County. Future development within a FEMA designated floodplain will need to follow FEMA procedures and guidelines. Future developments will also need to follow the City of Fort Collins or Larimer County floodplain guidelines, depending on the location of the development.

A significant aspect of floodplain regulation for this basin is increasing drainage conveyance capacity, thereby reducing inadvertent ponding on the surrounding community. The floodplain regulations for this basin also focus on preserving the basin's existing floodplain storage. In terms of regulation for the Upper Cooper Slough Basin, the floodplain for all the drainageways shall be regulated according to City criteria (Chapter 10 of the City Code), including;

- No development should be allowed within the existing conditions 100-year floodway without demonstrating "no adverse impact", and meeting all City Criteria;
- Floodplain storage reduced by development should be compensated;
- Proposed construction or development shall not cause an offsite rise in the existing conditions 100-year water surface elevations;
- Construction of utilities shall be avoided within the floodplains and buffer limits. Utilities constructed within these areas shall be adequately protected in a manner acceptable to the City.
- It is recommended that future development in the Upper Cooper Slough Basin map the floodplain through the proposed development for flows that are greater than 200 cfs.

5.1.5 Basin Storage

The floodplain storage within a natural system such as the Upper Cooper Slough drainageway in very important. This storage is a benefit to the system by reducing discharges and velocities, as well as benefiting the quality of the water by reducing erosion, and allowing sediments to settle. The elimination of existing storage can increase the peak discharge, and increasing storage can decrease the peak discharge.

Allowing stormwater runoff to travel across natural land surfaces slows water. Slower moving water reduces discharge peaks due to timing, as well as forcing it to occupy a greater volume. The elimination of storage within the system can increase peak discharge by decreasing travel times and peak attenuation due to volumetric routing.

A reduction in the floodplain storage could significantly increase flood hazards, as well as increase stream instabilities and degrade the quality of the existing riparian habitat. Floodplain storage reduction can take many forms, from simple encroachment to modifying conveyance characteristics. The enlargement of a culvert to eliminate overtopping of a road, or channelization to reduce the floodplain width may reduce the storage within the reach and increase the downstream discharges.

This Selected Plan for the Upper Cooper Slough basin includes preserving flood storage. Proposed floodplain development that reduces storage within a reach should analyze the impacts of the storage reduction and compensate by constructing compensatory storage, or conveyance improvements downstream to mitigate the impacts. Storage can be created by excavation below the water surface elevation or by rising the water surface elevation.

The hydrology model for the Upper Cooper Slough basin does not analyze the impacts of many of the existing floodplain storage areas. The City, in reviewing development proposals, requires detailed analyses demonstrating “no adverse impact”. All existing storage within the basin must be considered. The fact that floodplain storage is not accounted for in the hydrology model does not imply the storage may be eliminated without a negative impact.

5.2 Ecological Assessment

Through implementation of the improvements identified in the Select Plan, the Cooper Slough Channel below the L&W will experience more frequent and increased flows than in the past. To quantify the effects of these additional flows, an ecological report was prepared that assessed the impacts of these flows on the water quality, habitat and waterfowl populations in Cooper Slough between the L&W Canal and State Highway 14. In addition, an assessment of the impact of the more frequent and increased flows in Cooper Slough on channel stability was also conducted. The results of this work effect are summarized below.

The ecological assessment included completion of the following tasks:

- Assessment of waterfowl use at Cooper Slough through the identification of the Slough’s physical, vegetative and hydrologic characteristics;
- Identification of the proposed changes to Cooper Slough;
- Identification of the mitigation/enhancement measures for waterfowl in Cooper Slough; and
- Identification of future monitoring needs.

Based on water quality data collected by the City of Fort Collins, there does not appear to be a threat to waterfowl species that use Cooper Slough. Despite the scarcity of these data, the extremely high-water hardness and dissolved solid levels (i.e.: hard water) may reduce the toxicity of metals present to waterfowl within Cooper Slough. The principal metal of concern is selenium (SE), due to its known occurrence in natural formations in and around Fort Collins are and adverse effects to waterfowl. To date, no data (current or historical) are available to demonstrate that selenium or other metals pose a problem within Cooper Slough.

Groundwater and surface water flows will likely increase and become more frequent in the upper reaches of Cooper Slough. Cooper Slough should remain in more of a "warm-water" condition (e.g.: ice-free through portions of the winter). This may potentially allow slightly more migratory and winter use by waterfowl species than has been historically observed. A significant increase in waterfowl usage and in waterfowl habitat will not occur, however, because of the poor structural diversity in vegetation and narrowness of the channel in Cooper Slough.

It should be noted that waterfowl and its habitat in Cooper Slough may be adversely impacted as a result of diverting both irrigation return flows and runoff associated with future development into the drainage channel. These impacts, however, are expected to be mild, assuming the groundwater flows increase and continue to maintain the warm-water condition that presently exists. Should the increase in irrigation return flows and surface water inflows considerably increase and create more significant impacts to waterfowl, implementation of best management practices (BMPs) is recommended and will considerably reduce the impacts to Cooper Slough.

Based on the results of the ecological assessment, the following recommendations are provided. The City should continue to collect water samples in Cooper Slough and evaluate the water quality on a regular basis. This information will provide a better understanding of the potential waterfowl impacts within Cooper Slough. At least four sampling locations should be identified along the length of Cooper Slough to maximize statistical accuracy and validity of the water quality data, and to demonstrate the impacts of various human uses and features along Cooper Slough. Furthermore, it is recommended that formal monitoring of water, waterfowl habitat and other characteristics in Cooper Slough north of Vine Street be conducted quarterly, to confirm the absence or presence of unique waterfowl/shore birds and/or their habitat.

The ecological assessment is provided in its entirety in **Appendix D**.

5.3 Stability Assessment

The stability assessment was limited to the reach of Cooper Slough from State Highway 14 to the Larimer and Weld Canal. The work effort initially focused on the identification of the nature and extent of the existing stability problems within Cooper Slough channel. Much of the initial work was completed during the field reconnaissance and inventory of Cooper Slough conducted as part of the Boxelder Creek/Cooper Slough Basin master planning effort. The results of the initial field reconnaissance and inventory work are documented in the report entitled "Technical Summary for the Problem Identification, Channel Stability Evaluation, and Habitat Assessment for the Boxelder Creek/Cooper Slough Basin" by Anderson Consulting Engineers, Inc., May 30, 2002.

Similar to Boxelder creek, the Cooper Slough channel has been significantly influenced by manmade impacts. The study reach has been subjected to agricultural practices along with highway, street, railroad and canal crossings that have encroached onto the active channel and historical floodplain. Runoff tributary to the study reach has been significantly reduced by the capture of these flows in the Larimer and Weld Canal. Consequently, the channel forming flows are generated by the contributing watershed that is located south of the Larimer and Weld Canal. In addition to the storm runoff in the watershed, seepage and runoff associated with agricultural activities (field drains, return flows, seepage losses, tec.) provide inflows to the channel as well as inflows from springs located adjacent to the channel north of Vine Drive.

In general, the Cooper Slough channel is moderately sinuous within the study reach. The channel is very shallow (less than 2 feet) in the lower (above State Highway 14) and upper (above Vine Drive) portions of the study reach and is typically located in a wide terraced floodplain that is moderately encroached by vegetation. In these areas, bank erosion is relatively minor given the shallow nature of the channel section. Immediately south of Vine Drive, Cooper Slough transitions to a narrower, more incised channel with heights ranging from 3 to 4 feet. Channelization/stabilization of Cooper Slough in this reach is evident in the form of fill placement and the installation of bank protection measures along the west bank. Further to the south, the demarcation of the channel and the floodplain is ill defined as the drainageway becomes more heavily encroached by phreatic vegetation/wetlands created by the railroad embankment. Channel degradation within the study reach is minimal since several crossings tend to act as a grade control to stabilize the channel bed.

As stated previously, implementation of the improvements identified in the Select Plan may result in more frequent and increased flows in the Cooper Slough channel. The additional flow in the channel will likely exacerbate existing channel stability problems and may create additional stability problems through channel degradation and/or channel widening. Based on the results of the stability assessment, the following conclusions and recommendations are provided:

1) Where channel degradation is evident, place rock grade control structures in the channel to stabilize the channel bed. Given the length of the channel coupled with the number of road crossings within the study reach, it is anticipated that not more than three structures or riffle-pool sequences may be required should degradation of the channel become evident.
2) Where appropriate, mitigation bank erosion through placement of hard armor near the toe of the channel bank and utilize vegetation or biotechnical bank protection in the upper bank area. Based on the existing bank stability assessment, bank protection improvements may be required along the west bank in the reach immediately south of Vine Drive.
3) Should implementation of the Selected Plan occur, it is recommended that the Cooper Slough channel be monitored (annually, as minimum) for changes in bed and bank stability, and as necessary, the channel stabilization measures identified above as installed.

Details of typical bank stabilization and rock grade control structures are present in Appendix A of the report entitled "Technical Summary for the Problem Identification, Channel Stability Evaluation, and Habitat Assessment for the Boxelder Creek/Cooper Slough Basin" by Anderson Consulting Engineers. Inc., May 30, 2002.

Section 6 –Selected Plan Costs

6.1 Summary of Costs

Table 10 provides a summary of component costs from the original Boxelder Creek/Cooper Slough Selected Plan.

Table 10: Summary of Component Costs for the Boxelder Creek/Cooper Slough Selected Plan

Location	Right-of-way	Construction	Construction Contingency[a]	Engineering/ Project Management[b]	City Project Management[c]	Total Project Costs
Group 1: Mulberry Street to Boxelder Creek						
Cooper Slough Channel Improvements from Lake Canal to Boxelder Creek	$500,000	$4,021,660	$1,608,664	$1,126,065	$337,819	$7,594,208
Cooper Slough Outfall from State Highway 14 (Mulberry Street) to the Lake Canal Crossing	$16,357	$2,022,500	$809,000	$566,300	$169,890	$3,584,047
Cooper Slough Crossing of the Lake Canal Crossing (3) 15'x'3' RCBCs	$14,205	$1,777,918	$711,167	$497,817	$149,345	$3,150,452
Mulberry Street Culverts (2) 11'Wx6'H RCBCs	$0	$1,479,484	$591,794	$414,256	$124,277	$2,609,811
Cooper Slough Channel Improvements upstream of Mulberry St to culverts	$700,000	$250,100	$100,040	$70,028	$21,008	$1,141,176
Outfall system for the business park located at the northwest corner of I-25 and State Highway 14.	$0	$1,372,460	$548,984	$384,289	$115,287	$2,421,019
Lake Canal side-flow spillway and conveyance channel, us of Mulberry	$50,000	$372,416	$148,966	$104,276	$31,283	$706,941
Selected Plan - Group 1	$1,280,561	$11,296,538	$4,518,615	$3,163,031	$948,909	$21,207,654
Group 2: Cooper Slough Improvements Vine Drive & Downstream						
Bank and channel improvements along CS waterway, below the L&W Canal.	$0	$65,700	$26,280	$18,396	$5,519	$115,895
Improvements to the Vine Drive culverts at Cooper Slough.	$0	$468,860	$187,544	$131,281	$39,384	$827,069
Selected Plan - Group 2	$0	$534,560	$213,824	$149,677	$44,903	$942,964
Group 3: Montava Regional Improvements						
Improvements to the C&S /Crumb Detention Pond & Outfall to AB Pond	$1,050,000	$5,720,214	$2,288,085	$1,601,660	$480,498	$11,140,457
Improvements to the AB Detention Pond & Overflow Flume	$0	$301,500	$120,600	$84,420	$25,326	$531,846
Construction of C&S / Crumb Overflow Pond & Outfall to L&W Canal	$0	$1,318,281	$527,313	$369,119	$110,736	$2,325,448
Montava Swale and Mt Vista Crossing	$875,000	$1,422,041	$568,816	$398,171	$119,451	$3,383,480
Montava Pond A Construction	$1,100,000	$1,750,748	$700,299	$490,209	$147,063	$4,188,320

Location	Right-of-way	Construction	Construction Contingency[a]	Engineering/ Project Management[b]	City Project Management[c]	Total Project Costs
Selected Plan - Group 3	$3,025,000	$10,512,784	$4,205,114	$2,943,580	$883,074	$21,569,551
Group 4: No. 8 Outlet Ditch Improvements						
Mountain Vista Diversion from the No 8 to C&S/Crumb Detention Pond	$0	$357,100	$142,840	$99,988	$29,996	$629,924
Selected Plan - Group 4	$0	$357,100	$142,840	$99,988	$29,996	$629,924
Group 5: North Poudre Reservoir and Sod Farm Improvements						
Construction of the Sod Farm Improvements and Sod Farm Diversion off the No. 8.	$1,950,000	$301,500	$120,600	$84,420	$25,326	$2,481,846
Improvements to the North Poudre Reservoir No. 6 Spillway.	$0	$36,285	$14,514	$10,160	$3,048	$64,007
Selected Plan - Group 5	$1,950,000	$337,785	$135,114	$94,580	$28,374	$2,545,853
Selected Plan - Total	$6,255,561	$23,038,767	$9,215,507	$6,450,855	$1,935,256	$46,895,947

Notes:

a = 40% of Construction Costs
b = 20% of (Construction Costs + Construction Contingency)
c = 5% of (Construction Costs + Construction Contingency + Engineering/Project Management)

Section 7–Summary

The Selected Plan focuses on improvements in the Upper Cooper Slough Basin specifically reducing flows in the eastern portion of the basin, attenuating flows from the eastern portion of the basin to Cooper Slough through the use of regional detention and providing regional outfall channels in both the eastern and western portions of the basin. The total project costs for the Upper Cooper Slough Basin Selected Plan Improvements were determined to be $47 million. This Selected Plan of Improvements is necessary to address the rapid and proposed development within the basin.

Section 8 – References

1. ICON Engineering, 2017. “Cooper Slough Selected Plan Update,” October.
2. Anderson Consulting Engineers (ACE), 2006. “Hydrologic Modeling of the Existing Drainage Facilities, Box Elder Creek/Cooper Sough Basin as part of the FEMA DFIRM For Larimer County,” May.
3. Anderson Consulting Engineers (ACE), 2006. “Final Report, Upper Cooper Sough Basin Selected Plan of Improvements.”
4. Ayres Associates, 2015. “Conditional Letter Of Map Revision (CLOMR) For East Side Detention Facility (ESDF), Larimer & Weld Canal Crossing Structure (LWCCS), Opening Of I-25 Boxes Siphon Of Lake Canal Prospect Road Bridge Replacement, Boxelder Creek Overflow. Also Known As (Boxelder 6).” Prepared for Boxelder Basin Regional Stormwater Authority, City of Fort Collins, Town of Timnath, February.
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6. City of Fort Collins, Advance Planning Department, 2009. “Mountain Vista Subarea Plan,” September
7. City of Fort Collins, 2018. “Stormwater Criteria Manual,” Fort Collins, CO.
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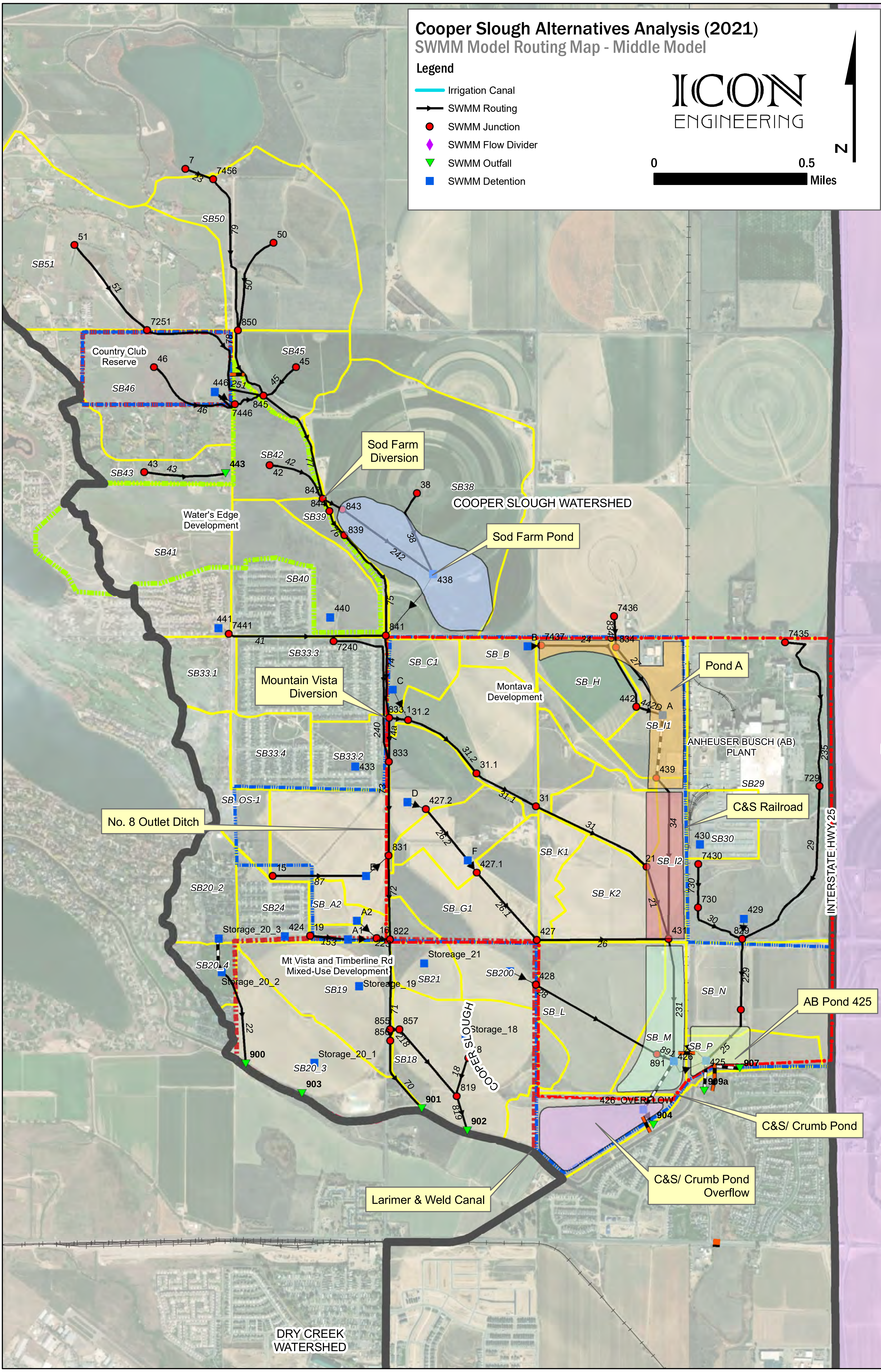
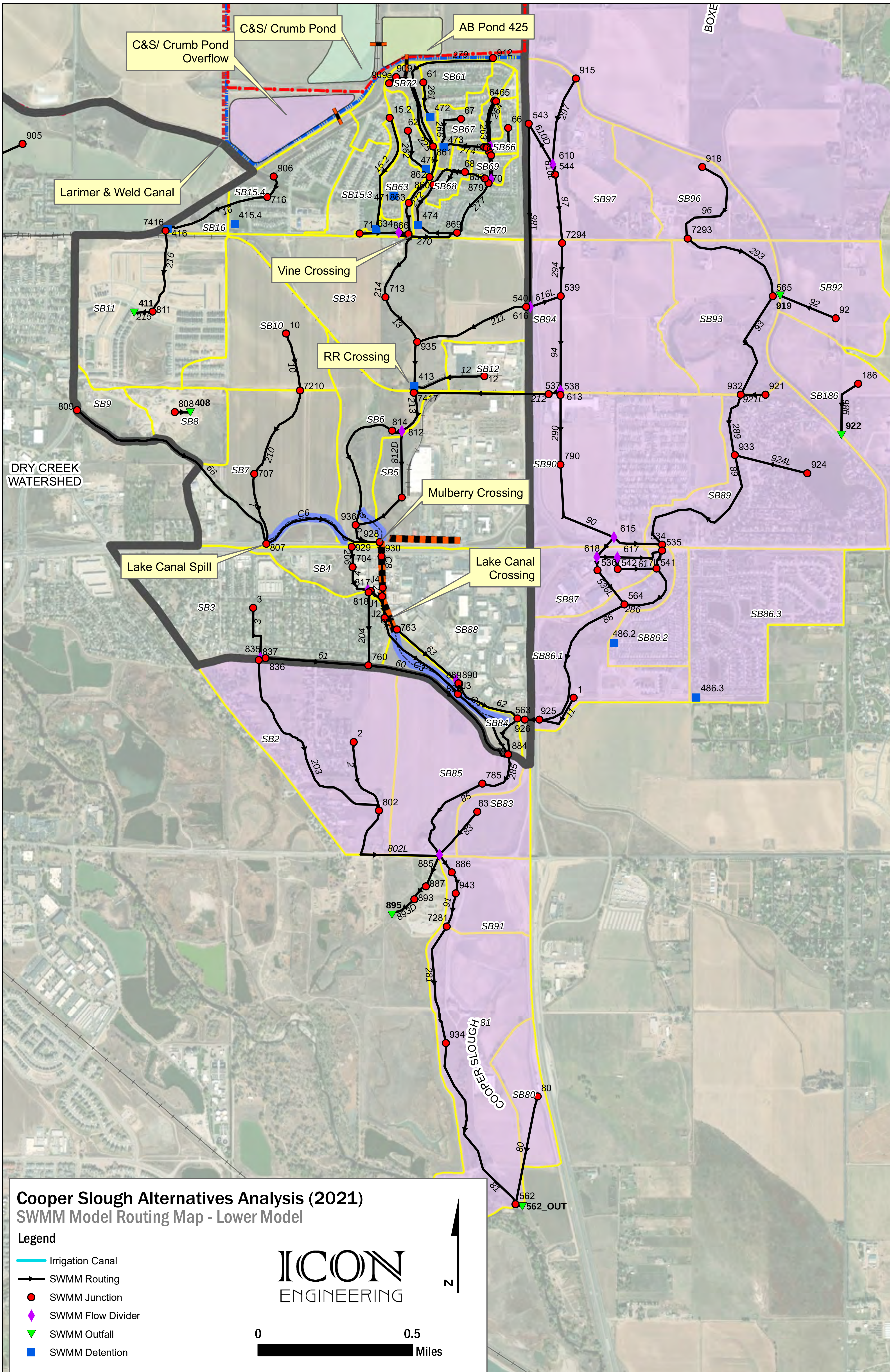
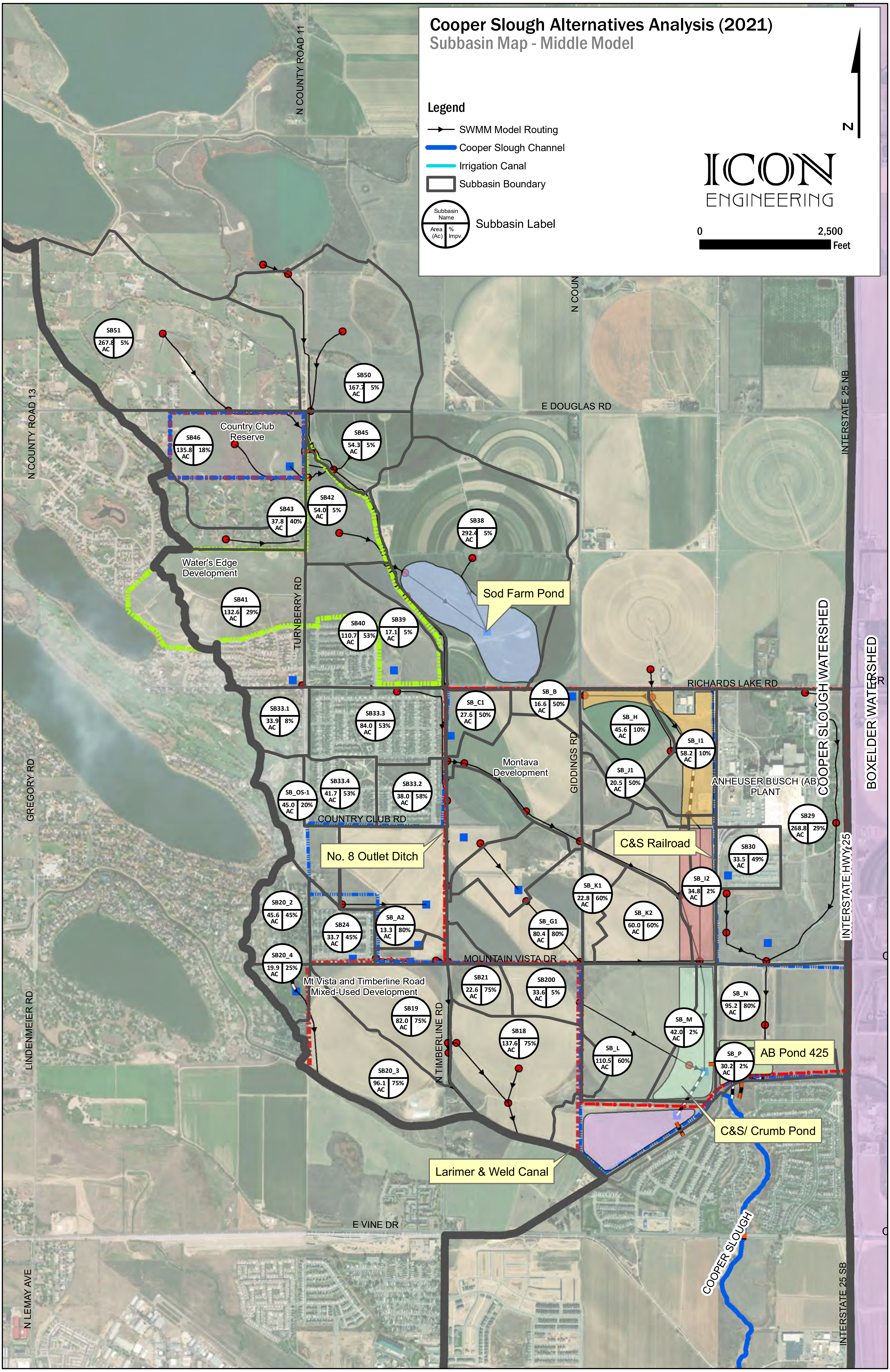
9. State of Colorado, Department of Natural Resources, Division of Water Resources, Office of the State Engineer, Dam Safety Branch, 2019. "Dam Safety Rules”.
10. United States Army Corps of Engineers Hydrologic Engineering Center, 2010. “Hydrologic Engineering Center - River Analysis System (HEC-RAS)”, version 4.1.0.
11. United States Environmental Protection Agency, 2020. “EPA Stormwater Management Model,” version 5.1.015.

