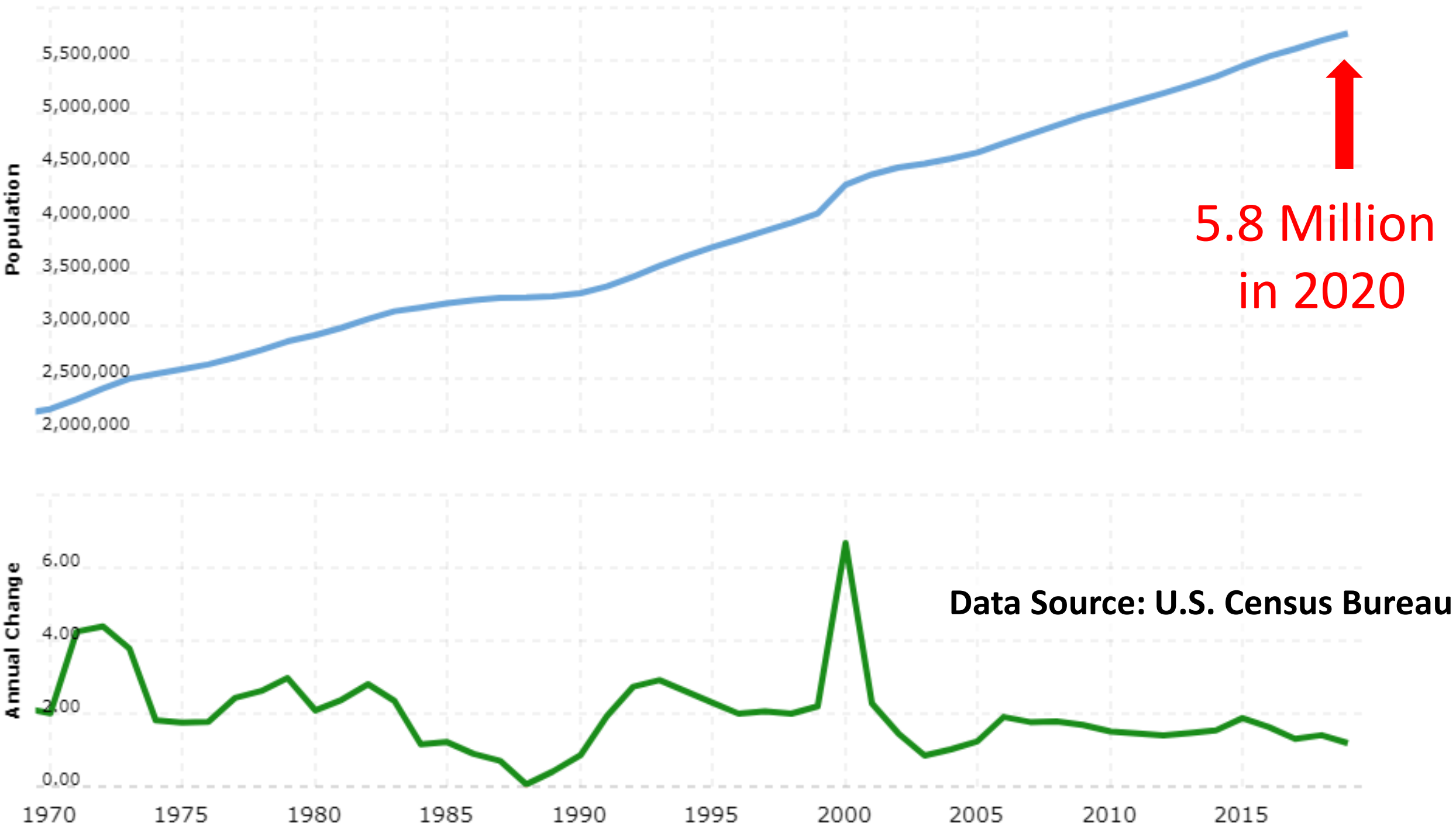
Partnering with Development: A Sterling Gulch Example

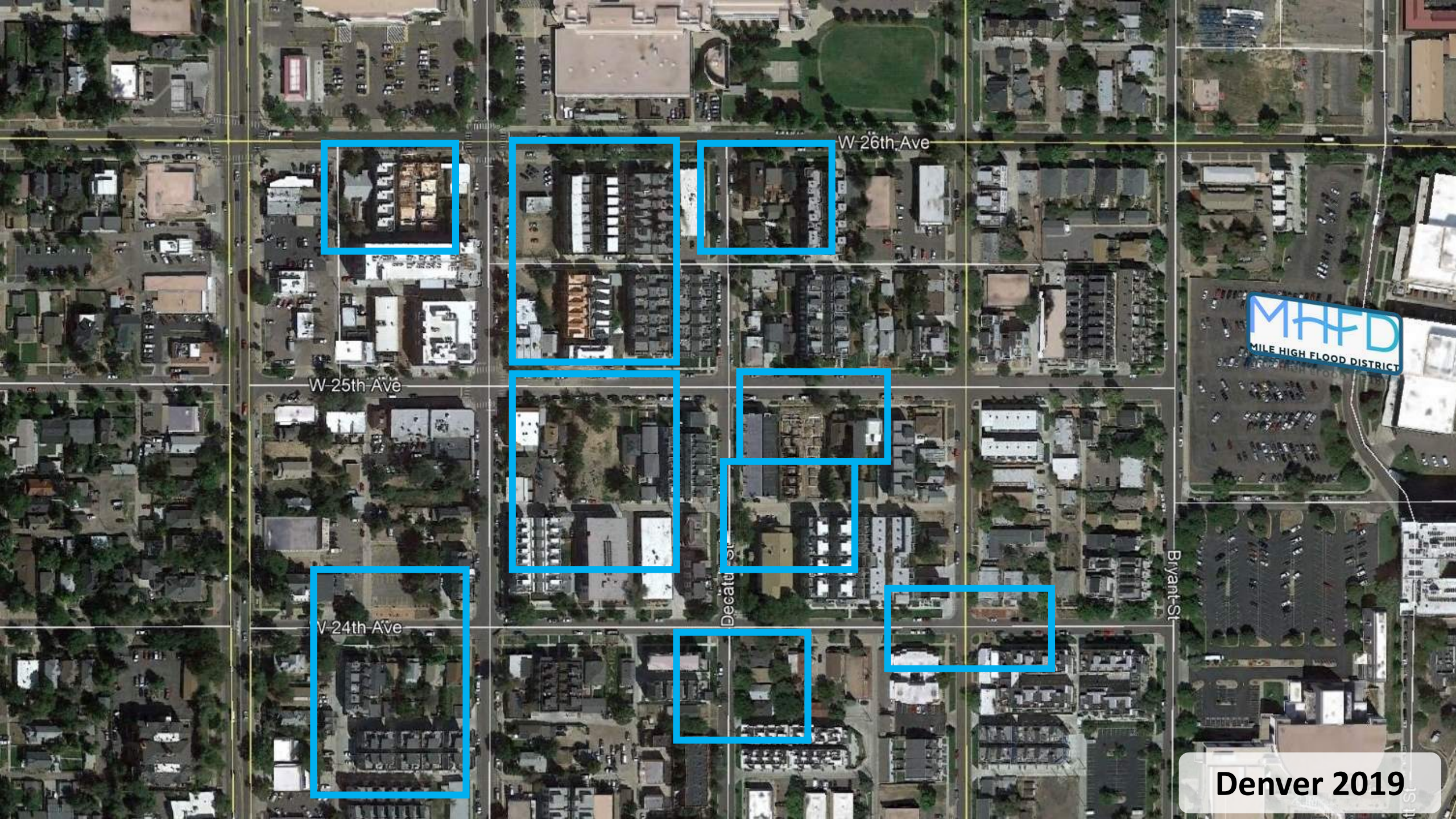
Colorado Association of Stormwater and Floodplain Managers

September 30, 2020

Photo Credit: Hart Van Denburg- CPR News

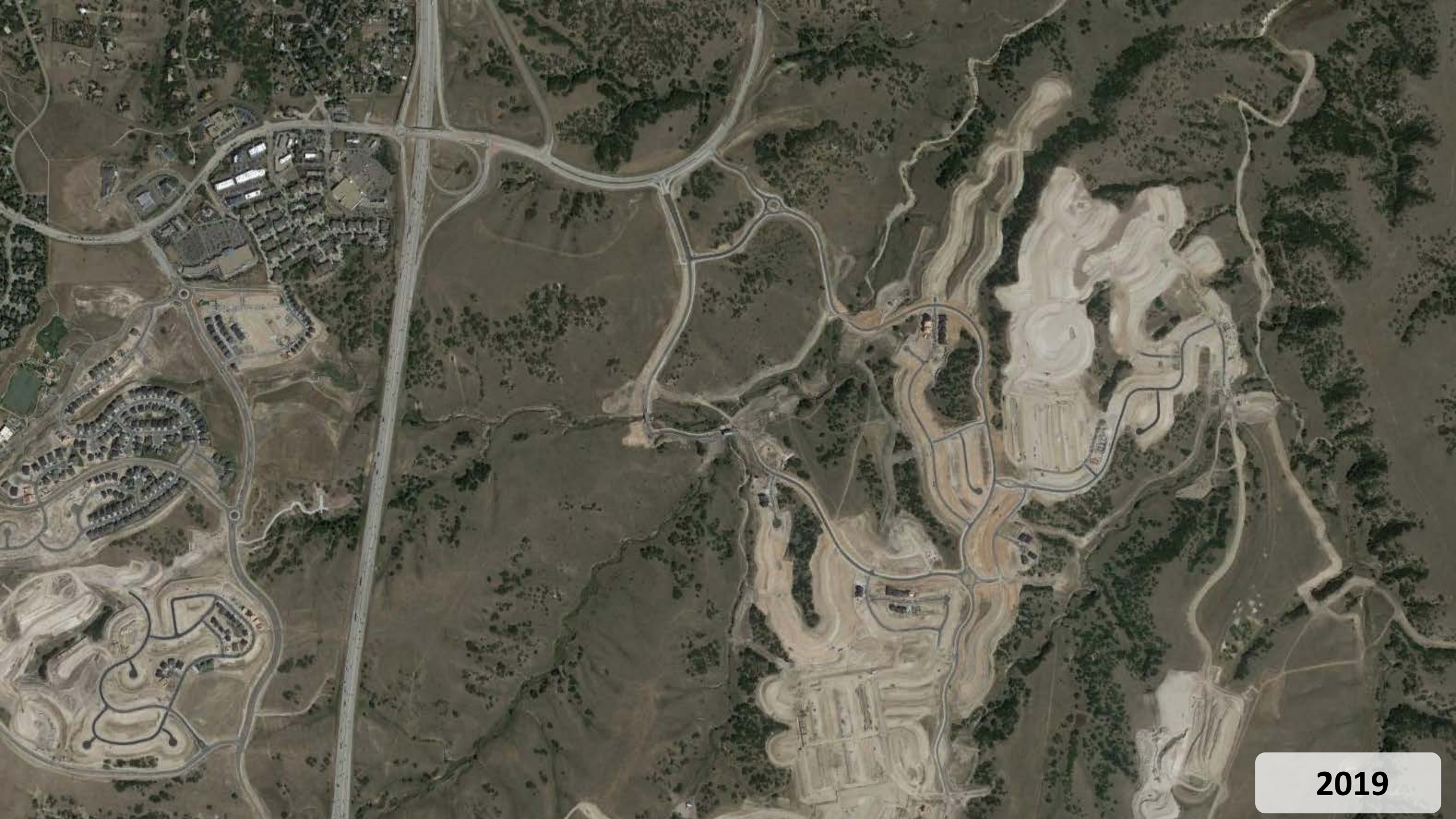

Population
5,500,000
5,000,000
4,500,000
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
5.8 Million
in 2020
Annual Change
6.00
4.00
2.00
0.00
Data Source: U.S. Census Bureau
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015


W 26th Ave
W 25th Ave
W 24th Ave
Decatur St
Bryant St
MHFD
MILE HIGH FLOOD DISTRICT
Denver 2010


W 26th Ave
W 25th Ave
W 24th Ave
Decatur St
Bryant St
MHFD
MILE HIGH FLOOD DISTRICT

Denver 2019


2010


2019

Westerly Creek 1993

Westerly Creek 2019

Development Analytics

Developer Built

75%

Developer $ Invested

$ 100,000,000

MEP Submittals
*2016

3990

MHFD Land Area
*sq miles

1608

Increase collaboration?

Development

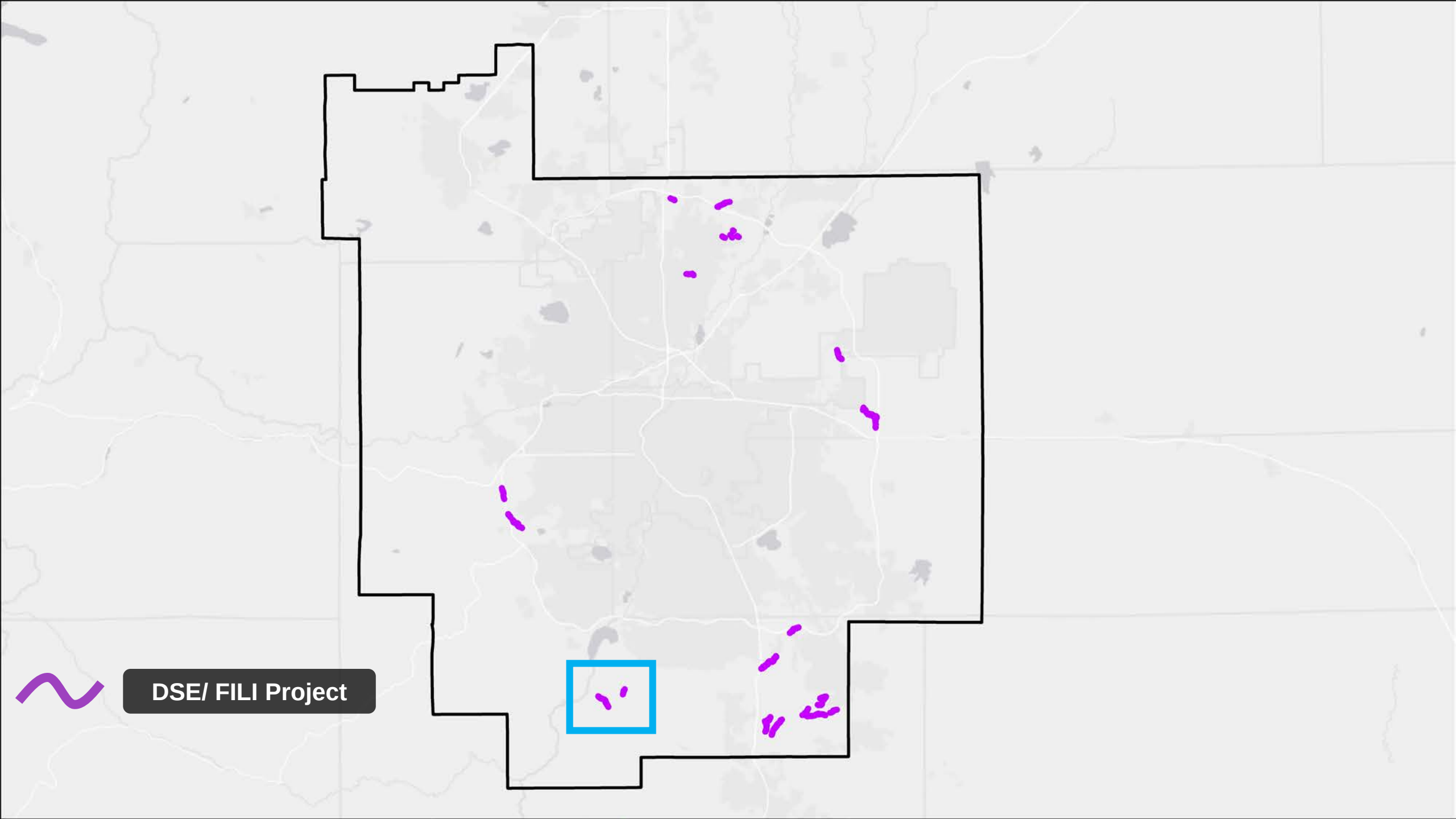
- Criteria - Develop Framework for High Functioning Low Maintenance Stream
- Training – Stream Management Academy
- Fee-In-Lieu Improvement Option

Resolution No. 38, Series of 2017:

Authorization to Establish a Development Services Enterprise (DSE)

The DSE may:

- Collect voluntary fees from land developers.
- Use fees to hire contractors to complete preliminary designs, final designs, cost estimates, and to construct regional infrastructure.
- District, Land Developer, and all affected Local Governments must agree in writing to proceed.


DSE/ FILI Project

When to Consider FILI

- Create an Amenity
- Permit
- Schedule

When to Consider FILI

- ✓ Create an Amenity
  - Permit
- ✓ Schedule

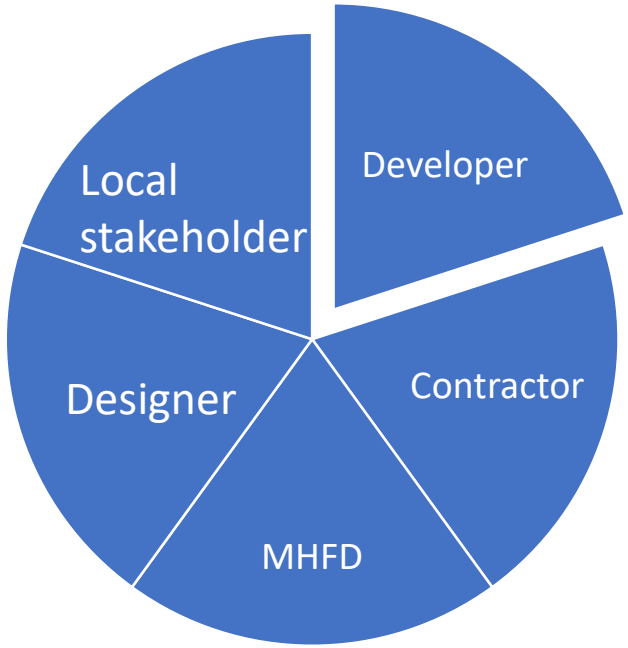
NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Lessons Learned

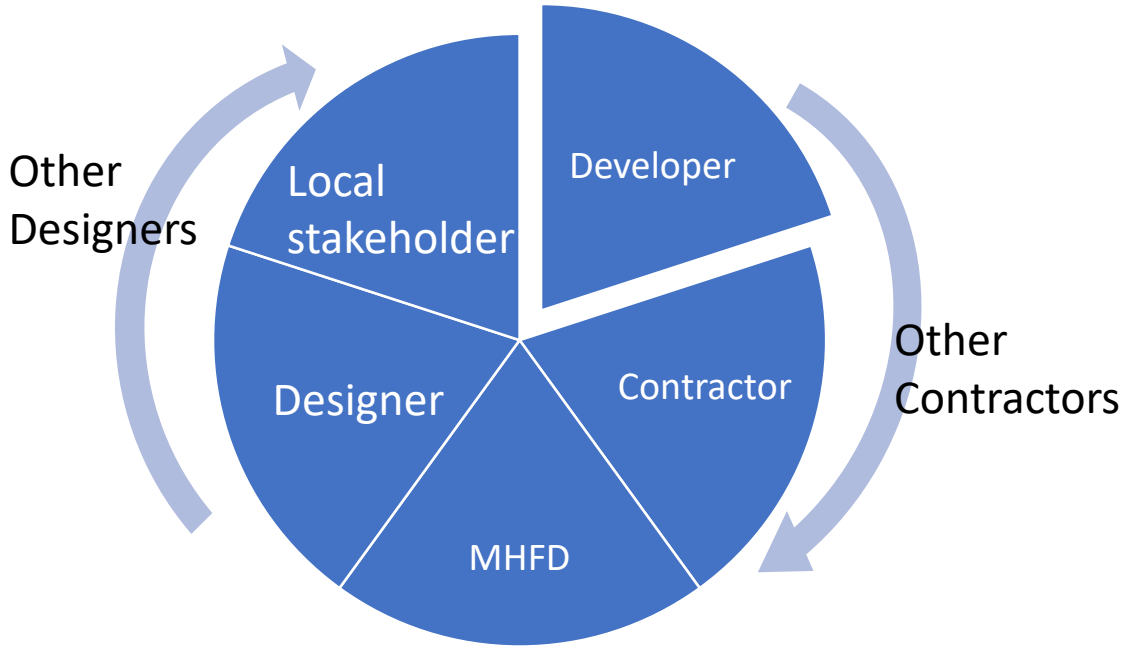
- **Project Partners**
- **Relationship based process**
- **Fast Tracking Trust**
  - Assume the best
  - Stay positive
  - Open communication



NARANJO CIVIL CONSTRUCTORS EST. 1982 MHFD MILE HIGH FLOOD DISTRICT Matrix

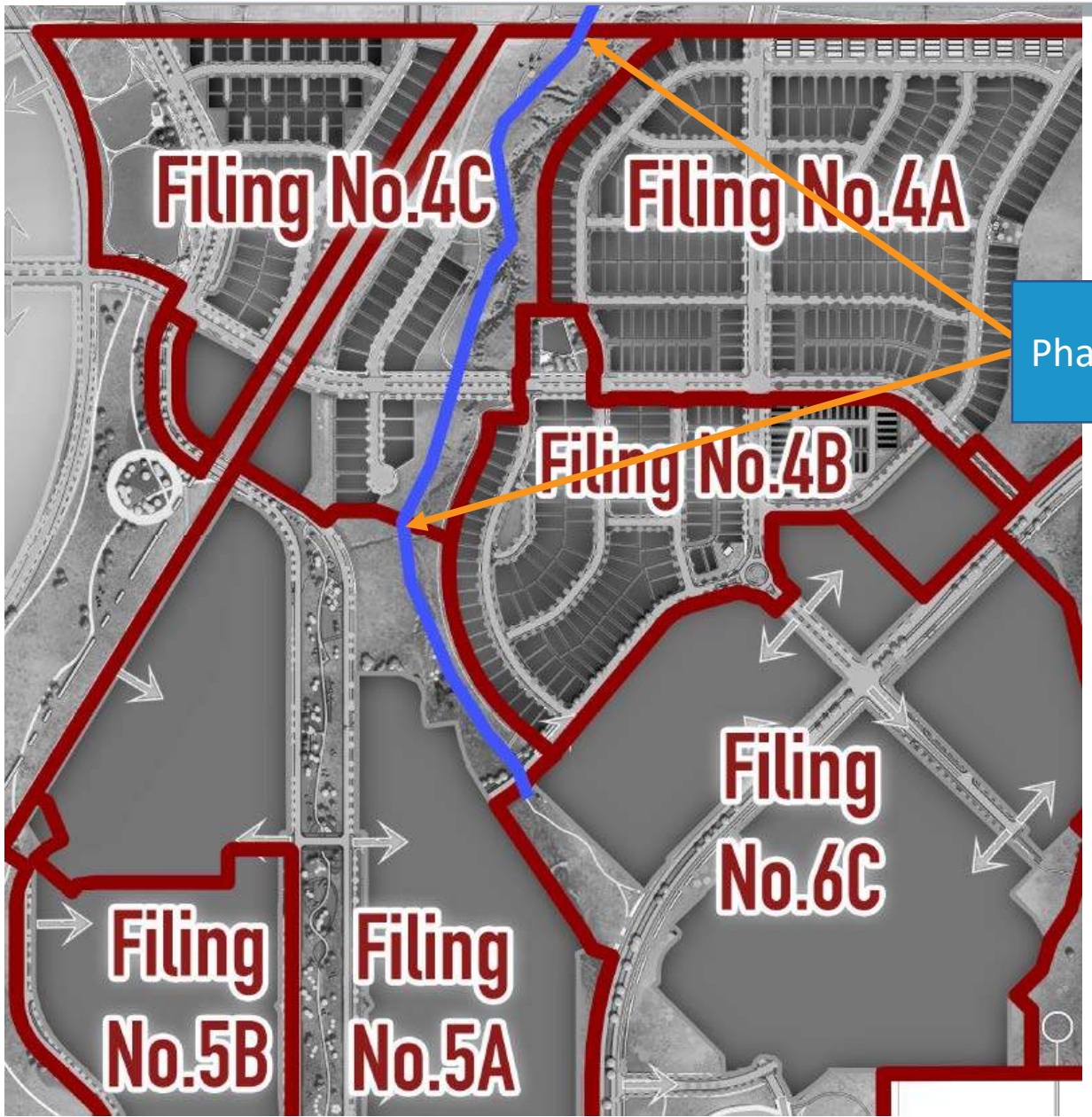
Lessons Learned

- **Communication Plan**
  - Early coordination meetings
    - Design
    - Construction



NARANJO CIVIL CONSTRUCTORS EST. 1982 MHFD MILE HIGH FLOOD DISTRICT Matrix

Lessons Learned



Phase 2 limits

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Lessons Learned

- **Design Elements**
  - Equestrian trail
  - Outfalls

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Lessons Learned

- Trying new things

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Lessons Learned

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

STERLING RANCH

FIRST FILI PROJECT

MHFD 2019

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix

A perfect marriage…

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

An arranged marriage…

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

It takes effort and training…

- Attitude
- Culture
- Expectations

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix

A Project Within a Project

Matrix

Staging

- Organized
- Signage
- No Trash

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD 2019


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD
2019


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD
2019


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD
2019


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD
2019


N
STERLING
RANCH
FIRST FILI PROJECT
MHFD
2019


Actual Staging
Planned South Staging
Make-shift Staging
Planned North Staging
Make-shift Staging
N
STERLING RANCH
FIRST FILI PROJECT
MHFD 2019

Safety

- Corporate Compliance
- Adaptation
- Teamwork

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

STERLING RANCH

FIRST FILI PROJECT

MHFD 2019

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Takeaways

- Best intentions
- Open mind
- Early and often communication
- Build trust
- Be flexible