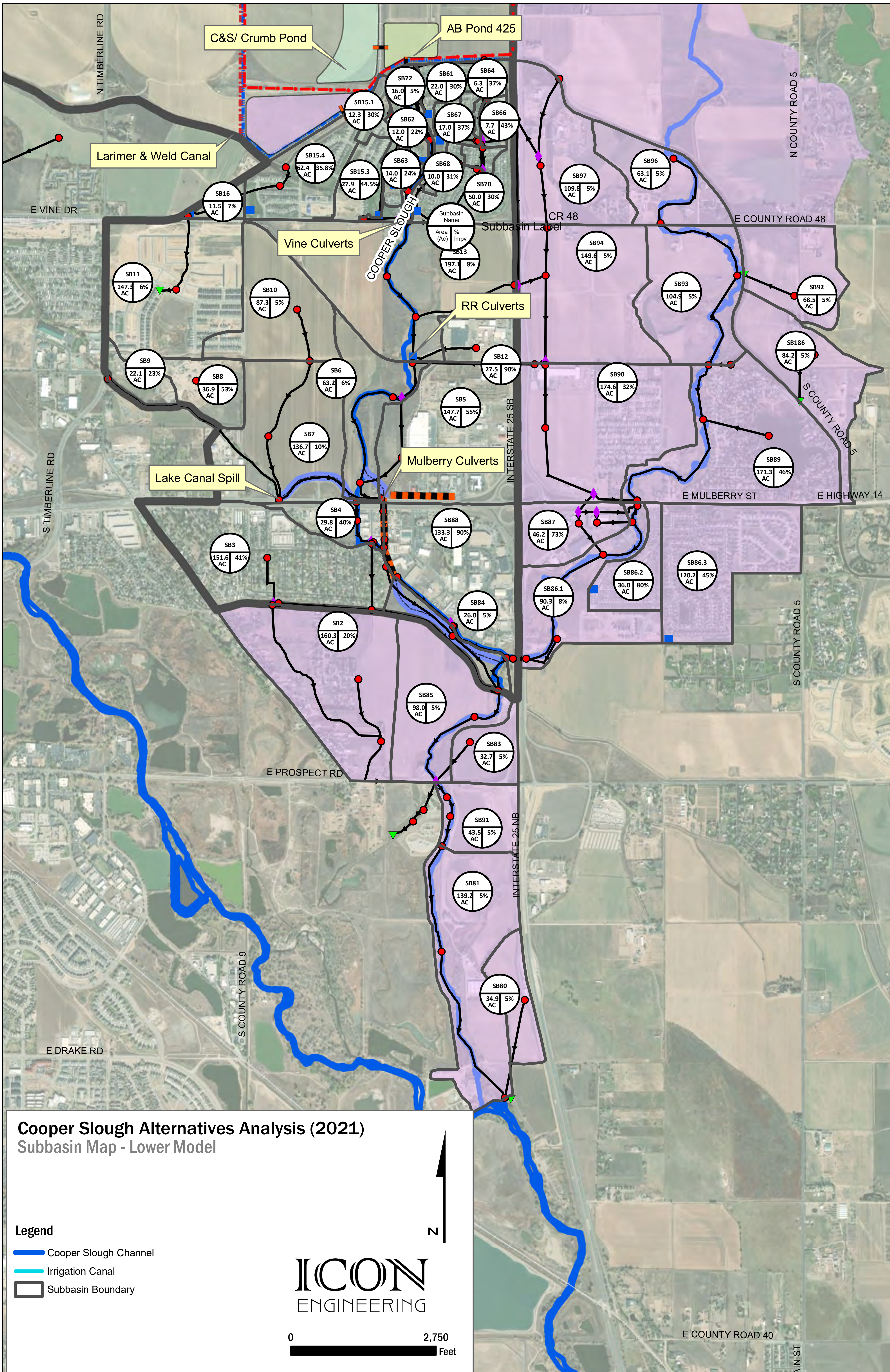
Appendix A – Hydrology and Master Plan Maps


Cooper Slough Alternatives Analysis (2021)
SWMM Model Routing Map - Middle Model
Legend
Irrigation Canal
SWMM Routing
SWMM Junction
SWMM Flow Divider
SWMM Outfall
SWMM Detention
ICON ENGINEERING
0
0.5
Miles
N
COOPER SLOUGH WATERSHED
Sod Farm Diversion
Sod Farm Pond
Country Club Reserve
Water's Edge Development
Mountain Vista Diversion
Montava Development
Pond A
ANHEUSER BUSCH (AB) PLANT
C&S Railroad
No. 8 Outlet Ditch
INTERSTATE HWY 25
Mt Vista and Timberline Rd Mixed-Use Development
AB Pond 425
426 OVERFLOW
C&S/ Crumb Pond
C&S/ Crumb Pond Overflow
Larimer & Weld Canal
COOPER SLOUGH
DRY CREEK WATERSHED


Cooper Slough Alternatives Analysis (2021)
SWMM Model Routing Map - Lower Model
Legend
Irrigation Canal
SWMM Routing
SWMM Junction
SWMM Flow Divider
SWMM Outfall
SWMM Detention
ICON ENGINEERING
N
0
0.5
Miles
C&S/ Crumb Pond
AB Pond 425
C&S/ Crumb Pond Overflow
Larimer & Weld Canal
Vine Crossing
RR Crossing
Mulberry Crossing
Lake Canal Spill
Lake Canal Crossing
DRY CREEK WATERSHED
COOPER SLOUGH
562_OUT

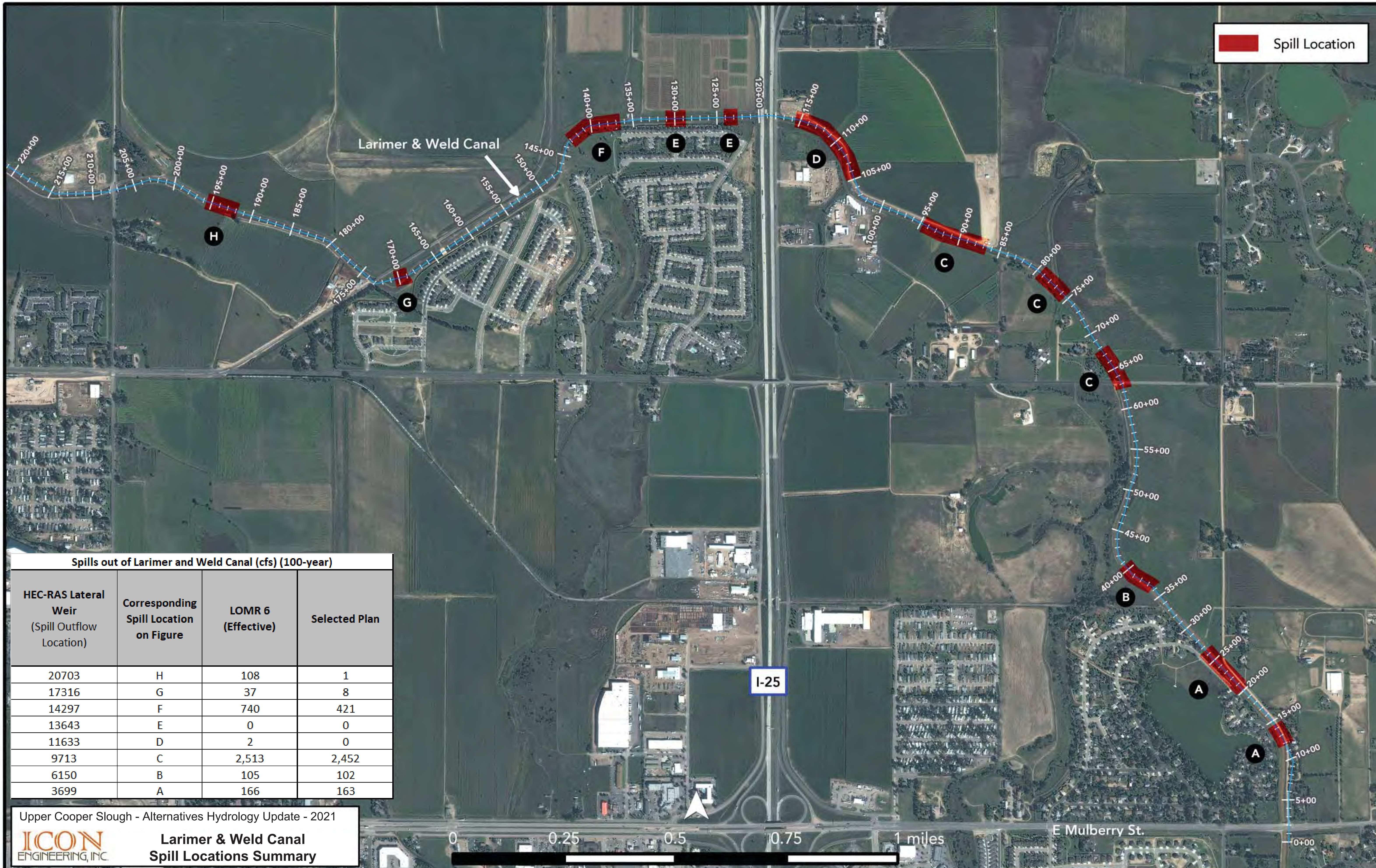


Cooper Slough Alternatives Analysis (2021)
Subbasin Map - Middle Model
Legend
SWMM Model Routing
Cooper Slough Channel
Irrigation Canal
Subbasin Boundary
Subbasin Name
Area (Ac)
% Impv.
Subbasin Label
ICON ENGINEERING
0
2,500
Feet
N
N COUNTY ROAD 11
N COUNTY ROAD 13
E DOUGLAS RD
INTERSTATE 25 NB
Country Club Reserve
Water's Edge Development
TURNBERRY RD
Sod Farm Pond
RICHARDS LAKE RD
Montava Development
GIDDINGS RD
ANHEUSER BUSCH (AB) PLANT
COOPER SLOUGH WATERSHED
BOXELDER WATERSHED
GREGORY RD
COUNTRY CLUB RD
No. 8 Outlet Ditch
C&S Railroad
INTERSTATE HWY 25
MOUNTAIN VISTA DR
Mt Vista and Timberline Road Mixed-Used Development
N TIMBERLINE RD
LINDENMEIER RD
AB Pond 425
C&S/ Crumb Pond
Larimer & Weld Canal
E VINE DR
COOPER SLOUGH
N LEMAY AVE
INTERSTATE 25 SB
SB51 267.8 AC 5%
SB50 167.7 AC 5%
SB46 135.8 AC 18%
SB45 54.3 AC 5%
SB42 54.0 AC 5%
SB43 37.8 AC 40%
SB38 292.4 AC 5%
SB41 132.6 AC 29%
SB40 110.7 AC 53%
SB39 17.1 AC 5%
SB33.1 33.9 AC 8%
SB33.3 84.0 AC 53%
SB_C1 27.6 AC 50%
SB_B 16.6 AC 50%
SB_H 45.6 AC 10%
SB_I1 58.2 AC 10%
SB_J1 20.5 AC 50%
SB_OS-1 45.0 AC 20%
SB33.4 41.7 AC 53%
SB33.2 38.0 AC 58%
SB29 268.8 AC 29%
SB30 33.5 AC 49%
SB_I2 34.8 AC 2%
SB_K1 22.8 AC 60%
SB_K2 60.0 AC 60%
SB_G1 80.4 AC 80%
SB20_2 45.6 AC 45%
SB24 33.7 AC 45%
SB_A2 13.3 AC 80%
SB20_4 19.9 AC 25%
SB21 22.6 AC 75%
SB200 33.6 AC 5%
SB_N 95.2 AC 80%
SB_M 42.0 AC 2%
SB19 82.0 AC 75%
SB18 137.6 AC 75%
SB_L 110.5 AC 60%
SB_P 30.2 AC 2%
SB20_3 96.1 AC 75%



Cooper Slough Alternatives Analysis (2021)
Subbasin Map - Lower Model

Appendix B – Larimer & Weld Canal Modeling Results



Spills out of Larimer and Weld Canal (cfs) (100-year)

HEC-RAS Lateral Weir (Spill Outflow Location)	Corresponding Spill Location on Figure	LOMR 6 (Effective)	Selected Plan
20703	H	108	1
17316	G	37	8
14297	F	740	421
13643	E	0	0
11633	D	2	0
9713	C	2,513	2,452
6150	B	105	102
3699	A	166	163

Upper Cooper Slough - Alternatives Hydrology Update - 2021

ICON ENGINEERING, INC.

Larimer & Weld Canal
Spill Locations Summary

Appendix C – Selected Plan Components

N. Poudre Reservoir No. 6

2016 Cooper Slough Alternatives Update - ICON Engineering

Location: North Poudre No. 6 Reservoir
SWMM Elements: Storage Node 476; Link 476_Out
Modification: Addition of 8" sill to reservoir spillway to increase flood storage. Modify SSD table in model.

Target Parameters from 2006 Master Plan		
Parameter	**Value**	
Q100 out	671	cfs
Storage	717	AF
100yr WSE		ft

Stage-Storage-Discharge Table for N. Poudre Reservoir #6 - From 2006 Upper Cooper Slough Master Plan

Stage	Elevation	Total Reservoir Storage (AF)	Effective Storage (Flood Storage) (AF)	Storage (ft^3)	delta storage (ft3)	Area (SF)	Discharge (cfs)	Notes
	5126	0	0					
0	5162	10969	0	0			0	Emergency Spillway - Normal Opertating Level
0.67	5162.67	11328.8	360	15,681,600	15,681,600		8	
1	5163	11506	537	23,391,720	7,710,120		218	
2	5164	12087	1118	48,700,080	25,308,360		1683	
3	5165	12653	1684	73,355,040	24,654,960		3882	
4	5166	13567	2598	113,168,880	39,813,840		6619	
5	5167	13865	2896	126,149,760	12,980,880		9804	
6	5168	14514	3545	154,420,200	28,270,440		13381	Top of Dam

SSD Table from 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - Appendix D - Provided by Ayres Study

Other information from 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - MODSWMM Files

UCS100SP.in

UCS100SP.out

Stage-Area-Discharge Table for N. Poudre Reservoir #6 - Existing Condition ICON Engineering 2014

Stage	Elevation	Flood Storage (AF)	Storage (ft^3)	delta storage (ft3)	Area (SF)	Discharge (cfs)	Notes
0		0.00	0	0	20,000,000	0	
1		539.49	23,500,000	23,500,000	27,000,000	1050	
2		1159.32	50,500,000	27,000,000	27,000,000	3000	
3		1779.16	77,500,000	27,000,000	27,000,000	5458	
4		2398.99	104,500,000	27,000,000	27,000,000	8405	
5		3018.82	131,500,000	27,000,000	27,000,000	11748	
6		3638.66	158,500,000	27,000,000	27,000,000	15446	

SSD Table from 2014 Hydrologic Analysis of the Box Elder/ Cooper Slough Watershed, ICON Engineering.

Proposed Stage-Area-Discharge Table for N. Poudre Reservoir #6 - 2016 Cooper Slough Alternatives Analysis

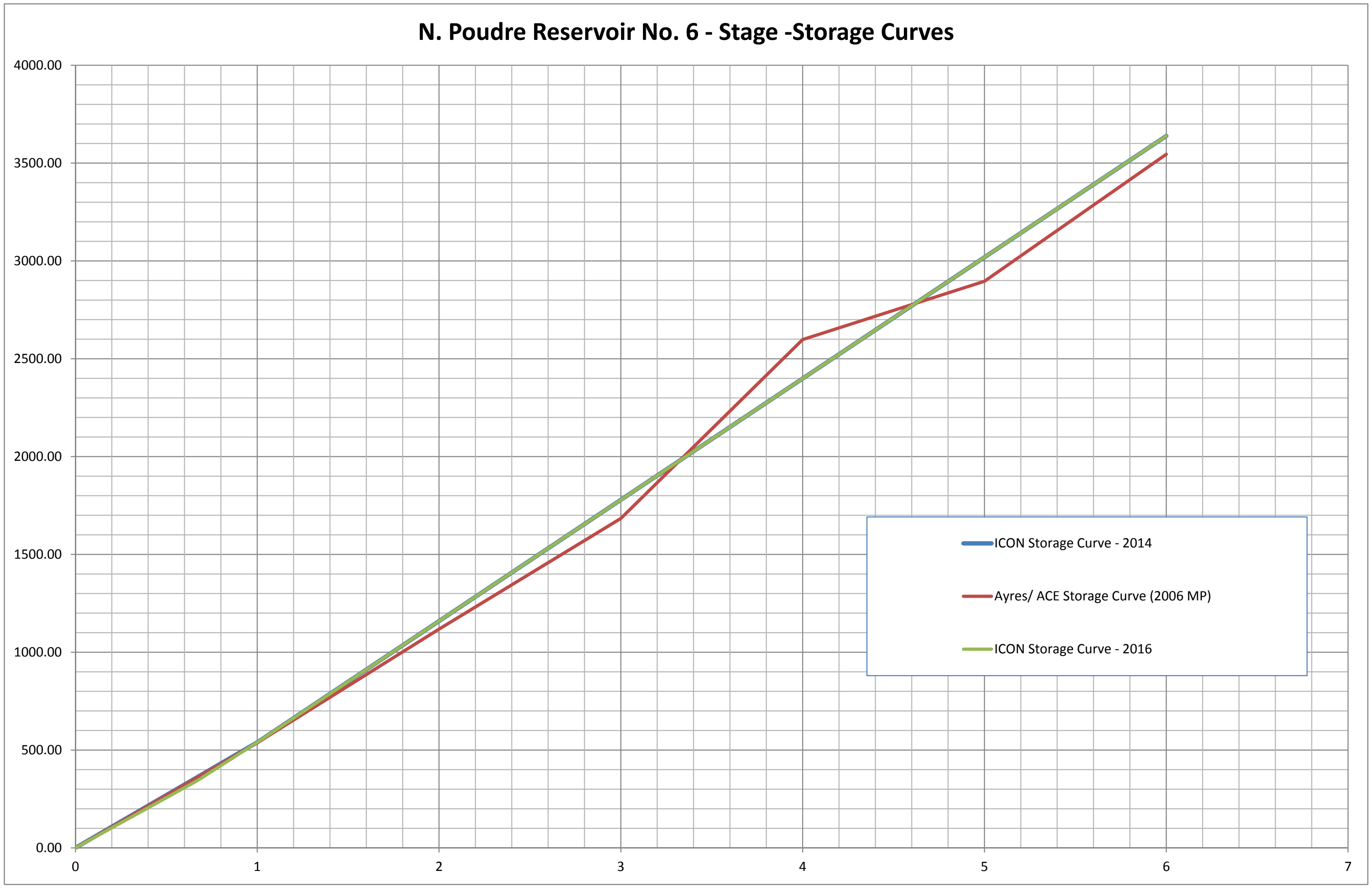
Stage	Elevation	Flood Storage (AF)	Storage (ft^3)	delta storage (ft3)	Area (SF)	Discharge (cfs)	Notes
0	5162	0.00	0	0	20,000,000	0	Emergency Spillway - Normal Opertating Level
0.67	5162.67	343.69	14,971,150	14,971,150	24,690,000	8	
1	5163	539.49	23,500,000	8,528,850	27,000,000	218	
2	5164	1159.32	50,500,000	27,000,000	27,000,000	1683	
3	5165	1779.16	77,500,000	27,000,000	27,000,000	3882	
4	5166	2398.99	104,500,000	27,000,000	27,000,000	6619	
5	5167	3018.82	131,500,000	27,000,000	27,000,000	9804	
6	5168	3638.66	158,500,000	27,000,000	27,000,000	13381	Top of Dam

Discharge rating table obtained from 2006 Upper Cooper Slough Master Plan

Stage-area table obtained from 2014 Hydrology Report for Box Elder/ Cooper Slough

2016 Cooper Slough Alternatives Update - ICON Engineering

Location: North Poudre No. 6 Reservoir
SWMM Elements: Storage Node 476; Link 476_Out
Modification: Addition of 8" sill to reservoir spillway to increase flood storage. Modify SSD table in model.



Sod Farm Diversion

2016 Cooper Slough Alternatives Update - ICON Engineering

Location:	**Sod Farm Diversion**

SWMM Elements:	**Modification:**
Diversion Node 842	Revise rating table

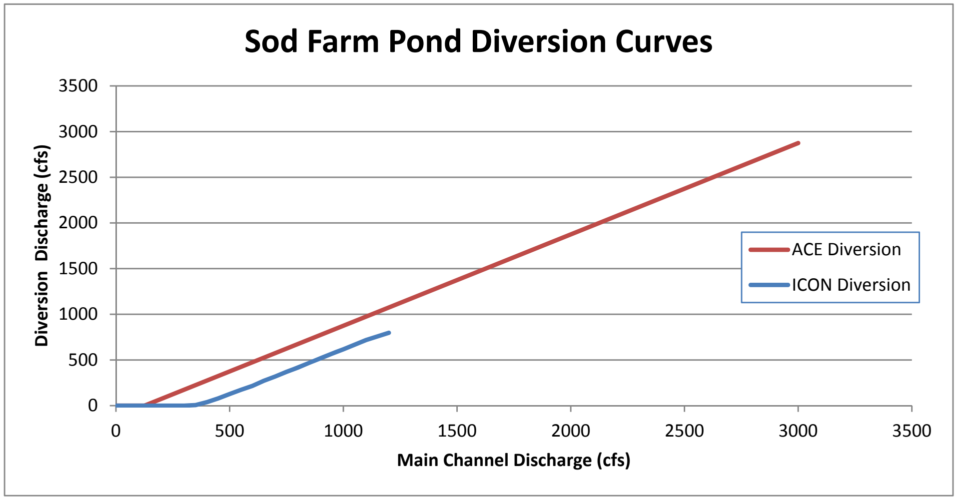
Diversion from the No 8 into the Sod Farm Pond

Diversion Rating Table - SELECTED PLAN	
Main Channel Discharge (cfs)	**Diversion Discharge (cfs)**
0	0
250	0
3000	2875

From 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - MODSWMM Files UCS100SP.in

2006 Diversion Table to be used in 2016 Alternatives Analysis without modifications

Diversion Rating Table - ICON 2014 Ex. Cond.	
Main Channel Discharge (cfs)	**Diversion Discharge (cfs)**
0	0
100	0
150	0
200	0
250	0
300	0
350	6.42
400	38.2
450	79.82
500	127.8
550	173.91
600	216.2
650	272.31
700	319.17
750	370.31
800	416.39
850	469.76
900	518.83
950	569.02
1000	616.97
1100	718.32
1200	797.91



Sod Farm Detention Pond

2016 Cooper Slough Alternatives Update - ICON Engineering

Location: **Sod Farm Detention Pond**

SWMM Elements:	Modification:
Storage Node 438	Revise storage table
Link 438_Out	Revise outet rating table
Node 839	Change outlet node from 7438 to 839

Stage-Storage-Discharge Table for Sod Farm Pond - From 2006 Upper Cooper Slough Master Plan

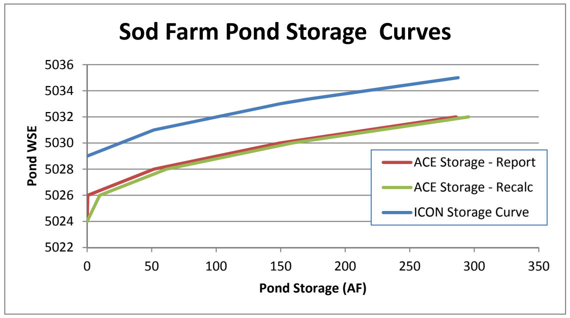
Stage	Elevation	Storage (AF)	*Storage (ft^3)*	*delta storage (ft3)*	Area (SF)	Discharge (cfs)	Notes
0	5024	0	*0*	*0*	0	0	
2	5026	0.5	*21,780*	*21,780*	636,032	20.6	
4	5028	51.75	*2,254,230*	*2,232,450*	1,704,434	51.2	
6	5030	149.18	*6,498,281*	*4,244,051*	2,569,051	72.1	
8	5032	285.9	*12,453,804*	*5,955,523*	3,405,739	87.6	

SSD Table from 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - Appendix D

Other information from 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - MODSWMM Files

UCS100SP.in

UCS100SP.out



Stage-Area-Discharge Table for Sod Farm Pond - Existing Condition ICON Engineering 2014

Stage		Elevation	*Flood Storage (AF)*	Storage (ft^3)	delta storage (ft3)	Area (SF)	Discharge (cfs)	Notes
0		5029	*0*	0	0	636,033	0	
2		5031	*52*	2,254,439	2,254,439	1,704,435	0	
4		5033	*149*	6,508,734	4,254,295	2,580,000	0	
	4.1	5033.1	*155*	6,768,894	260,160	*2,623,258*	25	
	4.2	5033.2	*161*	7,033,380	264,486	*2,666,516*	75	
	4.3	5033.3	*168*	7,302,191	268,812	*2,709,774*	150	
	4.4	5033.4	*174*	7,575,329	273,137	*2,753,032*	250	
6		5035	*288*	12,523,544	4,948,215	3,445,159		

SSD Table from 2014 Hydrologic Analysis of the Box Elder/ Cooper Slough Watershed, ICON Engineering.

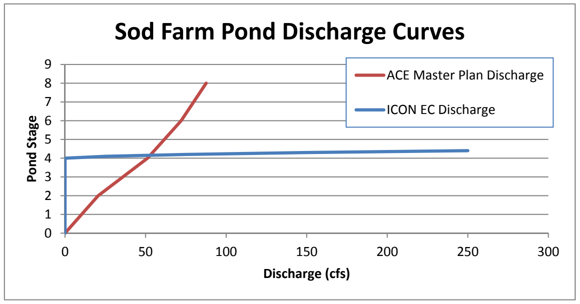
Proposed Stage-Area-Discharge Table for Sod Farm Pond - 2021 Cooper Slough Alternatives Analysis

Stage	Elevation	*Flood Storage (AF)*	Storage (ft^3)	delta storage (ft3)	Area (SF)	Discharge	Notes
0	5029	*0.0*	0	0	636032	0	
2	5031	*51.8*	2,254,437	2,254,437	1704434	20.6	
4	5033	*149.2*	6,498,462	4,244,025	2569051	51.2	
6	5035	*285.9*	12,453,628	5,955,166	3405739	72.1	
8	5037					87.6	

Discharge rating table obtained from 2006 Upper Cooper Slough Master Plan

Stage-Area rating table obtained from 2006 Upper Cooper Slough Master Plan

Grey highlight = calculated values



Notes:

[1] Greyed and italicized values were back calculated from data provided

[2] Storage values (which were not provided) were calculated using the pyramidal frustum volume equation:

$$V = \frac{1}{3} h \left(A_1 + A_2 + \sqrt{A_1 A_2} \right).$$

Mountain Vista Diversion

2016 Cooper Slough Alternatives Update - ICON Engineering

Location: **Mountain Vista Diversion**

SWMM Elements:	**Modification:**
Diversion Node 828	Revise rating table

Diversion Rating Table - Ex Cond. - ICON	
Main Channel Discharge	**Diversion Discharge**
cfs	cfs
0	0
250	0
300	0
350	0
400	0
450	0
500	0
550	27.81
600	68.75
650	112.56
700	157.56
750	203.01
800	248.82
850	294.48
900	340.25
950	387.76
1000	434.45

From 2014 ICON Existing Conditions model

Diversion Rating Table - Ex Cond. - ACE	
Main Channel Discharge	**Diversion Discharge**
cfs	cfs
0	0
300	0
350	9
400	28
450	51
500	77
550	104
600	135
650	168
700	205
750	246
800	286
850	320
900	367
950	415
1000	459

From 2006 Anderson Existing Conditions model

From 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan - MODSWMM Files

UCSEX100.IN

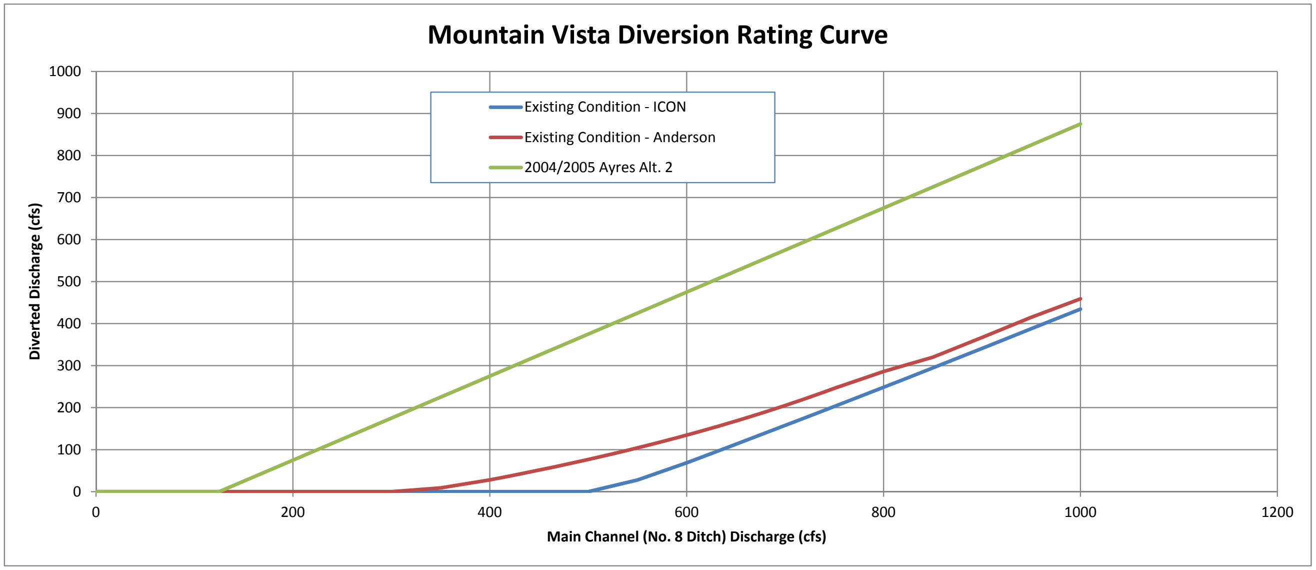
Diversion Rating Table - Ayres (2004/2005) Alternative 2	
Main Channel Discharge	**Diversion Discharge**
cfs	cfs
0	0
250	0
251	1
1000	875

From 2004/2005 Ayres Alternatives model

Part of the 2006 Anderson Consulting Engineers Upper Cooper Slough Master Drainage Plan Study

This diverts all flows above the 125 cfs decreed discharge from the No. 8 Outfall Ditch into the Mountain Vista Channel

2004/2005 Ayres Associates Alternative 2 diversion rating table to be used in 2016 Alternatives Analysis without modifications



Montava Development
AB Pond 425
C&S/ Crumb Pond 426
Overflow Pond
Pond A
Montava Swale

Information from these improvements were obtained from the EPA SWMM modeling from the Montava Development

SCHEMATIC LEGEND

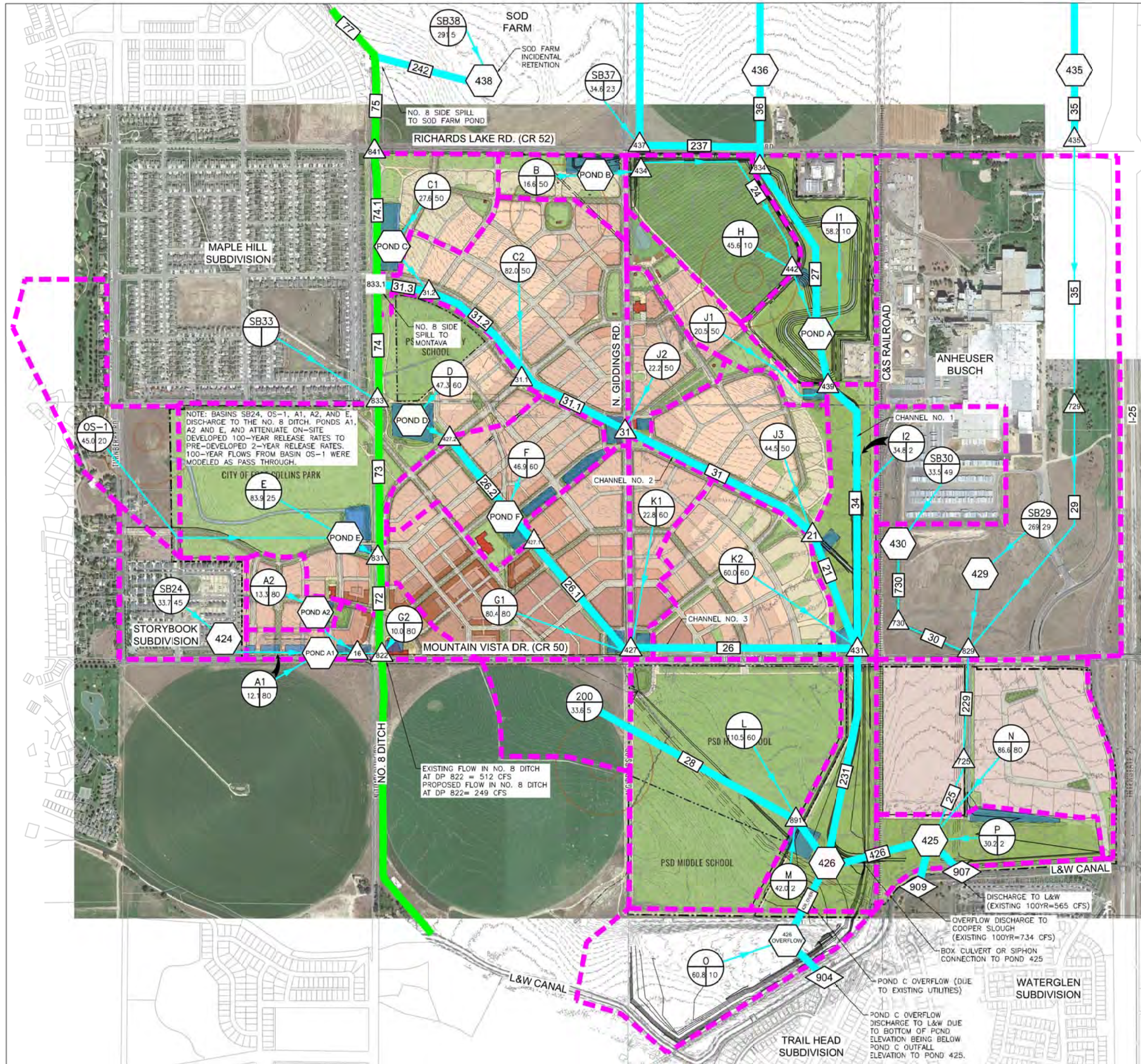
- SUB-CATCHMENT
- DETENTION ELEMENT
- DESIGN POINT/DESIGN FLOW
- CONVEYANCE ELEMENT
- OUTFALL ELEMENT
- DIVERSION ELEMENT

BASIN — B; AREA IN ACRES — 1.25; IMPERVIOUSNESS (%) — 53

- BASIN BOUNDARY
- IRRIGATION DITCH
- CONVEYANCE PATH

NOTES:

1. STORM ROUTING IS BASED ON MONTAVA FULL BUILD-OUT WITH EXISTING OFF-SITE CONDITIONS.
2. STORM ROUTING WAS DEVELOPED FROM EXISTING CONDITIONS SWMM MODELING PROVIDED BY ICON ENGINEERING, INC.
3. EXISTING TOPOGRAPHY SHOWN IS BASED ON SURVEY TST INFRASTRUCTURE, INC. IN MAY 2018 WITH SUPPLEMENTAL USGS 1-METER RESOLUTION 2014 FLOOD LIDAR TOPOGRAPHY. ELEVATIONS ARE REFERENCED TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88), U.S. SURVEY FEET.
4. SEE SHEET D2 FOR SWMM SUMMARY TABLES.