EST. 1982
NARANJO
CIVIL CONSTRUCTORS

MHFD
MILE HIGH FLOOD DISTRICT

Matrix

Naranjo Civil Constructors

20 years a Tier 1 Contractor with MHFD

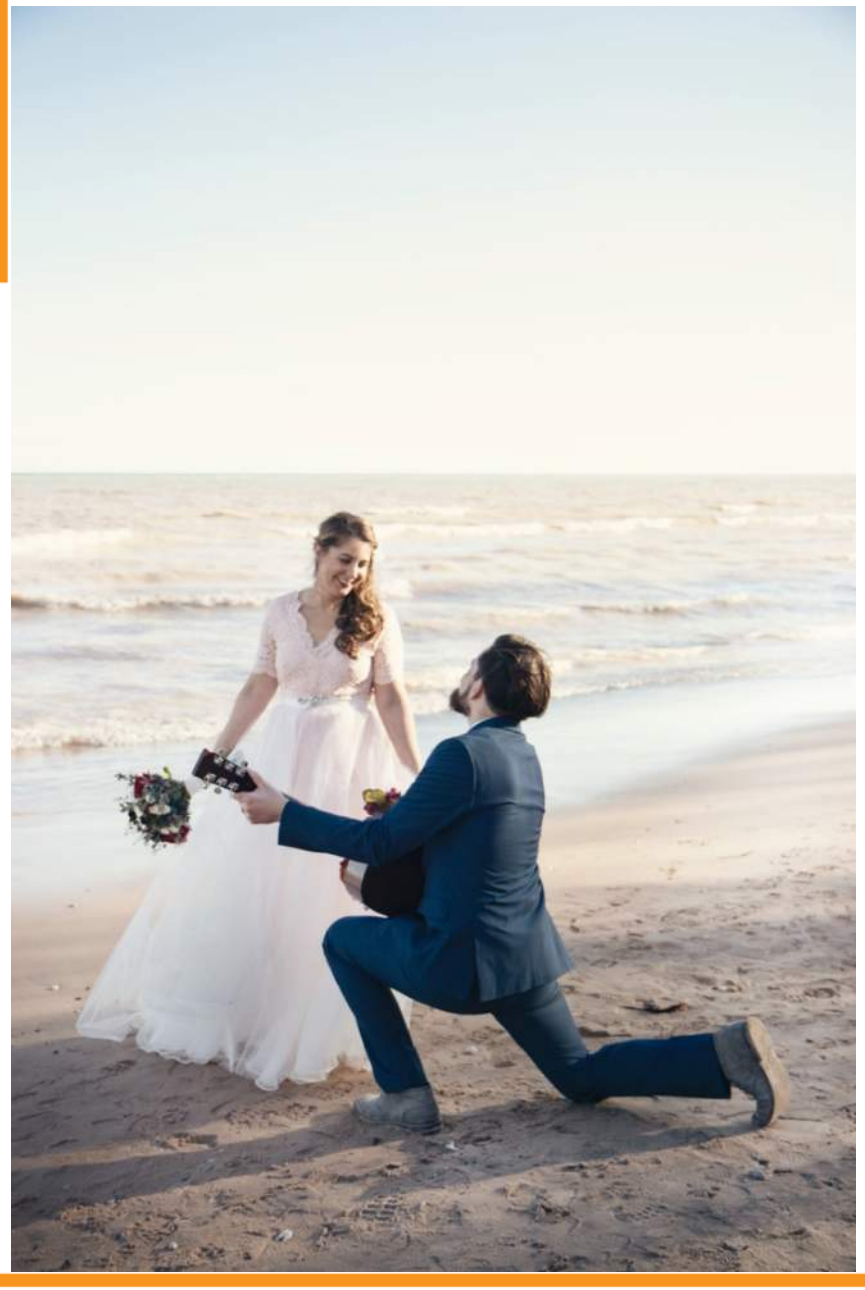
10 Riverine Construction Crews

38 Years in the Industry

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix



A perfect marriage…

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

An arranged marriage…

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Matrix

It takes work…

- Attitude
- Culture
- Expectations

EST. N 1982

NARANJO

CIVIL CONSTRUCTORS

Matrix

Staging

Organized

Signage

No Trash

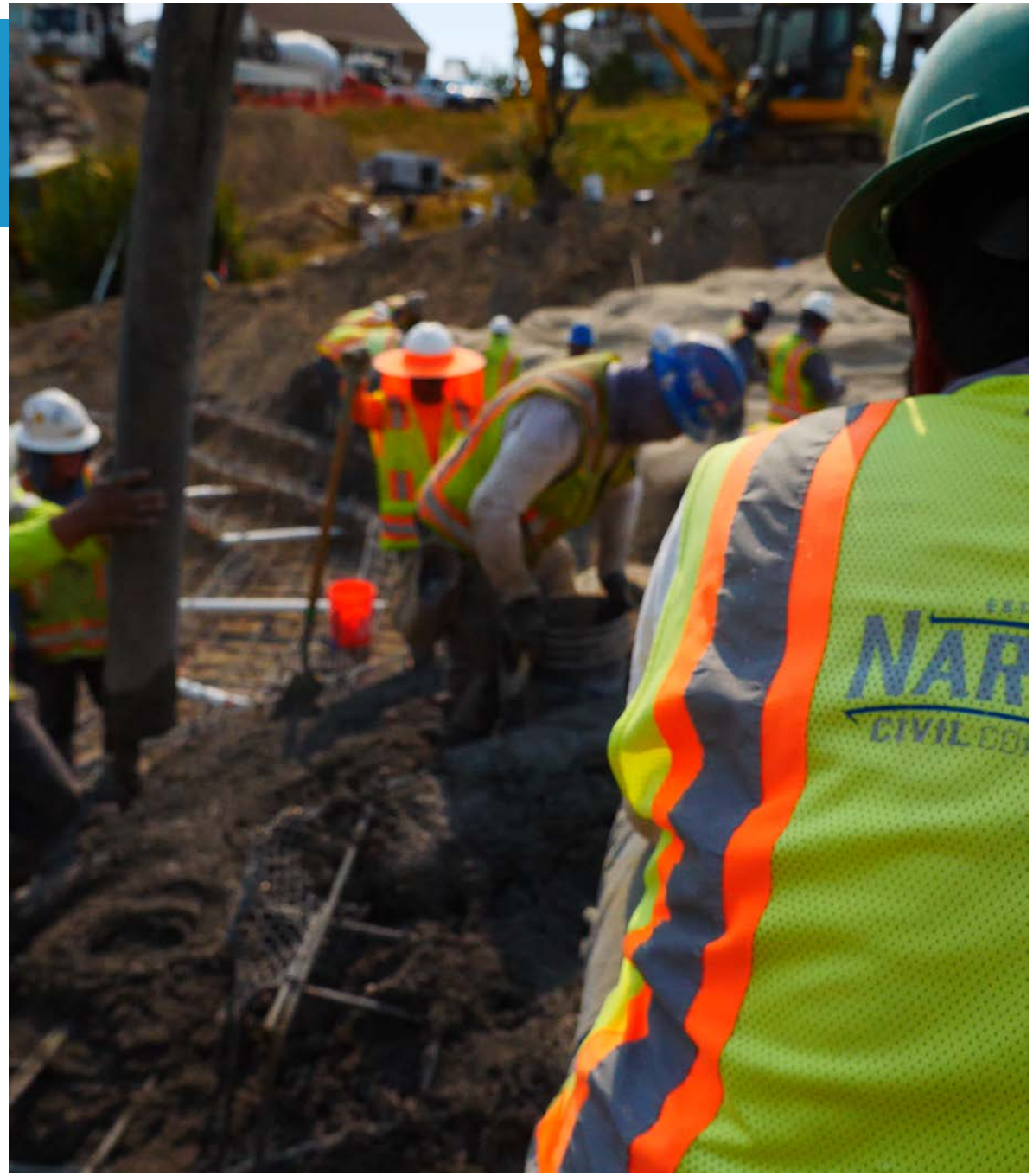
Matrix

Safety

Corporate Compliance

Adaptation

Teamwork



A Project Within a Project

Lessons Learned

- Trying new things

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

A Project Within a Project

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

A Project Within a Project

EST. 1982 NARANJO CIVIL CONSTRUCTORS

MHFD MILE HIGH FLOOD DISTRICT

Matrix

A Project Within a Project

NARANJO CIVIL CONSTRUCTORS EST. 1982

MHFD MILE HIGH FLOOD DISTRICT

Matrix

Lessons Learned in Developing Wetlands on Stream Restoration Projects

Ecologists Don't Know How to Get Engineers to Listen – And Other Lessons on Wetland Development

Presentation for 2020 CASFM Conference

Presentation Web Link

Full Presentation Web Link:

https://youtu.be/ResfXj19nWc

Presenters

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Natural Resources Specialist/ Principal

ERO Resources Corporation

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Mary L. Powell

Environmental Manager

Mile High Flood District

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Presentation Abstract

As project teams have evolved to have more specialists at the table, collaboration between all team members becomes critical to a successful design and construction implementation. However, as ecologists who are not always in the driver's seat when it comes to design or construction, it becomes difficult to voice concerns or speak in "engineer" talk to communicate what elements are necessary for ecology of the site to be successful. What is considered a success for geomorphology or sediment transport does not always equal success for wetland or riparian development – but how can we learn from these mistakes and improve communication between team members? This presentation will discuss the ecologist's point of view and several example projects where communication or collaboration failed and construction of the projects resulted in a lack of wetland or riparian vegetation success. This includes discussion of the common failures observed, including the term "bankfull" compared to wetland elevations. How can we improve in communicating together to find project solutions that result in successful outcomes for all project goals? How can ecologists improve in discussing elevation and hydrology needs for successful vegetation outcomes? Some recently constructed Mile High Flood District high functioning low maintenance stream projects will be discussed where the different perspectives on the design, bankfull, and wetland development were apparent.

Lessons Learned

- COMMUNICATE EARLY AND OFTEN
- ESTABLISH GOALS AND HOW TO MEET THEM
- SPEAK UP ON YOUR SUBJECT MATTER
- EQUAL VOICES ON A COLLABORATIVE TEAM
- USE GRAPHICS AND MAPS TO CONFIRM UNDERSTANDING
- RIGHT PEOPLE, RIGHT TIME FOR CONSTRUCTION INSPECTION

Why are the Wetlands Dry?

Lessons Learned When Ecologists Don’t Know How To Be Heard On Multidisciplinary Teams

Moneka Worah
ERO Resources Corporation

Mary L. Powell
Mile High Flood District

Multidisciplinary Teams

Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Common Terms

Flood prone area

Bankfull elevation

Inner berm

Stream bed

Base flow

Channel forming flows

Channel toe

Rosgen stream type

Groundwater table

Wetland bench/terrace

Saturation zone

wetland fringe

Riparian overbank

Hydrogeomorphic Classification

Trickle flow

Top of channel bank

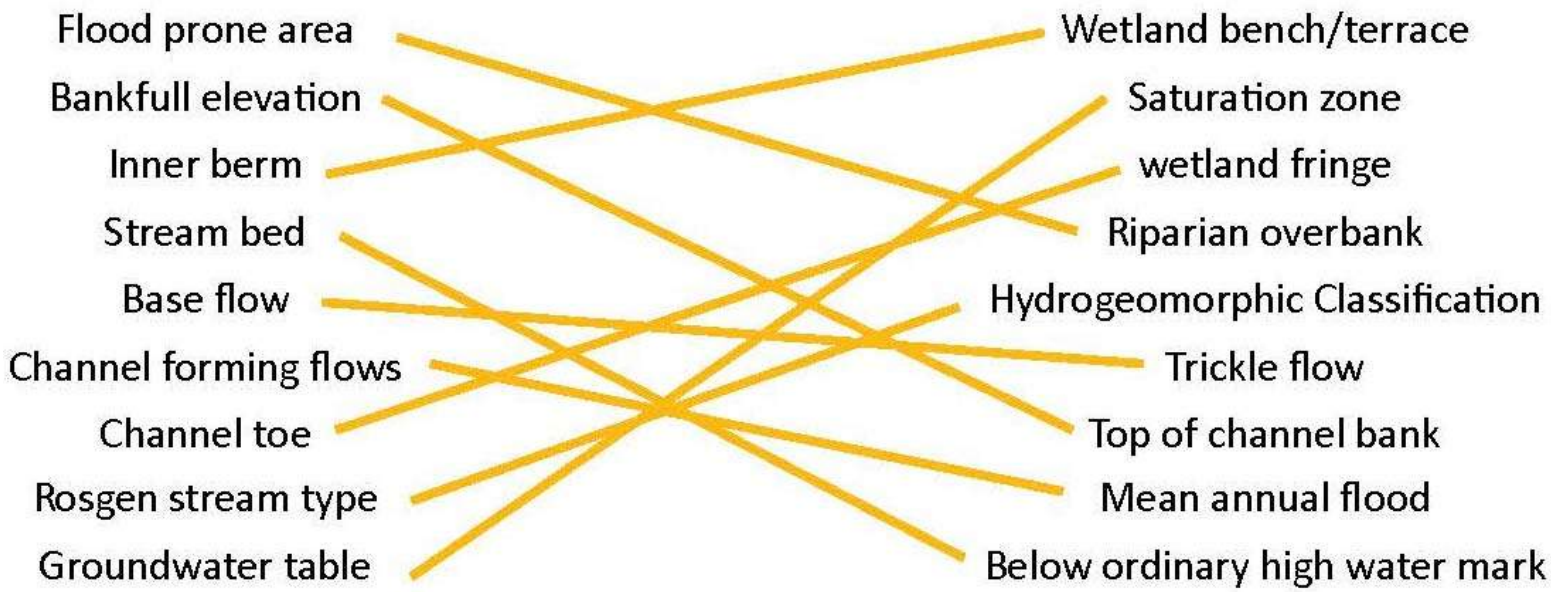
Mean annual flood

Below ordinary high water mark

Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Where Common Terms Intersect

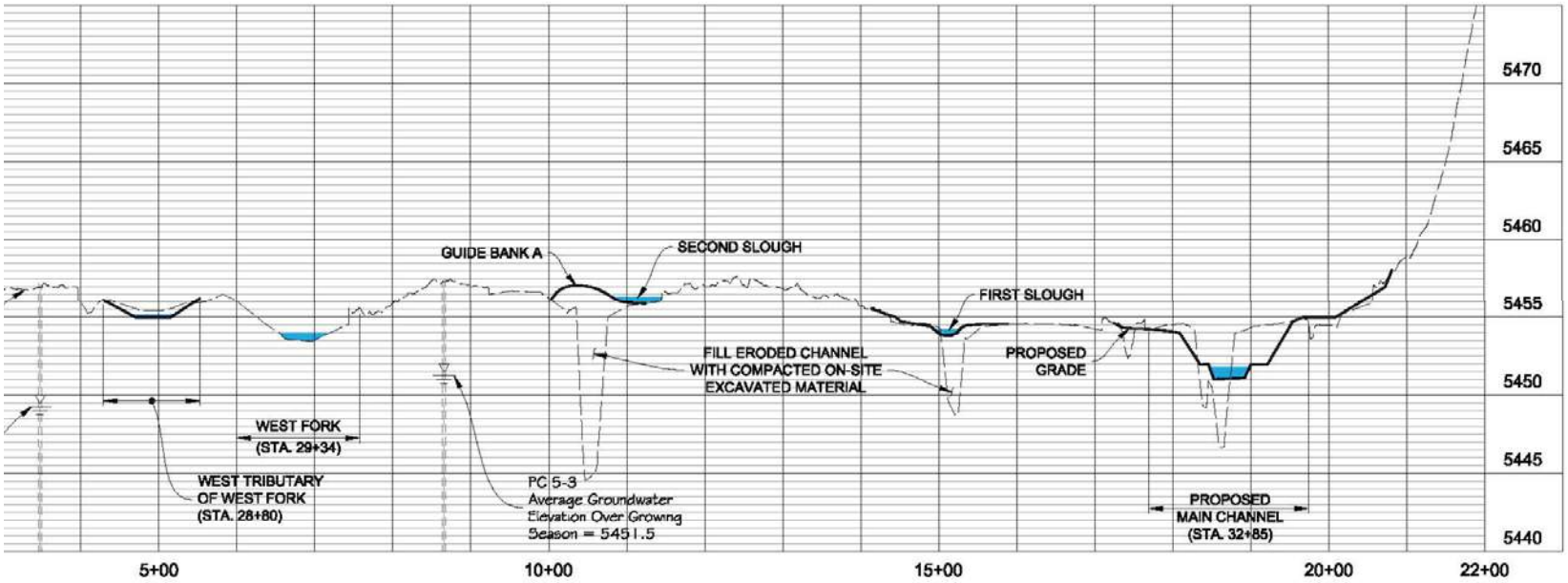


Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Communication Successes

Plum Creek at Chatfield State Park



PLUM CREEK CROSS SECTION 2
(LOOKING DOWNSTREAM)

0' 100' 200' (HORIZ.)

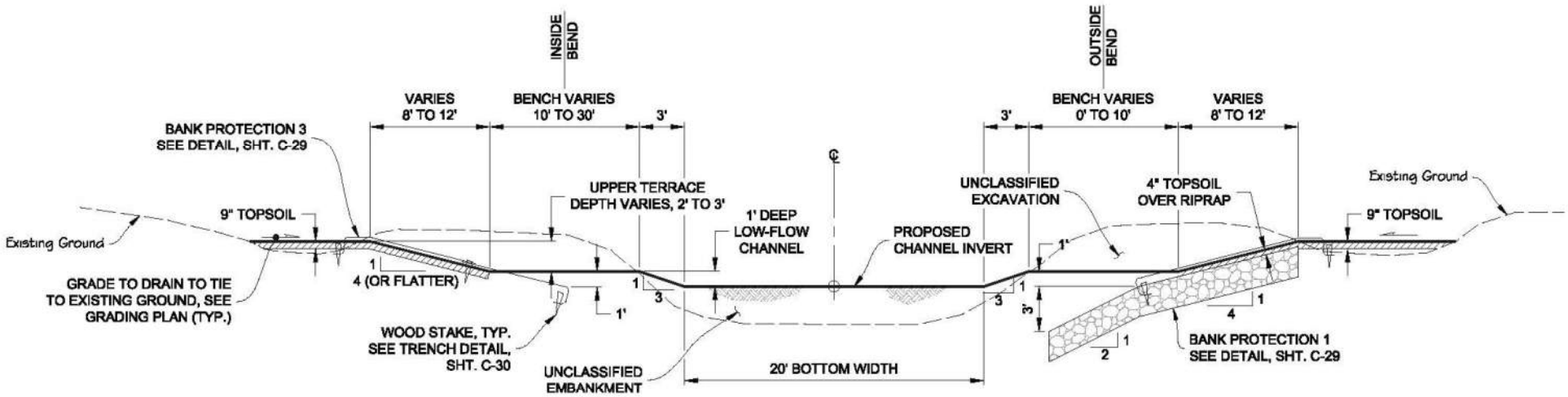
0' 5' 10' (VERT.)

NOTES:

1. GROWING SEASON FOR GROUNDWATER ANALYSIS RANGES FROM APRIL TO OCTOBER.
2. SEE SITE PLAN (SHT. G-5) FOR SECTION LOCATIONS.
3. SUITABLE TOPSOIL WITHIN GRADING LIMITS SHALL BE STRIPPED, STOCKPILED, AND REPLACED AS SHOWN. THICKNESS AND AREA EXTENTS OF SUITABLE TOPSOIL STRIPPING WILL BE AS DIRECTED BY ENGINEER. IF INSUFFICIENT QUANTITIES OF SUITABLE TOPSOIL ARE AVAILABLE ALONG CHANNELS, THE UPPER PORTIONS OF WEST BENCH EXCAVATIONS SHALL BE USED AS SUPPLEMENTAL TOPSOIL.

COLORADO LICENSED
JUERGENSEN
35809
11/1/2017
PROFESSIONAL ENGINEER

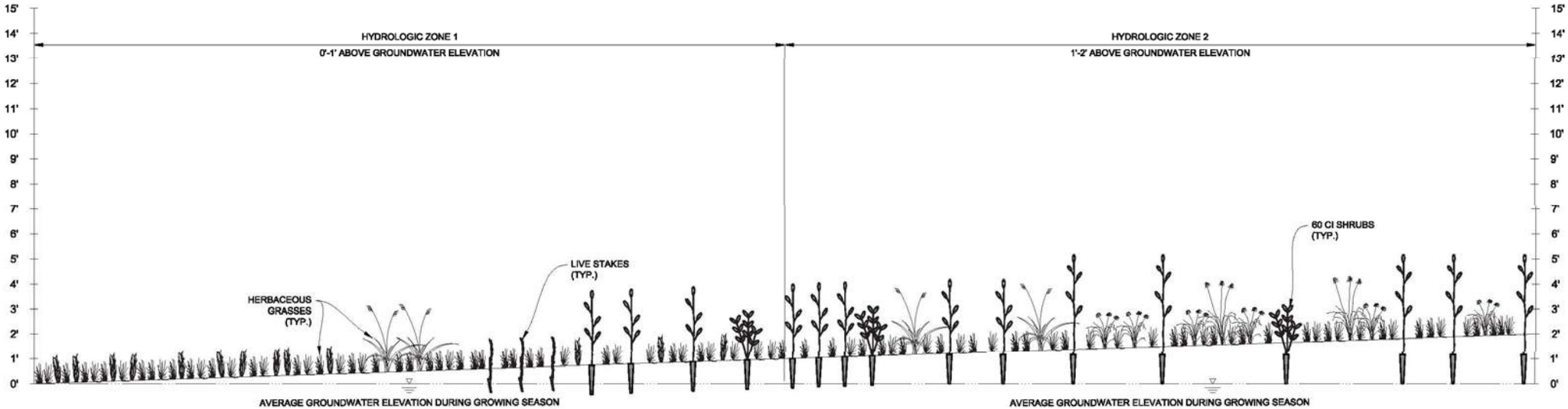
ESIGNED BY: SDW RAWN BY: MAB HEET CHK'D BY: JPJ ROSS CHK'D BY: PPROVED BY: DDJ ATE: NOVEMBER 1, 2017	MULLER ENGINEERING COMPANY	CHATFIELD RESERVOIR MITIGATION COMPANY CHATFIELD STORAGE REALLOCATION PROJECT EM2 - PLUM CREEK ONSITE ENVIRONMENTAL MITIGATION	CIVIL CROSS SECTIONS	PROJECT NO. 11-023.08 FILE NAME: SHEET NO. C-17



MAIN CHANNEL WITH BENCH ON OUTSIDE BEND

(LOOKING DOWNSTREAM)

0' 5' 10'



ZONE 1 TYPICAL SECTION

ZONE 1 VEGETATION TYPE: WETLAND, MAINLY HERBACEOUS

TYPICAL PLANT SCHEDULE — **INSTALLATION METHODS**

HERBACEOUS:

Seed Mix 1A: Wetland Mix for Sandy to Clay Loam	Broadcast seeding
Seed Mix 1B: Wetland Mix for Sandy Loam or Coarse Soil	Broadcast seeding

SHRUBS:

Quantity/Ac	Common Name	Scientific Name	Plant Material	Distribution	Minimum Spacing
189	Sandbar willow	*Salix exigua*	dormant live stakes	Groups of 15-30	2'
216	Sandbar willow	*Salix exigua*	60ci pots	Groups of 15-30	2'
27	Strapleaf willow	*Salix figulifolia*	dormant live stakes	Scattered	2'
27	Strapleaf willow	*Salix figulifolia*	60ci pots	Scattered	2'
27	Alder	*Alnus incana*	60ci pots	Scattered	20'
54	Red osier dogwood	*Acer negundo*	60ci pots	Scattered; Groups of 1-3	4'
Total 540					

TREES:

None — inadequate aerated soil volume

ZONE 2 TYPICAL SECTION

ZONE 2 VEGETATION TYPE: UPPER WETLAND/ MOIST MEADOW, WITH SHRUBS AND TREES

TYPICAL PLANT SCHEDULE — **INSTALLATION METHODS**

HERBACEOUS:

Seed Mix 2A: Sub-Irrigated Tallgrass Mix for Sandy to Clay Loam	Broadcast and drill seeding
Seed Mix 2B: Sub-Irrigated Tallgrass Mix for Sandy Loam or Coarse Soil	Broadcast and drill seeding

SHRUBS:

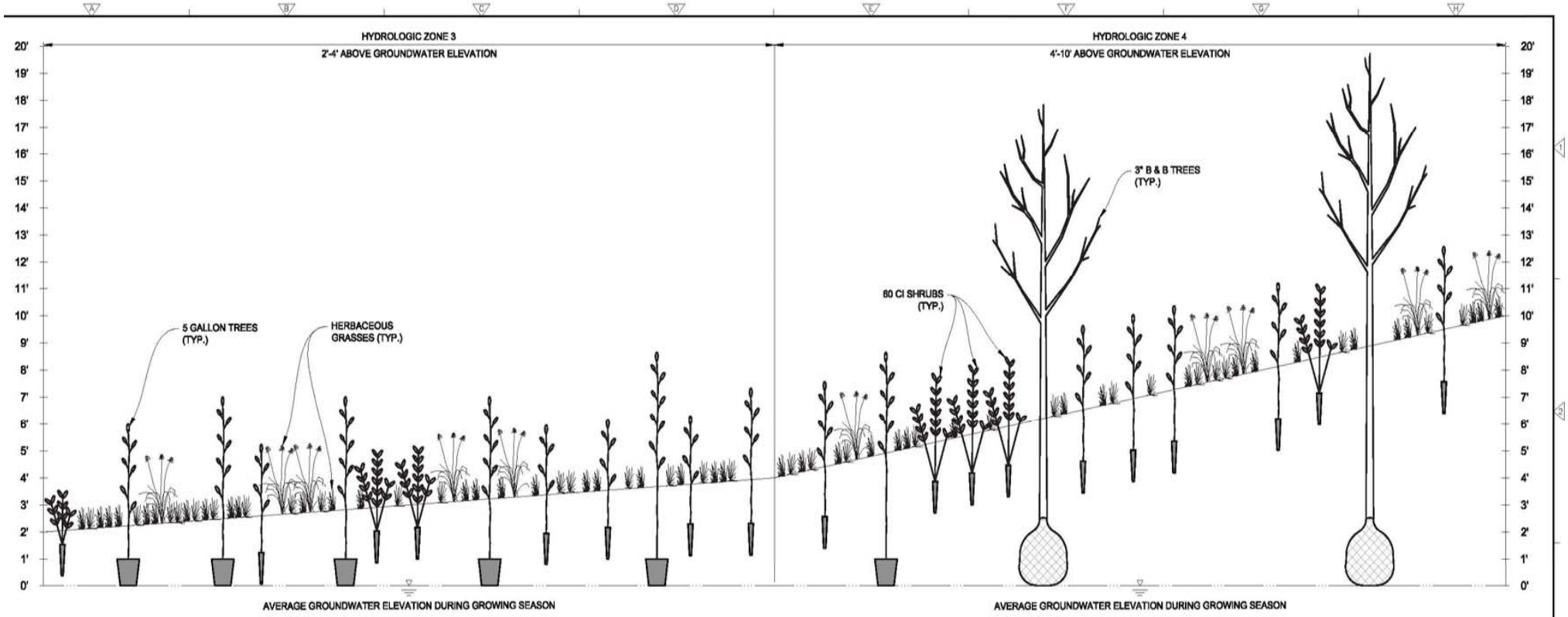
Quantity/Ac	Common Name	Scientific Name	Plant Material	Distribution	Minimum Spacing
135	Sandbar willow	*Salix exigua*	60ci pots*	Groups of 15-30	2'
54	Strapleaf willow	*Salix figulifolia*	60ci pots*	Scattered	2'
27	Alder	*Alnus incana*	60ci pots*	Scattered	20'
27	Red osier dogwood	*Swida sericea*	60ci pots*	Scattered; Groups of 1-3	4'
39	Golden currant	*Ribes aureum*	60ci pots*	Scattered; Groups of 1-3	4'
81	Chokecherry	*Padus virginiana*	60ci pots*	Groups of 5-20	5'
81	Wild plum	Prunus americana	60ci pots*	Groups of 5-20	5'
27	Leadplant	Amorpha fruticosa	60ci pots*	Scattered	15'
Total 471					

TREES:

Quantity/Ac	Common Name	Scientific Name	Plant Material	Distribution	Minimum Spacing
20	Peach-leaved willow	Salix amygdaloides	60ci pots*	Scattered	25'

*Use deep planting: place root ball into moist soil zone immediately above water table (standing water/ saturated soil) if plant height allows. Bury no more than ½ of above ground height of potted plant when deep planting. Use deeper hand dug or stinger dug holes for deep planting.

0' 2' 4'



ZONE 3 TYPICAL SECTION

ZONE 3 VEGETATION TYPE: MOIST MEADOW/RIPARIAN SHRUBS AND TREES

TYPICAL PLANT SCHEDULE | INSTALLATION METHODS

HERBACEOUS:

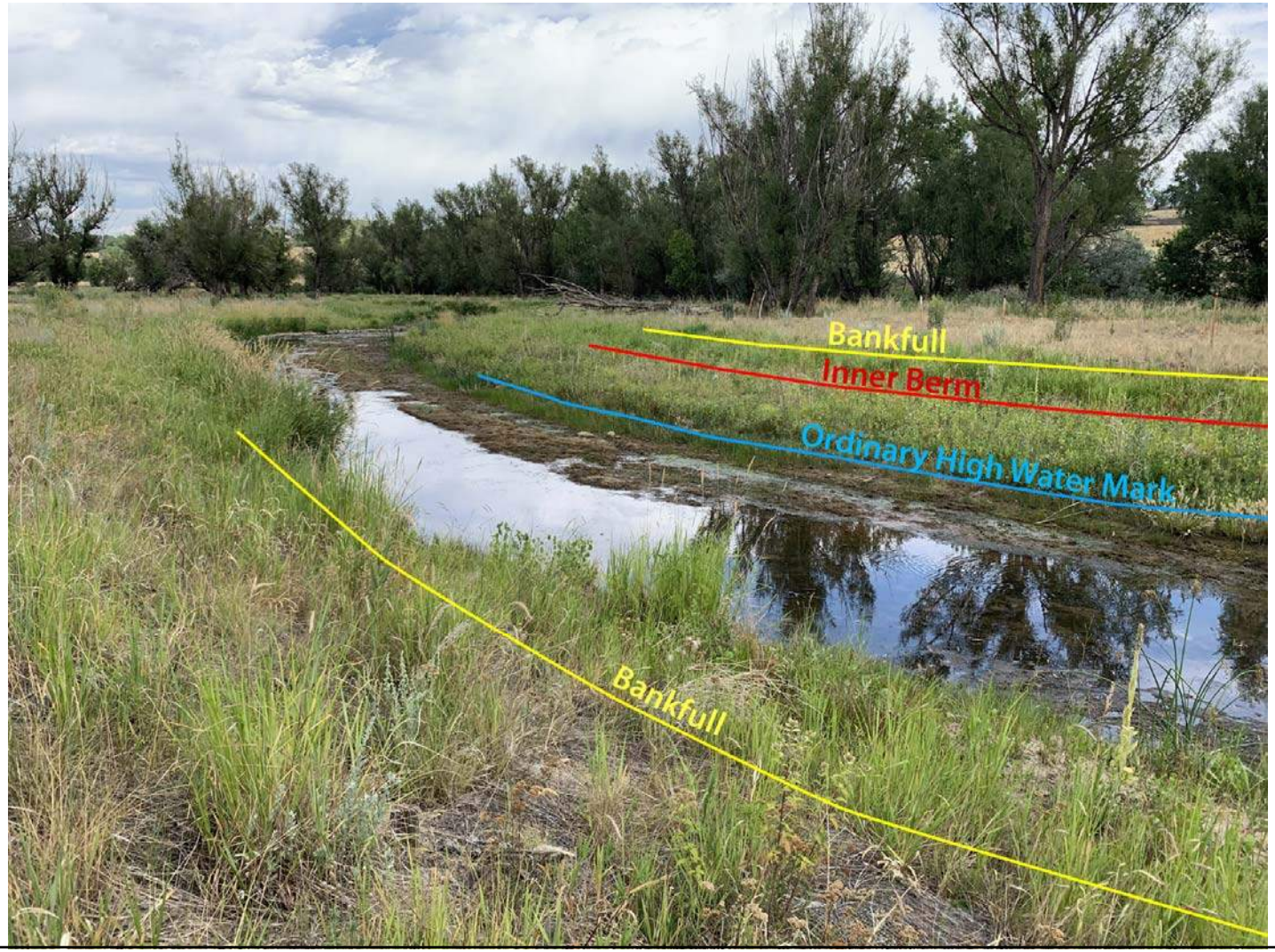
ZONE 4 TYPICAL SECTION

ZONE 4 VEGETATION TYPE: DRY MEADOW/RIPARIAN SHRUBS AND TREES

TYPICAL PLANT SCHEDULE | INSTALLATION METHODS

HERBACEOUS:

Communication Successes – Plum Creek at Chatfield State Park

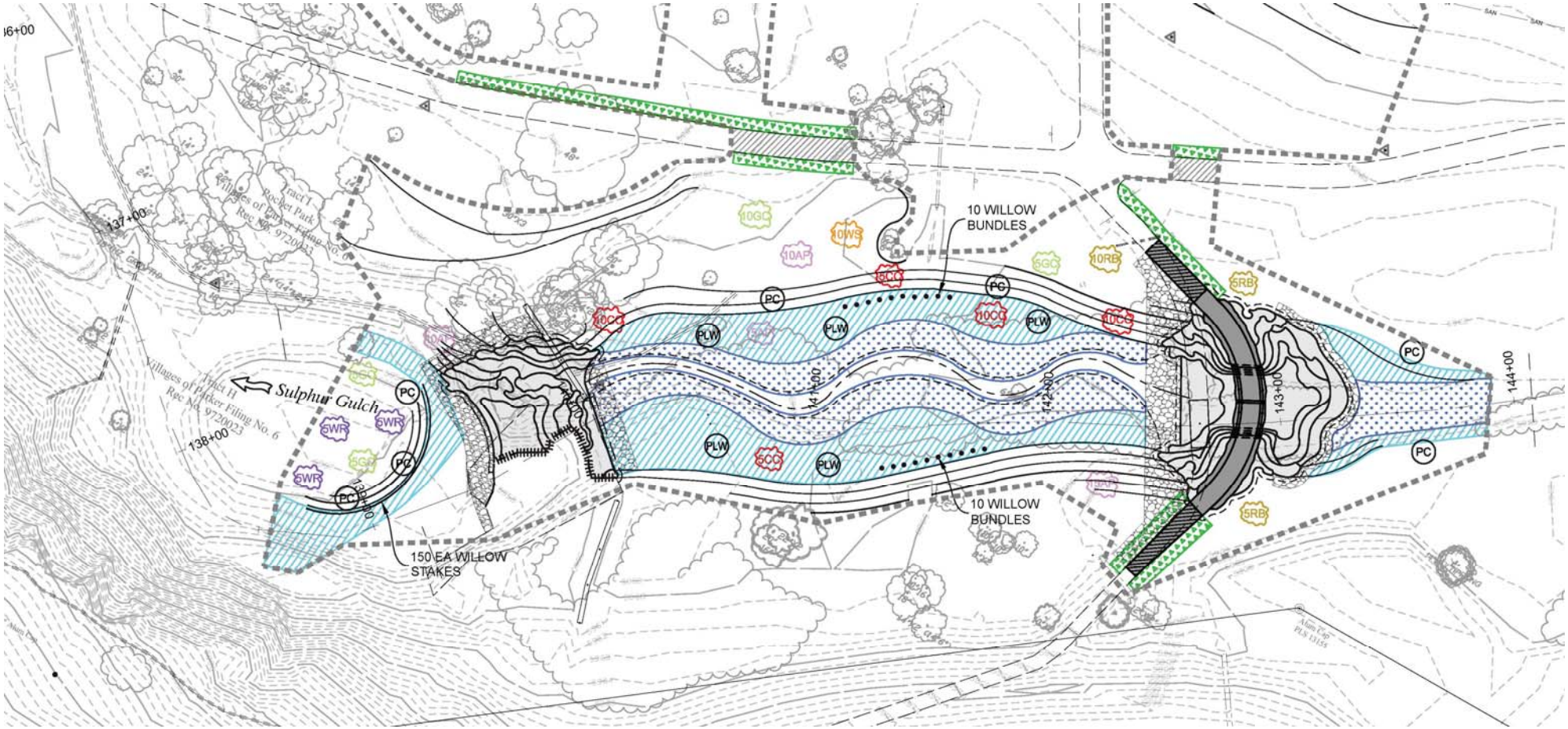


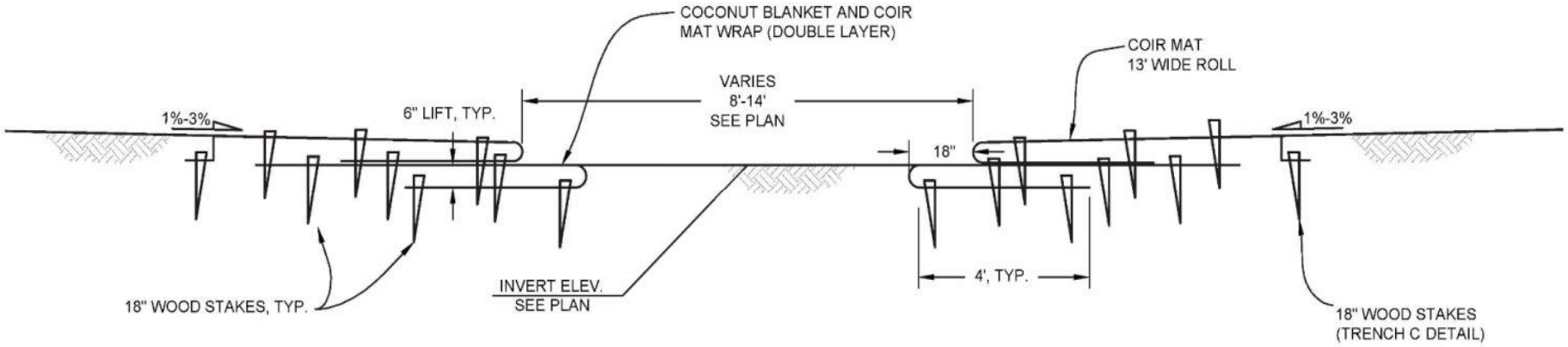
Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Communication Successes

Sulphur Gulch at Riva Ridge


Sulphur Gulch
10 WILLOW BUNDLES
10 WILLOW BUNDLES
150 EA WILLOW STAKES
137+00
138+00
139+00
141+00
142+00
143+00
144+00
PC
PLW
10GC
10WS
10AP
10CC
5GC
10RB
5RB
5WR
6WR
Tract H
Villages of Parker Filing No. 6
Rec No. 9720023
Tract I
Rocket Park
Villages of Parker Filing No. 6
Rec No. 9720023



LOW FLOW CHANNEL

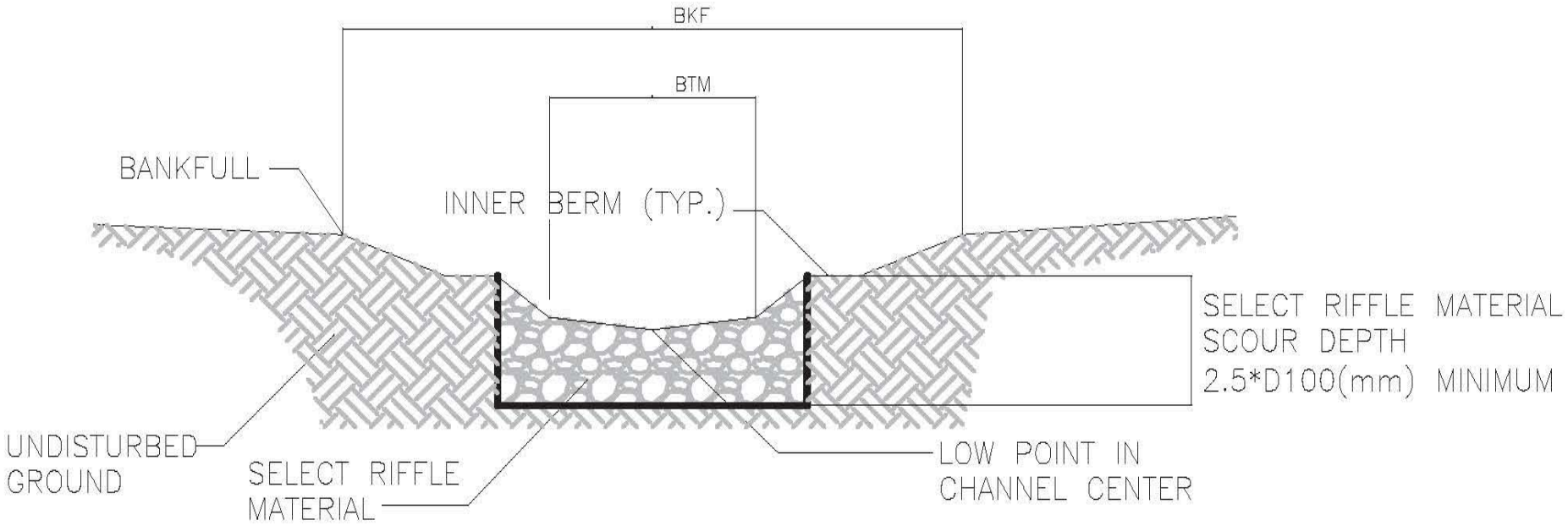
SCALE: 1" = 2'-0"

Why are the Wetlands Dry?

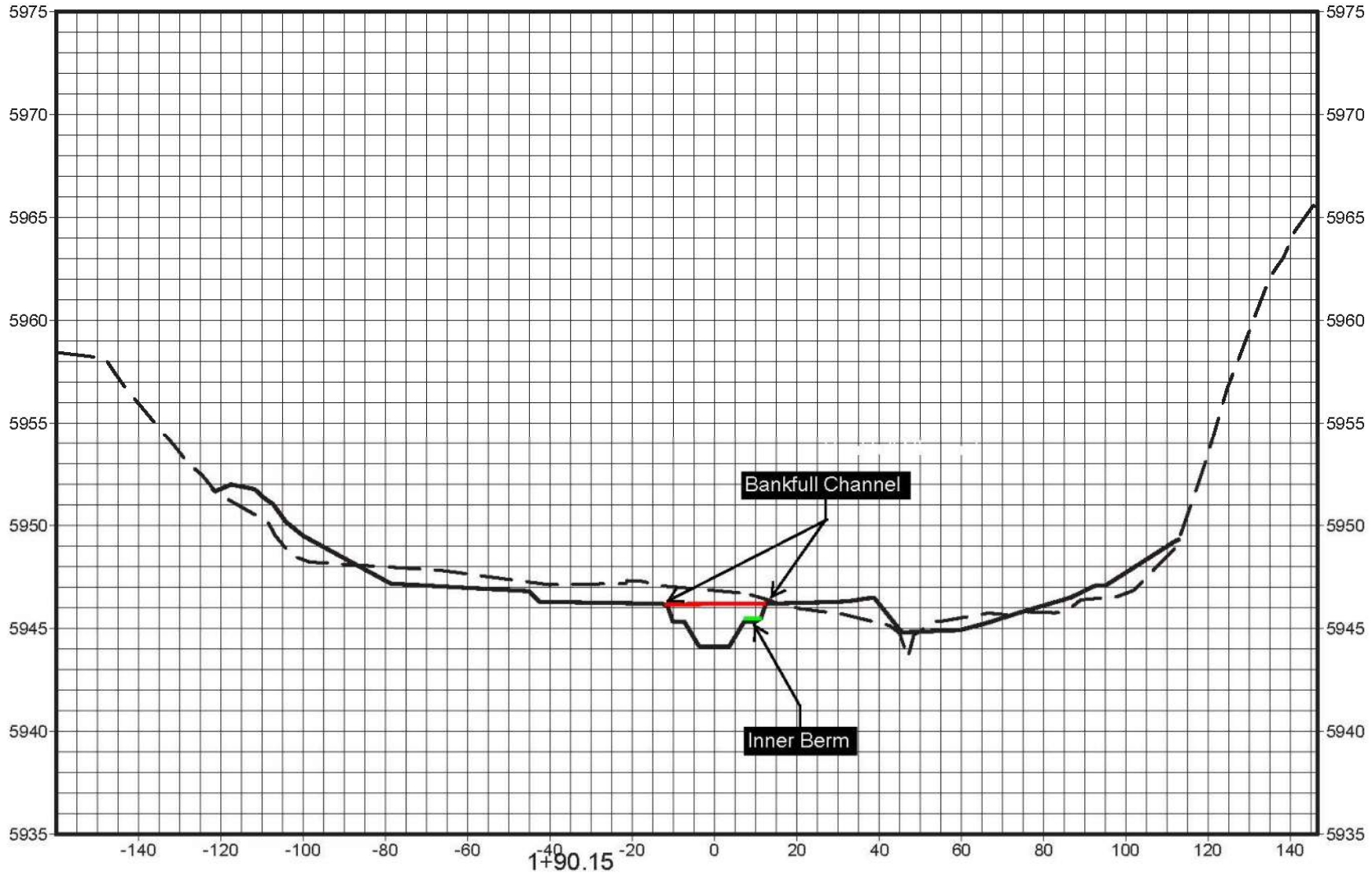
Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

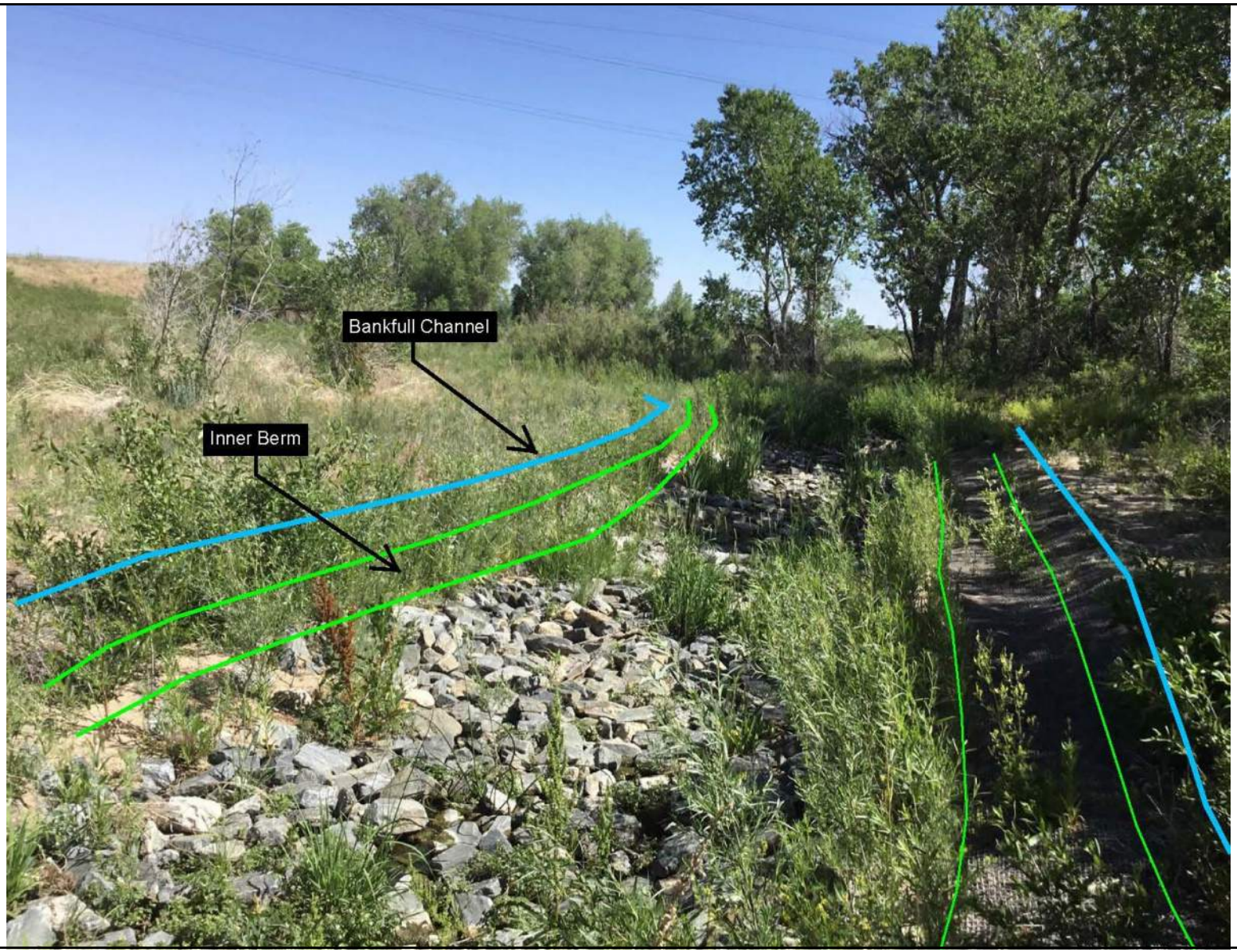
Communication Challenges

Newlin Gulch at Chambers Road


BKF
BTM
BANKFULL
INNER BERM (TYP.)
SELECT RIFFLE MATERIAL
SCOUR DEPTH
2.5*D100(mm) MINIMUM
UNDISTURBED
GROUND
SELECT RIFFLE
MATERIAL
LOW POINT IN
CHANNEL CENTER

SECTION
A–A'


5975
5970
5965
5960
5955
5950
5945
5940
5935
-140
-120
-100
-80
-60
-40
-20
0
20
40
60
80
100
120
140
Bankfull Channel
Inner Berm
1+90.15

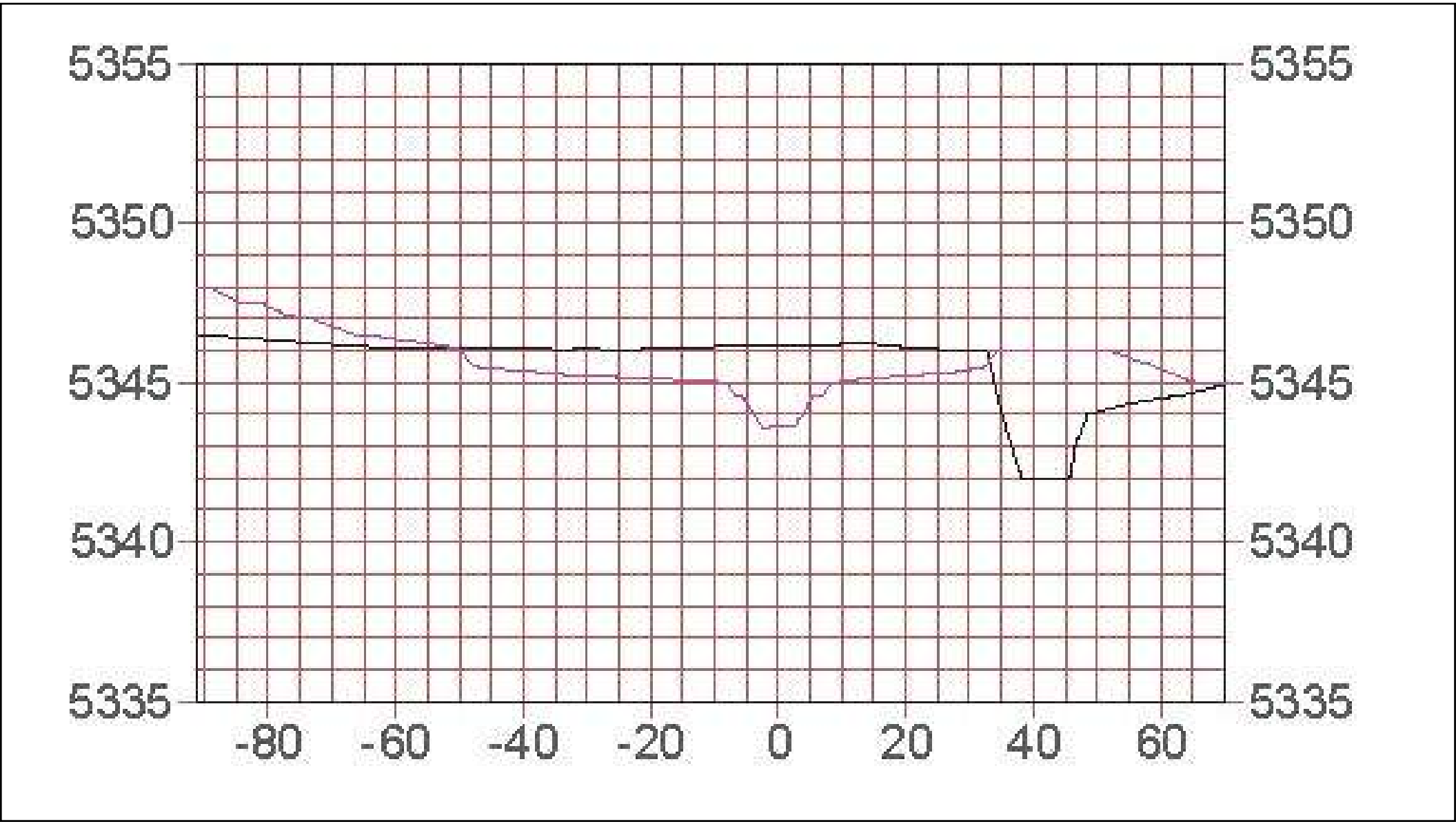

Bankfull Channel
Inner Berm

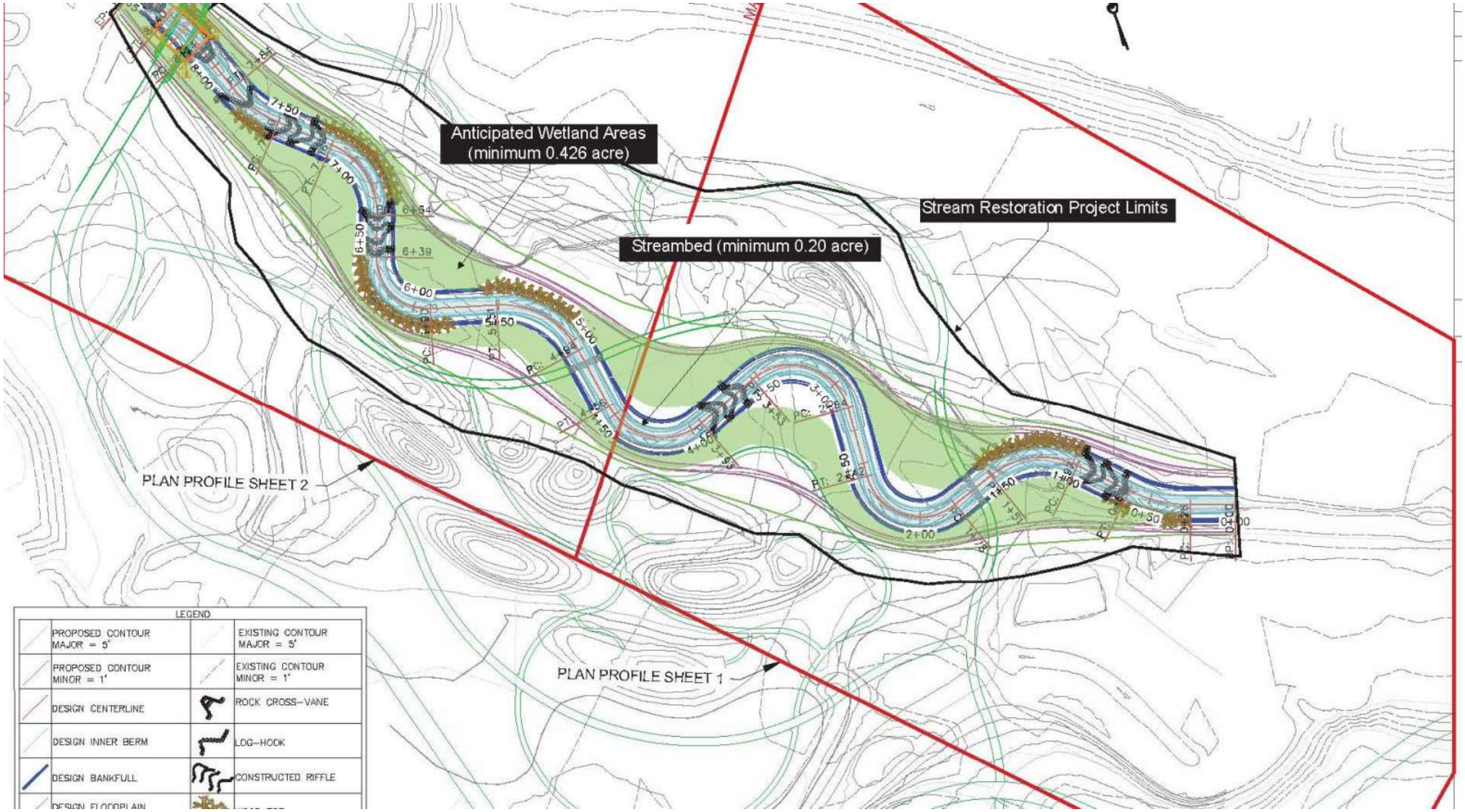
Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Communication Challenges

First Creek Upstream of Tower Road


5355
5350
5345
5340
5335
-80
-60
-40
-20
0
20
40
60

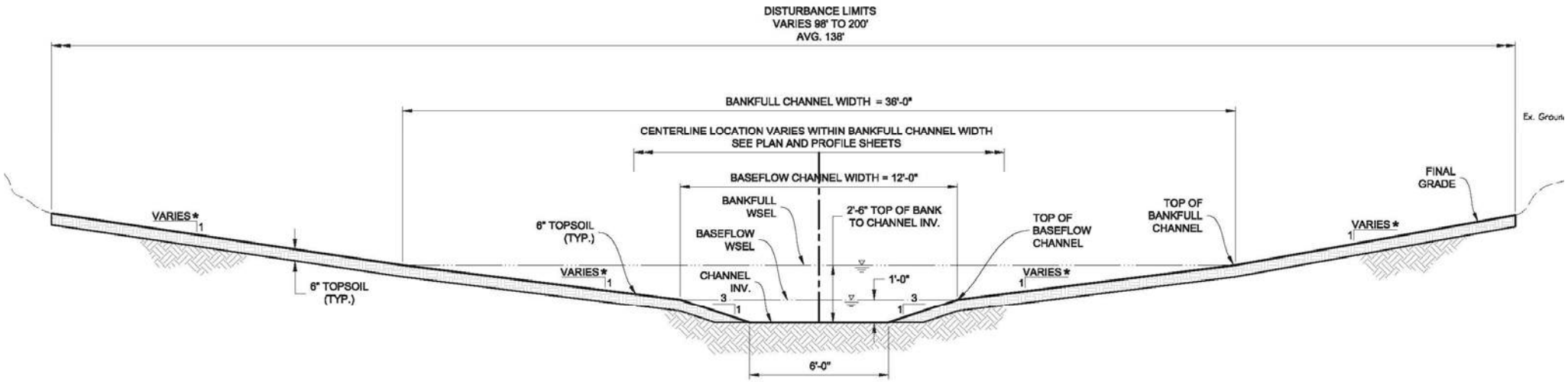

Anticipated Wetland Areas
(minimum 0.426 acre)
Streambed (minimum 0.20 acre)
Stream Restoration Project Limits
PLAN PROFILE SHEET 2
PLAN PROFILE SHEET 1
LEGEND
PROPOSED CONTOUR MAJOR = 5'
EXISTING CONTOUR MAJOR = 5'
PROPOSED CONTOUR MINOR = 1'
EXISTING CONTOUR MINOR = 1'
DESIGN CENTERLINE
ROCK CROSS-VANE
DESIGN INNER BERM
LOG-HOOK
DESIGN BANKFULL
CONSTRUCTED RIFFLE

Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Communication Challenges

West Fork Second Creek



CHANNEL SECTION (TYP.)