SCALE: 1"=500'
ALL DIMENSIONS SHOWN ARE U.S. SURVEY FEET

PLOT DATE: Wednesday, December 05, 2018 8:27 AM LAST SAVED BY: RBYRNE
DRAWING LOCATION: G:\SCHLAGETER\17.0946-Anheuser-Busch Mix-Used Development\PLANS\EXHIBITS\SWMM\Master_Routing_ICON_SWMM_Updates.dwg

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MONTAVA

MASTER DRAINAGE PLAN

DEVELOPED ROUTING SCHEMATIC

No.	Issue / Revision	Date	Name
1	SUBMITTED TO ICON FOR REVIEW	06/06/18	M/M
2	REVISED PER ICON SWMM UPDATES	07/18/18	M/M
3	REVISED PER MONTAVA POND GRADING	10/05/18	M/M
4	1ST PUD SUBMITTAL	10/22/18	M/M
5	2ND PUD SUBMITTAL	12/05/18	M/M

Job Number 17.0946
Project Manager P.BUCKLEY
Design By R.BYRNE
Drawn By N.KONTOUR
Principal In Charge M.SCHLAGETER

Sheet Number: D1

BASIN SUMMARY				
BASIN ID	AREA (AC)	% IMP	Q2 (CFS)	Q100 (CFS)
A1	12.1	80	11	70
A2	13.3	80	12	78
B	16.6	50	10	62
C1	27.6	50	17	107
C2	82.0	50	38	246
D	47.3	60	26	172
E	83.9	25	25	159
F	46.9	60	25	166
G1	80.4	80	36	249
G2	10.0	80	9	59
H	45.6	10	10	53
I1	58.2	10	8	49
I2	34.8	2	2	11
J1	20.5	50	9	58
J2	22.2	50	18	101
J3	44.5	50	25	158
K1	22.8	60	11	73
K2	60.0	60	27	180
L	110.5	60	55	361
M	42.0	2	2	14
N	86.6	80	61	400
O	60.8	10	12	65
P	30.2	2	2	12
OS-1	45.0	20	11	71
24	33.7	45	44	280
29	268.8	29	192	1000
30	33.5	49	44	231
37	34.6	23	22	148
38	290.7	5	42	469
200	33.6	5	5	46

CONVEYANCE ELEMENT SUMMARY	
SWMM ELEMENT	Q100 (CFS)
21	385
24	7
25	512
26	239
26.1	6
26.2	9
27	1780
28	45
29	413
30	27
31	353
31.1	338
31.2	276
31.3	271
34	1043
35	468
72	224
73	139
74	125
74.1	396
75	391
77	1000
229	513
231	1310
237	310
242	493
426	760
426_OVERFLOW	167

DESIGN POINT SUMMARY	
SWMM ELEMENT	Q100 (CFS)
16	15
21	385
31	355
31.1	338
31.2	277
427	319
427.1	6
427.2	9
431	1312
434	7
437	333
439	1043
442	53
725	513
729	415
730	28
822	249
829	513
831	224
833	138
834	1781
841	396
891	418

POND SUMMARY			
SWMM ELEMENT	Q100 IN (CFS)	Q100 OUT (CFS)	VOLUME (AC-FT)
425	883	819	47
426	1322	760	307
429	1000	390	13.6
430	231	29	5.5
435	468	415	30
436	1562	1548	25
438	732	0	88
426 OVERFLOW	167	138	59
POND A	1807	1042	123
POND A1	76	12	2.8
POND A2	78	3.5	3.0
POND B	62	7.2	2.3
POND C	107	7.1	4.6
POND D	172	8.6	9.0
POND E	174	91	3.2
POND F	166	6.4	11.4

DIVERSION SUMMARY			
SWMM ELEMENT	Q100 INFLOW (CFS)	Q100 DIVERTED (CFS)	Q100 REMAINING (CFS)
833.1	408	279	125
842	1000	617	384

OUTFALL SUMMARY	
SWMM ELEMENT	Q100 (CFS)
904	138
907	385
909	729

DESIGN POINT COMPARISON			
SWMM ELEMENT	Q100 (CFS)	Q100 (CFS) NO. 8 PIPED	
	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8
16	15	15	15
21	385	319	272
31	355	280	231
31.1	338	261	246
31.2	277	153	143
427	319	319	319
427.1	6	6	6
427.2	9	9	9
431	1312	1093	1055
434	7	7	7
435	415	415	415
437	333	333	333
439	1043	938	938
442	53	53	53
725	513	463	463
729	415	414	414
730	28	33	33
822	249	355	295
829	513	417	417
831	224	319	278
833	138	263	263
834	1781	1788	1788
841	396	417	392
891	418	375	375

SCHEMATIC LEGEND

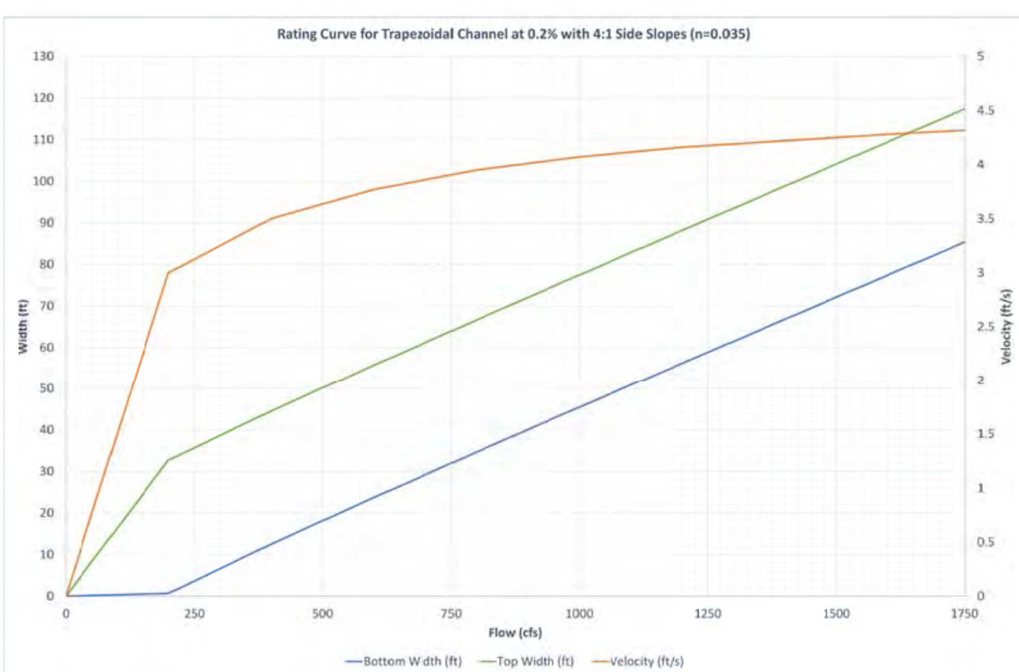
- SUB-CATCHMENT
- DETENTION ELEMENT
- DESIGN POINT/DESIGN FLOW
- CONVEYANCE ELEMENT
- OUTFALL ELEMENT
- DIVERSION ELEMENT

NOTES:

1. STORM ROUTING IS BASED ON MONTAVA FULL BUILD-OUT WITH EXISTING OFF-SITE CONDITIONS.
2. STORM ROUTING WAS DEVELOPED FROM EXISTING CONDITIONS SWMM MODELING PROVIDED BY ICON ENGINEERING, INC.

DIVERSION COMPARISON									
SWMM	Q100 IN (CFS)	Q100 IN (CFS) NO. 8 PIPED		Q100 DIVERTED (CFS)	Q100 DIVERTED (CFS) NO. 8 PIPED		Q100 REMAINING (CFS)	Q100 REMAINING (CFS) NO. 8 PIPED	
ELEMENT	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8
833.1	408	397	386	279	147	136	125	250	250
842	1000	1002	785	617	617	389	384	375	375

POND COMPARISON									
	Q100 IN (CFS)	Q100 IN (CFS) NO. 8 PIPED		Q100 OUT (CFS)	Q100 OUT (CFS) NO. 8 PIPED		V100 (AC-FT)	V100 (AC-FT) NO. 8 PIPED	
SWMM ELEMENT	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8	APPROVED MASTER	250 CFS IN NO. 8	NO 250 CFS IN NO. 8
425	883	724	717	819	684	674	47	47	46
426	1322	1097	1059	760	751	719	307	308	286
429	1000	1000	1000	390	285	285	13.6	19.6	19.6
430	231	231	231	29	29	29	5.5	5.5	5.5
435	468	468	468	415	415	415	30	30	30
436	1562	1562	1562	1548	1548	1548	25	25	25
438	732	862	630	0	0	0	88	138	81
426 OVERFLOW	167	187	176	138	148	142	59	77	67
POND A	1807	1780	1780	1042	937	937	123	125	125
POND A1	76	90	90	12	12	12	2.8	2.1	2.1
POND A2	78	78	78	3.5	3.5	3.5	3.0	3.0	3.0
POND B	62	62	62	7.2	7	7	2.3	2.4	2.4
POND C	107	107	107	7.1	7	7	4.6	4.6	4.6
POND D	172	172	172	8.6	9	9	9.0	9.0	9.0
POND E	174	187	196	91	63	73	3.2	3.7	2.7
POND F	166	166	166	6.4	6	6	11.4	10.7	10.7



OPEN CHANNEL RATING

CULVERT SIZE BY DESIGN POINT			
SWMM ELEMENT	BARRELS-SIZE	Q100 (CFS)	HEADWATER DEPTH (FT)
21	2-8x4	385	4.4
31	2-7x4	355	4.6
31.1	2-8x4	338	4.1
31.2	4-48"D	277	4.1
427	2-6x4	319	4.7
427.1	1-18"D	6	1.6
427.2	1-18"D	9	2.6
431	1-15x10 & 1-5x12	1312	7.6
434	1-18"D	7	1.9
437	3-6x3	333	4.2
822	3-48"D	249	4.6
831	3-48"D	224	4.3
833	2-48"D	138	4.1
834	4-10X5	1781	7.3
841	2-5X5	396	6.2
904	1-60"D	138	13.0

PLOT DATE: Wednesday, December 05, 2018 8:29 AM LAST SAVED BY: RBYRNE
DRAWING LOCATION: G:\SCHLAGETER\17.0946-Anheuser-Busch Mix-Used Development\PLANS\EXHIBITS\SWMM\Master_Routing_ICON_SWMM_Updates.dwg

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MONTAVA

MASTER DRAINAGE PLAN

DEVELOPED ROUTING SCHEMATIC

No.	Issue / Revision	Date	Name
1	SUBMITTED TO ICON FOR REVIEW	06/06/18	M/M
2	REVISED PER ICON SWMM UPDATES	07/18/18	M/M
3	REVISED PER MONTAVA POND GRADING	10/05/18	M/M
4	1ST PUD SUBMITTAL	10/22/18	M/M
5	2ND PUD SUBMITTAL	12/05/18	M/M

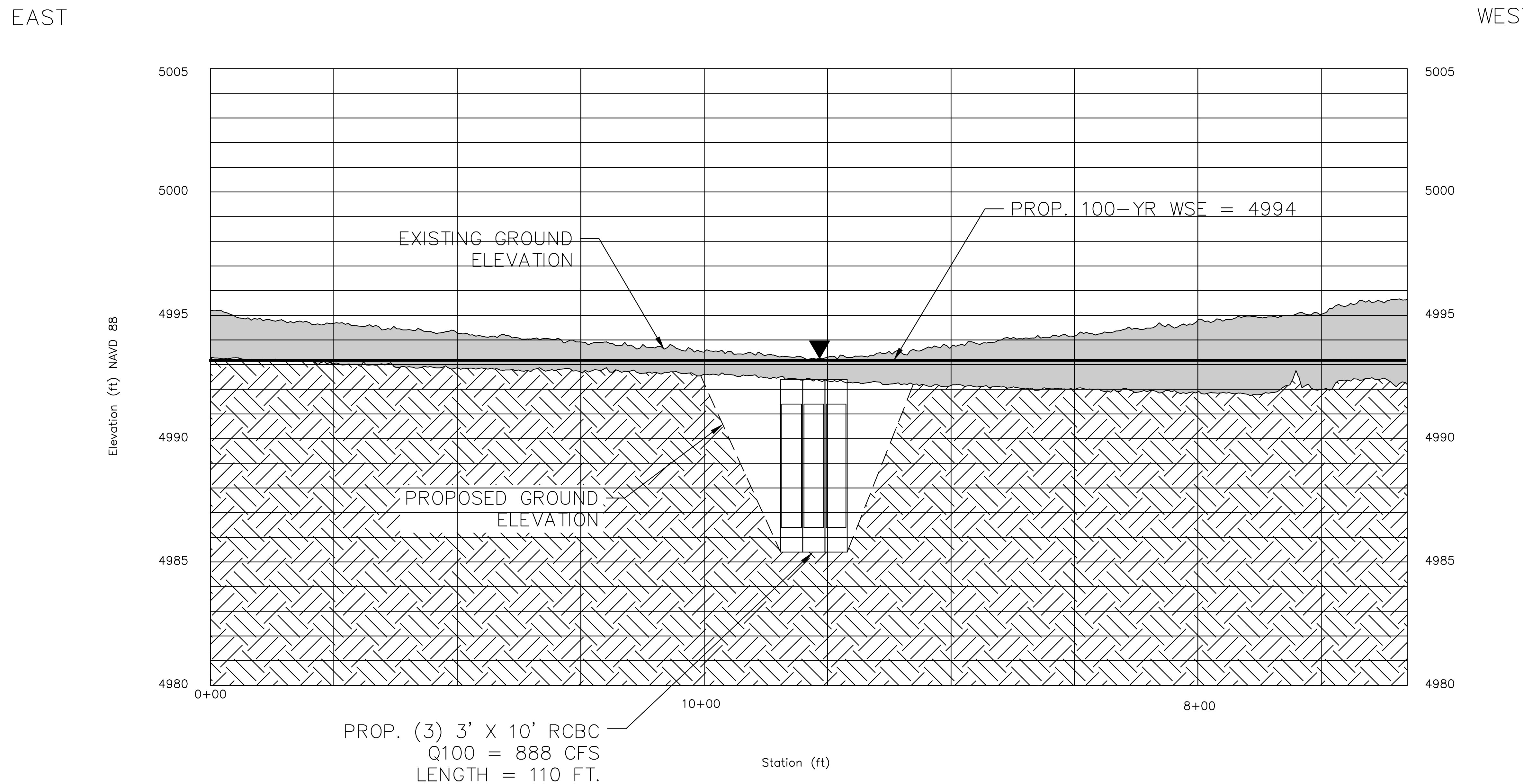
Job Number 17.0946
Project Manager P.BUCKLEY
Design By R.BYRNE
Drawn By N.KONTOUR
Principal In Charge M.SCHLAGETER

Sheet Number:

D2

Culvert Improvements

COOPER SLOUGH AT MOUNTAIN VISTA DRIVE
WEST FLOW PATH
COOPER SLOUGH MASTER PLAN ALTERNATIVES UPDATE (2021)
(NORTH OF ANHESUER-BUSCH PLANT LOOKING DOWNSTREAM/ SOUTH)



No.	DATE	REVISIONS	APPR.	PLAN	UTILITIES
				DRAWN MGS	RESEARCHED
				DESIGNED MGS	DRAWN
				CHECKED CDJ	CHECKED

City of Fort Collins

ICON ENGINEERING

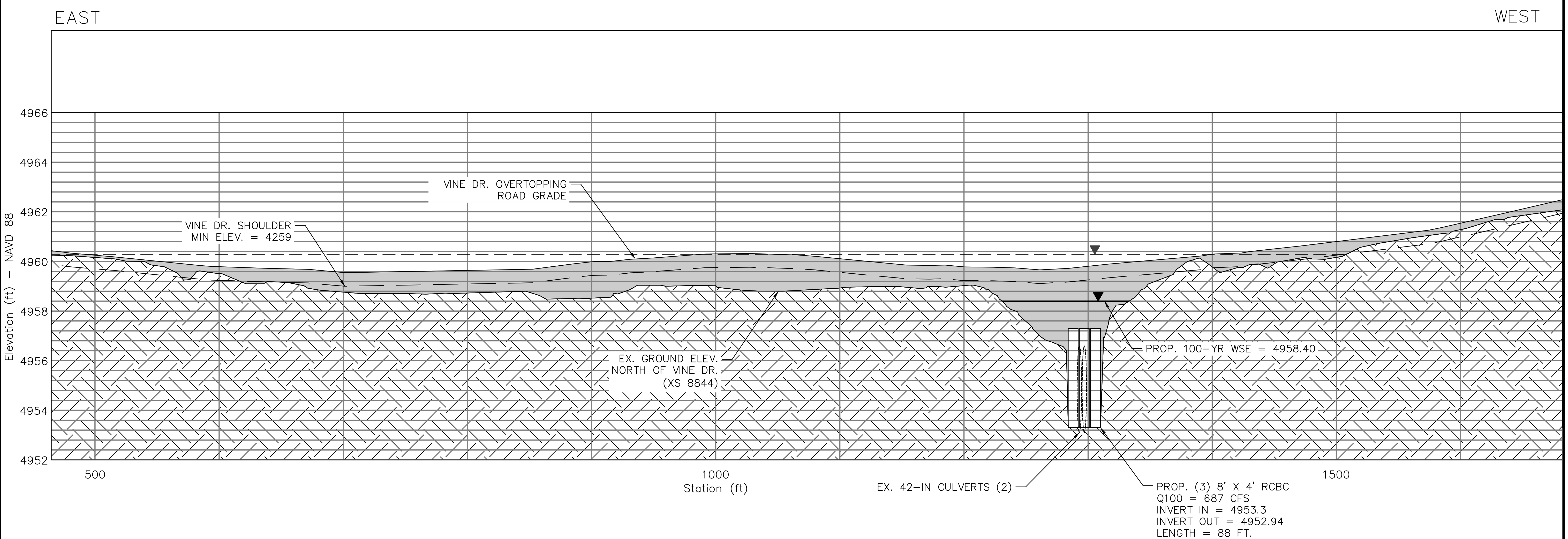
COOPER SLOUGH ALTERNATIVES ANALYSIS UPDATE
PROPOSED MOUNTAIN VISTA CROSSING
CITY OF FORT COLLINS UTILITIES

ICON PROJECT No. 16010UCS

DATE 09/06/2021

SHEET MTV02

COOPER SLOUGH AT E. VINE DRIVE CROSSING
COOPER SLOUGH MASTER PLAN ALTERNATIVES UPDATE (2021)
(NORTH OF VINE DR. LOOKING DOWNSTREAM/ SOUTH)



NOTE: CULVERT INSTALLATION MAY REQUIRE CHANNEL IMPROVEMENTS DOWNSTREAM FOR APPROX. 50–100'

No.	DATE	REVISIONS	APPR.	PLAN	UTILITIES
				DRAWN MGS	RESEARCHED
				DESIGNED MGS	DRAWN
				CHECKED CDJ	CHECKED

City of Fort Collins

ICON ENGINEERING

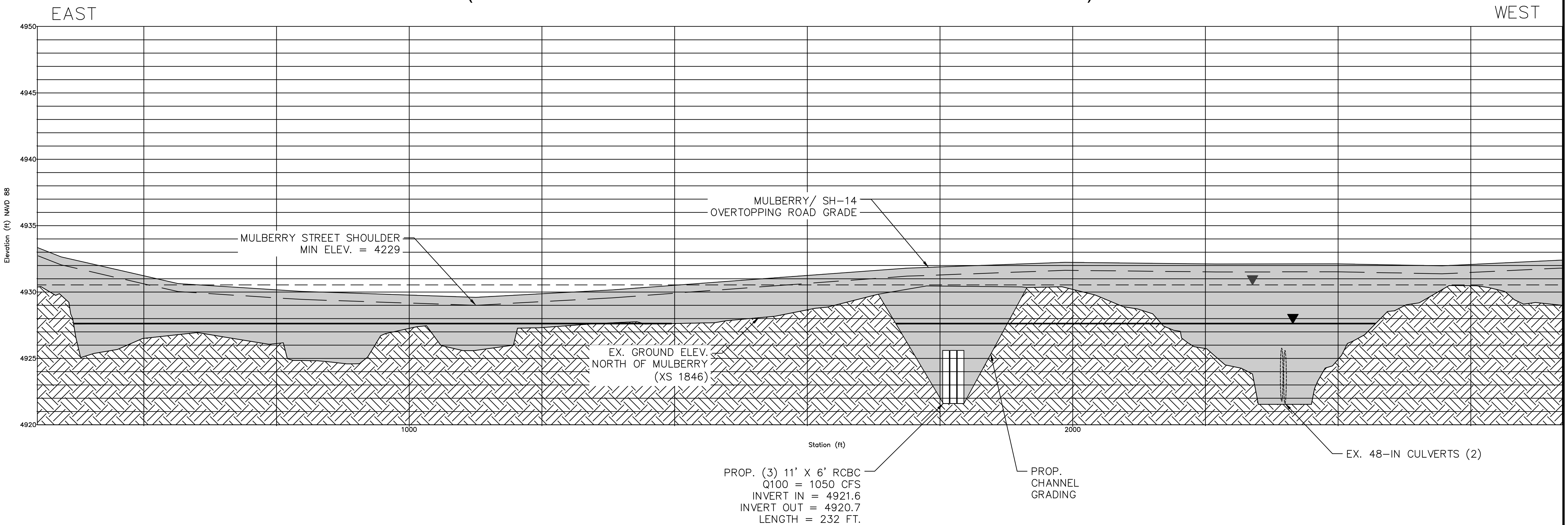
COOPER SLOUGH ALTERNATIVES ANALYSIS UPDATE
PROPOSED VINE DRIVE CROSSING
CITY OF FORT COLLINS UTILITIES

ICON PROJECT No. 16010UCS

DATE 10/12/2021

SHEET VINE01

COOPER SLOUGH AT MULBERRY ST./ SH-14 CROSSING
COOPER SLOUGH MASTER PLAN ALTERNATIVES UPDATE (2021)
(NORTH OF MULBERRY LOOKING DOWNSTREAM/ SOUTH)



P:\P20-004_UCS_SP_Update\06_DWG\Dwg\06_EXHIBITS\UCS_PP_CULVERTS_MULBERRYandVINE.dwg; Remote; Page Setup:----; ICON-HALF-SIZE.ctb; 1/10/2021 5:47 PM