0' 2.5' 5'


L1.0
KEYMAP
SHRUB MASSING, TYP.
TREE MASSING, TYP.
CHANNEL TOE (BANKFULL), TYP.
FUTURE TRAIL (APPROX. LOCATION)
RIPRAP, TYP.
LIMITS OF CONSTRUCTION
EXST. TREE TO REMAIN, TYP.
MATCHLINE RE: SHEET L1.0
MATCHLINE RE: SHEET L1.2

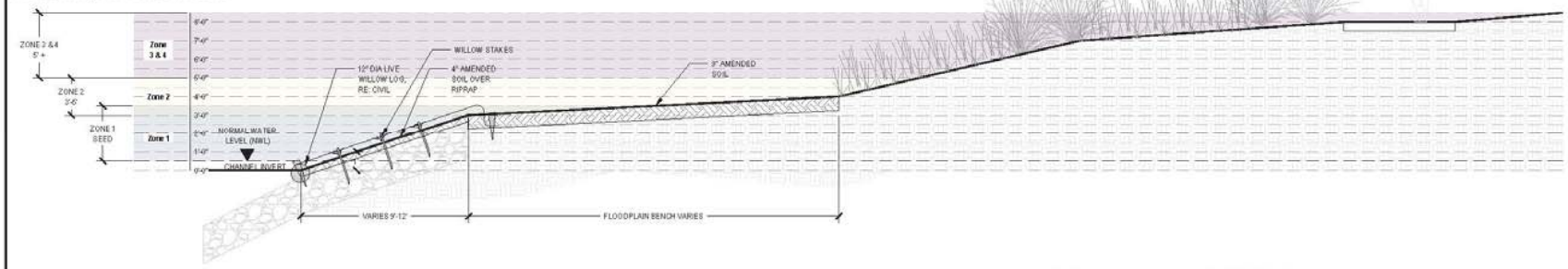
Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

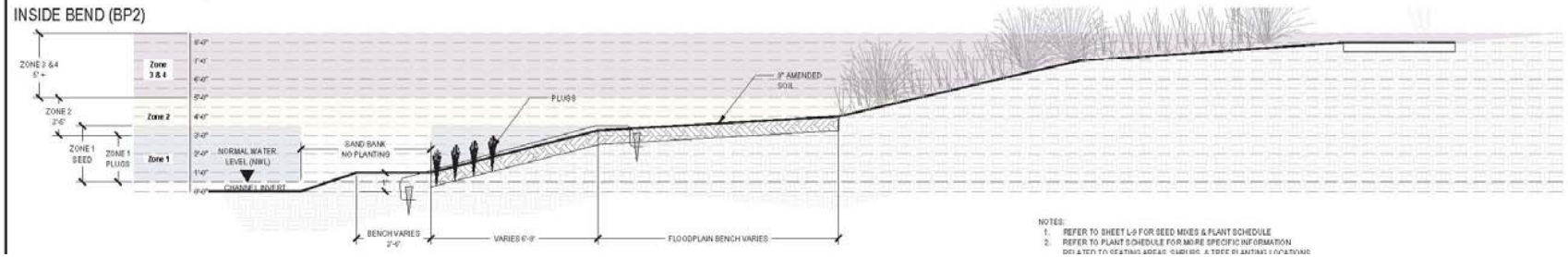
Communication Successes

Cherry Creek at Iliff

OUTSIDE BEND (BP1) - NO BENCH, WITH WILLOW LOG



INSIDE BEND (BP2)



NOTES:

1. REFER TO SHEET L-9 FOR SEED MIXES & PLANT SCHEDULE
2. REFER TO PLANT SCHEDULE FOR MORE SPECIFIC INFORMATION RELATED TO SEATING AREAS, SHRUBS, & TREE PLANTING LOCATIONS

Why are the Wetlands Dry?

Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Lessons Learned

- Communicate early and often
- Establish goals and how to meet them
- Speak up on your subject matter
- Equal voices on a collaborative team
- Use graphics and maps to confirm understanding
- Right people, right time for construction inspections

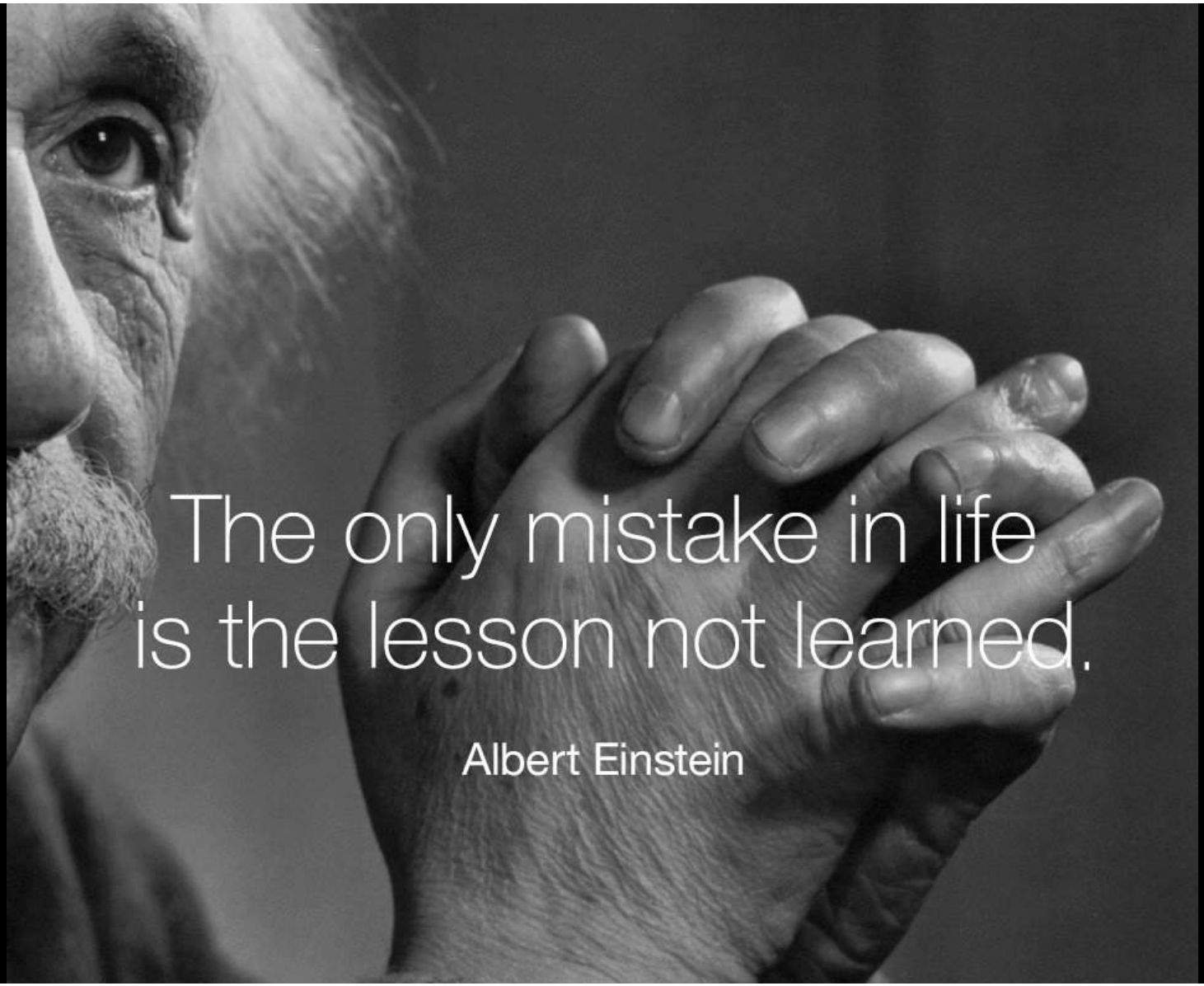
Why are the Wetlands Dry?

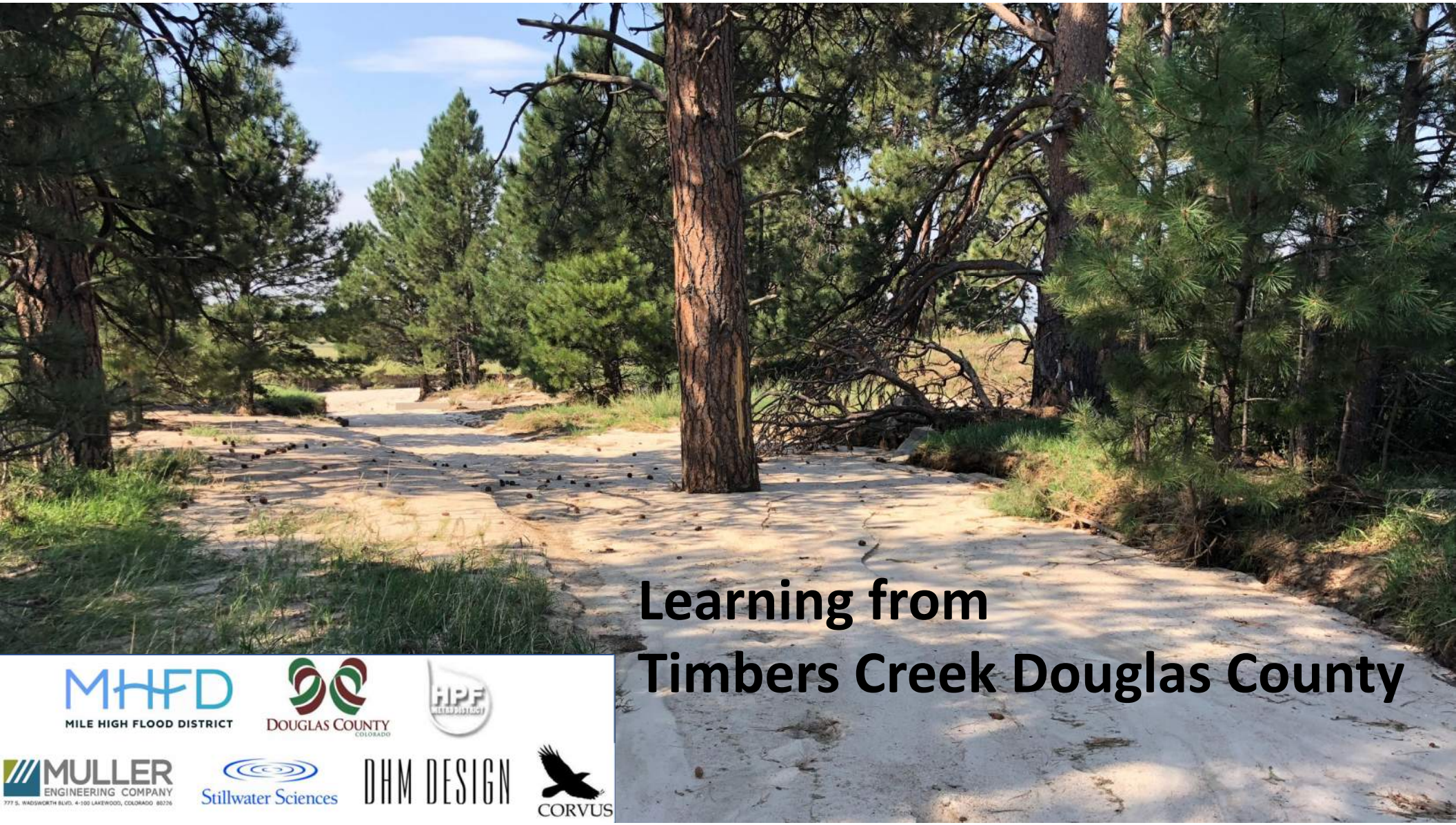
Lessons learned when ecologists don't know how to be heard on multidisciplinary teams

Questions or Comments

ERO Resources Corporation

MILE HIGH FLOOD DISTRICT


The only mistake in life
is the lesson not learned.
Albert Einstein



Learning from Timbers Creek Douglas County

MHFD MILE HIGH FLOOD DISTRICT

DOUGLAS COUNTY COLORADO

HPF METRO DISTRICT

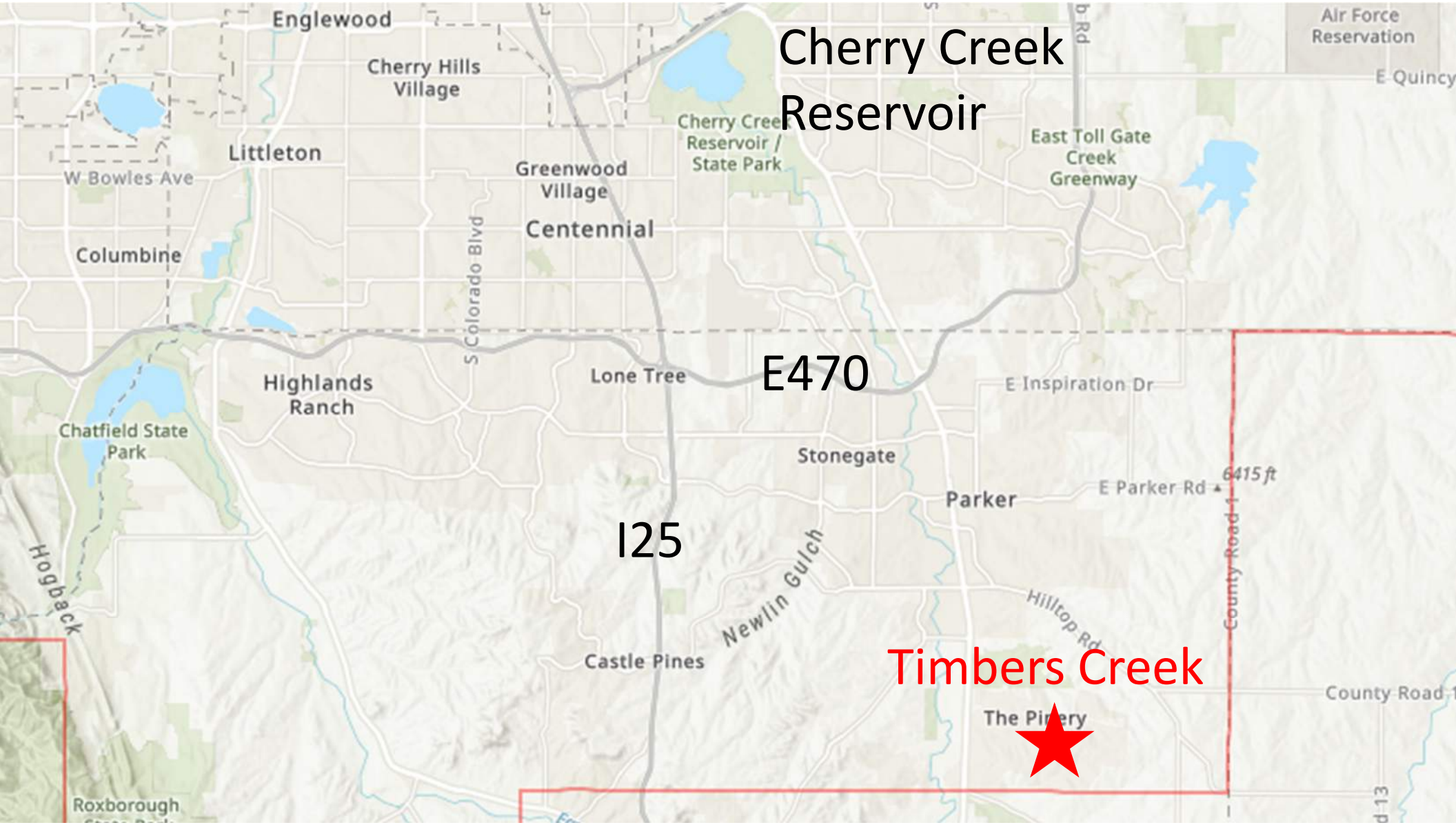
MULLER ENGINEERING COMPANY 777 S. WADSWORTH BLVD. 4-100 LAKEWOOD, COLORADO 80226

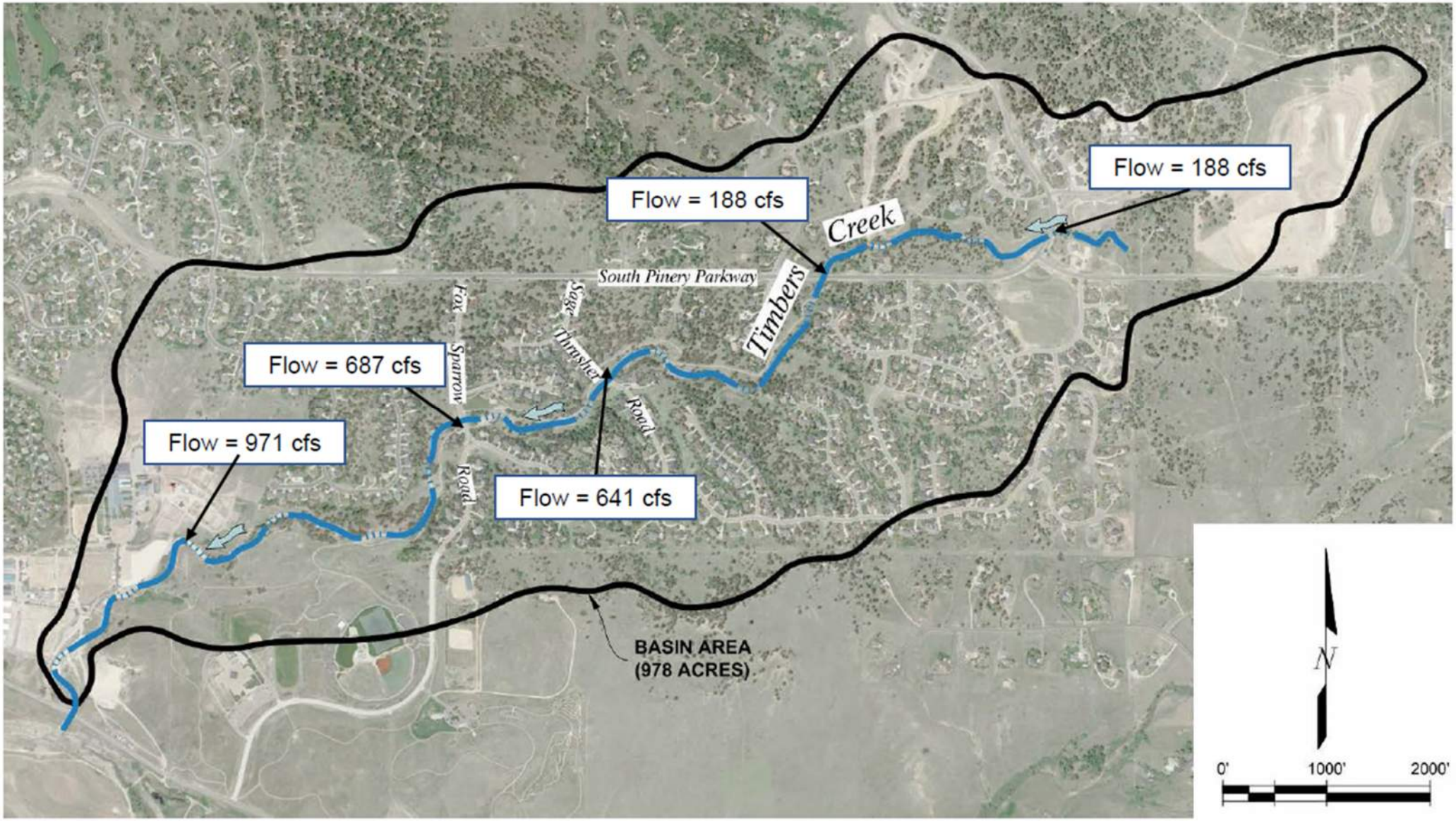
Stillwater Sciences

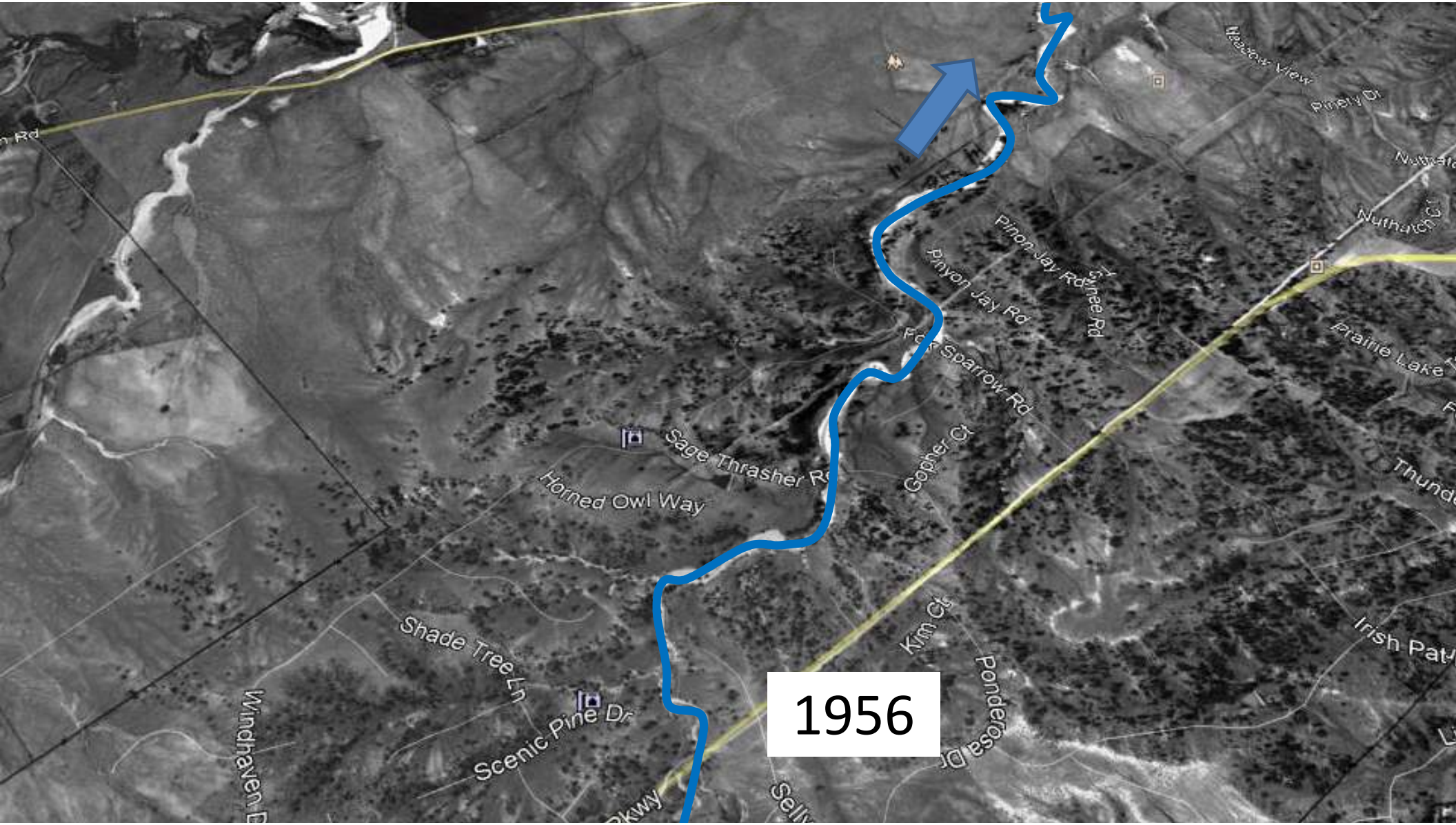
DHM DESIGN

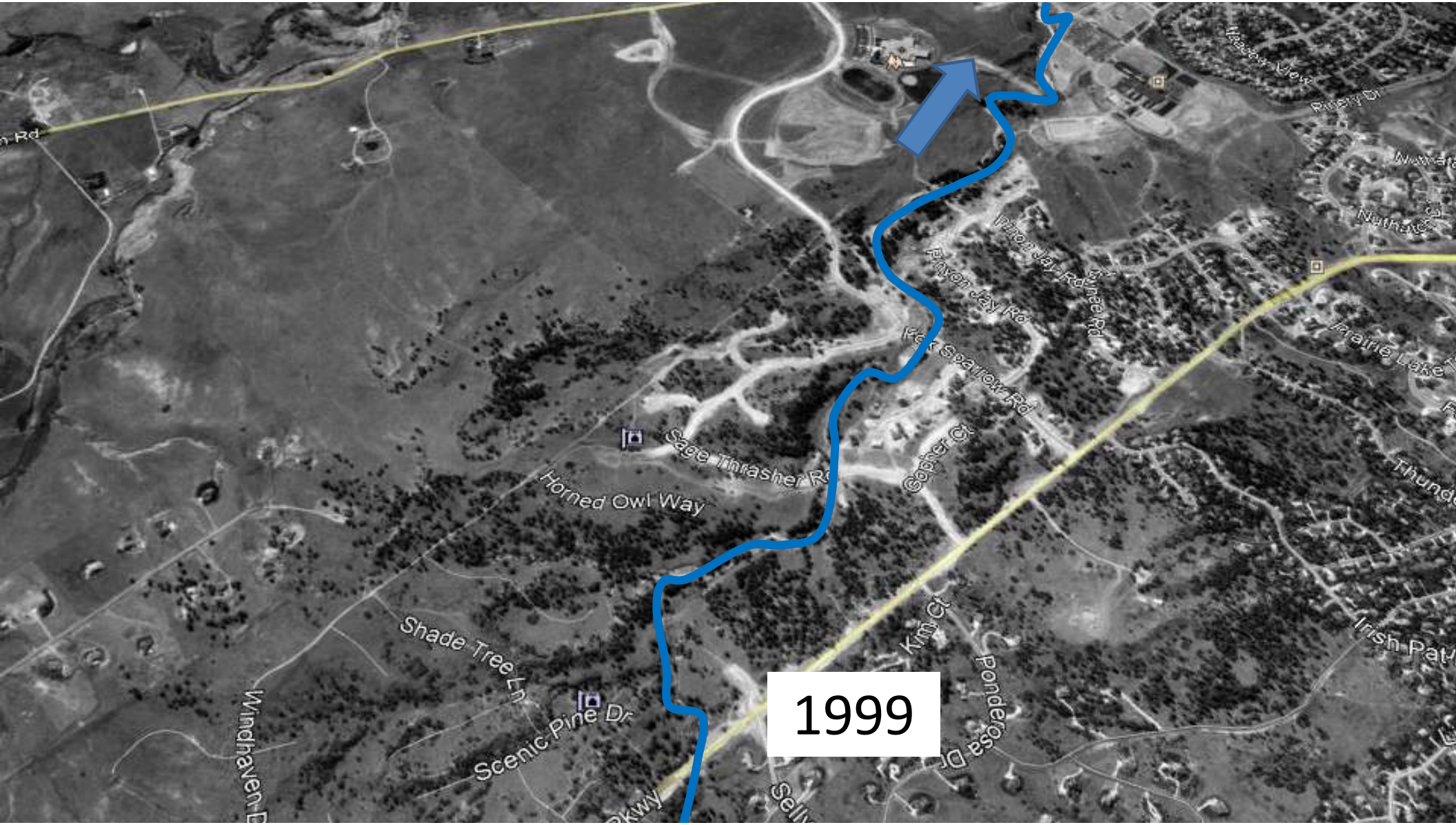
CORVUS

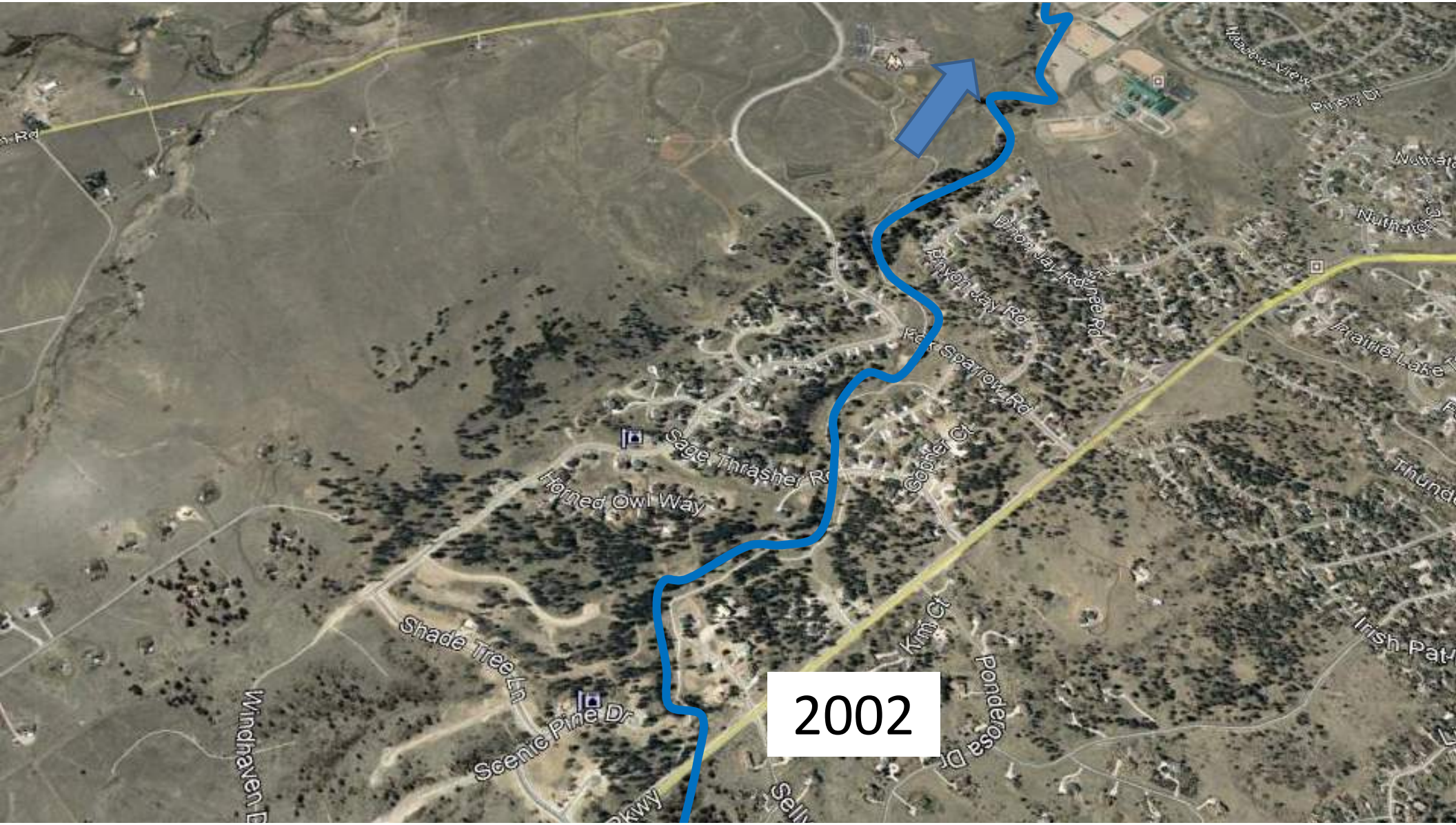

What not to do when you see this?


Cherry Creek Reservoir
E470
I25
Timbers Creek
Englewood
Cherry Hills Village
Littleton
W Bowles Ave
Greenwood Village
Centennial
Cherry Creek Reservoir / State Park
East Toll Gate Creek Greenway
Air Force Reservation
E Quincy
Columbine
S Colorado Blvd
Highlands Ranch
Lone Tree
E Inspiration Dr
Chatfield State Park
Stonegate
Parker
E Parker Rd
6415 ft
Hogback
Newlin Gulch
Hilltop Rd
County Road 1
Castle Pines
The Pinery
County Road
Roxborough

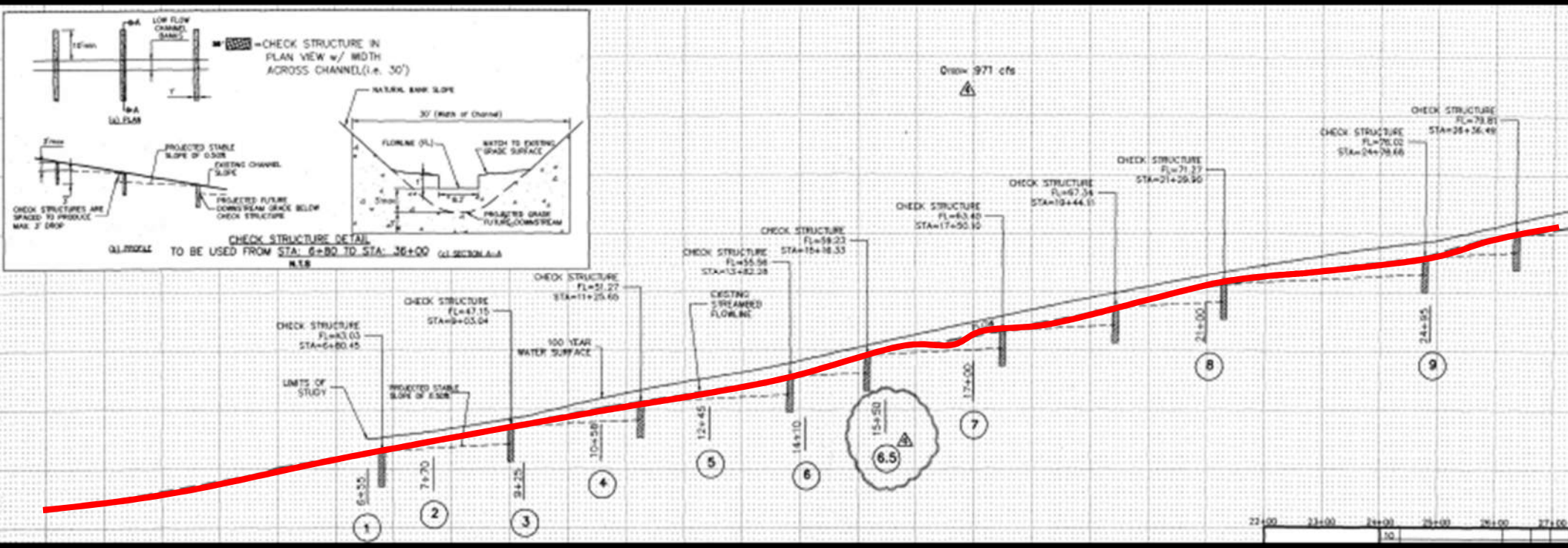

Flow = 188 cfs
Flow = 188 cfs
Creek
Timbers
South Pinery Parkway
Fox
Sparrow
Sage
Thrasher
Road
Road
Flow = 687 cfs
Flow = 971 cfs
Flow = 641 cfs
BASIN AREA
(978 ACRES)
N
0'
1000'
2000'


Meadow View
Piney Dr
Nuthatch Ct
Pinon Jay Rd
Pinyon Jay Rd
Pine Rd
Fox Sparrow Rd
Prairie Lake
Sage Thrasher Rd
Horned Owl Way
Gopher Ct
Thunde
Shade Tree Ln
Scenic Pine Dr
Kim Ct
Ponderosa Dr
Irish Pat
Windhaven D
1956


Sage Thrasher Rd
Horned Owl Way
Shade Tree Ln
Scenic Pine Dr
Windhaven
Canyon Jay Rd
Rock Sparrow Rd
Gopher Ct
Kim Ct
Ponderosa Dr
Prairie Lake
Irish Pat
1999


2002
Canyon Jay Rd
Rock Sparrow Rd
Sage Thrasher Rd
Horned Owl Way
Shade Tree Ln
Scenic Pine Dr
Windhaven
Ponderosa Dr
Irish Pat
Prairie Lake
Nuthatch
Pinery Dr


Pinon Jay Rd
Pinon Jay Rd
Rock Sparrow Rd
Prairie Lake
Sage Thrasher Rd
Horned Owl Way
Gopher Ct
Shade Tree Ln
Scenic Pine Dr
Kim Ct
Ponderosa Dr
Windhaven
2004


=CHECK STRUCTURE IN PLAN VIEW w/ WIDTH ACROSS CHANNEL(i.e. 30')
LOW FLOW CHANNEL BANK
(a) PLAN
NATURAL BANK SLOPE
30' (Width of Channel)
FLOWLINE (FL)
MATCH TO EXISTING GRADE SURFACE
PROJECTED STABLE SLOPE OF 0.50%
EXISTING CHANNEL SLOPE
PROJECTED FUTURE DOWNSTREAM GRADE BELOW CHECK STRUCTURE
CHECK STRUCTURES ARE SPACED TO PRODUCE MAX. 2' DROP
PROJECTED GRADE FUTURE DOWNSTREAM
(b) PROFILE
CHECK STRUCTURE DETAIL
TO BE USED FROM STA: 6+80 TO STA: 36+00
N.T.S.
(c) SECTION A-A
Qmax 971 cfs
CHECK STRUCTURE FL=63.03 STA=6+80.45
CHECK STRUCTURE FL=47.15 STA=9+03.04
CHECK STRUCTURE FL=51.27 STA=11+25.60
CHECK STRUCTURE FL=55.56 STA=13+82.28
CHECK STRUCTURE FL=59.23 STA=15+18.33
CHECK STRUCTURE FL=63.40 STA=17+50.10
CHECK STRUCTURE FL=67.34 STA=19+44.15
CHECK STRUCTURE FL=71.27 STA=21+29.90
CHECK STRUCTURE FL=75.02 STA=24+79.68
CHECK STRUCTURE FL=79.81 STA=26+36.49
LIMITS OF STUDY
PROJECTED STABLE SLOPE OF 0.50%
100 YEAR WATER SURFACE
EXISTING STREAMBED FLOWLINE
6+55
7+70
9+75
10+58
12+45
14+10
15+50
17+00
21+00
24+95
1
2
3
4
5
6
6.5
7
8
9
22+00
23+00
24+00
25+00
26+00
27+00
50


06.20.2012


2002
Gopher Ct


2004
Gopher Ct


2008
Gopher Ct

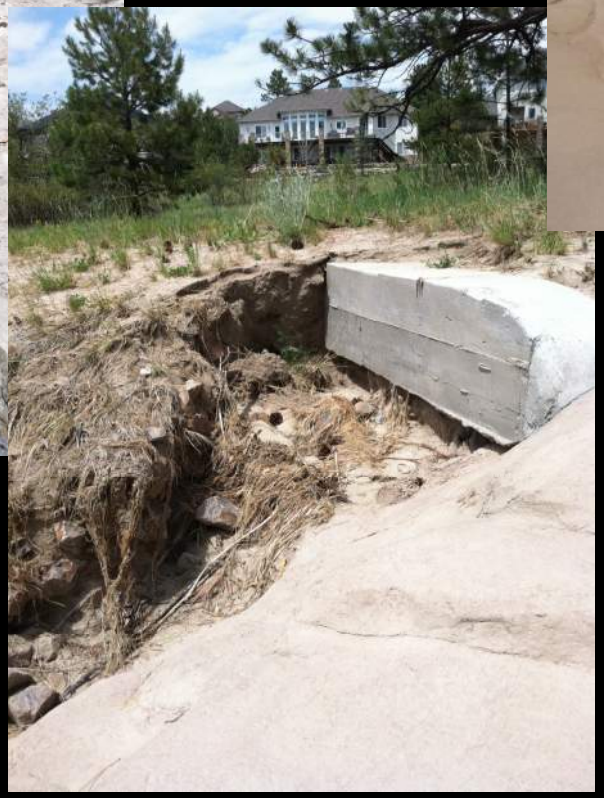

2008


EXISTING GROUND
2-YR WATER SURFACE HGL
APPROX 2-YR WATER SURFACE HGL
S= 0.1%
DROP #4 - SCULPTED
DROP SEE DWG C-7 AND C-8
S= 0.4%
S= 0.5%
PROPOSED GROUND
SHEET PILE, TYP
SHEET PILE, TYP
SHEET PILE, TYP
DROP 2 TOE
STA 5+45.47
ELEV 621.33
DROP 2 CREST
STA 5+75.72
ELEV 621.06
DROP 3 TOE
STA 7+29.06
ELEV 621.76
DROP 3 CREST
STA 7+44.36
ELEV 621.20
DROP 4 TOE
STA 9+46.25
ELEV 621.10
DROP 4 CREST
STA 9+60
ELEV 621.35

2010

2010


2010



2012

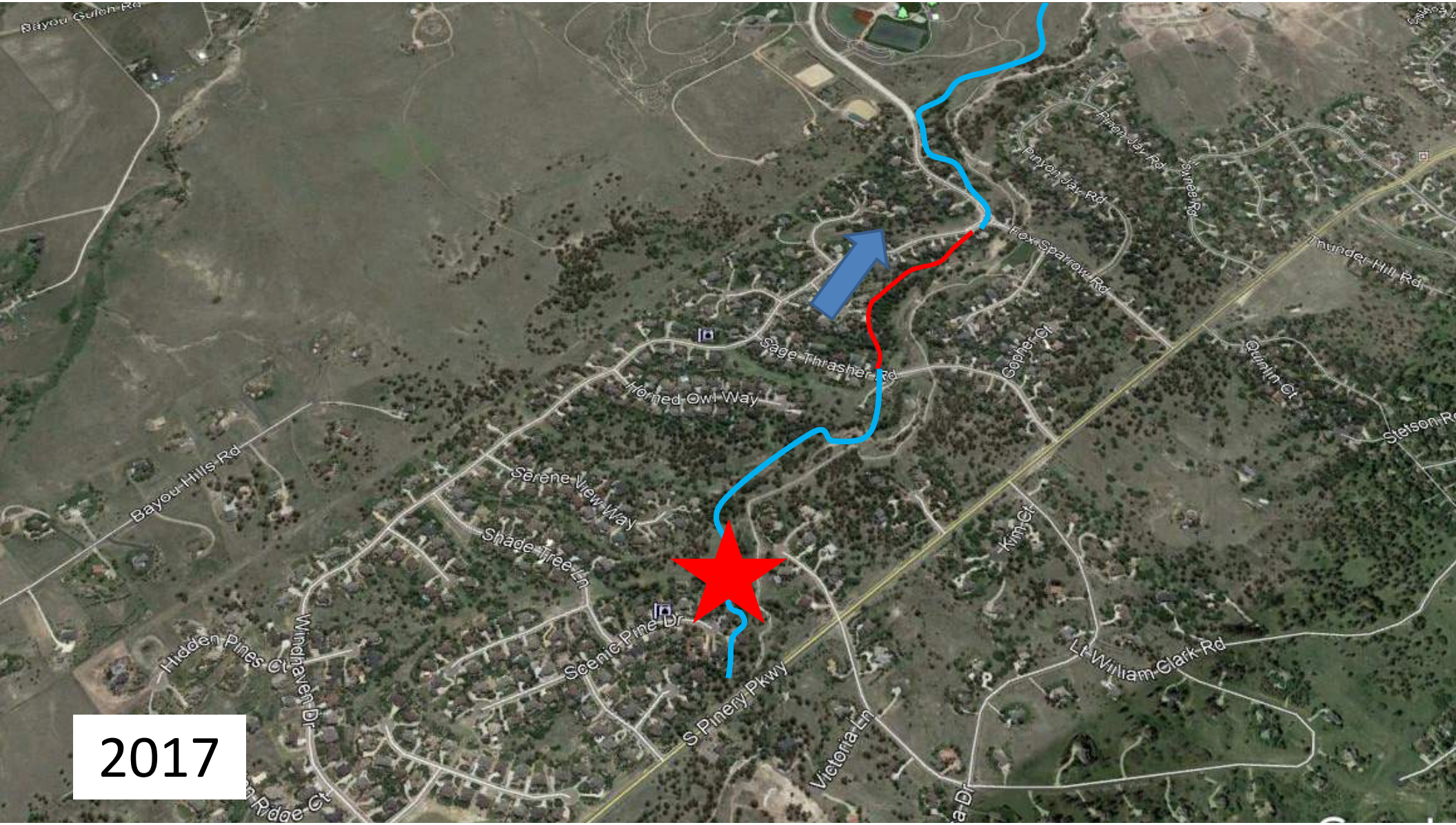
2013

2013

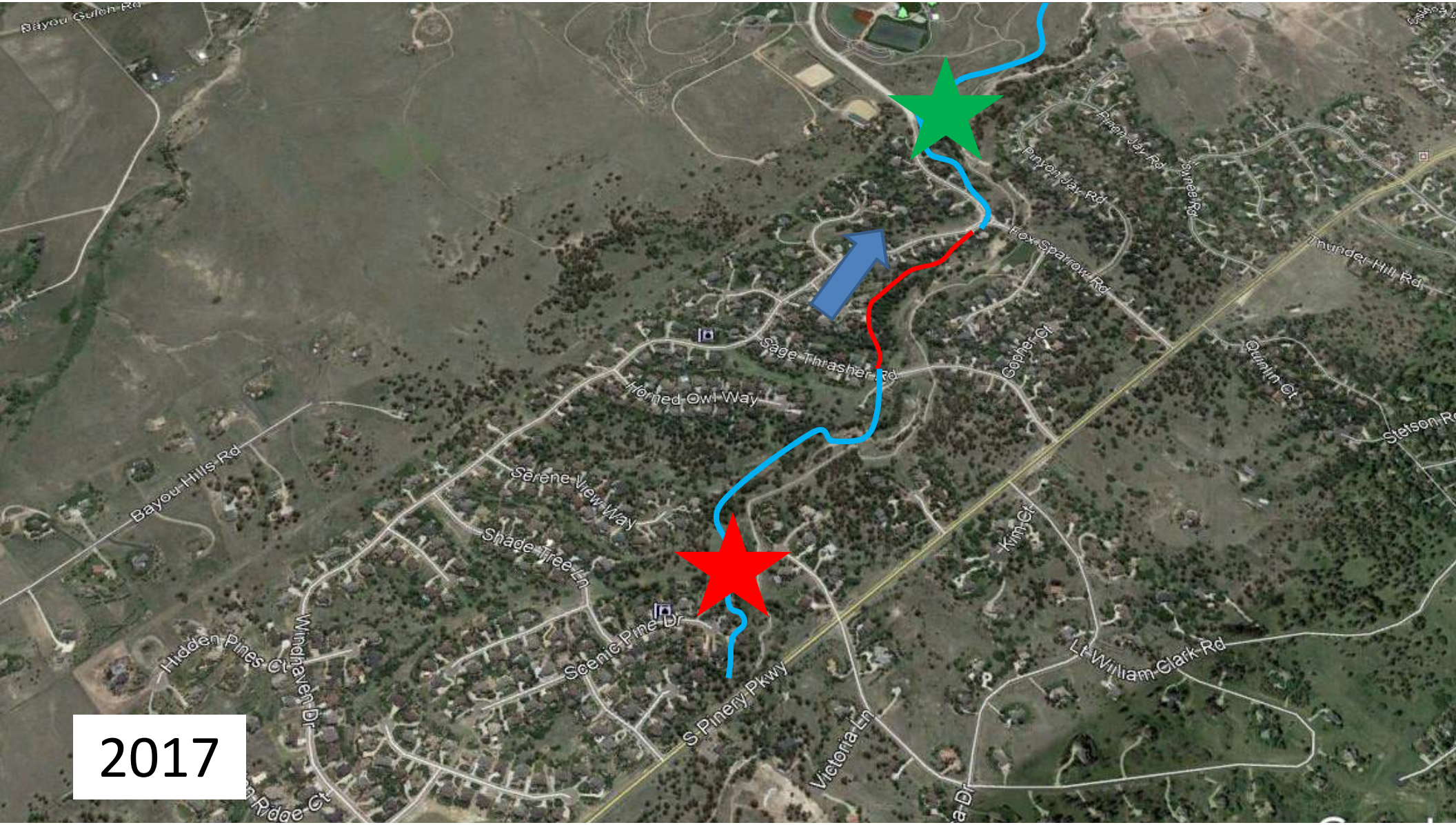
2015

2018


2019


Bayou Gulch Rd
Pinyon Jay Rd
Finch Jay Rd
Swiss Rd
Lox Sparrow Rd
Thunder Hill Rd
Sage Thrasher Rd
Horned Owl Way
Gopher Ct
Quinlin Ct
Stetson Rd
Bayou Hills Rd
Serene View Way
Shade Tree Ln
Kim Ct
Scenic Pine Dr
Hidden Pines Ct
Windhaven Dr
S Pinery Pkwy
Victoria Ln
Lt William Clark Rd
Rdge Ct

2017


Bayou Gulch Rd
Pinon Jay Rd
Silvies Rd
Lex Sparrow Rd
Thunder Hill Rd
Sage Thrasher Rd
Gopher Ct
Quinlin Ct
Horned Owl Way
Stetson Rd
Bayou Hills Rd
Serene View Way
Shade Tree Ln
Kim Ct
Hidden Pines Ct
Windhaven Dr
Scenic Pine Dr
Lt William Clark Rd
S Pinery Pkwy
Victoria Ln
2017