DATE	REVISIONS	APPR.	PLAN	UTILITIES
			DRAWN MGS	RESEARCHED
			DESIGNED MGS	DRAWN
			CHECKED CDJ	CHECKED

City of Fort Collins

ICON ENGINEERING

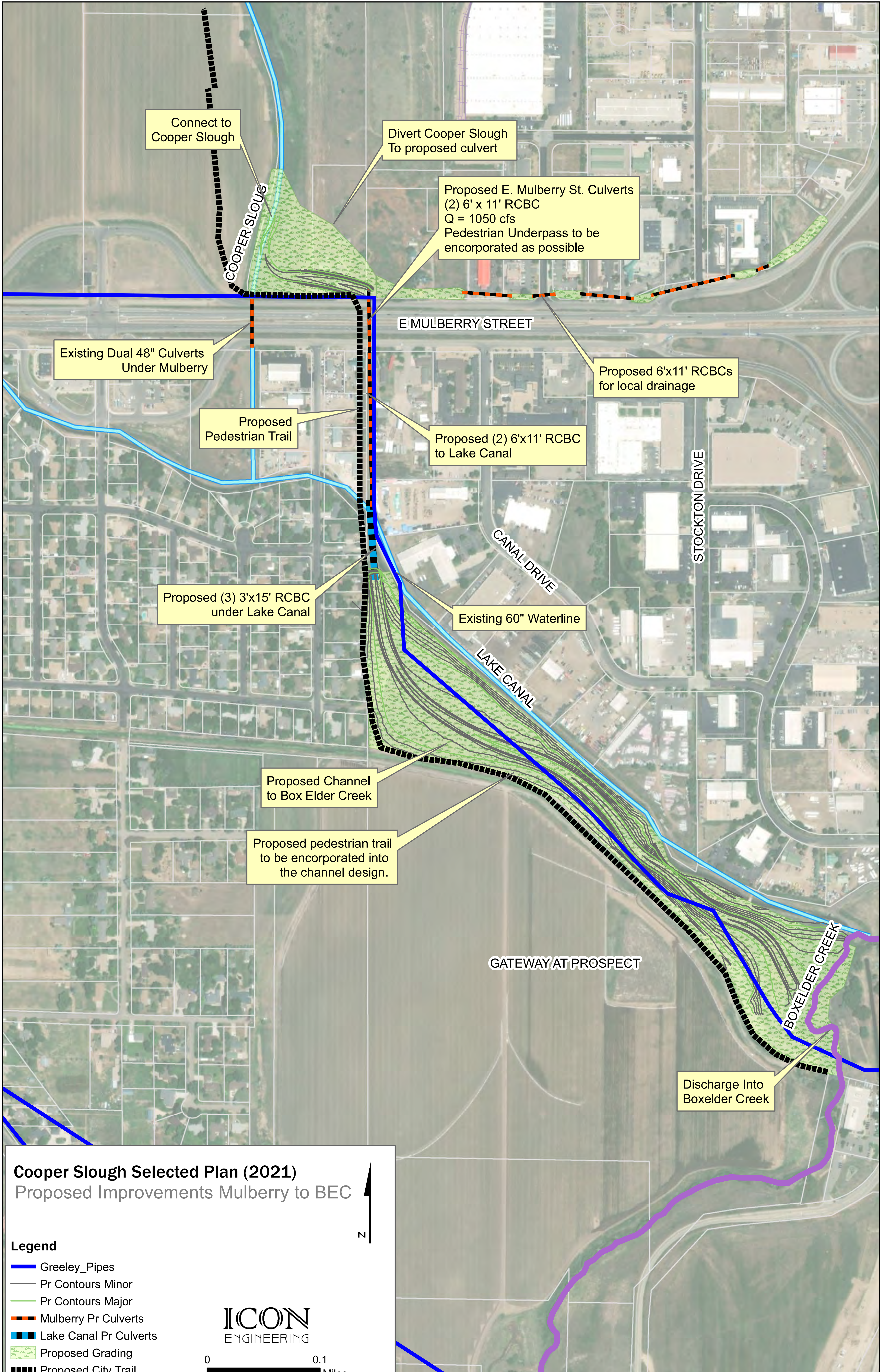
COOPER SLOUGH ALTERNATIVES ANALYSIS UPDATE
PROPOSED MULBERRY ST (SH-14) CROSSING
CITY OF FORT COLLINS UTILITIES

ICON PROJECT No. 16010UCS

DATE 10/11/2021

SHEET MUL01

Improvements Downstream of Mulberry


Connect to Cooper Slough
Divert Cooper Slough To proposed culvert
Proposed E. Mulberry St. Culverts
(2) 6' x 11' RCBC
Q = 1050 cfs
Pedestrian Underpass to be encorporated as possible
COOPER SLOUG
E MULBERRY STREET
Existing Dual 48" Culverts Under Mulberry
Proposed 6'x11' RCBCs for local drainage
Proposed Pedestrian Trail
Proposed (2) 6'x11' RCBC to Lake Canal
STOCKTON DRIVE
CANAL DRIVE
Proposed (3) 3'x15' RCBC under Lake Canal
Existing 60" Waterline
LAKE CANAL
Proposed Channel to Box Elder Creek
Proposed pedestrian trail to be encorporated into the channel design.
GATEWAY AT PROSPECT
BOXELDER CREEK
Discharge Into Boxelder Creek
Cooper Slough Selected Plan (2021)
Proposed Improvements Mulberry to BEC
N
Legend
Greeley_Pipes
Pr Contours Minor
Pr Contours Major
Mulberry Pr Culverts
Lake Canal Pr Culverts
Proposed Grading
Proposed City Trail
ICON ENGINEERING
0
0.1
Miles

Appendix D – Ecological Assessment

WATER QUALITY AND WATERFOWL IMPACT ASSESSMENT OF COOPER SLOUGH

Prepared for:

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and

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September 10, 2005

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APPENDIX D – WILL RUNOFF FROM THE NORTH DEGRADE WATER QUALITY?
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1.0 INTRODUCTION

1.1 STUDY DESCRIPTION

The City of Fort Collins (City) is considering routing surface flows from the largely agricultural watershed to the north of the Larimer-Weld Canal (canal), which currently flow south into the canal, into Cooper Slough. The area north of the canal receives runoff from irrigated agriculture fields and the Anheuser-Busch facility. Significant development is planned for the area north of the canal. Water quality in the watershed to the north of the canal will change when the development is completed. The City is concerned about future impacts to waterfowl habitat, water quality and local waterfowl populations when these flows are diverted beneath the canal into the Cooper Slough.

Smith Environmental Inc. (SEI), as a sub-consultant to Anderson Consulting Engineers, evaluated the effects of adding runoff, from the watershed to the north of the canal, on water quality and waterfowl in the slough. To complete this evaluation SEI has:

1. Assessed waterfowl use at Cooper Slough through the identification of the slough's physical, vegetative and hydrologic characteristics;
2. Identified the proposed changes to Cooer Slough;
3. Identified mitigation/enhancement measures for waterfowl in the slough; and
4. Identified future monitoring needs.

Currently, the City has little to no surface or groundwater quality data of the slough or the watershed to the north. Concurrent with SEI's determination of impacts to water quality and waterfowl, the City plans to collect and analyze water samples from the slough in the coming months.

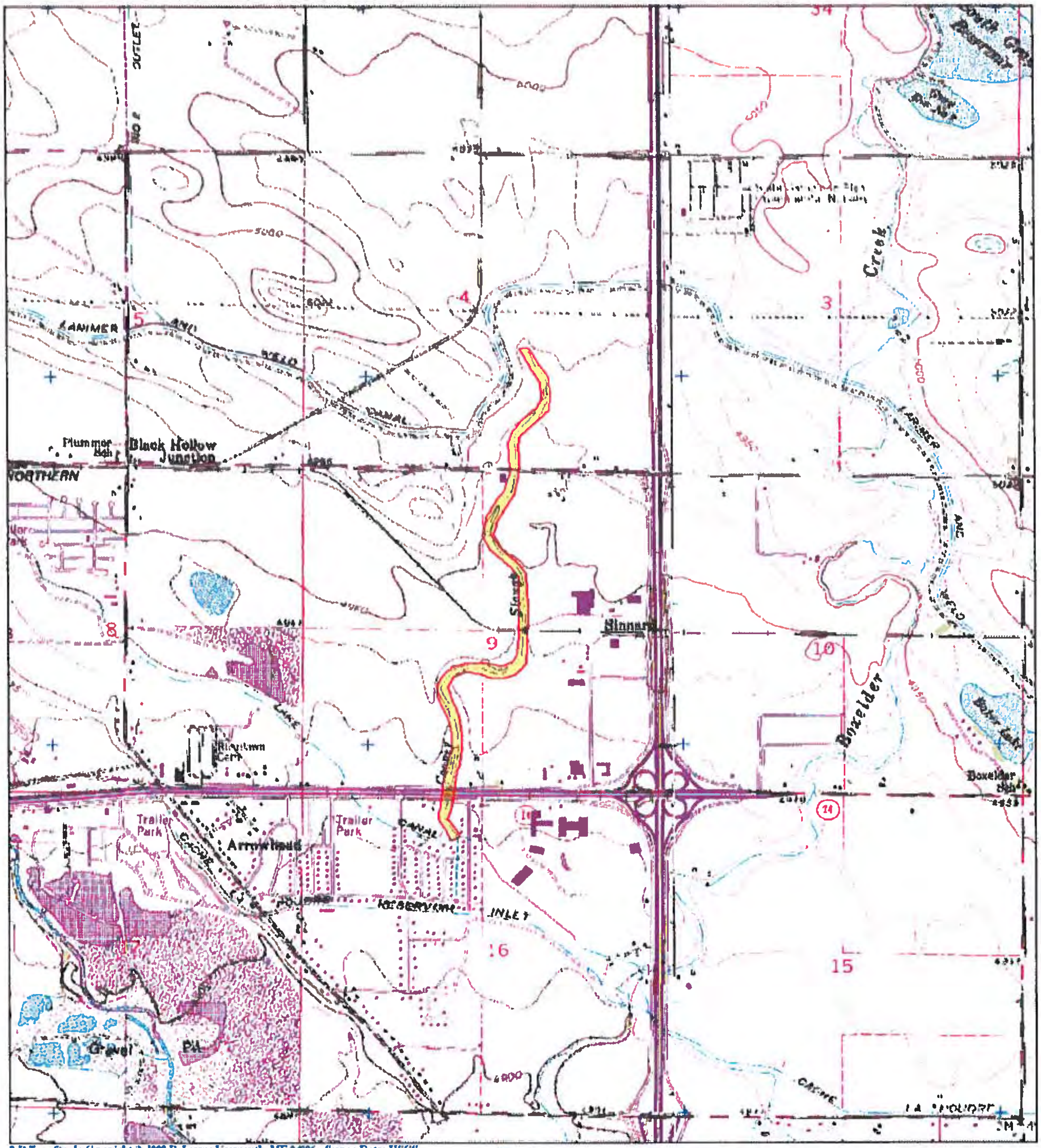
1.2 STUDY AREA DESCRIPTION

Cooper Slough is a drainage extending from north to south between the canal and the Lake Canal, south of State Highway (SH) 14, in Larimer County, northeast of the city of Fort Collins. The Cooper Slough study area occurs within the SE quarter of Section 4, Section 9, and the north half of the north half of Section 16, Township 7 North, Range 68 West, on the Fort Collins quadrangle. The study area is shown in Figure 1. The Cooper Slough study area ranges in elevation from 4,955 to 4,910 feet above mean sea level. The agricultural watershed north of the canal is several square miles, but the portion of interest to this water quality/waterfowl impact assessment is in the north half and the SW quarter of Section 4 and east half of Section 5 in Township 7 North, Range 68 West, and portions of Sections 32 and 33 in Township 8 North, Range 68 West.

1.3 METHODS

SEI reviewed a variety of literature to determine waterfowl species presence and expected baseline levels for various water quality parameters within Cooper Slough. SEI also examined various literature to determine the chronic and acute toxicity thresholds for various compounds and metals relative to waterfowl. SEI personnel made several concurrent site visits in the winter

Figure 1 – Study Area Map



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS

700 ft Scale: 1 : 24,000 Detail: 13-1 Datum: WGS84

of 2004-2005, spring of 2005 and summer of 2005 to observe the local environment, waterfowl species usage, and human use/disturbance attributes.

2.0 RESULTS AND DISCUSSION

2.1 ASSESSMENT OF WATERFOWL USE AT COOPER SLOUGH

2.1.1 Physical Characteristics of Cooper Slough

2.1.1.1 Geology

Tweto (1979) maps eolian deposits over alluvium in and around the Cooper Slough area, specifically in Sections 4, 5, 9, and 16 in Township 7 North, Range 68 West, and in Sections 32 and 33 in Township 8 North, Range 68 West. The nearest occurrence of shale bedrock (the upper unit of the Pierre shale formation) is about two miles north and west of the slough (Tweto 1979). Ihnat (1987) indicates that elevated levels of Se and Bo are common in Pierre shale. SEI believes that this bedrock is too far from Cooper Slough to be affecting the geochemistry of the soils within a one-mile radius of Cooper Slough.

2.1.1.2 Soils

The Soil Conservation Service (SCS), now the Natural Resources Conservation Service (NRCS), has mapped and characterized the soils of the Cooper Slough area and agricultural watershed to the north (SCS 1980). The SCS maps Satanta, Ascalon, Fort Collins, Nunn, Otero, Stoneham, Kim, Caruso, and Longmont soils in these two areas. Loveland soils are mapped in and bordering Cooper Slough. Caruso and Longmont soils are somewhat poorly drained and poorly drained soils, respectively; the remaining soils in the area are well drained. Except for Otero, the above soils are medium to fine textured. All the above soils are derived from eolian and alluvial material and probably overlay highly permeable, alluvial sands and gravels. Loveland soils typically form in clayey sediments derived from shale (SCS 1980), however this is not true for the Loveland soil mapped in and around the slough. Coarse alluvium underlies the Loveland soil in and around Cooper Slough. SEI has observed saline and sodic conditions of Longmont soils mapped elsewhere in Larimer and Weld counties. This is caused by a rising water table bringing salts to the surface in this area, from the deeper underlying saline and sodic alluvium. SEI has observed Loveland soils where they are not forming in material derived from shale, but forming in alluvium. Soils derived from shale are not mapped in Sections 4, 5, 9, and 16 in Township 7 North, Range 68 West, nor are they mapped in Sections 32 and 33 in Township 8 North, Range 68 West.

Site-specific chemical characterization of the soils in the Cooper Slough area does not exist, however, ranges are given by the SCS (1980) of the pH, percent organic matter (POM), electrical conductivity (EC), and sodium adsorption ratio (SAR) for the aforementioned soils. The pH ranges from 7.0 to 7.6 in the surface horizon and from 7.4 to 8.4 in subsoil horizons, except in Loveland soils, which may have pH that ranges from 7.6 to 8.8 in subsoil horizons. The POM ranges from 2-4 % in the surface horizon of these soils. The EC is typically less than 2 decisiemens/meter in surface horizon and less than 4 decisiemens/meter in subsoil horizons, except in Loveland soils, which can have an EC as high as 12 decisiemens/meter in the surface horizon and 35 decisiemens/meter in the subsoil horizons. The SAR is typically less than 2 in surface horizon and less than 4 in subsoil horizons, except in Loveland soils, which can have a SAR as high as 15 in the surface horizon and 30 in the subsoil horizons. Soils in several areas adjacent to Cooper Slough have a white crust, indicative of a high water table and saline and sodic conditions. The NRCS does not provide metals data for the abovementioned soils so it is unknown if these soils contain elevated levels of selenium (Se), boron (Bo), or other metals. Nitrogen and phosphorus fertilizers have been applied to the irrigated farmland to the north of the canal for many years. Irrigated farmland in Colorado that has been regularly fertilized for many years and has a water table above 20 ft below ground surface (highly permeable subsoil horizons above the water table) have shown an increase in nitrates (NO_3) and phosphorus (P) in the ground water.

2.1.2 Vegetation

Vegetative structure at Cooper Slough consists primarily of an herbaceous cover. Tree cover is sparse and occurs to the south of East Vine Drive. There is no tree cover to the north of East Vine Drive. With the exception of cattails (*Typha latifolia*) located south of East Vine Drive, and watercress north of East Vine Drive, herbaceous cover in the slough channel affords little in the way of shade or protective cover to support a diverse aquatic or waterfowl community. Waterfowl use of the slough for nesting is limited due to the lack of structural habitat diversity.

Cooper Slough, and the adjacent detention basins support sodic and saline-affected Palustrine Emergent wetlands. Wetland plant species observed include water sedge (*Carex aquatilis*), Nebraska sedge (*C. nebraskensis*), Baltic rush (*Juncus arcticus*), three-square bulrush (*Schoenoplectus pungens*), softstem bulrush (*Scirpus palidus*), rabbit-foot grass (*Polypogon monspeliensis*), alkaligrass (*Puccinellia aroiides*), alkali sacaton (*Sporobolus airodies*), inland saltgrass (*Distichlis stricta*), reed canarygrass (*Phalaroides arundinacea*), prairie cordgrass (*Spartina pectinata*), foxtail barley (*Hordeum jubatum*), alkali muhly (*Muhlenbergia asperifolia*), showy milkweed (*Asclepias speciosa*), smartweed (*Periscaria* sp.), curly dock (*Rumex crispus*), watercress (*Nasturtium officinale*), and others. Cattails (Typha sp.) are especially prevalent in, and adjacent to, areas of ponded water throughout the slough, and form an expansive monoculture south of East Vine Drive. Plant species in upland areas adjacent to the slough include tall wheatgrass (*Thinopyrum ponticum*), inland saltgrass, smooth brome (*Bromopsis inermis*), white clover (*Melilotus alba*), annual sunflower (*Helianthus annus*), kochia (*Kochia scoparia*), field bindweed (*Convolvulus arvensis*), Canada thistle (*Cirsium arvensis*), flixweed (*Descurania sophia*), and others. Tree cover adjacent to the slough is sparse and consists of plains cottonwood (*Populus deltoides*) and Russian olive (*Elaeagnus angustifolia*).

2.1.3 Hydrology

The hydrology of the Cooper Slough has been, and continues to be influenced by the presence of irrigation ditches, railroads, roads, irrigated fields, and industrial, commercial and residential development (Anderson Consulting Engineers 2002). Water appears to discharge into the slough from four locations along the canal (Anderson Consulting Engineers 2002). Groundwater flows into the slough and daylights at several small springs at the upper end (headwaters) of the slough about 0.4 miles north of East Vine Drive and 0.2 mile south of the canal. This water flows south toward East Vine Drive, and flows are supplemented by flow from several culverts and swales along the way. These culverts and swales north of East Vine Drive provide surface water flows into the slough from residential subdivision detention ponds on both sides of the slough in response to rain and snow events, and general urban runoff. The water is culverted under East

Vine Drive and the drainage has been channelized, for approximately 100 yards south of East Vine Drive. South of this channelized area, the drainage is characterized by flatter topography and a somewhat more natural meandering flow. The portion of the slough from East Vine Drive to SH 14 receives limited surface runoff from irrigated agricultural fields that border the slough. Water flows are partially dammed by the Burlington Northern railroad tracks in the middle of Section 9, halfway between East Vine Drive and SH 14. The water flows under the railroad tracks. Surface flows continue south toward SH 14 and appear to have less volume as the slough approaches SH 14, apparently becoming ephemeral at certain times of the year (Knight Piesold 2002b). The remaining flows pass under SH 14 and its northern frontage road, continuing south through a channelized, weed-choked portion of the slough. Flows in the slough's southern terminus pass into an elevated inlet structure, which conveys flow into the Lake Canal. The Lake Canal flows into Boxelder Creek the Cache la Poudre River.

The hydrology of the agricultural watershed to the north is driven by the irrigation water. Numerous lateral ditches and irrigation return flow ditches characterize this watershed. Irrigation return flow and flow from the No. 8 Ditch empty into the Larimer and Weld Canal. Irrigation return flow typically is high in Total Dissolved Solids (TDS).

2.1.3.1 Water Flow

Water flow in Cooper Slough was observed to be approximately 0.5 to 1.0 cubic feet per second during on-site visits by SEI personnel in the winter of 2004-2005 and summer 2005. As the agricultural watershed to the north is urbanized and the farmland runoff into the slough becomes a mixture of urban and farmland runoff, the portion of total flow in the slough from groundwater could decrease due to reduced agricultural return flows into the Larimer-Weld Canal. This loss could be offset, however, by groundwater recharge from urban landscape irrigation. For example, the City of Thornton, Colorado receives return flow credits by the state for lawn irrigation returns to groundwater (Jensen 2005). As with agricultural return flows, urban return flows are seasonal. Currently, the canal runs only from May to August and only when there is enough water for crops. The canal does not contain water year round (Varra 2005).

2.1.3.2 Water Temperature

Cooper Slough has historically been known to be a warm water slough that does not freeze over in winter months (Ringelman 1993). It does not freeze in winter because it is fed primarily by groundwater.

The Colorado standard (CDPHE 2004a) for acceptable surface water temperature fluctuations in the South Platte Basin, in regards to protecting aquatic life, is as follows: "Temperatures shall maintain a normal pattern of diurnal and seasonal fluctuations with no abrupt changes and shall have no increase in temperature of a magnitude, rate and duration deemed deleterious to the *resident aquatic life*. Generally, a maximum 3 degree C increase over a minimum of a four-hour period, lasting 12 hours maximum is deemed acceptable for discharges fluctuating in volume or temperature."