1. Buried concrete structures throughout reach.

2. Large amounts of aggradation. No defined active channel.

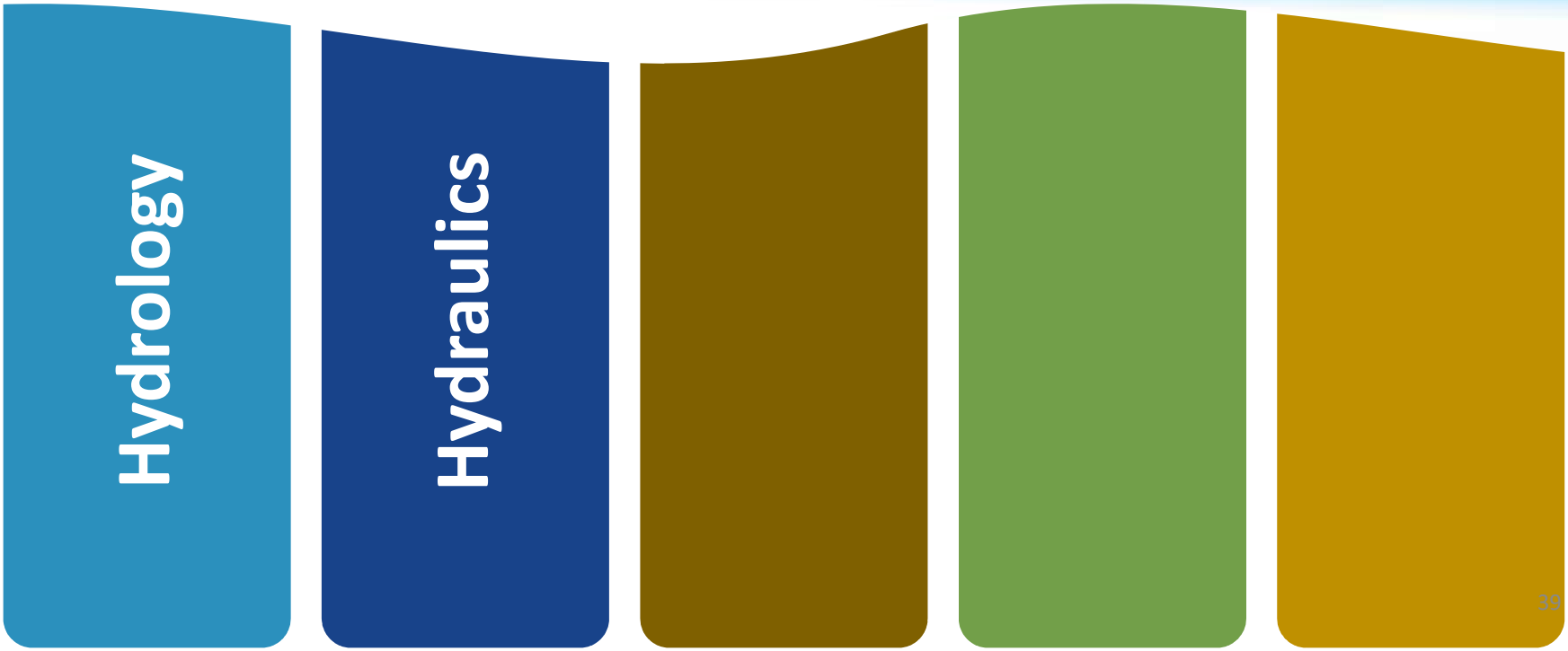
Lesson Learned 1

Stable Stream Network

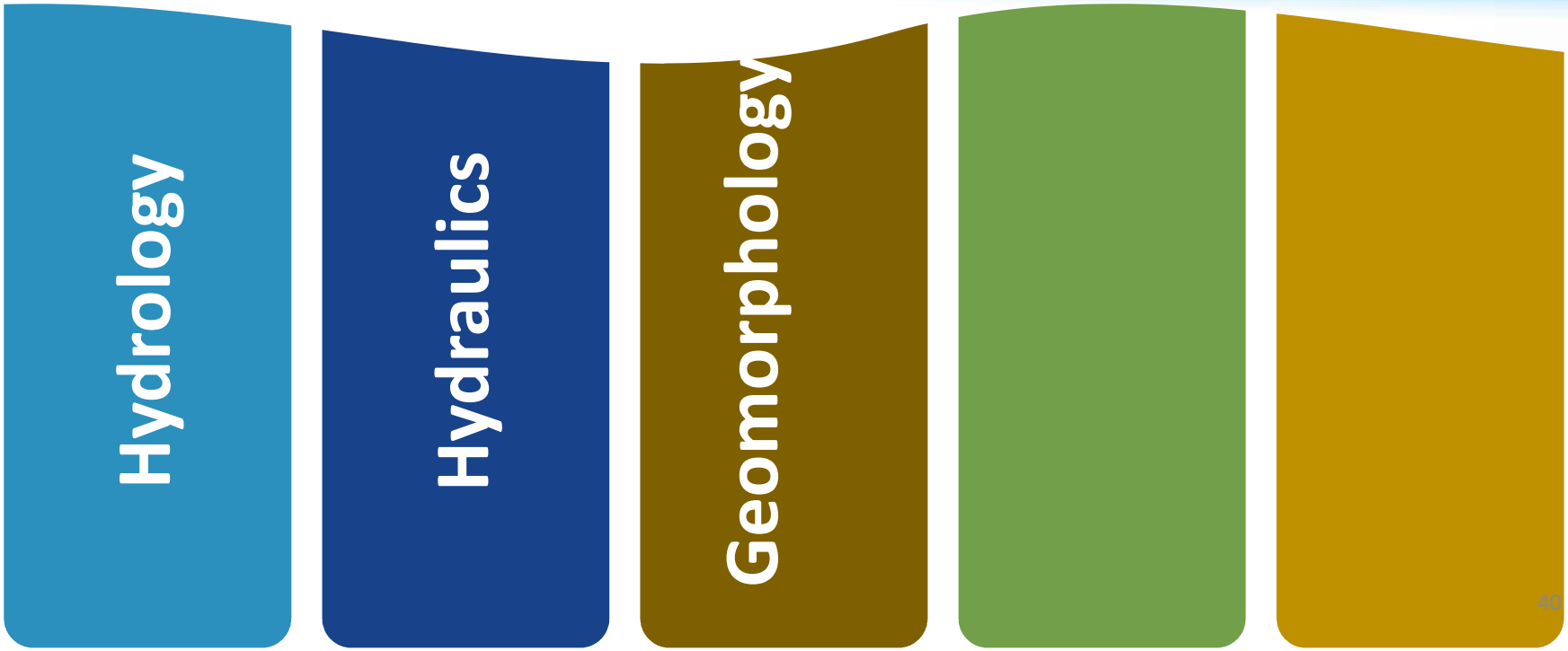
Stable Stream Network

Hydrology

Stable Stream Network



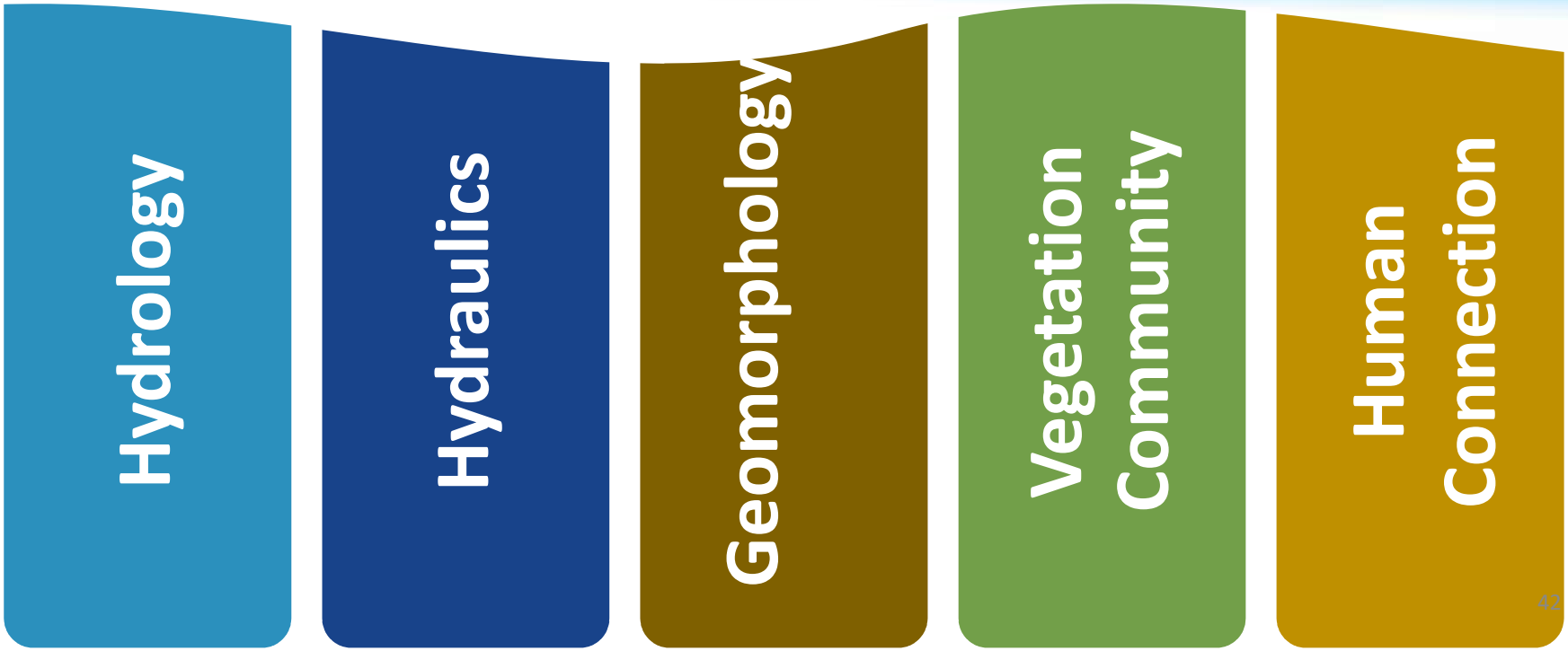
Stable Stream Network



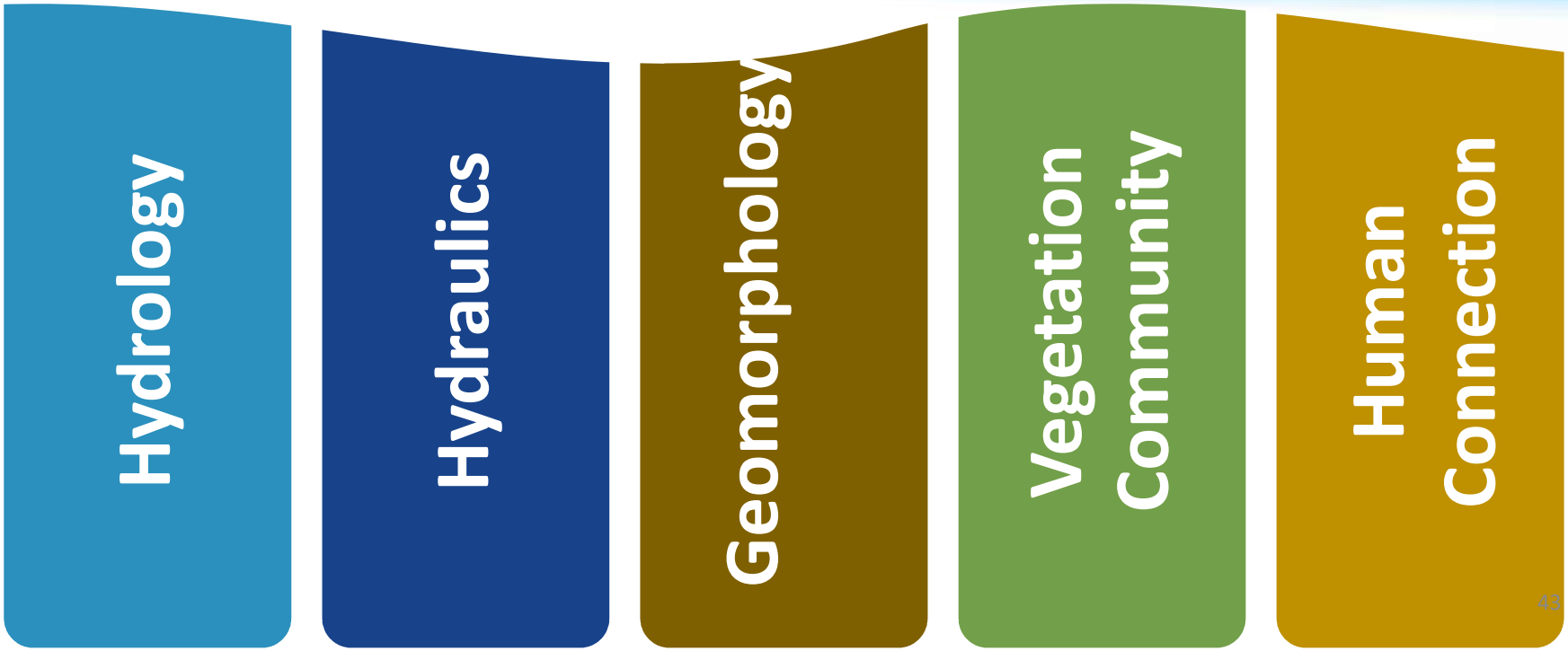
Stable Stream Network

- Hydrology
- Hydraulics
- Geomorphology
- Vegetation Community

Stable Stream Network

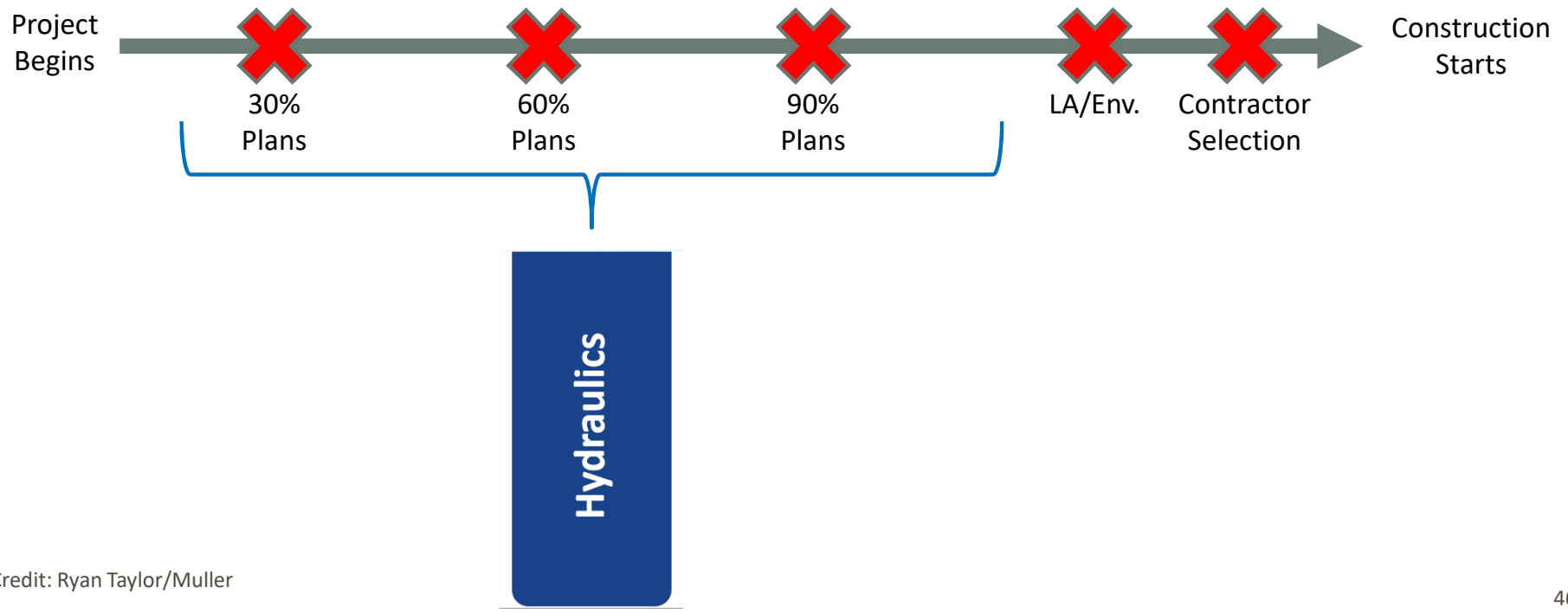


Stable Stream Network



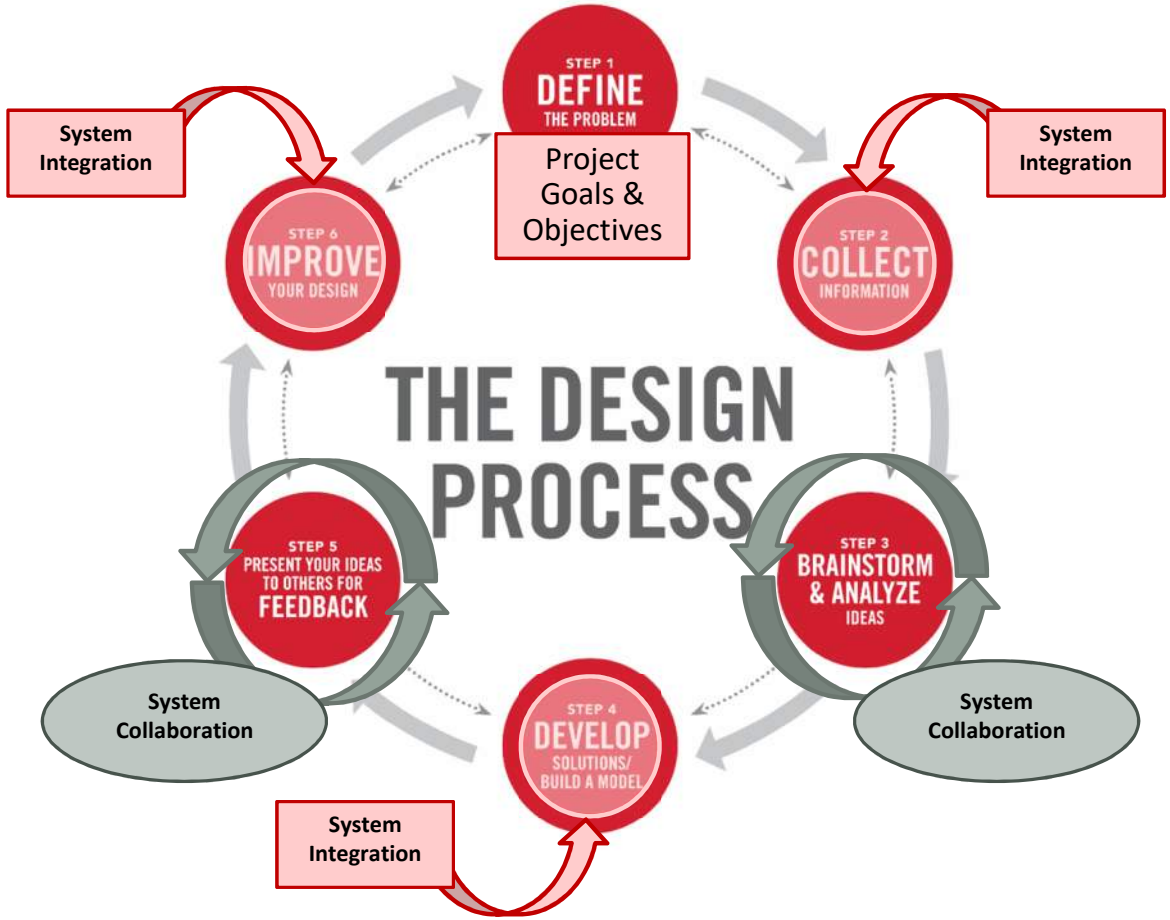
Lesson Learned 2

SILOED DESIGN APPROACH

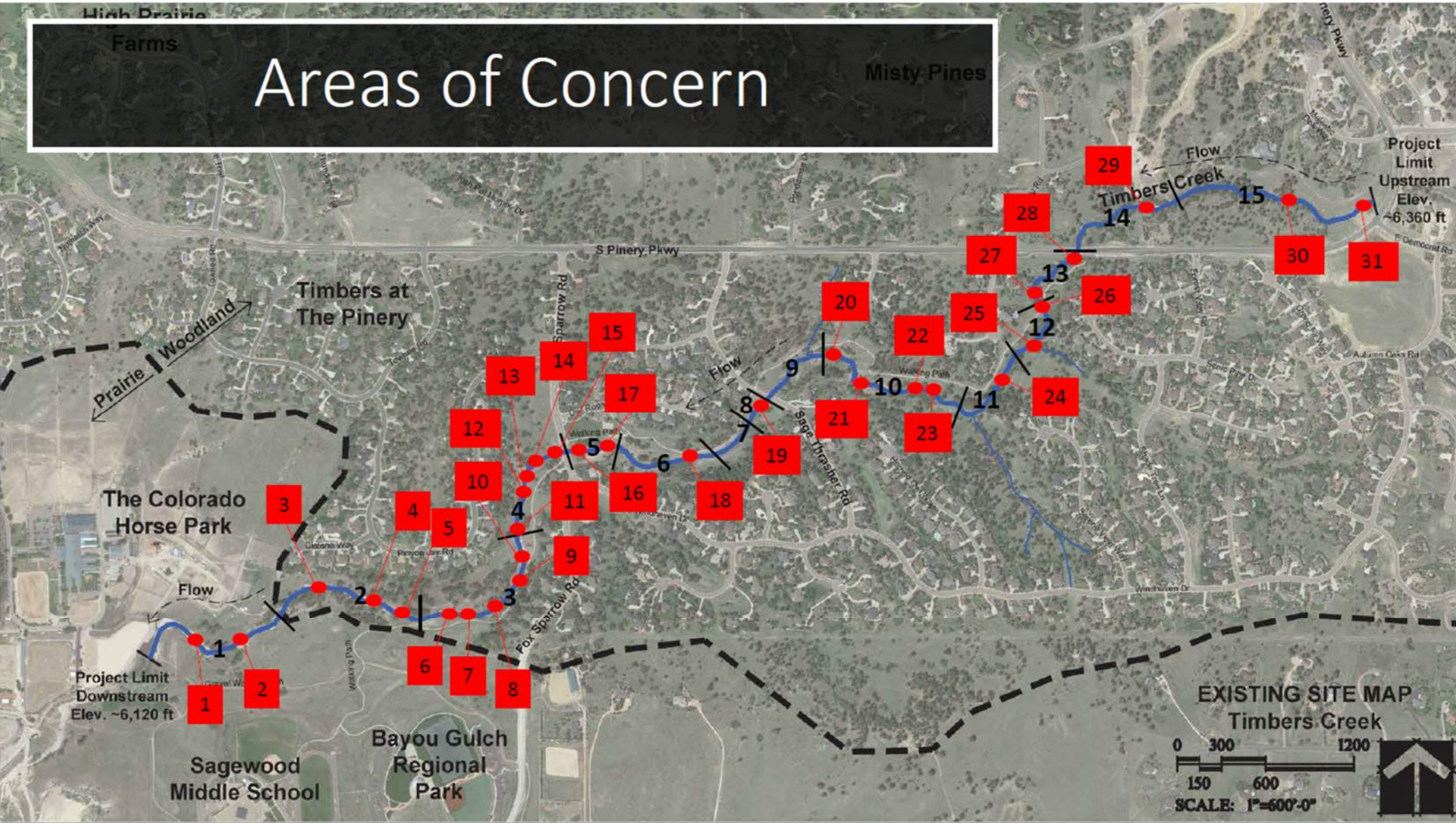


*Slide Credit: Ryan Taylor/Muller

ENGAGE A MULTI-DISCIPLINE TEAM



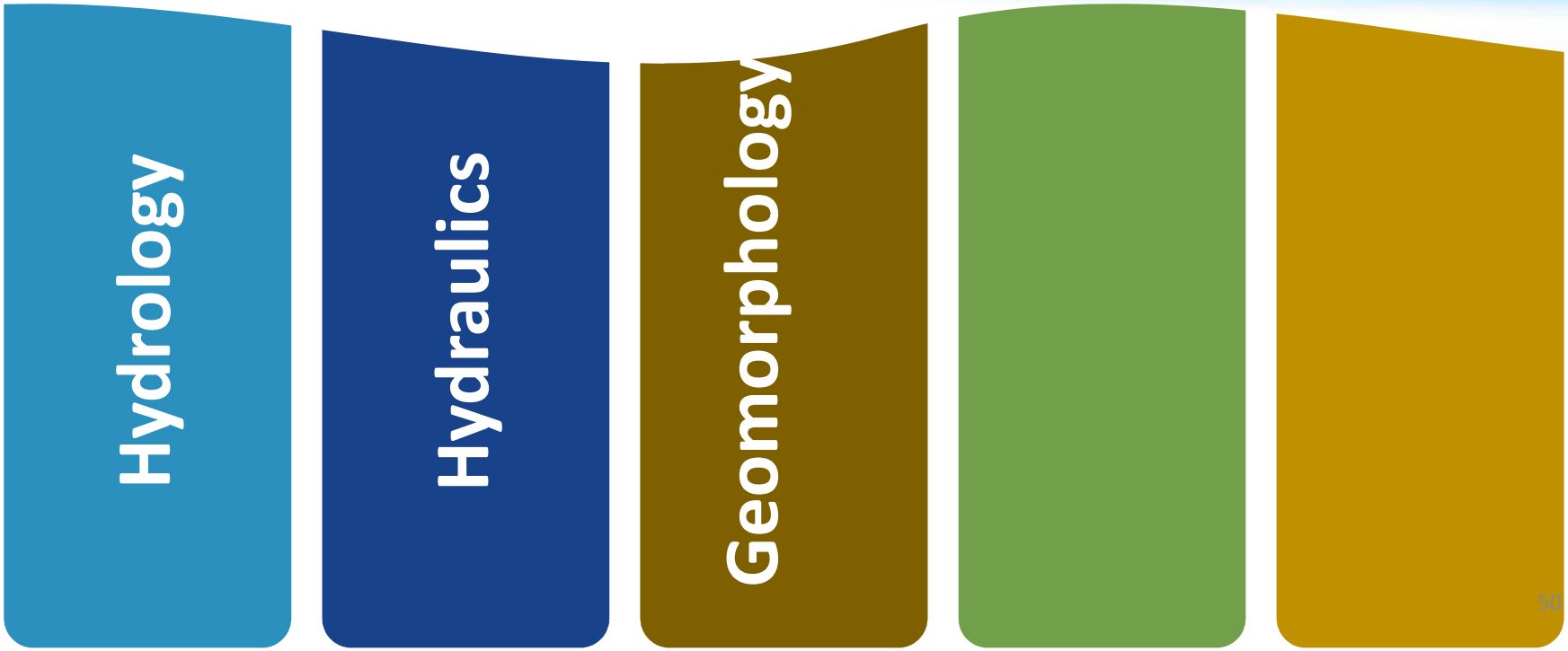
Areas of Concern

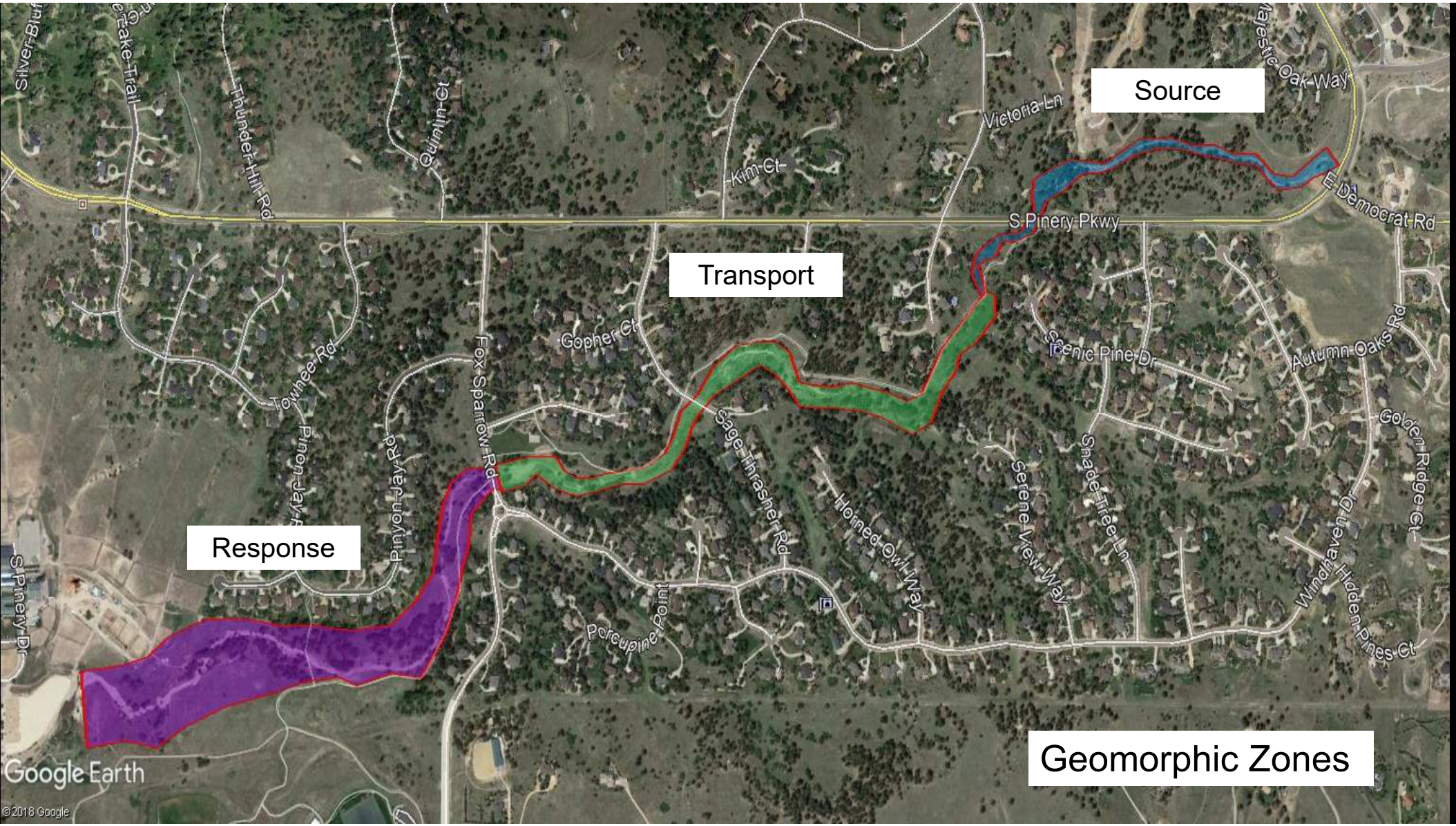


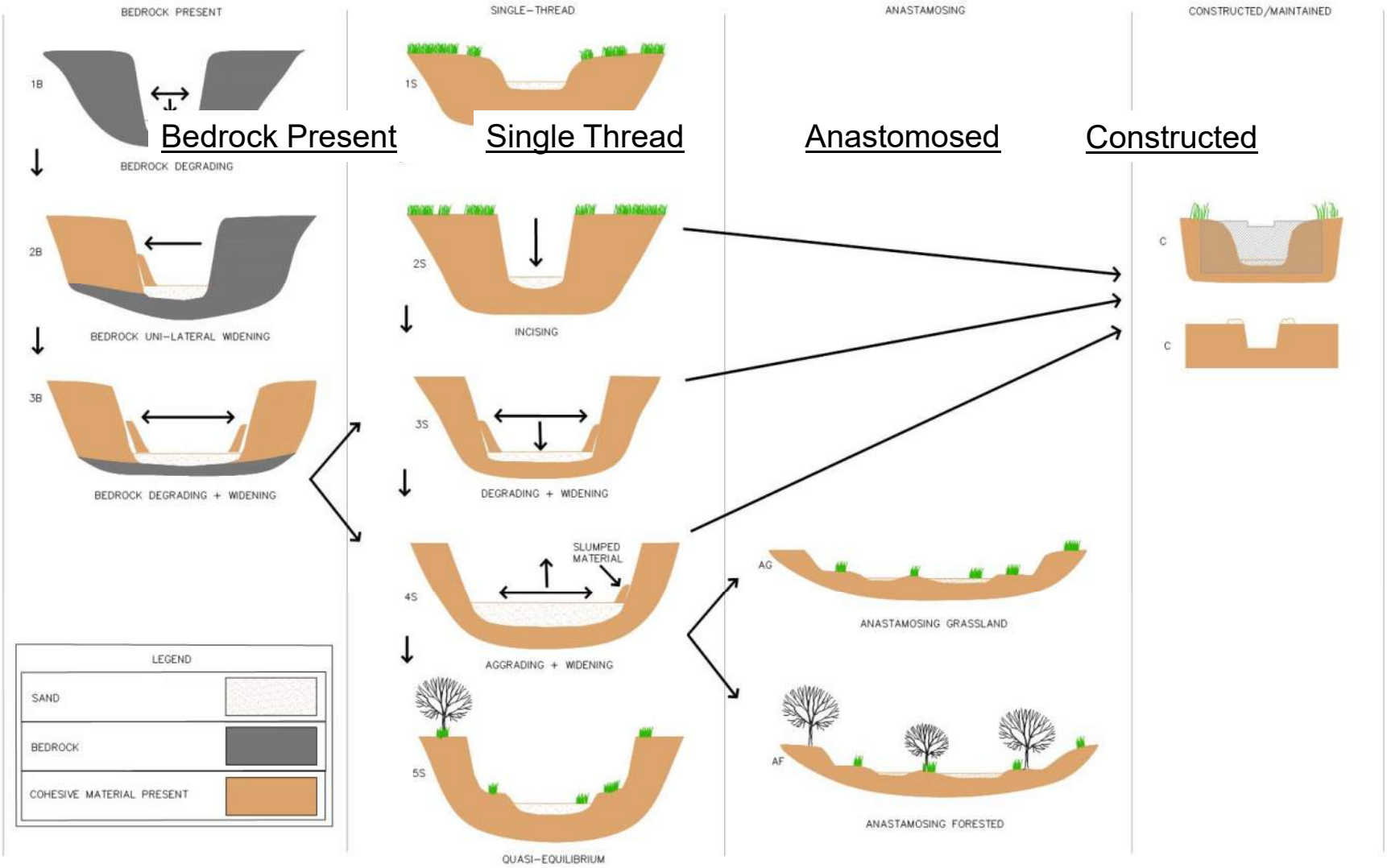
Stable Stream Network

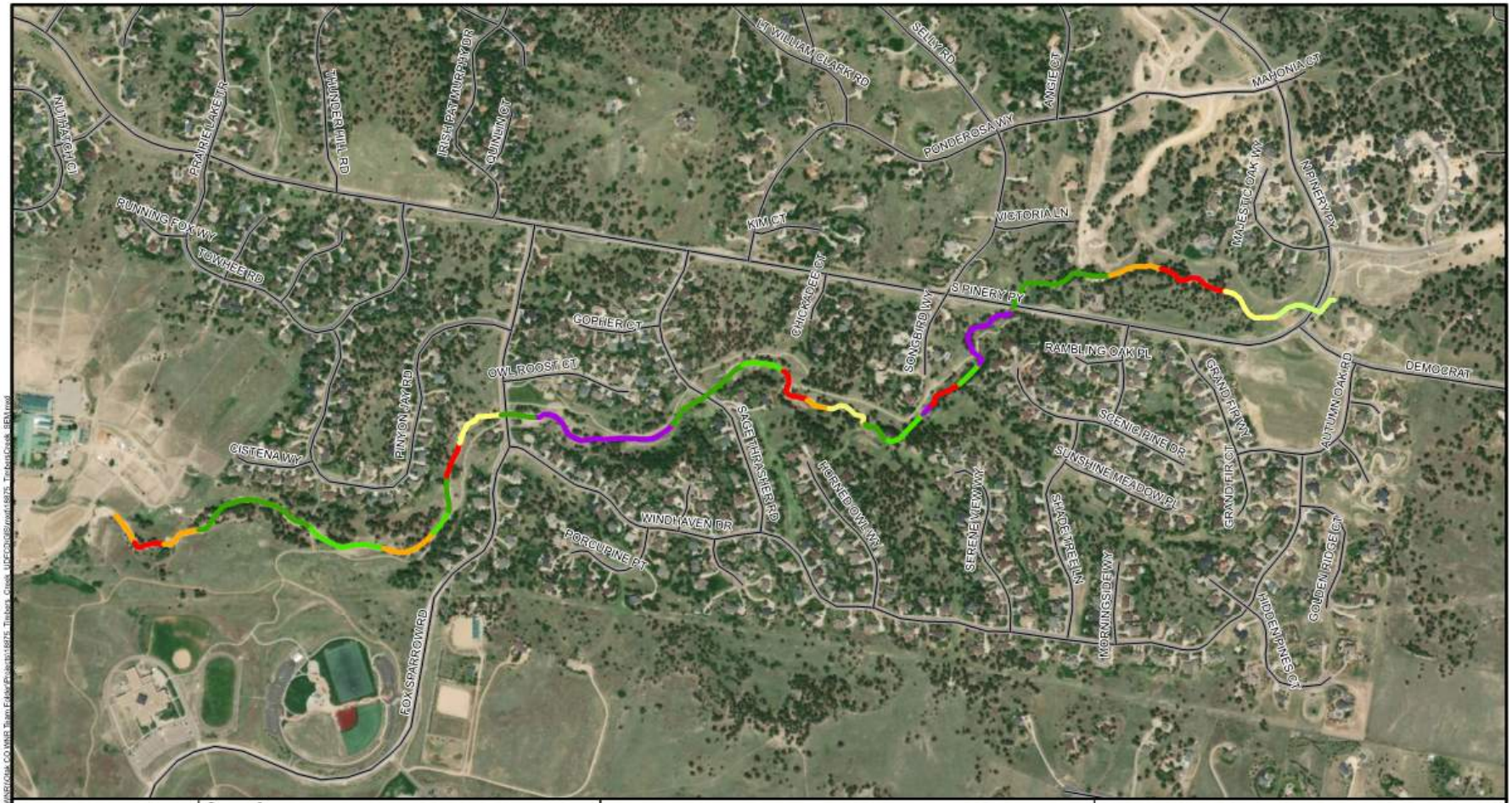
Hydrology

Stable Stream Network




Source
Transport
Response
Geomorphic Zones
Silver Bluff
Lake Trail
Thunder Hill Rd
Quinlin Ct
Kim Ct
Victoria Ln
Majestic Oak Way
E Democrat Rd
S Pinery Pkwy
Gopher Ct
Fox Sparrow Rd
Towhee Rd
Pinyon Jay Rd
Sage Thrasher Rd
Horned Owl Way
Porcupine Point
Scenic Pine Dr
Autumn Oaks Rd
Serene View Way
Shade Tree Ln
Windhaven Dr
Hidden Pines Ct
Golden Ridge Ct
S Pinery Dr
Google Earth
© 2018 Google


BEDROCK PRESENT
SINGLE-THREAD
ANASTAMOSING
CONSTRUCTED/MAINTAINED
1B
BEDROCK DEGRADING
2B
BEDROCK UNI-LATERAL WIDENING
3B
BEDROCK DEGRADING + WIDENING
1S
2S
INCISING
3S
DEGRADING + WIDENING
SLUMPED MATERIAL
4S
AGGRADING + WIDENING
5S
QUASI-EQUILIBRIUM
AG
ANASTAMOSING GRASSLAND
AF
ANASTAMOSING FORESTED
C
C
LEGEND
SAND
BEDROCK
COHESIVE MATERIAL PRESENT
Bedrock Present
Single Thread
Anastomosed
Constructed



Otak

Legend

SEM_Stage: 1B, 2B, 3B, 3S, 4S, 5S, AF, AG, C

LOCAL ROADS
HIGHWAYS
MAJOR ROADS

TIMBERS CREEK STREAM EVOLUTION MODEL REACHES

Date: 11/28/2018

0 335 670 1,340 Feet

N

*This map contains data compiled from multiple sources and is for information purposes only. The data used to create the map are not guaranteed to be complete or accurate. The locations of all features are approximate.