2.1.3.3 Water Chemistry

The effect of any toxin on waterfowl may be altered by variations in water hardness, pH (acidity/alkalinity), and dissolved oxygen content. Water hardness, for example, causes such great variation in the toxicity of various elements that they must be calculated by mathematical formulas, rather than "fixed" or "standard" values. This is especially true with most metals and metal-like elements (USDI 1998). Typically, increasing water hardness decreases the toxicity of metals (EPA 2002).

2.1.4 Current Waterfowl Use

SEI personnel observed use of the slough by the following waterfowl or shorebirds during winter 2004-2005, and spring and summer 2005:

- Mallard (*Anas platyrhynchos*)
- Canada Goose (*Branta canadensis*)
- Killdeer (*Charadrius vociferus*)
- Common Snipe (*Gallinago gallinago*

SEI personnel observed use of the slough by other avian species during these same periods:

- Red-winged Blackbird (*Agelaius phoeniceus*)
- Rock Dove (*Columba livia*)
- Western Meadowlark (*Sturnella neglecta*)
- House Sparrow (*Passer domesticus*)
- House Finch (*Carpodacus mexicanus*)
- Northern Flicker (*Colaptes auratus*)

During these site visits SEI personnel also observed mallards and Canada geese using the detention pond areas adjacent to the slough. These observations confirm those made by previous studies (Knight Piesold 2002a, 2000b; Flick *et al.* Undated; Cedar Creek Associates, Inc. 2000). Ringelman (1993) observed migrating waterfowl use in the slough during winter months for foraging and roosting; as it provides flowing water at a time when other nearby water bodies are frozen over.

Species of waterfowl that could potentially use the resources provided by the slough include:

- Blue-winged Teal (*Anas discors*)
- Green-winged Teal (*Anas crecca*)
- Northern Pintail (*Anas acuta*)
- Cinnamon Teal (*Anas cyanoptera*)
- Northern Shoveler (*Anas clypeata*)
- Gadwall (*Anas strepera*)
- American Wigeon (*Anas americana*)
- Canvasback (*Aythya valisineria*)
- Redhead (*Aythya americana*)
- Ring-necked Duck (*Aythya collaris*)
- Lesser Scaup (*Aythya affinis*)
- Common Goldeneye (*Bucephala clangula*)
- Bufflehead (*Bucephala albeola*)

- Ruddy Duck (*Oxyura jamaicensis*)
- American Coot (*Fulica americana*)
- Hooded Merganser (*Lophodytes cucullatus*)

SEI personnel observed several shotgun shell casings along the portion of Cooper between Vine Drive and Colorado Highway 14, which appears to indicate the slough's use for waterfowl hunting.

There is little structural diversity in vegetation in Cooper Slough; therefore, shade and protective cover are insufficient to support a variety of nesting species. Overall, the quality of waterfowl habitat in the slough is better than other wetlands, however because there is little structural diversity in the vegetation, the waterfowl habitat is not as exceptional as it could be. The quality of waterfowl habitat provided by Cooper Slough also depends upon the season. Habitat is better in the spring and summer, than the winter, however, there is some waterfowl use at Cooper Slough in the winter months because of the "warm-water" conditions.

2.1.4.1 Invertebrates and Other Species

When SEI personnel visited Cooper Slough in winter 2004-2005 and early spring 2005, the slough appeared to have little diversity of aquatic invertebrates. Common water striders (*Gerris remigis*) and two crayfish (*Cambarus diogenes*) were noted during an April field survey. As there are no existing surface water connections to either the Larimer and Weld Canal or the Lake Canal, SEI believes that the crayfish observed might have been introduced to the slough, possibly by children playing in the Larimer and Weld Canal, where SEI personnel also observed crayfish occurrence. Fish were not observed in the slough during any of the surveys. SEI believes that the lack of upstream and downstream surface water connections likely precludes the presence of fish within the slough. The slough is undoubtedly used by other mammal and herpetofaunal species that were not observed during site visits. The slough's macroinvertebrate species are more plentiful and diverse in the summer, when emergent vegetation is also more abundant.

2.1.5 Evaluation of Water Quality Data as it Affects Waterfowl

The City of Fort Collins collected water samples at two points along Cooper Slough in the late winter of 2005. One sampling point (Point #1) is near the headwater of Cooper Slough where groundwater daylights into the slough. The second sampling point (Point #2) is just north of Vine Drive, and is presumably impacted by water-cooling, human disturbance (supplemental culverts), and other factors. The results of this sampling and laboratory analyses are presented in the four right columns of Table 1. After four sampling efforts, data for various water quality parameters have either not been generated, or their analyses are still pending. Therefore, the results of these tests provide a very limited glimpse of water quality in the slough. SEI has been unable to locate historical records of water quality data for Cooper Slough.

Data in Table 1 were considered in this waterfowl assessment. Water quality parameters presented can affect waterfowl directly, or affect some component of their habitat (e.g., growth or abundance of plant or invertebrate species and populations). This water quality parameter list is not all-inclusive, but represents the most common or likely–occurring harmful agents. Table 1

Table 1 – Water Quality Data and Waterfowl Suitability Limits for Cooper Slough

Parameter	UNITS	Chronic Waterfowl Toxicity Value	Acute Waterfowl Toxicity Value	City of Fort Collins Cooper Slough Sample Site #1 (2/28/2005)	City of Fort Collins Cooper Slough Sample Site #1 (3/29/2005)	City of Fort Collins Cooper Slough Sample Site #2 (2/28/2005)	City of Fort Collins Cooper Slough Sample Site #2 (3/29/2005)
Ammonia (NH_4)	mg/L	N/A[4]	N/A	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic (As)	mg/kg	N/A	17.4 – 47.6 mg/kg body weight[11]	N/A	N/A	N/A	N/A
Base Flow Discharge	cfs	N/A	N/A	0.26	0.22	2	1.96
Boron (B)	mg/kg	100 mg/kg fresh weight[9]	1,000 mg/kg dry weight[12]	N/A	N/A	N/A	N/A
Cadmium (Cd)	mg/kg	>20[15]	>100[15]	N/A	N/A	N/A	N/A
Chromium (Cr) (III and IV)	ug/L	>30[15]	N/A	N/A	N/A	N/A	N/A
Dissolved Copper (Cu)	mg/kg	>200 mg/kg[8]	N/A	N/A	N/A	1.8 ug/L	N/A
Dissolved Oxygen	mg/L	N/A[3]	N/A	6.4	9.3	5.7	6.8
Dissolved Selenium (Se)	mg/kg	>3 mg/kg Fresh weight[9]	≥ 20[10]	N/A	N/A	N/A	N/A
Escherichia coli	cfu	N/A[2]	N/A	17	8.7	10	5.3
Hardness (as CaCO3)	mg/L	N/A	N/A	1800	2200	1470	1600
Iron (Fe)	ug/L	N/A	N/A	N/A	N/A	N/A	N/A
Lead (Pb)	mg/kg	2.8 mg/kg body weight[15]	50 mg/kg body weight[15]	N/A	N/A	N/A	N/A
Mercury (Hg)	mg/kg	>0.5 mg/L diet 6 mg/L wet weight[14]	> 10 mg/L diet >20 mg/L organ tissues[14]	N/A	N/A	N/A	N/A
Nitrite (NO_2)	mg/L	N/A[5]	N/A	< 0.1	< 0.1	< 0.1	< 0.1
Nitrate (NO_3)	mg/L	N/A[5]	N/A	9.83	9.03	8.24	8.41

Parameter	UNITS	Chronic Waterfowl Toxicity Value	Acute Waterfowl Toxicity Value	City of Fort Collins Cooper Slough Sample Site #1 (2/28/2005)	City of Fort Collins Cooper Slough Sample Site #1 (3/29/2005)	City of Fort Collins Cooper Slough Sample Site #2 (2/28/2005)	City of Fort Collins Cooper Slough Sample Site #2 (3/29/2005)
Organic Phosphorus (P)	mg/kg	0.5[6]	3-4[6]	< 0.005	< 0.005	< 0.005	< 0.005
pH	S.U.	N/A[1]	N/A	N/A	N/A	N/A	N/A
Total Copper (Cu)	mg/kg	>200 mg/kg[8]	N/A	N/A	N/A	1.9 ug/L	N/A
Total Keljal Nitrogen (TKN)	mg/L	N/A	N/A	0.36	0.17	0.43	0.15
Total Dissolved Solids (TDS)	mg/L	N/A	N/A	2588	N/A	2216	N/A
Total Phosphorus (TPHOS)	mg/kg	0.5[6]	3-4[6]	0.01	N/A	<0.01	N/A
Water Temperature	°C	N/A	N/A	11.3	9.4	9.1	9.2
Zinc (Zn)	mg/kg	N/A	740 mg/kg body weight[7]	N/A	N/A	N/A	N/A

N/A = value not available S.U. = pH Standard Unit

[1] pH levels recommended for waterfowl between 6.5 and 8.5 (EPA 2005)
[2] Toxic effects to waterfowl are known (Wildpro 2005), but toxicity threshold levels are not known.
[3] Not known to adversely affect waterfowl directly, but has adverse impacts to various aquatic life at differing concentrations. Recommended by the EPA (1986) to be maintained at >5.0 mg/L for fish populations.
[4] Levels of adverse effect to waterfowl not found in available literature. Chronic and acute values vary widely for aquatic invertebrates and fish species, and are listed by the EPA (1986); they are 0.0017-0.612 mg/L and 0.083-4.60 mg/L, respectively.
[5] Chronic values for warm water fish species - listed by the EPA (1986) as >90 mg/L.
[6] Per Hoffman et al. (2003) as white phosphorus (P4). Recommended standard for phosphate (PO_3) is ≤ 25 ug/L.
[7] Listed value from Eisler (2000b). Both Eisler (2000b) and the U.S. Department of the Interior (1998) cite an acute toxicity threshold for zinc in mallard diets of >2,500 mg/kg.
[8] Listed value from the U.S. Department of the Interior (1998).
[9] Listed value from Eisler (2000b)
[10] Listed value from the U.S. Department of the Interior (1998).
[11] Listed value from Eisler (2000b). Other literature (Irwin 1997) suggests a chronic toxicity value for mallards of 205 mg/kg, indicating that these values may be higher than the listed value)
[12] Listed value from Eisler (2000a) and the U.S. Department of the Interior (1998).
[13] Listed value from Eisler (2000a). Eisler (2000a) also lists a chronic toxicity threshold for Chromium $^{6=}$ as > 10ug/L.
[14] Listed values by Wayland (1999). Eisler (2000a) presents chronic toxicity values ranging from 50 to 500 ug/kg (diet) and 2.2-23.5 mg/kg (body weight).
[15] Listed value from Eisler (2000a)

includes various "standard" water quality parameters in the left columns, such as water hardness, total dissolved solids, temperature, pH, dissolved oxygen. Table 1 also includes the water quality standards for bacteria *Escherichia coli* (*E. coli*), ammonia (NH_4), nitrite (NO_2), nitrate (NO_3), Total Kjeldahl Nitrogen (TKN), and organic and total phosphorus (TP), zinc (Zn), copper (Cu), Se, arsenic (Ar), Bo, cadmium (Cd), chromium (Ch), iron (Fe), lead (Pb), and mercury (Hg). Some of these elements are essential for waterfowl life (e.g., Zn, Cu and Se), and may result in harmful effects if waterfowl have a deficiency or critical excess of these elements. Some are not required for life (e.g., Pb, Hg, Cd) and can have harmful effects, even at low concentrations. SEI generally lists the most restrictive values presented in available literature for evaluation purposes.

City-generated water quality data for the slough (Table 1) suggest current water quality conditions do not pose a problem or indicate a threat to waterfowl species that use the slough. None of Cooper Slough water quality data exceed waterfowl-sensitive water quality standards. Furthermore, SEI believes that if ground water flows in the upper reaches of the slough or farmland runoff in the lower portions of the slough were having an adverse impact on waterfowl that it would have been discovered by now, since farming has been gong on for over 100 years and ground water (the primary source of water to the slough over the last 100 years) has been getting recharged by the irrigation in the farmland and by the seepage in the canal.

2.2 PROPOSED CHANGES TO COOPER SLOUGH

2.2.1 Drainage System and Hydrology

Conversion of land from agricultural/rangeland to urban usage decreases the imperviousness of watersheds and alters ecosystem functions. In Colorado's high plains, urbanization results in increased rates and volumes of storm runoff, increased runoff events, increased pollutant loads, and decreased biological integrity of receiving waters (Urbonas 2003).

Urbonas (2003) estimates that conversion of a tract of Colorado's high plains rangeland to residential use increases runoff volume by 700%, runoff events by more than 3000% and total suspended solids loads by more than 500%. Small particle total suspended sediments (less than 60 micro grams) are harmful to receiving water macroinvertebrate species (Urbonas 2003). The result of these changes is downstream channel enlargement and reduced habitat diversity.

Conversion of agricultural land to residential can also contribute to an increase in temperature and nutrients, which may shift the structure (i.e., species composition and abundance) of the aquatic invertebrate and plant communities. Runoff with fertilizers and warmer flows within the slough may result in the undesirable proliferation of algae, which would lower dissolved oxygen levels, adversely affecting various trophic levels in the slough.

When agricultural runoff is initially piped to the slough beneath the canal and flow in the slough increases, it is expected that TDS, dissolved and total P and nitrates, will increase with agriculture flow. SEI believes that the overall balance of chemicals (urban versus agricultural) may change slightly. SEI believes that concentrations of sediment, heavy metals, fecal coliform bacteria, petroleum hydrocarbons, oils, soaps and synthetic detergents, and other chemicals from urban runoff may increase, unless detention ponds effectively treat/filter all urban runoff. Water that is not treated in the detention pond would presumably, be filtered out by various organisms or settle in soils and sediments along the slough. The remainder would likely remain in the water column, potentially affecting environments downstream of the slough. The types and amounts of these future contaminants would determine their behavior within the environment (e.g., toxicity, duration of persistence, potential for bioaccumulation, etc.). Pesticide and fertilizers have historically been applied to agricultural areas adjacent to Cooper Slough and have probably caused an increase in NO_3 and P levels. It is speculative to address potential changes to parameter values as they pertain to proposed development in the watershed north of the slough. It seems reasonable that current levels of pesticides, herbicides and fertilizer will decrease to varying extents. It remains to be seen whether this potential decrease will be offset by the addition of the chemicals from increased urban runoff.

2.2.2 Waterfowl Impact Assessment

The absence of water quality data for irrigated farmland return flow makes assessing future hazard to waterfowl in the slough, based on water quality data, very difficult to assess. Despite the scarcity of data, however, it appears that the extremely high water hardness and TDS levels would likely reduce the toxicity of metals are present in the water within the slough.

As areas to the north are developed and greater amounts of surface runoff enter the slough, winter water temperatures could become cooler. This could lead to occurrences of freezing water in the slough, which would reduce suitability of habitat for winter use by waterfowl.

Since flows in the upper part of the slough originate from groundwater, SEI believes that ambient levels of various metals (Ar, Cd, Cr, Se, Bo, Fe, Pb) are fairly low. The principal metals of concern to waterfowl are Se, Bo, Ar, and Cd, due to their possible occurrence in the Pierre shale two miles north and west of the slough. To date, no data (current or historical) are available to SEI to demonstrate that Se or other metals pose a problem within the slough. Future dissolved Se water quality data will be helpful in furthering answering the question of whether future Se levels create an adverse environmental to waterfowl.

Based on the experience in Thornton where groundwater discharge increased when subdivisions were built, the flow in the slough will probably change as the groundwater flows increase and the surface water flow increases and is more frequent. An increase in groundwater discharge into the slough could compensate for the additional surface water runoff and may keep the upper reaches of the slough in its current "warm-water" condition (e.g., ice-free through portions of the winter) in the upstream portions of the slough. This would allow continued migratory and winter use by waterfowl species than have been historically observed in the slough.

SEI believes that there will be impacts to the waterfowl and its habitat in the slough as a result of the diverting irrigation return flows and future subdivision runoff into the slough. These impacts, however, are expected to be mild, assuming the groundwater flows increase and maintain somewhat of a warm-water condition. Waterfowl impacts associated with increased surface flows resulting from adding irrigation return flows or subdivision runoff to the slough, could be significant, however if Best Management Practices (BMPs) are required of both the irrigation return flows or subdivision runoff, impacts should be reduced.

2.3 MITIGATION MEASURES

Negative impacts to the Cooper Slough stream channel could be mitigated by the use of BMPs. Effective Best management Practices (BMPs) will reduce the runoff volumes and rates of flow as well as total suspended sediments that could enter the slough. BMPs include grass swales, grass buffer strips, porous landscape and pavement detention areas, and extended detention basins. Mitigation of sediment accumulation to the slough should be of particular concern during construction phases of residential areas to the north of the slough. One potential drawback to detention basins is that they could become breeding grounds for mosquitoes if holding times exceed 72 hours (Urbonas 2003). Other recommendations include:

- The City of Fort Collins should verify the existence of the 2.95 cubic feet/second water right (Varra 2005) on the slough. Any changes to the slough that may potentially impact this water right must be taken into consideration.

- Water quality and stream bank integrity can be preserved or enhanced by adhering to stormwater runoff guidelines put forth by the CDPHE (1994, 2003), the Colorado Department of Transportation (1999), and the Urban Storm Drainage Criteria Manual volume 3, Urban Drainage and Flood Control District (1999). The Urban Storm Drainage Criteria manual contains detailed planning and design specifications for Best Management Practices that are effective for use in Colorado.

- Stream bank stabilization measures should be considered in Cooper Slough to reduce erosion from increased runoff events (Urbonas 2003).

- Implement public education opportunities for the citizens of Fort Collins (especially for adjacent residents) on the environmental importance of the slough. Public education will make residents aware of pesticide and fertilizer use and pet waste impacts to the receiving waters of the slough. An effective education program will enable residents to make better choices when applying chemicals to their lawns, which can reduce the potential pollutant load to Cooper Slough.

2.4 FUTURE MONITORING

SEI recommends formal, quarterly monitoring of waterfowl and other related characteristics in Cooper Slough north of Vine Street to confirm absence or presence of unique waterfowl/shore birds and/or habitat. SEI waterfowl shore bird observations recorded herein should be added these formal observations. Other characteristics to record during the quarterly monitoring include presence of feeding, roosting, loafing, or nesting birds. If nests are present, determine if they are non-active or active. During all monitoring periods, observations should be completed four times each in the morning, evening, and mid day. Spring observation periods should be from late March to mid May, and fall observation periods should be from late August to mid October. During the summer, species observations should be made before and during the fledgling period (late May – mid August). During the winter, species observations should be made opportunistically on a warm day (>60 degrees F), cold day (< minus 15 degrees F), snowing day, and the day after a heavy snow.

In regards to future water quality sampling, SEI recommends one more sampling location downstream and one above the canal in the irrigation return flow going into the canal. Data accuracy and validity would be considerably enhanced by the collection of water quality data within the slough over a period of several years. To gain a clearer picture of water quality and potential waterfowl impacts within and immediately adjacent to the slough, SEI recommends analyses for the parameters mentioned in Regulation 31, Total Petroleum Hydrocarbons (TPH), pesticides used most commonly on agricultural and residential lands, and the following metals (at least one time to verify their absence): Ar, Cd, Cr, Se, Bo, Fe, Pb. Future dissolved Se water quality data will be very helpful in furthering answering the question of whether future Se levels create an adverse environmental to waterfowl.

Other data would be helpful in assessing the overall condition of the slough. It is recommended this monitoring be completed on a quarterly basis and include sediment aggradation or degradation measurements; vegetation species and abundance both in and around the slough; loss or gain of wetlands or a change in type; detailed field notes and data on substrate conditions; and macro invertebrate species and abundance.

3.0 SUMMARY

Smith Environmental Inc. (SEI), as a sub-consultant to Anderson Consulting Engineers, has evaluated the effects of adding runoff from the watershed to the north of the Larimer and Weld Canal on waterfowl and its habitat within the Cooper Slough. The evaluation was completed to assist the City of Fort Collins in making informed land zoning and use decisions. To complete this evaluation, SEI completed the following tasks: 1) Assessed waterfowl use at Cooper Slough through the identification of the slough's physical, vegetative and hydrologic characteristics; 2) Identified the proposed changes to Cooer Slough; 3) Identified mitigation/enhancement measures for waterfowl in the slough; and 4) Identified future monitoring needs.

City-collected water quality data for the Cooper Slough does not appear to indicate a threat to waterfowl species that use the slough. Despite the scarcity of these data, SEI believes that the extremely high water hardness and dissolved solid levels (i.e., hard water) may reduce the toxicity of metals present to waterfowl within the slough. The principal metal of concern is Se, due to its known occurrence in natural formations in and around the Fort Collins area and adverse affects to waterfowl. To date, no data (current or historical) are available to SEI to demonstrate that Se or other metals pose a problem within the Cooper Slough.

To gain a clearer picture of water quality and potential waterfowl impacts within the Cooper Slough, more parameters and sampling locations should be included in future water quality analyses. At least four sampling locations should be used along the length of the slough to maximize statistical accuracy and validity, and to show the impacts of various human uses and features along the slough.

SEI believes groundwater flows will increase as the surface water flow will also increases and become more frequent in the upper reaches of the slough. The slough should remain in more of a "warm-water" condition (e.g., ice-free through portions of the winter). This may potentially allow slightly more migratory and winter use by waterfowl species than has been historically observed in the slough. Significant increases waterfowl usage and significant increase in waterfowl habitat will not occur, however, because of the poor structural diversity in vegetation and narrowness of the channel in the slough.