Bedrock Present eSEM Stages

1B –Bedrock Degrading

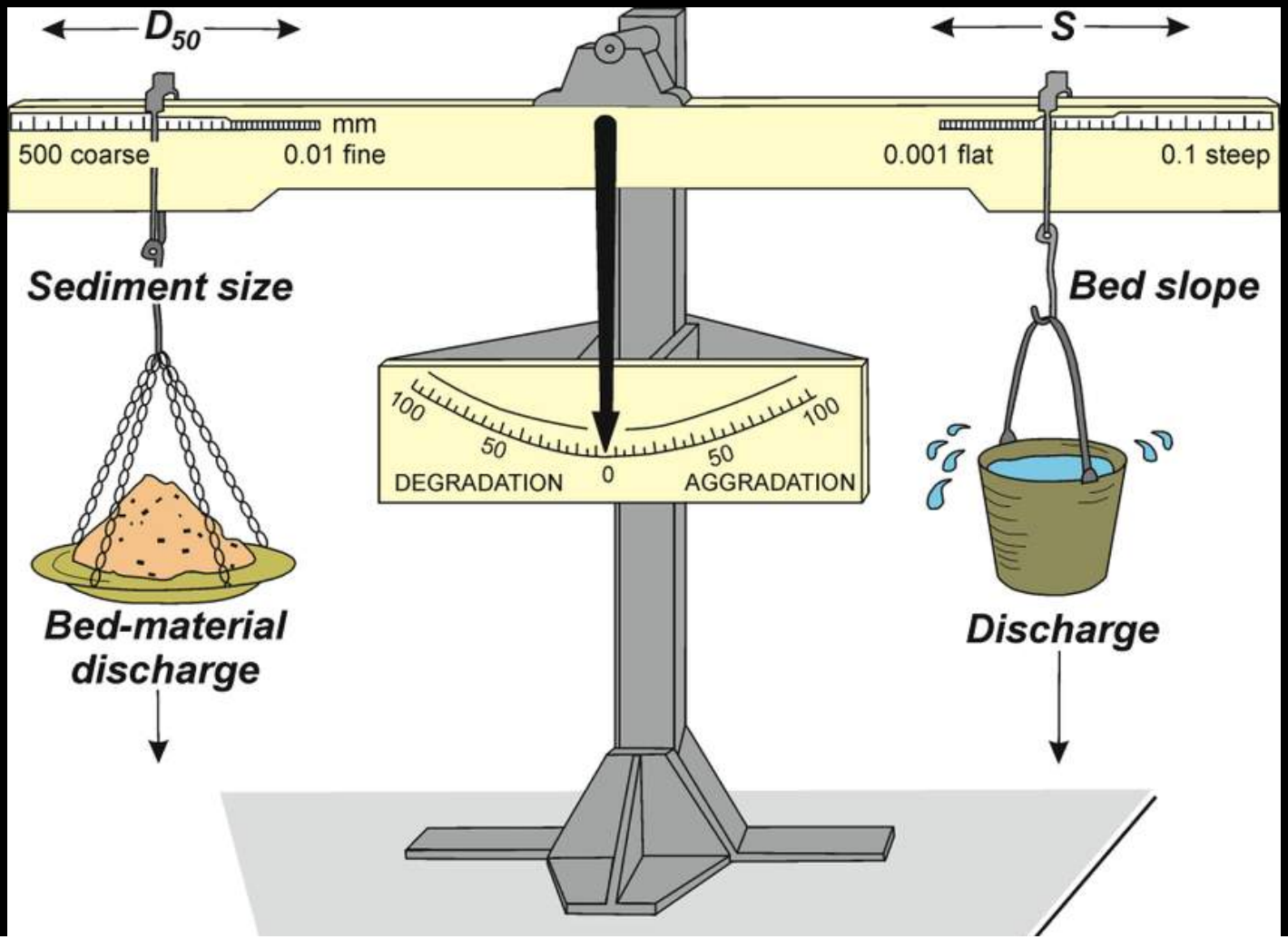
2B –Bedrock Uni-lateral Widening

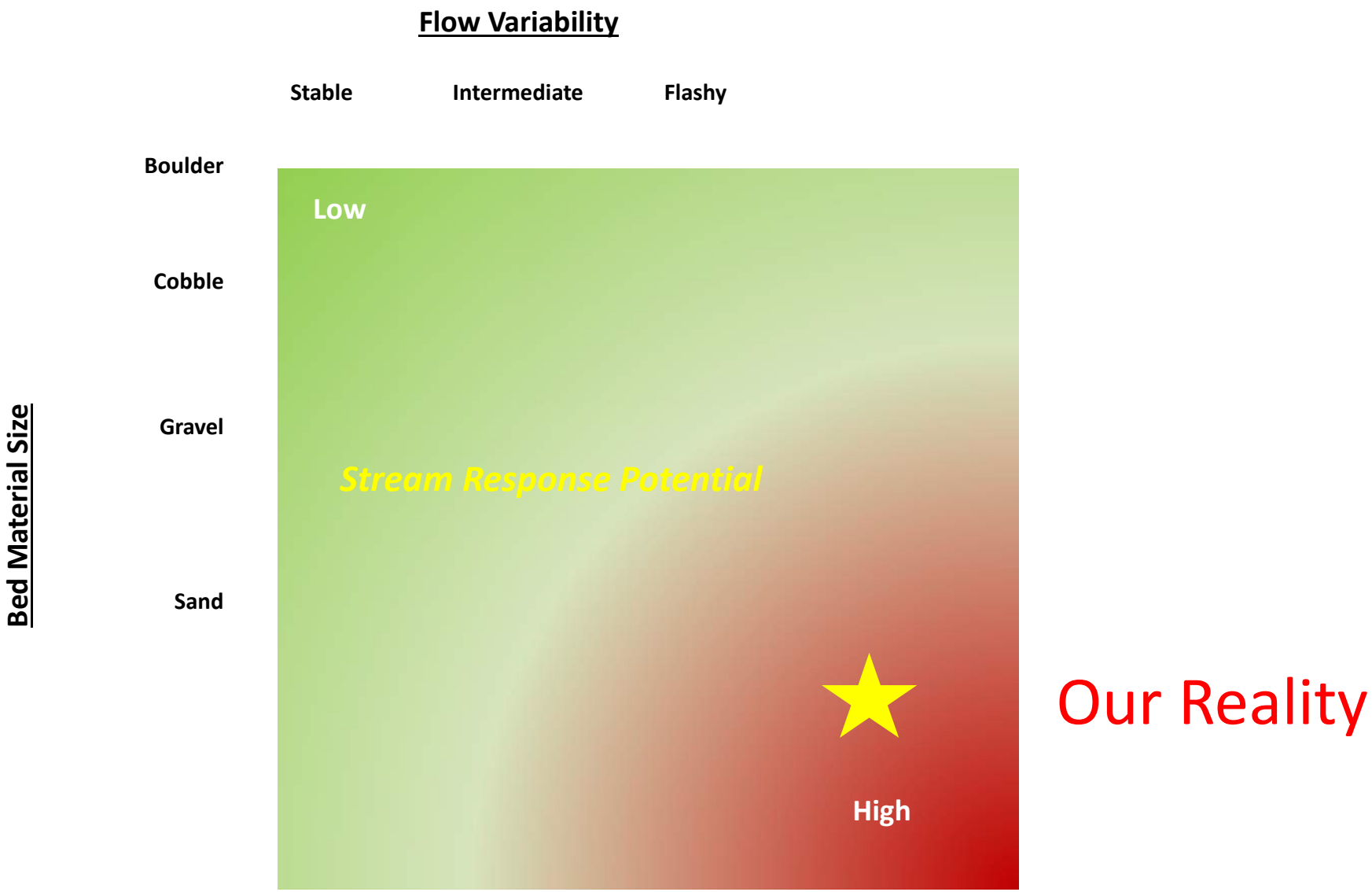
3B –Bedrock Degrading + Widening

Single Thread eSEM Stages

Anastomosed eSEM Stages

The Balance of Sediment and Water in Streams




Flow Variability
Stable
Intermediate
Flashy
Bed Material Size
Boulder
Cobble
Gravel
Sand
Low
Stream Response Potential
High
Our Reality

Upstream Reach Sediment Transport Model

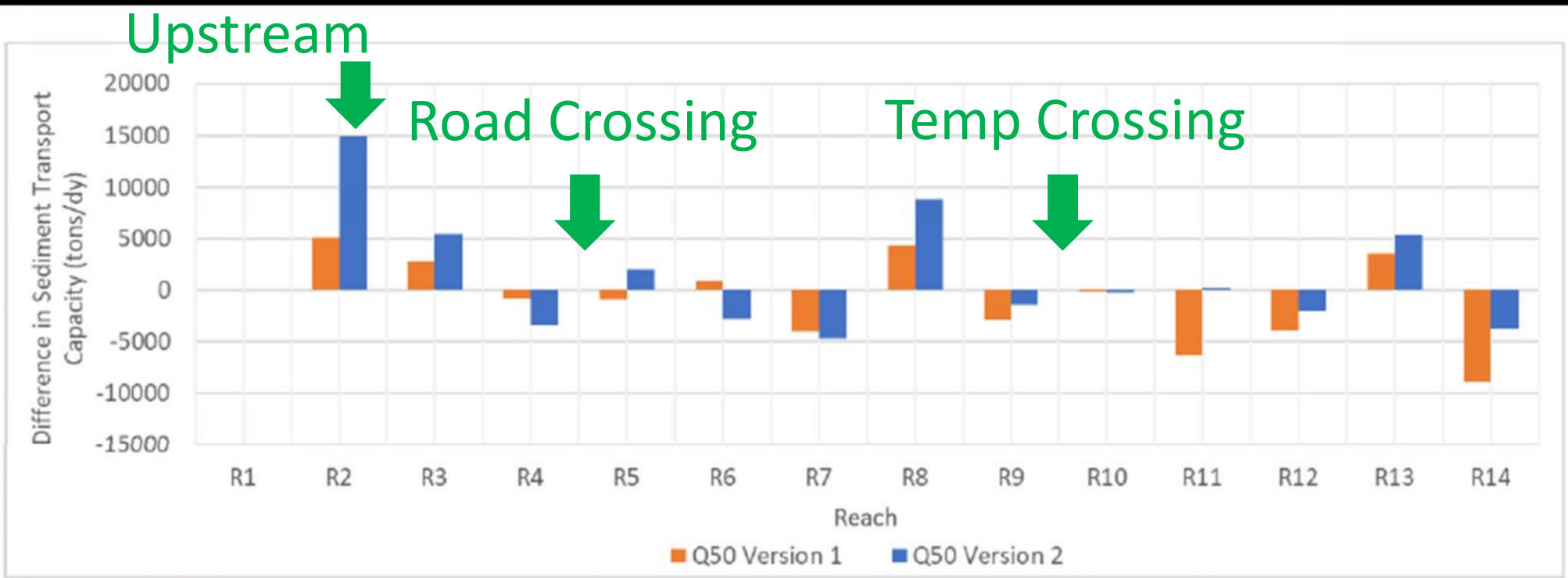


Figure 29: Sediment transport capacity balance plot using Brownlie (1981), 14 Reaches, and Version 1 (Orange) and Version 2 (Blue) data inputs for Q_{50} event.

Stable Stream Network

- Hydrology
- Hydraulics
- Geomorphology
- Vegetation Community

Floodplain - High Elevation

In the middle and lower reaches of the project area, a more dry, xeric floodplain was observed adjacent to Timbers Creek. Typically the edges of stream systems have perennial riparian vegetation located along the edge of the channel, but this was not observed in these sections of the creek. Encroachment of xeric plant species into the floodplain typically occurs when riparian species abandon a floodplain due to unnatural flows of water. This particular section of Timbers Creek, within the project area, has been altered by man-made interventions including regrading of the creek bed, and the addition of permanent structures within the channel. These interventions have impacted the ecosystems within and adjacent to the channel.

Upland - Shortgrass Prairie

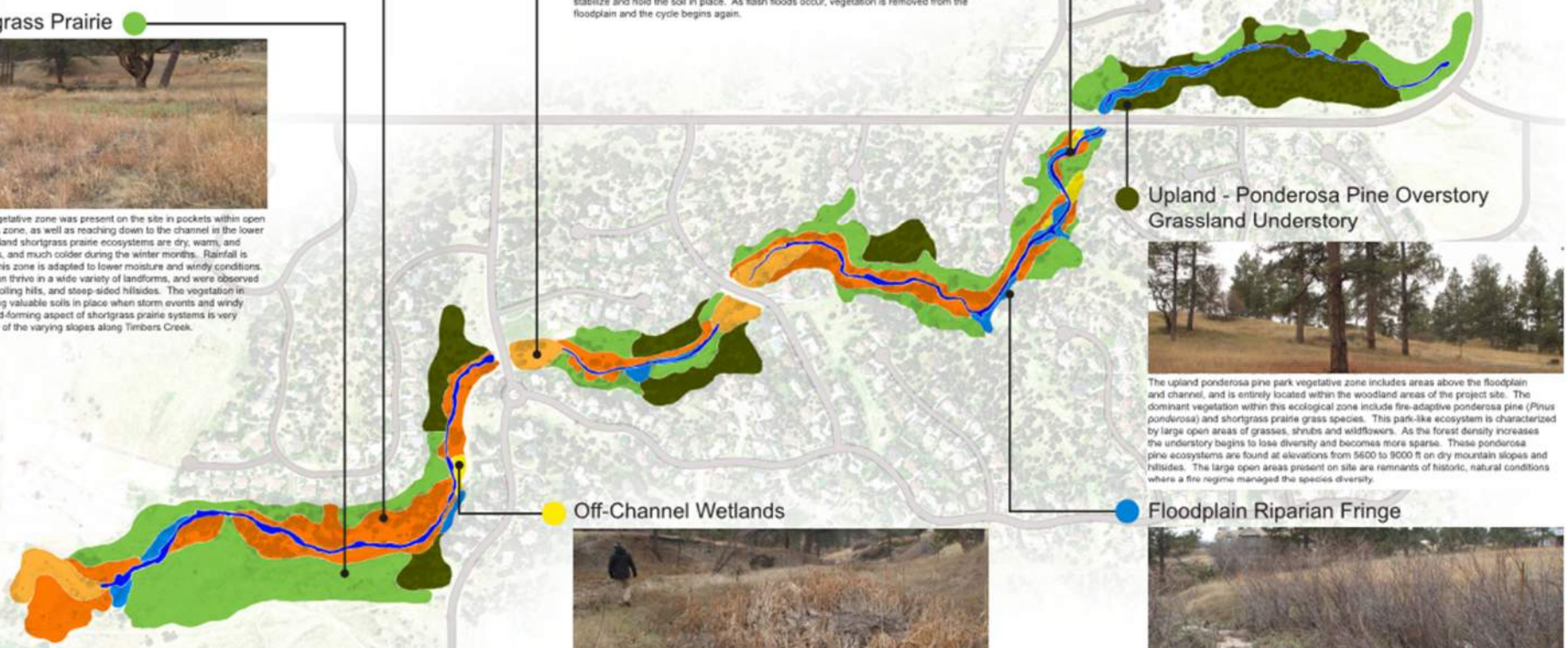
The upland shortgrass prairie vegetative zone was present on the site in pockets within open areas of the ponderosa pine park zone, as well as reaching down to the channel in the lower elevations of Timbers Creek. Upland shortgrass prairie ecosystems are dry, warm, and sunny during the summer months, and much colder during the winter months. Rainfall is relatively low, and vegetation in this zone is adapted to lower moisture and windy conditions. Shortgrass prairie ecosystems can thrive in a wide variety of landforms, and were observed on the project site on flat areas, rolling hills, and steep-sided hillsides. The vegetation in this ecosystem is crucial in holding valuable soils in place when storm events and windy conditions occur on site. This sod-forming aspect of shortgrass prairie systems is very important to maintain the stability of the varying slopes along Timbers Creek.

Floodplain - Low Elevation

Wide floodplains were observed on site in multiple locations along Timbers Creek, with the two largest floodplains occuring upstream of major road crossings. Historically these floodplains would have provided habitat for many deciduous riparian trees and shrubs, but the wide floodplains observed on site had little diversity of this vegetation type. The floodplains on site were dominated by grasses, small ephemeral wetland pockets, and ponderosa pine ecosystems at the edges. Typically floodplain systems are continually changing as the stream channel fluctuates through the wide areas of the floodplain. As the channel meanders across the floodplain, sand is deposited in bars and along the edge. Slowly these sandy areas are populated with willows, followed by cottonwood trees that help stabilize and hold the soil in place. As flash floods occur, vegetation is removed from the floodplain and the cycle begins again.

Riverine Wetlands

The channel, or the path of flowing water and sediment within a stream system, is present in any waterway with water flowing seasonally and/or year-round. Natural channels are constantly evolving and moving depending on the streamflow, sediment loads, floodplain slopes, and vegetation. Because this is generally the most consistently wet part of a stream system, wetland vegetation is present within this zone. Natural channel systems typically do not have a straight and narrow path, but rather weave in and out of the landscape, changing course as water flows erode banks, and deposit on sandbars.



Upland - Ponderosa Pine Overstory Grassland Understory

The upland ponderosa pine park vegetative zone includes areas above the floodplain and channel, and is entirely located within the woodland areas of the project site. The dominant vegetation within this ecological zone include fire-adaptive ponderosa pine (*Pinus ponderosa*) and shortgrass prairie grass species. This park-like ecosystem is characterized by large open areas of grasses, shrubs and wildflowers. As the forest density increases the understory begins to lose diversity and becomes more sparse. These ponderosa pine ecosystems are found at elevations from 5600 to 9000 ft on dry mountain slopes and hillsides. The large open areas present on site are remnants of historic, natural conditions where a fire regime managed the species diversity.

Off-Channel Wetlands

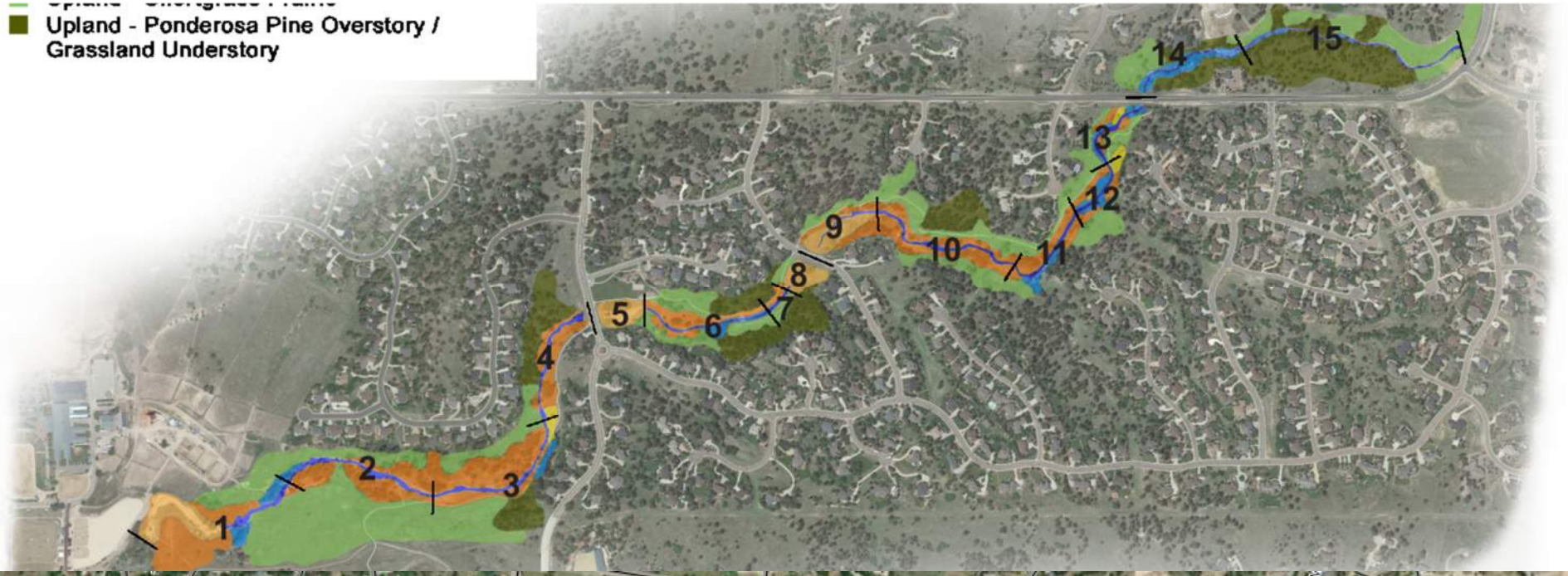
Off-channel wetlands are naturally found in stream systems in areas where the channel has been abandonded, such as oxbows, side channels and ponds. These features are constantly being created and abandoned as the water migrates across the floodplain, and changes course. These ecosystems are predominantly vegetated by bulrush (*Schoenoplectus lacustris*), broad-leaved cat-tail (*Typha latifolia*), sedges and rushes.

Floodplain Riparian Fringe

The edge between the channel and the upland areas is typically vegetated with riparian species. Within the project area, riparian vegetation located in the floodplain was observed only in small pockets in wet areas within the channel. Riparian fringe habitat is crucial for stream health, providing not only important habitat for birds, mammals, and reptiles, but this ecosystem also provides benefits to natural stream morphology.


Riverine Wetlands
Off-Channel Wetlands
Floodplain Riparian Fringe
Wide Floodplain - Low Elevation
Xeric Floodplain - High Elevation
Upland - Shortgrass Prairie
Upland - Ponderosa Pine Overstory / Grassland Understory
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0 300 1200
150 600
SCALE: 1"=600'-0"

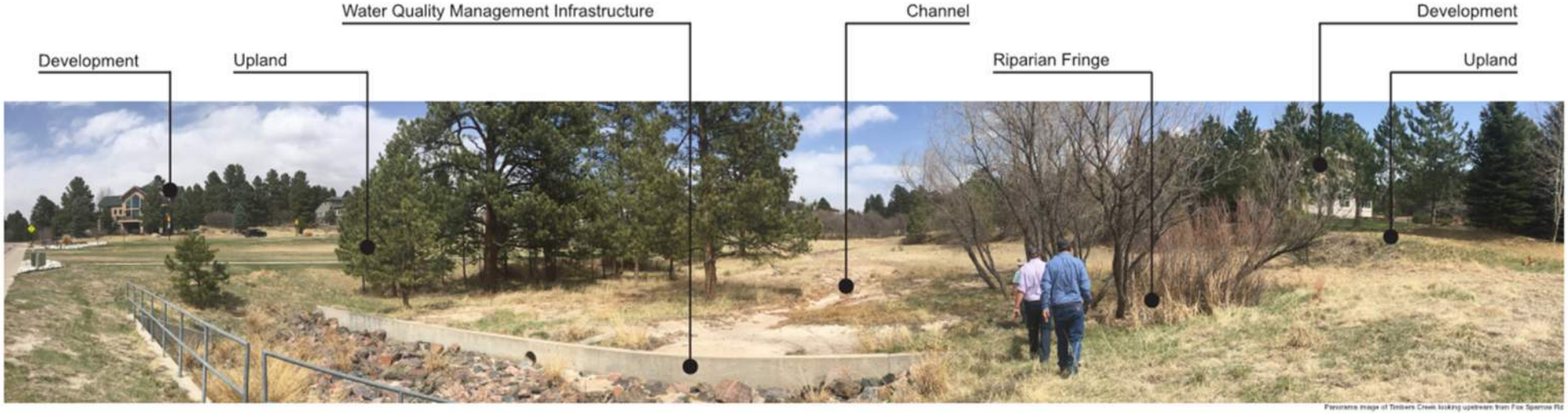
Upland - Ponderosa Pine Overstory / Grassland Understory



Upland Zone

Floodplain/Riparian Zone

Channel/Wetlands Zone

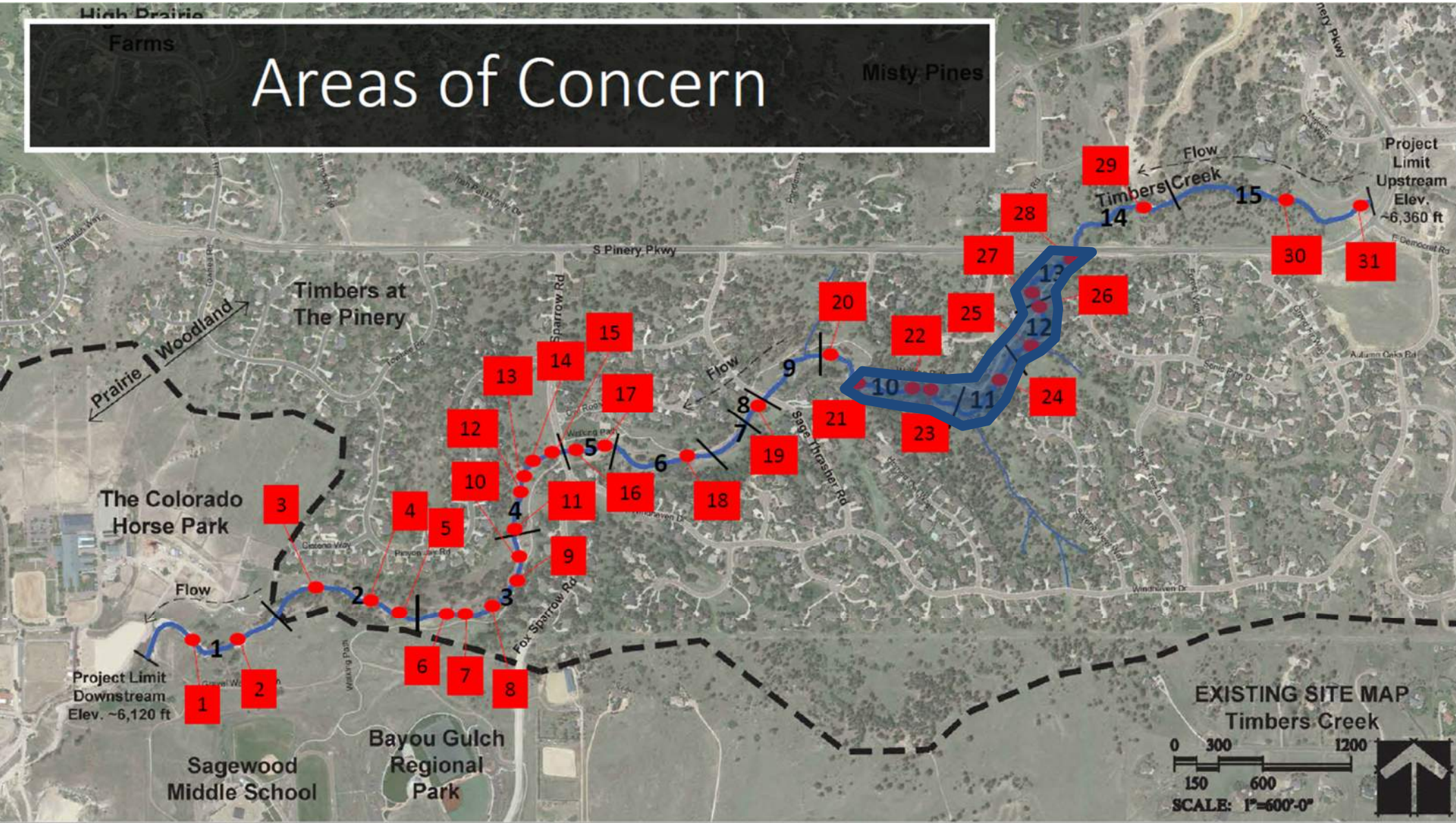


Panorama image of Timbers Creek looking upstream from Fox Sparrow Rd

Stable Stream Network

- Hydrology
- Hydraulics
- Geomorphology
- Vegetation Community
- Human Connection