SEI believes that there could be adverse impacts to the waterfowl and its habitat in the slough as a result of the diverting both irrigation return flows and future subdivision runoff into the slough. These impacts, however, are expected to be mild, assuming the groundwater flows increase and maintain somewhat of a warm-water condition. Waterfowl impacts associated with increased surface flows to the slough, could be significant, however, if BMPs are required of the irrigation return flows or subdivision runoff, impacts should be reduced considerably.

SEI recommends formal, quarterly monitoring of water, waterfowl habitat and other characteristics in Cooper Slough north of Vine Street, to confirm absence or presence of unique waterfowl/shore birds and/or habitat.

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APPENDIX A – EFFECTS OF CHEMICAL PARAMETERS ON WATERFOWL

The majority of adequate environmental toxicology data fails to clearly define toxicity threshold values of compounds and metals relative to waterfowl. This lack clarity is attributed to a broad spectrum of factors. The sum of these problematic nuances result in the formation an incomplete (and often uncertain) database by which to determine chemical effects and toxicity thresholds for waterfowl. Therefore, SEI has attempted to extract these values as accurately as the existing literature allows.

INTERPRETING TOXICOLOGICAL DATA

This section describes some of the better-known factors that may complicate the interpretation of toxicity data. Much of this information has been adapted from a thorough review published in the *National Irrigation Water Quality Program Information Report No. 3* [U.S. Department of the Interior (USDI) 1998].

Inconsistencies in Water Quality Parameter Definitions, Field Sampling and Laboratory Analysis Protocols

The comparability of environmental toxicology data proves difficult for numerous reasons. Field sampling methods and technologies are constantly changing. There are innumerable different "standard methods" that have been published by the Environmental Protection Agency (EPA), other federal agencies, state agencies, municipalities, and various private groups. There is a lack of agreement on standard ways of defining many water quality parameters. As a result, there is no single nationally accepted standard for field sampling or laboratory analyses protocol. Oftentimes, the sampling and analyses of water quality parameters are a combination of various standard protocols and impromptu "improvements" designed to fit the needs of the sampling agency or individual researcher. Different organizations may collect data using identical or standard methods, but identify them by different names, or use the same name for data collected by different methods. The degree of variation in sampling methods and analyses produces results that vary widely, and are occasionally contradictory. Therefore, it is the exception, rather than the rule, that water quality data can be compared on a scientifically sound basis (EPA 1986, USDI 1998).

Confusion About Measurements

Chemical concentrations in plants, animals, soil, sediment, and water are measured in various ways, and there is even greater variety in the way these measurements are expressed. Concentrations in any solid medium (such as organic tissues, sediment, or animal feed) may be measured on a dry-weight (DW) or wet-weight (WW) basis. The resulting values are markedly different, and the DW value is invariably higher. In fish and animal tissues, the DW value is typically three to five times higher than the WW value, but there is no set conversion factor. The ratio between DW and WW depends on the water content of the tissue, which varies between species and between organs, and even varies within individual organs over time. Criteria based on WW should not be used to assess the toxicity of DW concentrations and vice versa (USDI 1998).

"Fresh weight" describes a wet-weight measurement that is made either in the field or within a few hours after collection. Media such as eggs and animal tissue may begin losing water as soon as they are collected, which results in higher WW concentrations of most other constituents if they are not analyzed promptly (USDI 1998).

Many chemical elements have two or three different valences or oxidation states that are common in the environment, and the toxicity of these varying forms can differ greatly. Some sampling protocols do not differ between these different forms of the same element, grouping them as a "total" concentration of the element (USDI 1998).

Even where the valence state does not vary, the various compounds an element makes with other elements can greatly affect toxicity (e.g., dimethyl mercury is more toxic than inorganic mercury). It is common for organic (carbon-based) compounds to be more toxic than others because they are readily adsorbed by the intake and metabolic processes of living organisms (USDI 1998).

Concentrations of elements or compounds in water may be measured in two different ways. Under one method, water samples are filtered before analysis to remove all microorganisms and other suspended particles. The resulting measurement is called a *total dissolved* concentration. In the other method, no filtering is done, and the resulting measurement is a *total recoverable* concentration. The difference between these figures can be strongly influenced by the overall biotic productivity of a water body. Nutrients and toxins are quickly taken up by microorganisms in highly productive waters, leaving only small amounts of nutrients and toxins dissolved in the water column, and available through the food chain. Where productivity is low, the dissolved concentration will be very close to the total recoverable concentration (USDI 1998).

Unnatural Laboratory Settings

Most laboratory studies test toxicity under completely unnatural conditions. They most commonly test the effect of a single compound on a single waterfowl species, delivered by only one pathway under carefully controlled conditions. In the wild, waterfowl are exposed to many different chemical and physical agents simultaneously.

Generally, laboratory specimens in an experimentally contaminated environment are given food from outside, uncontaminated sources, whereas wild waterfowl must eat food that has grown in the same environment that may have bioaccumulated lethal levels of whatever toxins are present. For example, waterfowl under wild conditions could die in areas where toxin concentrations are at levels that caused no harm to laboratory specimens. Conversely, most laboratory specimens are taken from uncontaminated populations, which have no previous history of exposure to the toxin being tested. In the wild, organisms living in a contaminated environment may have acclimated or adapted to the toxin, especially if the contamination developed gradually. In this case waterfowl might thrive in areas where toxin concentrations would be lethal to laboratory specimens.

Waterfowl under laboratory conditions are rarely threatened by weather, predators or challenged by others of their own kind in mating competitions, whereas their wild conspecifics routinely deal with these conflicts, adding to the overall stress on wild animals. This often makes wild animals more susceptible to toxic effects. Conversely, the higher metabolic rates of creatures in conflict may help them dispose of toxins more readily (USDI 1998).

Interactions

The toxicity of an element or compound may be either reinforced or weakened through its interaction with other substances. In toxicology studies, such interactions are generally classified as being adversely additive, synergistic (greater than additive), or antagonistic (less than additive or even acting to neutralize one another). Synergistic relationships exist between boron and selenium, and copper and zinc, meaning that when both elements are present their toxic effect is greater (in combination) than would be expected just from adding their individual effects. Antagonistic relationships occur between arsenic and selenium, and cadmium and copper. Tests show (USDI 1998) these combinations of elements to be less toxic (in combination) than either would be by itself. The relationship between selenium and mercury, for example, is complex in that these two elements are antagonistic to each other in their effect on adult mallards and synergistic in their effect on mallard reproduction (USDI 1998).

In some cases, two substances that interact antagonistically at first may eventually become synergistic with increasing concentrations. For example, some interactions may transform a toxic compound to a less toxic, but also less soluble form. These low-solubility compounds may then accumulate in the liver, kidneys, or other bodily organs, eventually overtaxing capacity of these storage sites. Physical damage may occur to organs within waterfowl storing too many solids (USDI 1998).

Scientific understanding of bio-geochemical interactions is still rudimentary. The potential combinations of trace elements are essential infinite, and research to date has defined the additive, antagonistic, and synergistic effects of only a few simple elemental combinations. Some compounds cause toxic effects by interfering in essential chemical metabolic pathways, yet different chemical species of the same two elements may interact on different metabolic pathways and produce a completely different result. Many discrepancies appear in available literature and more research is clearly needed (USDI 1998).

Disease

It seems likely that waterfowl (individuals and populations) weakened by disease would be more susceptible to toxins and vice versa, though empirical evidence of this relationship is scarce. However, the presence of disease in a population can complicate the interpretation of which deaths and other effects are attributable to toxins and which are due to disease.

Body Condition/Nutrition

Waterfowl susceptibility to toxins may be affected not only by a shortage of food, but also by variations in the quality of food. Birds obliged to deviate from their customary diets may lack crucial vitamins, minerals, or proteins that play a role in detoxifying harmful elements and compounds (U.S. Department of the Interior 1998). Susceptibility to toxins may also be functions of age, genetics, body condition/health, metabolism, stress levels, agent ingestion pathways, duration of toxin exposure, time of year, and type or period of activity (e.g., reproduction, gestation, egg-laying, embryonic development, and growth).

Temperature

Waterfowl have optimal temperature ranges in which they function most efficiently. Outside of these ranges they will be more susceptible to toxins. Temperature fluctuations affect the rate of chemical reactions, the solubility of chemical species, and the metabolic rates of organisms. High temperatures generally increase the reaction rate and solubility of most solid substances. Many gases, however, are more soluble in cold water than in warm. The effect of temperature on metabolism depends on whether organisms are exothermic ("cold-blooded") or endothermic ("warm-blooded"). Among exotherms (including fish and invertebrates which are a food source to waterfowl), higher temperatures cause metabolic rates to rise. Endotherms, such as waterfowl, increase their metabolism at lower temperatures to maintain a constant body temperature. An elevated metabolism increases the intake of a toxin and distributes it more rapidly to sensitive organs within the body.

Sampling Biases

Interpretation of field data for plants and animals can be confounded by a sampling bias that favors "survivors". Most biological sampling techniques are designed to sample live biota. In contaminated environments, live biota represent "survivors" and, therefore, these are likely to be the organisms that were either less sensitive to a toxin, or had less exposure to it. For this reason, bird eggs are frequently sampled as they are probably less affected by this bias than other media because they are sampled without regard for the status of the embryo inside the egg. As long as the egg is intact, live and dead embryos have equal probabilities of being sampled (USDI 1998).

Off-Site Exposure

Waterfowl travel considerable distances and may be exposed to toxins at places other than the sampling site. Many bird species feed many miles from where they nest, or seasonally migrate over long distances. Therefore, adverse responses to toxins may not be attributable to local environmental factors (USDI 1998).

APPENDIX B – WATER QUALITY AND STATE USE DESIGNATIONS

Cooper Slough and surrounding areas occur within the Cache la Poudre River watershed, which is a subset of the South Platte River basin. The CDPHE (2005) indicates segments of the Cache la Poudre are directly affected by Cooper Slough. These segments include: 1) the main stem off the Cache la Poudre River from Shields Street in Fort Collins, to a point immediately above the confluence with Box Elder Creek; and 2) the main stem of the Cache La Poudre River from a point immediately above the confluence with the Box Elder Creek to the confluence with the South Platte River (CDPHE 2005).

Segments of the Cache la Poudre River system that encompass the Cooper Slough area are use-protected for the following designated uses; agriculture, recreation 2, and aquatic life 2 (cold or warm). These two segments are designated as use-protected for recreation 2, agriculture, and aquatic life warm 2. Section 13 (1) (CDPHE 2005) describes these use classifications as follows:

1. *Recreation 2—Secondary Contact*. Surface waters that are not suitable for primary contact recreation uses, but are suitable for recreational uses including but not limited to wading, fishing and other streamside or lakeside recreation.

2. *Agriculture.* Surface waters that are suitable for irrigating crops normally grown in Colorado and that are not hazardous as drinking water for livestock.

3. *Aquatic Life—General*. Surface waters with suitable conditions to support aquatic life uses. Aquatic life uses can be further classified as class 1 cold and warm water aquatic life or class 2 cold and warm water aquatic life.

    a. *Class 1 Warm and Cold Aquatic Life.* These waters currently are capable of sustaining a wide variety of cold or warm water life forms, including sensitive species. The physical habitat, water flows or levels and water quality conditions of Class 1 waters result in no impairment to the support of the abundance and diversity of species.

    b. *Class 2—Cold and warm water Aquatic Life.* These waters are not capable of sustaining a wide variety of cold or warm water life, including sensitive species, due to physical habitat, water flows or levels, or uncorrectable water quality conditions. Conditions in Class 2 waters result in substantial impairment of the abundance and diversity of species.

The wetlands in the Cooper Slough are tributary wetlands, meaning they are hydrologically connected to nearby surface waters. Tributary wetlands are protected by Section 404 of the Clean Water Act and by Regulation 31 based on the standards for the connected surface waters (CDPHE 2004); therefore, wetlands associated with Cooper Slough are also classified for the beneficial uses of agriculture, aquatic life warm 2, and recreation 2. Cooper Slough water quality data presented in Table 1 meet State standards for agriculture use, recreation 2, and aquatic life 2 (warm or cold).

SEI compared City-generated data for Cooper Slough against surface water quality standards established by the Colorado Department of Public Health and Environment (CDPHE 2004) in the Water Quality Control Commission's *Regulation No.31, the Basic Standards and Methodologies for Surface Water (5 CCR 1002-31)*. This comparison/evaluation is presented in the fourth column of Table 1. Regulation No. 31 establishes water quality standards and classifies state surface waters as prescribed by the Colorado Water Quality Control Act. The purpose of the regulation is to insure that Colorado's waters are suitable for beneficial uses such as recreation, public water supplies, agriculture and the protection of terrestrial and aquatic life.

According to Section 8(2)(b), certain Colorado waters are designated as use-protected. A use-protected water body is one in which water quality must be maintained for a specific use or combination of uses (e.g., agricultural use, recreation, aquatic life, etc.). Under Section 8(2)(b), use-protected water bodies do not require special water quality protection, such as an anti-degradation review by the CDPHE. A minimal amount of water quality degradation is permitted within use-protected waters, provided water quality degradation does not exceed a level that would interfere with or impede these designated uses.

APPENDIX C – PARAMETERS AT ISSUE WHEN CONVERTING AGRICULTURAL LAND TO URBAN USE

Water quality in streams draining a watershed is affected when agricultural land is converted to residential land. As compared to native grassland, irrigated farming activities affect TDS, suspended solid concentrations, total and dissolved P, nitrate levels and metals concentrations (if the farming is metals-rich soils/geologic material) in streams and creeks draining the farmland area. Similarly, water quality is affected by runoff from an urban area. From a nationwide survey (Horner et al. 1994), Table 2 shows the pollutant category source of urban areas and the corresponding water quality parameters that are affected. Changes to these water quality parameters should be expected when urbanization commences north of Cooper Slough.

Table 2 – Water Quality Parameters Affected By Urban Land Uses

Pollutant Category Source	Solids	Nutrients	Pathogens	DO Demands	Metals	Oils	Synthetic Organics
Soil erosion	X	X		X	X		
Cleared vegetation	X	X		X			
Fertilizers		X					
Human waste	X	X	X	X			
Animal waste	X	X	X	X			
Vehicle fuels and fluids	X		X	X	X	X	
Fuel combustion						X	
Vehicle wear	X			X	X		
Industrial and household chemicals	X	X		X	X	X	X
Industrial processes	X	X		X	X	X	X
Paints and preservatives					X	X	
Pesticides				X	X	X	
Stormwater facilities	X				X		

Source: Horner et al. 1994

Aurora and Denver conducted a study (Aurora et al. 1992) in the early 1990's to determine the water quality in flows from their residential streets. Table 3 shows the event mean concentrations (mg/l) of water quality parameters evaluated in this study. This information provides a general idea of the changes the City may expect when urbanization commences north of Cooper Slough. While a comparison of residential runoff water quality to native grassland runoff water quality is not exactly what would happen in the agricultural area north of the slough, it does give a general idea of the changes that may occur when an agricultural watershed north of the slough shifts to residential use.

Table 3 – Event Mean Concentrations (mg/l) of Water Quality Parameters In Denver Metropolitan Area Runoff

Parameter	Native Grassland	Residential
Total Phosphorus	0.4	0.65
Dissolved or Ortho-Phosphorus	0.1	0.22
Total Nitrogen	3.4	3.4
Total Kjeldahl Nitrogen	2.9	2.7
Ammonia Nitrogen	0.1	0.7
Nitrite + Nitrite Nitrogen	0.5	0.65
Lead (Total Recoverable)	0.1	0.053
Zinc (Total Recoverable)	0.1	0.18
Copper (Total Recoverable)	0.04	0.029
Cadmium (Total Recoverable)	Not Detected	Not Detected
COD	72	95
Total Organic Carbon	26	72
Total Suspended Solids	400	240
Total Dissolved Solids	678	119
BOD	4	17

Source: Aurora et al. 1992

APPENDIX D – WILL RUNOFF FROM THE NORTH DEGRADE WATER QUALITY?

At present, the water quality in the slough north of Vine Drive is driven by groundwater quality at the upper end of the slough, except during storm runoff events. This groundwater is presumably recharged by irrigation flows in the farmland north of the canal and by subsurface seepage from the canal. The percolation of farm irrigation and canal water through the soil and into the groundwater probably treats, rather than degrades this water, because of the chemical characteristics of the soil in the area.

4.1.1 Agricultural Runoff

Diverting the agricultural runoff from the north, which also contains runoff from the Anheuser-Busch facility, beneath the canal into the upper reach (north of Vine Drive) will affect water quality in the slough. Past agricultural practices have most likely added small amounts of NO_3 and P to the slough, via the ground water, however P and NO_3 were within limits for the state-designated uses (see Table 1). Bypassing the filtration effect of the soil and passing irrigated farmland runoff directly into the slough will probably increase TDS, TSS, salts levels, total and dissolved P, NO_3 levels, and possibly metals concentrations. The extent of these changes is unknown because of the lack of Cooper Slough and irrigation return flow water quality data. The other issue that will affect water quality in the slough when water is passed directly into the slough is the volume and more specifically the energy of the water that will flow down the upper reaches of the slough.

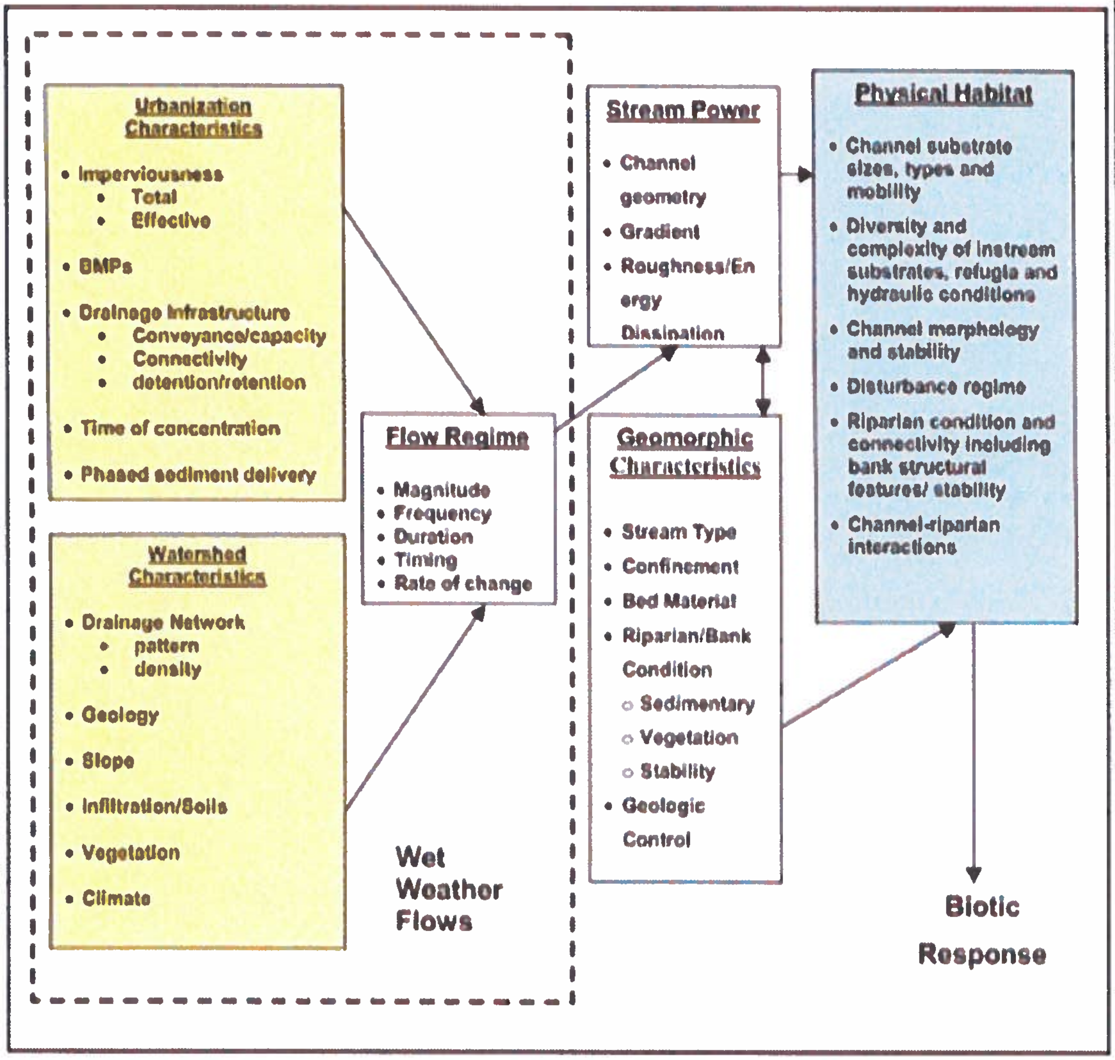
4.1.2 Residential Runoff

As the agricultural watershed to the north is urbanized, surface flow to the slough will consist of an increasingly larger amount of urban runoff and a decreasingly smaller amount of farmland runoff. Urban runoff impacts are complex as was mentioned before, including chemical, physical and biological responses. Experts have developed helpful schemes for categorizing and interrelating adverse receiving water impacts. One valuable representation is provided in Figure 2.

There are a variety of potential consequences that could arise from the conversion of existing farmland areas to urban areas. The increase in the impervious surface will increase the frequency and volume of runoff, as well as the temperature of water runoff. Even with the residential area having detention ponds, stormwater runoff could carry additional sediment, NO_3, dissolved and total P, petroleum hydrocarbons, metals, fecal coliform bacteria, oils, soaps and synthetic detergents, and other contaminants washed off of impervious surfaces. Impacts on the slough's water quality from residential runoff are also discussed in the previous section.

Anheuser-Busch has obtained a Colorado Discharge Permit (CO-0039977) from the CDPHE to discharge effluent to land application sites, shallow groundwater, and to Black Hollow Creek (CDPHE 2002). Anheuser-Busch must adhere to effluent limitations and monitoring requirements, as required by the permit. As long as effluent is being treated and applied to farmland lands in accordance with the permit, these releases should not affect the slough. If runoff from impervious surfaces surrounding the Anheuser-Busch facility is diverted to the slough, there could be resulting adverse water quality impacts from petroleum hydrocarbons.

FIGURE 2 – Interrelating Receiving Water Impacts at Cooper Slough

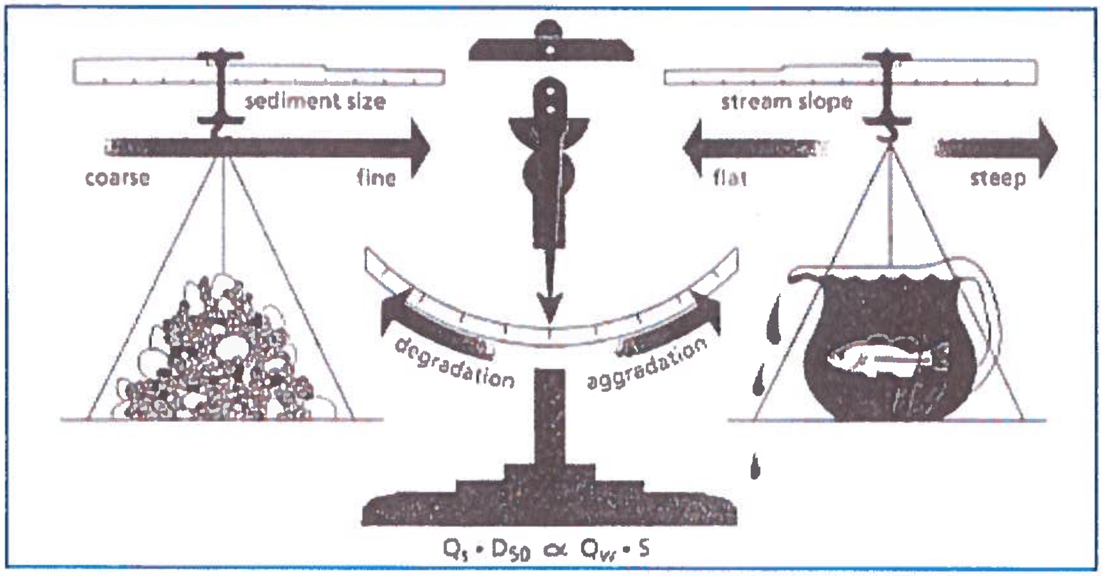


Source: Roesner, L. A. and B. P. Bledsoe. 2003. *Physical Effects of Wet Weather Flows on Aquatic Habitats*. Water Environment Research Foundation: Alexandria, VA. Co-published by IA Publishing: United Kingdom.

APPENDIX E – LANE'S BALANCE

The widely cited Lane's Balance is helpful in understanding the physical impacts of unmitigated urbanization as shown in Figure 3. The schematic demonstrates that if runoff is created as a consequence of urbanization (or adding farmland runoff), the right side of the scale will drop and the left side of the scale will rise, thus leading to channel degradation, in the absence of mitigation. By contrast, if excessive sediment is added to the stream while receiving farmland runoff, the left side of the scale drops and the right side rises, leading to aggradation (deposition of sediment in the channel).

Figure 3 – Lane's Balance



Source: Rosgen, D. 1996. *Applied River Morphology.* Pagosa Springs, Colorado: Wildland Hydrology.

When

Appendix E – Cost Estimates

Conceptual Cost Estimate

Group 1: State Highway 14/Mulberry Street Culverts

Description	Quantity	Units	Cost/Unit	Total Cost
RCBC Dual (2) 11'W x 6'H	520	LF	$ 1,325.00	$ 689,000.00
Wingwalls and Headwalls	1	LS	$ 35,000.00	$ 35,000.00
Riprap	200	CY	$ 120.00	$ 24,000.00
Waterline Protection	100	LF	$ 1,500.00	$ 150,000.00
Utility Adjustments	1	LS	$ 500,000.00	$ 500,000.00
Roadway Asphalt Patching	1019	SY	$ 80.00	$ 81,484.44
			Subtotal	$ 1,479,484.44
			Construction Contingency (40%)	$ 591,793.78
			Engineering/Project Management (20%)	$ 414,255.64
			City Project Management (5%)	$ 124,276.69
			Total	$ 2,609,810.56

Group 1: Cooper Sloug Channel Improvements upstream of Mulberry St to Mulberry Culverts

Description	Quantity	Units	Cost/Unit	Total Cost
Grading	9000	CY	$ 20.00	$ 180,000.00
Top Soil replacement and Reseed	5	AC	$ 2,500.00	$ 12,500.00
Stream Restoration	720	LF	$ 80.00	$ 57,600.00
Land Acquisition	1	LS	$ 700,000.00	$ 700,000.00
			Subtotal	$ 250,100.00
			Construction Contingency (40%)	$ 100,040.00
			Engineering/Project Management (20%)	$ 70,028.00
			City Project Management (5%)	$ 21,008.40
			Total	$ 1,141,176.40

Group 1: Cooper Slough Outfall from State Highway 14 (Mulberry Street) to the Lake Canal Crossing

Description	Quantity	Units	Cost/Unit	Total Cost
RCBC Dual (2) 11'W x 6'H (88 LF each)	1350	LF	$ 1,325.00	$ 1,788,750.00
Vault Manhole	1	EA	$ 100,000.00	$ 100,000.00
Utility Adjustments	1	LS	$ 50,000.00	$ 50,000.00
Building Relocation	1	LS	$ 50,000.00	$ 50,000.00
Site Restoration	675	LF	$ 50.00	$ 33,750.00
Land Acquisition	0.65	AC	$ 25,000.00	$ 16,356.75
			Subtotal	$ 2,022,500.00
			Construction Contingency (40%)	$ 809,000.00
			Engineering/Project Management (20%)	$ 566,300.00
			City Project Management (5%)	$ 169,890.00
			Total	$ 3,584,046.75

Conceptual Cost Estimate

Group 1: Cooper Slough Crossing of the Lake Canal Crossing				
Description	Quantity	Units	Cost/Unit	Total Cost
RCBC Triple (3) 3'W x 15'H (330 LF each)	1320	LF	$ 1,250.00	$ 1,650,000.00
Type H Riprap	267	CY	$ 120.00	$ 32,040.00
Headwalls and Wingwalls	1	EA	$ 75,000.00	$ 75,000.00
Bentomite Clay Mat	949	SY	$ 22.00	$ 20,878.00
Land Acquisition	0.57	AC	$ 25,000.00	$ 14,204.55
			Subtotal	$ 1,777,918.00
			Construction Contingency (40%)	$ 711,167.20
			Engineering/Project Management (20%)	$ 497,817.04
			City Project Management (5%)	$ 149,345.11
			Total	$ 3,150,451.90

Group 1: Cooper Slough Channel Improvements from Lake Canal to Boxelder Creek				
Description	Quantity	Units	Cost/Unit	Total Cost
Grading	82903	CY	$ 20.00	$ 1,658,060.00
Top Soil replacement and Reseed	20	AC	$ 2,500.00	$ 50,000.00
Stream Restoration	2920	LF	$ 80.00	$ 233,600.00
Riprap	1000	CY	$ 80.00	$ 80,000.00
Waterline Protection and Utility Adjustments	1	LS	$ 2,000,000.00	$ 2,000,000.00
Land Acquisition	20	AC	$ 25,000.00	$ 500,000.00
			Subtotal	$ 4,021,660.00
			Construction Contingency (40%)	$ 1,608,664.00
			Engineering/Project Management (20%)	$ 1,126,064.80
			City Project Management (5%)	$ 337,819.44
			Total	$ 7,594,208.24

Group 1: Outfall system for the business park located at the northwest corner of I-25 and State Highway 14.				
Description	Quantity	Units	Cost/Unit	Total Cost
RCBC 11'W x 6'H (88 LF each)	360	LF	$ 1,325.00	$ 477,000.00
Utility Conflicts	1	LS	$ 335,460.00	$ 335,460.00
Grading	10000	CY	$ 20.00	$ 200,000.00
Stream Restoration	2300	LF	$ 80.00	$ 184,000.00
Roadway Asphalt Patching	1200	SY	$ 80.00	$ 96,000.00
Riprap	1000	CY	$ 80.00	$ 80,000.00
			Subtotal	$ 1,372,460.00
			Construction Contingency (40%)	$ 548,984.00
			Engineering/Project Management (20%)	$ 384,288.80
			City Project Management (5%)	$ 115,286.64
			Total	$ 2,421,019.44

Conceptual Cost Estimate

Group 1: Construction of the Lake Canal side-flow spillway and conveyance channel, upstream of State Highway 14

Description	Quantity	Units	Cost/Unit	Total Cost
Grading	2778	CY	$ 12.50	$ 34,722.22
Top Soil replacement	1613	CY	$ 7.00	$ 11,293.33
Channel Improvements	1500	LF	$ 80.00	$ 120,000.00
Riprap at outlet	80	CY	$ 80.00	$ 6,400.00
Radial Gate Structure	1	EA	$ 200,000.00	$ 200,000.00
Land Acquisition	2	AC	$ 25,000.00	$ 50,000.00
			Subtotal (without land acquisition)	$ 372,415.56
			Construction Contingency (40%)	$ 148,966.22
			Engineering/Project Management (20%)	$ 104,276.36
			City Project Management (5%)	$ 31,282.91
			Total	**$ 706,941.04**

** Costs are approximate and will be adjusted by Montava Development*

Group 2: Bank and channel improvements along Cooper Slough waterway, below the L&W Canal.

Description	Quantity	Units	Cost/Unit	Total Cost
Miscellaneous Bank Improvements	1	LS	$ 65,700.00	$ 65,700.00
			Subtotal	$ 65,700.00
			Construction Contingency (40%)	$ 26,280.00
			Engineering/Project Management (20%)	$ 18,396.00
			City Project Management (5%)	$ 5,518.80
			Total	$ 115,894.80

Notes: The proposed improvement does not change from 2006 SP to 2021 SP (added inflation factor from 2006 to 20

Group 2: Improvements to the Vine Drive culverts at Cooper Slough

Description	Quantity	Units	Cost/Unit	Total Cost
RCBC Triple (3) 8'W x 4'H	264	LF	$ 715.00	$ 188,760.00
Wingwalls and Headwalls	2	LS	$ 30,000.00	$ 60,000.00
Riprap	160	CY	$ 120.00	$ 19,200.00
Channel Improvements Downstream (110LF)	445	SY	$ 20.00	$ 8,900.00
Roadway Asphalt Patching	2400	CY	$ 80.00	$ 192,000.00
			Subtotal	$ 468,860.00
			Construction Contingency (40%)	$ 187,544.00
			Engineering/Project Management (20%)	$ 131,280.80
			City Project Management (5%)	$ 39,384.24
			Total	$ 827,069.04

Conceptual Cost Estimate

Group 3: Improvements to the C&S /Crumb Detention Pond & Outfall to AB Pond				
Description	**Quantity**	**Units**	**Cost/Unit**	**Total Cost**
Grading	311373	CY	$ 12.50	$ 3,892,166.67
Top Soil replacement	33964	CY	$ 7.00	$ 237,747.06
Revegetation	42	AC	$ 10,000.00	$ 420,000.00
RCBC 13'w x 3'H (Open Cut under Railroad)	300	LF	$ 1,125.00	$ 337,500.00
RCBC 42" Outlet (Open Cut under Railroad)	300	LS	$ 260.00	$ 78,000.00
Restore Railroad	1	LS	$ 250,000.00	$ 250,000.00
Wingwalls and Headwalls	2	LS	$ 25,000.00	$ 50,000.00
Riprap	40	CY	$ 120.00	$ 4,800.00
Utility adjustments	1	LS	$ 200,000.00	$ 200,000.00
Lower 30-in AB Watermain	1	LS	$ 250,000.00	$ 250,000.00
Land Acquisition	42	AC	$ 25,000.00	$ 1,050,000.00
			Subtotal (without land acquisition)	$ 5,720,213.73
			Construction Contingency (40%)	$ 2,288,085.49
			Engineering/Project Management (20%)	$ 1,601,659.84
			City Project Management (5%)	$ 480,497.95
			Total	$ 11,140,457.02

** Costs are approximate and will be coordinated with the Montava Development*

Group 3: Construction of C&S / Crumb Overflow Pond & Outfall to L&W Canal				
Description	**Quantity**	**Units**	**Cost/Unit**	**Total Cost**
Grading	32751	CY	$ 12.50	$ 409,383.33
Top Soil replacement	27293	CY	$ 7.00	$ 191,053.49
Revegetation	34	AC	$ 10,000.00	$ 340,000.00
Overflow Weir	1	LS	$ 15,000.00	$ 15,000.00
Bank Protection	1111	SY	$ 22.00	$ 24,444.44
RCBC 48" Outlet (Bore Under Railroad)	80	LF	$ 3,000.00	$ 240,000.00
RCBC 48" Outlet	220	LS	$ 300.00	$ 66,000.00
Wingwalls and Headwalls	2	LS	$ 15,000.00	$ 30,000.00
Riprap	20	CY	$ 120.00	$ 2,400.00
			Subtotal (without land acquisition)	$ 1,318,281.27
			Construction Contingency (40%)	$ 527,312.51
			Engineering/Project Management (20%)	$ 369,118.75
			City Project Management (5%)	$ 110,735.63
			Total	$ 2,325,448.15

** Costs are approximate and will be coordinated with the Montava Development*

Appendix F – BCA Analysis (Group 1 Improvements)

Annual Discount Rate	7.00%	
Project Usual Life	50	years

Benefit Cost Ratio without Additional Benefits

Scenario	Annualized Damages	Expected Annual Benefit	Project Benefit over Project Useful Life	Project Cost	BCR before Additional Benefits
Ex. Conditions	$575,298	--	--	--	--
Pr. Conditions	$0	$575,298	$7,939,539	$20,500,713	0.39

In order to compare the future benefits to the current cost of the proposed mitigation project, a discount rate is applied over the life of the project to calculate the net present value of the expected annual benefits. For FEMA-funded mitigation projects, the discount rate is set by the Office of Management and Budget. Equation B-2 shows how to calculate the project benefits using the annual discount rate.

EQUATION B-2: PROJECT BENEFITS

$$B = EAB\left[\frac{1-(1+r)^{-T}}{r}\right]$$

where:

B = project benefits

EAB = total expected annual net benefit

r = annual discount rate used to determine net present value of benefits

T = estimated time the project will be effective, Project Useful Life

EQUATION B-1: EXPECTED ANNUAL BENEFIT

$$EAB = EAD_{Before\ Mitigation} - EAD_{After\ Mitigation}$$

where:

EAB = Expected annual benefit

$EAD_{Before\ Mitigation}$ = Expected annual damages before mitigation

$EAD_{After\ Mitigation}$ = Expected annual damages after mitigation

Existing Conditions FEMA BCA Calculation

BUILD ID	Account No.	Parcel No.	Assessor's Website	County Assessor Building Type	Assessor Building Sq Footage	Assessor Building Structure Value	FEMA Building Classification	FEMA Curve No.	Contents to Structure Value	Contents Value	LAG	FE	FFE	WSEL 2-yr	WSEL 10-yr	WSEL 100-yr	Structure Damages 2-yr	Structure Damages 10-yr	Structure Damages 100-yr	Content Damages 2-yr	Content Damages 10-yr	Content Damages 100-yr	Total Damages 2-yr	Total Damages 10-yr	Total Damages 100-yr
51	R1170473	8709414016	Website	Motel	30,494	2,781,000	Hotel	11	19%	$ 528,390	4928.72	4930.25	4922.25	4928.87	4930.10	4930.54	$ -	$ -	$ 1,163,930	$ -	$ -	$ 325,409	$ -	$ -	$ 1,489,339
93	R1098837	8716108002	Website	Indust Light Manufacturing	58,700	2,475,700	Industrial Light	26	47%	$ 1,163,579	4920.60	4921.10	4921.10	4922.25	4922.57	4922.96	$ 322,990	$ 387,261	$ 463,277	$ 241,343	$ 287,227	$ 341,497	$ 564,333	$ 674,487	$ 804,774
13	R0189995	8709400018	Website	Motel	90,594	2,002,300	Hotel	11	19%	$ 380,437	4927.07	4927.80	4927.80	4928.87	4930.10	4930.54	$ 242,816	$ 397,381	$ 448,360	$ 63,407	$ 108,077	$ 121,437	$ 306,224	$ 505,458	$ 569,796
9	R0710288	8716100064	Website	Motel	69,876	3,486,500	Hotel	11	19%	$ 662,435	4924.91	4926.00	4926.00	0.00	4926.13	4926.54	$ -	$ 88,135	$ 241,146	$ -	$ 13,404	$ 57,704	$ -	$ 101,539	$ 298,850
0	R0192791	8716223042	Website	Indust Light Manufacturing	7,616	612,600	Industrial Light	26	47%	$ 287,922	4921.88	4922.00	4922.00	0.00	0.00	4923.90	$ -	$ -	$ 116,687	$ -	$ -	$ 85,966	$ -	$ -	$ 202,653
86	R1098845	8716108003	Website	Storage Warehouse	21,174	1,501,200	Warehouse, Non-Refrig	27	47%	$ 705,564	4918.42	4919.80	4919.80	4919.58	4919.99	4920.34	$ -	$ 46,600	$ 103,463	$ -	$ 27,753	$ 80,205	$ -	$ 74,352	$ 183,668
59	R1209051	8709416001	Website	Motel	14,002	1,328,900	Hotel	11	19%	$ 252,491	4929.45	4930.00	4930.00	0.00	4930.10	4930.54	$ -	$ 29,982	$ 91,096	$ -	$ 4,064	$ 21,758	$ -	$ 34,046	$ 112,854
67	R0192287	8716107020	Website	Storage Warehouse	12,000	784,400	Warehouse, Non-Refrig	27	47%	$ 368,668	4917.41	4919.40	4919.40	4918.85	4919.20	4919.71	$ -	$ -	$ 34,644	$ -	$ -	$ 23,997	$ -	$ -	$ 58,641
80	R0191965	8716105004	Website	Storage Warehouse	7,200	373,000	Warehouse, Non-Refrig	27	47%	$ 175,310	4919.00	4919.50	4919.50	4919.32	4919.70	4920.17	$ -	$ 12,054	$ 30,684	$ -	$ 7,334	$ 24,519	$ -	$ 19,388	$ 55,204
85	R1343246	8716220006	Website	Service Garage	3,840	267,400	Service Station	21	83%	$ 221,942	4922.11	4922.61	4922.61	0.00	0.00	4923.39	$ -	$ -	$ 23,874	$ -	$ -	$ 27,721	$ -	$ -	$ 51,595
70	R0189898	8709400003	Website	Converted House - Ranch	1,259	124,800	House, One Story	5	100%	$ 124,800	4930.01	4930.50	4930.50	0.00	4930.10	4930.54	$ -	$ -	$ 17,200	$ -	$ -	$ 10,359	$ -	$ -	$ 27,559
15	R1170465	8709414015	Website	Restaurant	3,866	700,500	Non-Fast Food	13	26%	$ 182,130	4928.07	4930.50	4930.50	4928.87	4930.10	4930.54	$ -	$ -	$ 17,978	$ -	$ -	$ 1,942	$ -	$ -	$ 19,921
94	R0189898	8709400003	Website	Converted House - 1-+ Story Fin	2,506	124,800	House, Split Level	6	100%	$ 124,800	4929.11	4930.50	4930.50	0.00	4930.10	4930.54	$ -	$ -	$ 9,090	$ -	$ -	$ 3,705	$ -	$ -	$ 12,795
16	R0157198	8709000008	Website	Veterinary Hospital - Multiple - Residential	3,507	311,100	Hospital	14	30%	$ 93,330	4928.89	4930.50	4930.50	0.00	4930.10	4930.54	$ -	$ -	$ 3,970	$ -	$ -	$ 533	$ -	$ -	$ 4,503

Recurrence Interval (Years)	Expected Annual Number of Occurrences (EANO)	Total Damages Existing	Annualized Damage
2	50.0%	$ 749,346	$ 376,834
10	10.0%	$ 1,184,399	$ 168,773
100	1.0%	$ 2,969,089	$ 29,691
Total			$ 575,298

Scenario	Annualized Damages	Expected Annual Benefit	Project Benefit over Project Useful Life	Project Cost	BCR before Additional Benefits
Ex. Conditions	$575,298	--	--	--	--
Pr. Conditions	$0	$575,298	$7,939,539	$20,500,713	0.39