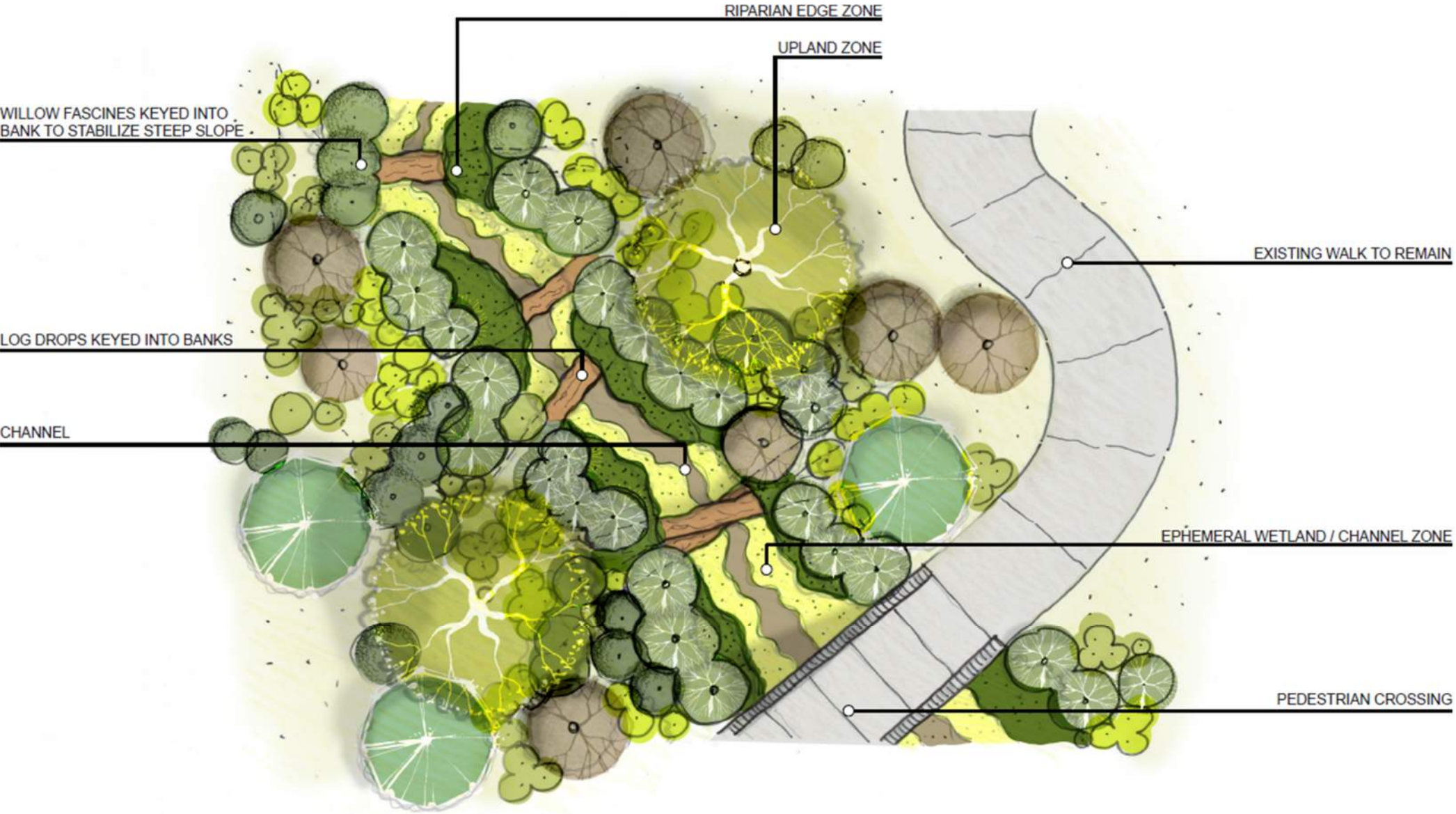
Areas of Concern



Existing Channel

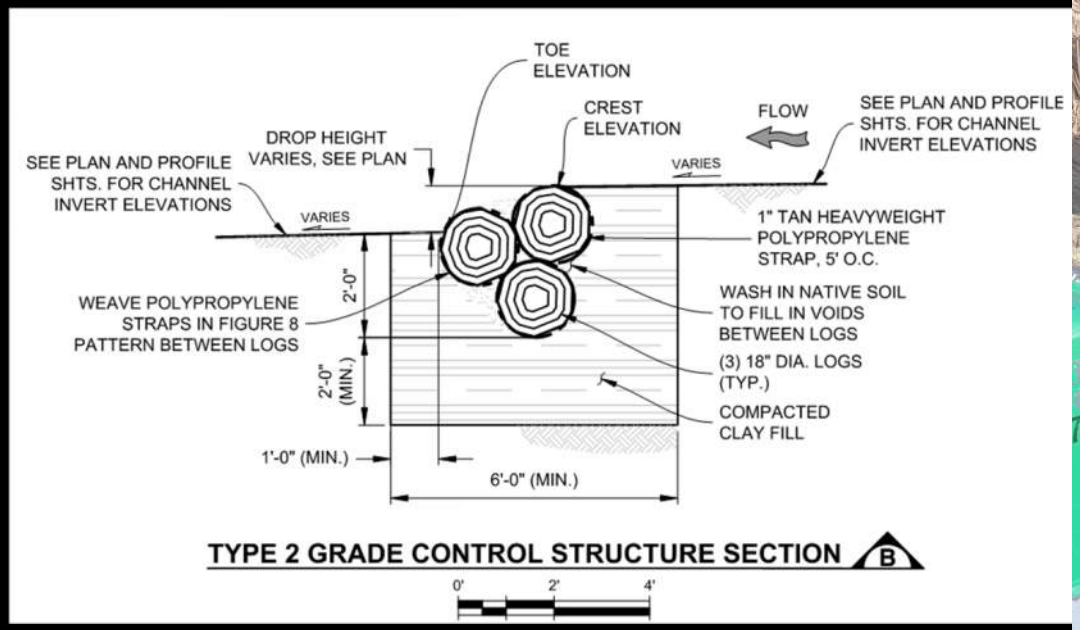
Spectrum of Urbanization

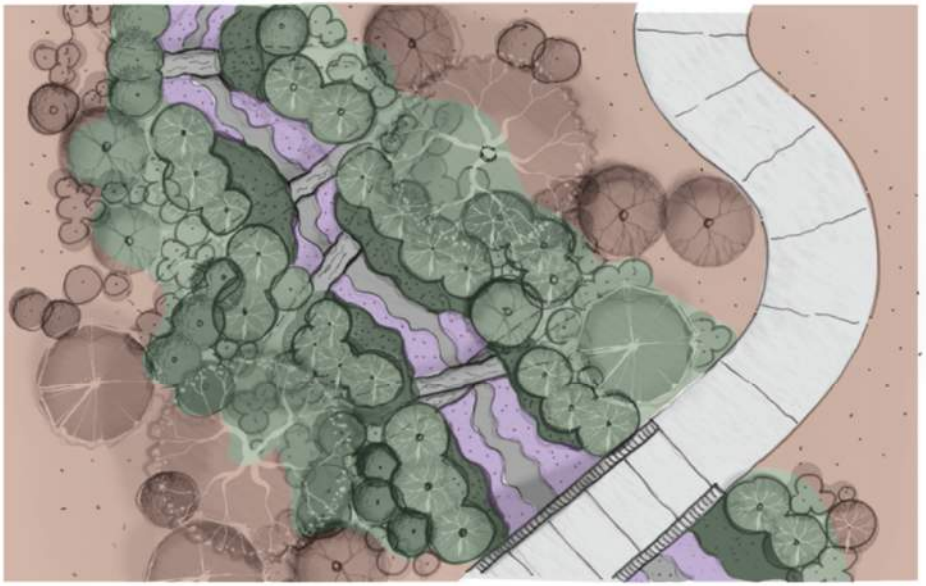
The transect. Duany PlaterZyberk & Company


RIPARIAN EDGE ZONE
UPLAND ZONE
WILLOW FASCINES KEYED INTO BANK TO STABILIZE STEEP SLOPE
EXISTING WALK TO REMAIN
LOG DROPS KEYED INTO BANKS
CHANNEL
EPHEMERAL WETLAND / CHANNEL ZONE
PEDESTRIAN CROSSING

Log Grade Control Structure

Clay Cutoff Wall





EPHEMERAL WETLAND / CHANNEL ZONE


baltic rush
Juncus articus


broadleaf cat-tail
Typha latifolia


Colorado rush
Juncus confusus


meadow fescue
Festuca pratensis


Nebraska sedge
Carex nebrascensis


prairie cord-grass
Spartina pectinata


woolly sedge
Carex pellita


Rocky Mountain sedge
Carex scoputorum


sneeze weed
Helenium autumnale

RIPARIAN EDGE


western wheatgrass
Pascopyrum smithii


bulrush
Schoenoplectus lacustris


chokecherry
Prunus virginiana


peach-leaved willow
Salix amygdaloides


prairie cord-grass
Spartina pectinata


saltgrass
Distichlis stricta


sandbar willow
Salix exigua


sand dropseed
Sporobolus cryptandrus


snowberry
Symphoricarpos occidentalis


wax currant
Ribes cereum


American plum
Prunus americana


plains cottonwood
Populus deltoides


water plantain
Alisma subcordatum


sunflower
Helianthus nuttallii

UPLAND ZONE


blue grama grass
Chondrosum gracile


buffalo grass
Bouteloua dactyloides


woods rose
Rosa woodsii


sheep fescue
Festuca ovina


Indian rice grass
Stipa hymenoides


mountain mahogany
Cercocarpus montanus


needle-and-thread grass
Stipa comata


threeleaf sumac
Rhus trilobata


snowberry
Symphoricarpos occidentalis

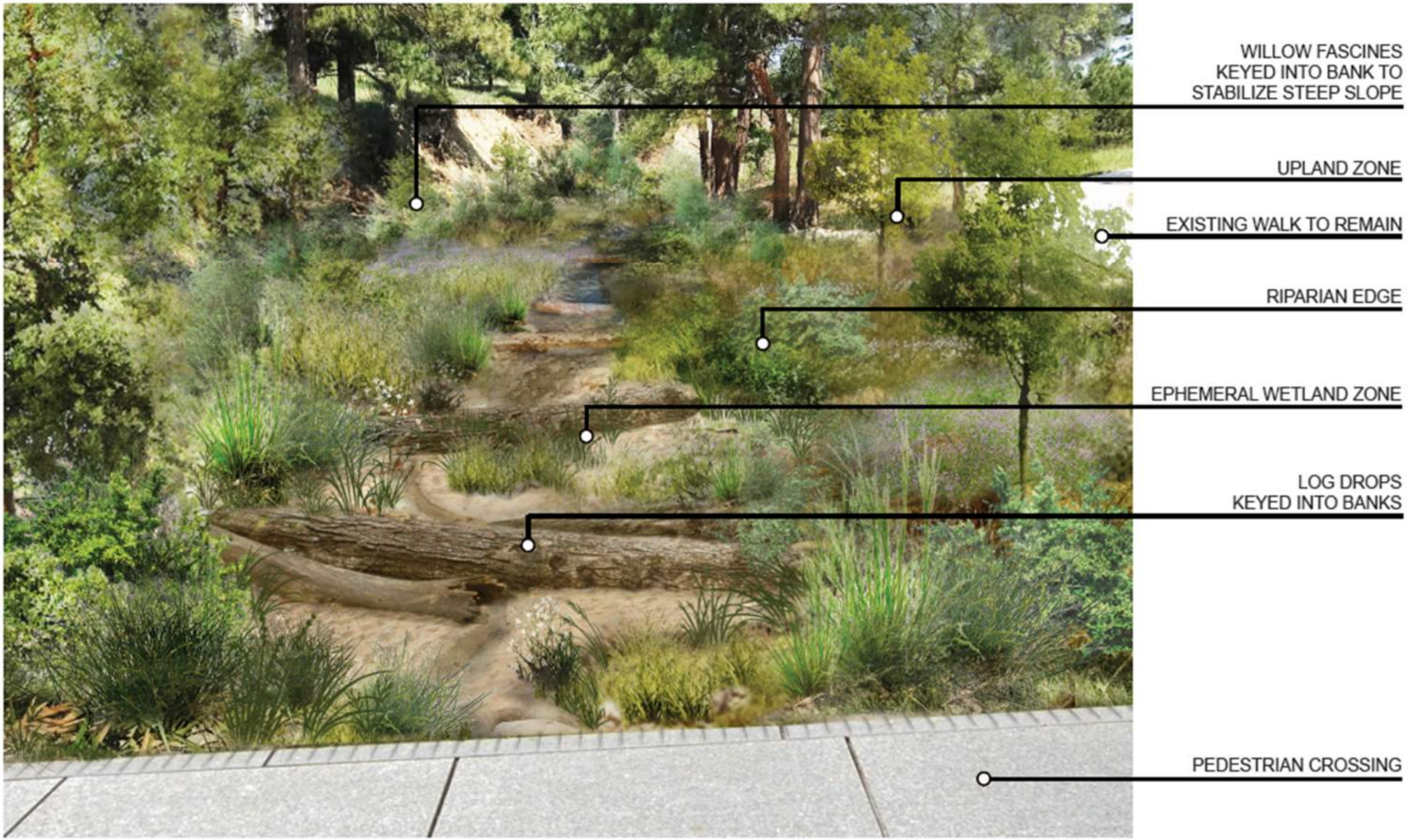

pasture sage
Artemisia frigida


whitestem gooseberry
Ribes inerme

MULLER ENGINEERING COMPANY DHM DESIGN Stillwater Sciences

Proposed Creek Improvements - Planting Zones

TIMBERS CREEK - MAY 10, 2019


WILLOW FASCINES
KEYED INTO BANK TO
STABILIZE STEEP SLOPE
UPLAND ZONE
EXISTING WALK TO REMAIN
RIPARIAN EDGE
EPHEMERAL WETLAND ZONE
LOG DROPS
KEYED INTO BANKS
PEDESTRIAN CROSSING

Before

After

Before

After

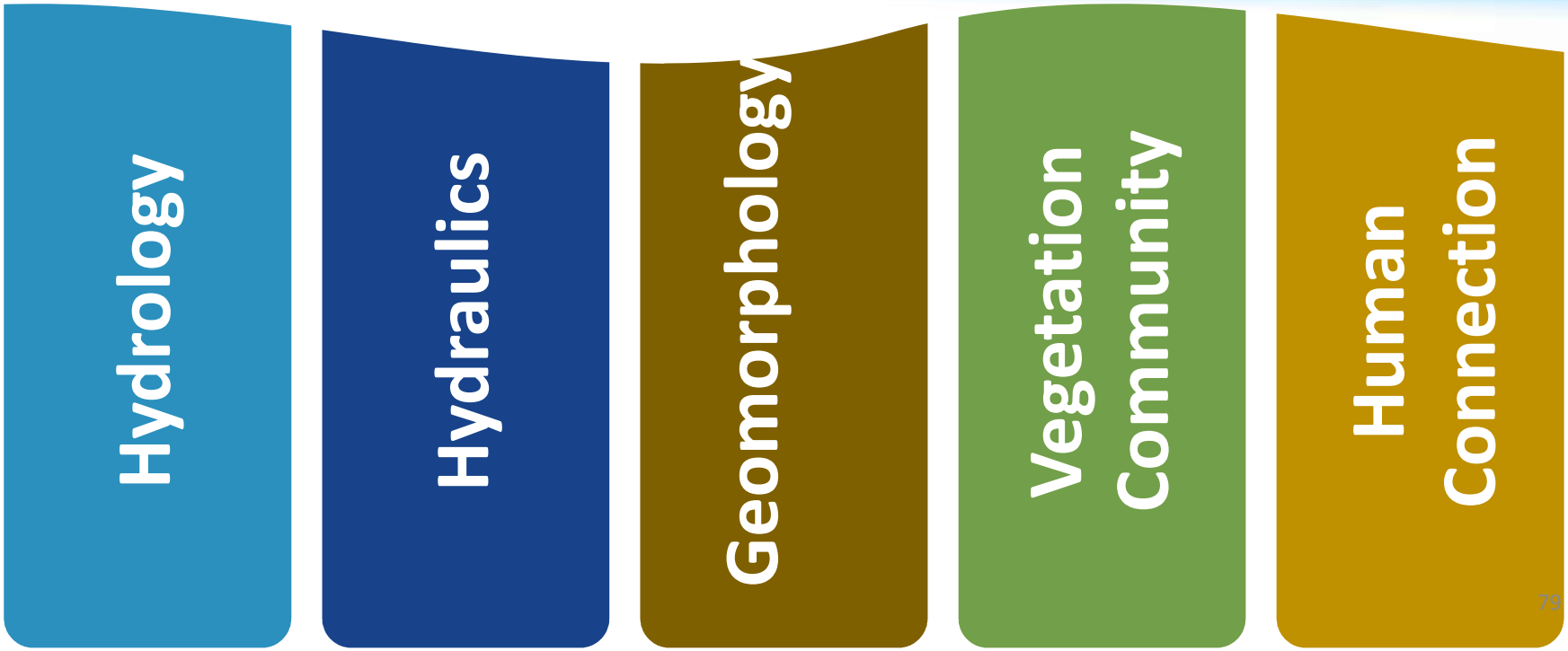
Before

After

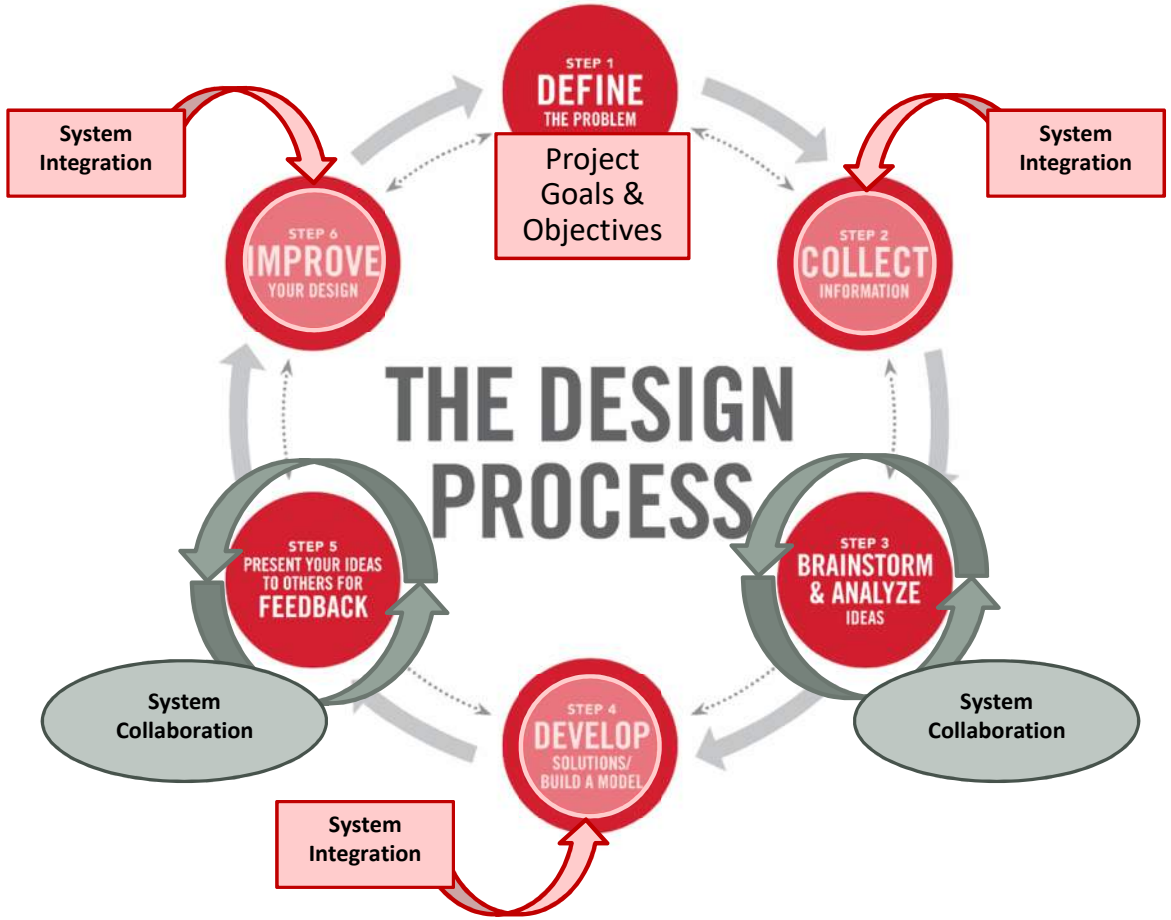
Before

After

Stable Stream Network



ENGAGE A MULTI-DISCIPLINE TEAM



$1100/ft

$850/ft

$50,000 Geomorphology/
Vegetation for 2 miles

2D Collaboration without Borders

2D Technical Consistency & Recommendations

CASFM: September 30, 2020 – 10:30 to 11 am

Geoff Uhlemann – Michael Baker

Josh Hill - Wood

About the Presenters…

Geoff Uhlemann - PE, CFM, PMP
Michael Baker – Denver, CO
Water Resources Project Manager

Josh Hill - EIT, CFM
Wood – Denver, CO
Water Resources Engineer

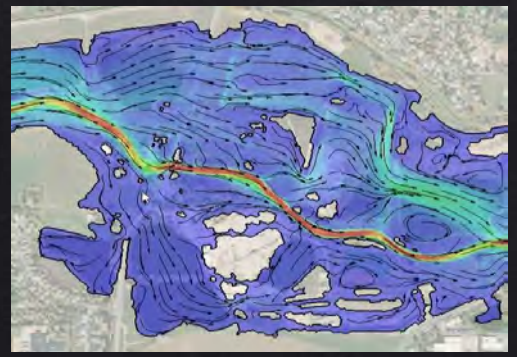
2D Collaboration without Borders

2D Technical Consistency and Recommendations

Overview + Rain-on-Mesh Best Practices

2D Result Communication & Use

End products & their use



2D National Efforts

Floodway IPT

Benefits of Collaboration

Rain-on-Mesh Best Practices Initiative

1) Consistency among contractors and teams

Improved product, methodology, & reviews

2) Resources/info for training and reference (internal & external)

Recommendations to FEMA for revised SIDs and refined guidance

Participants & Format

12-meeting series from Dec 2019 – Aug 2020
26 individuals from 7 states (CO, KS, KY, NJ, NY, UT, VA)
~350 hrs

AECOM

wood.

CDM Smith

Michael Baker INTERNATIONAL

U.S. Department of Transportation Federal Highway Administration

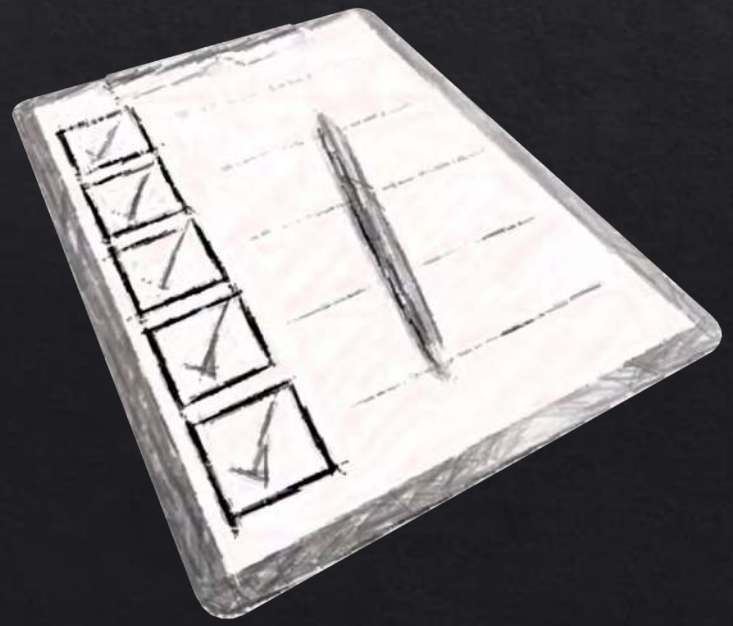
MHFD MILE HIGH FLOOD DISTRICT

Desired Session Outcomes

- Articulate importance and influence of each topic component
- Share common practice and agree on items that are best made consistent vs non-consequential differences
- Define principles, not processes – allowing flexibility in implementation but with guidance
- Document decisions & resources

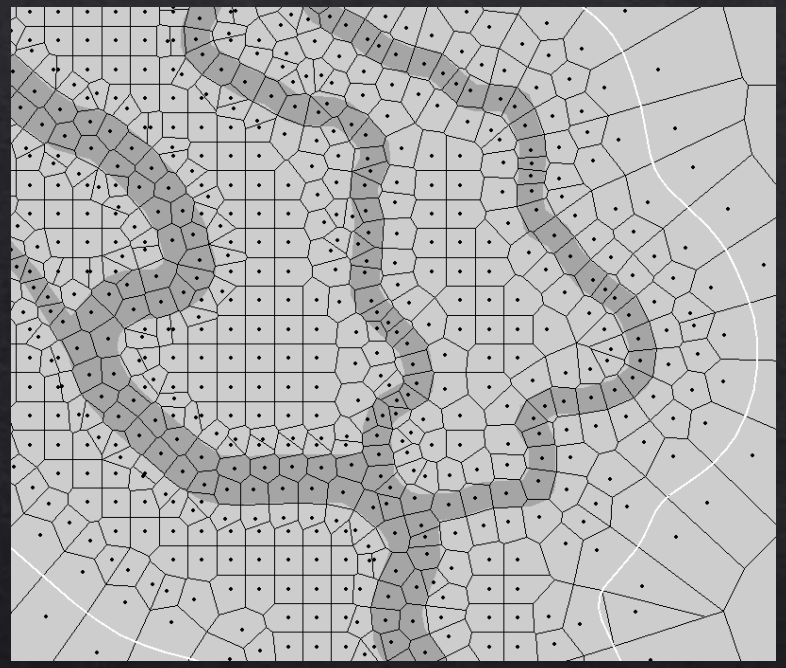
Topics Covered (& showcased)

1. Model Setup & Basin Delineation
2. Hydrology (Development & Application)
3. Model Detail & Refinements
4. Stormwater & Development Applications
5. Model Settings & Tolerances
6. Model Calibration & Validation
7. 2D Mapping & Rendering
8. Unsteady 2D Floodway
9. Updates to FEMA SIDs

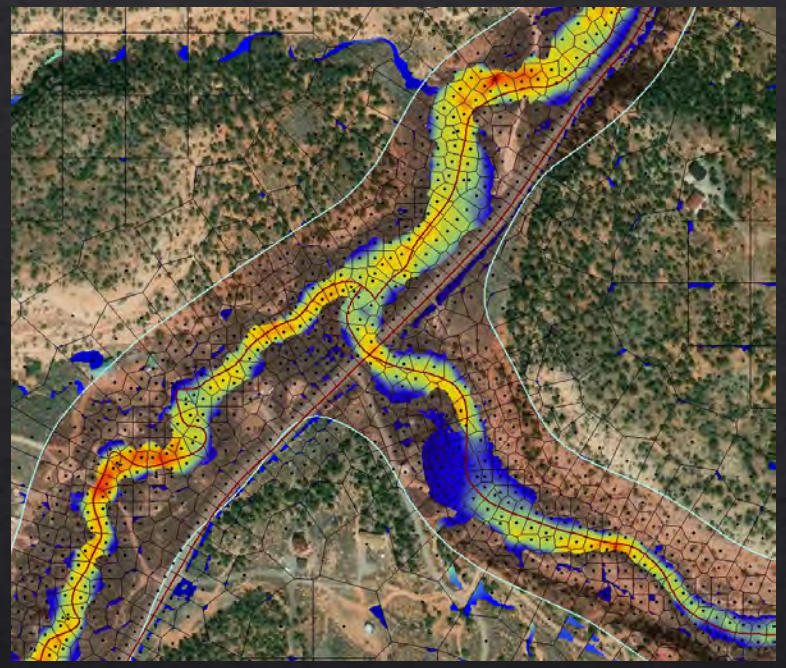


Model Detail & Refinements

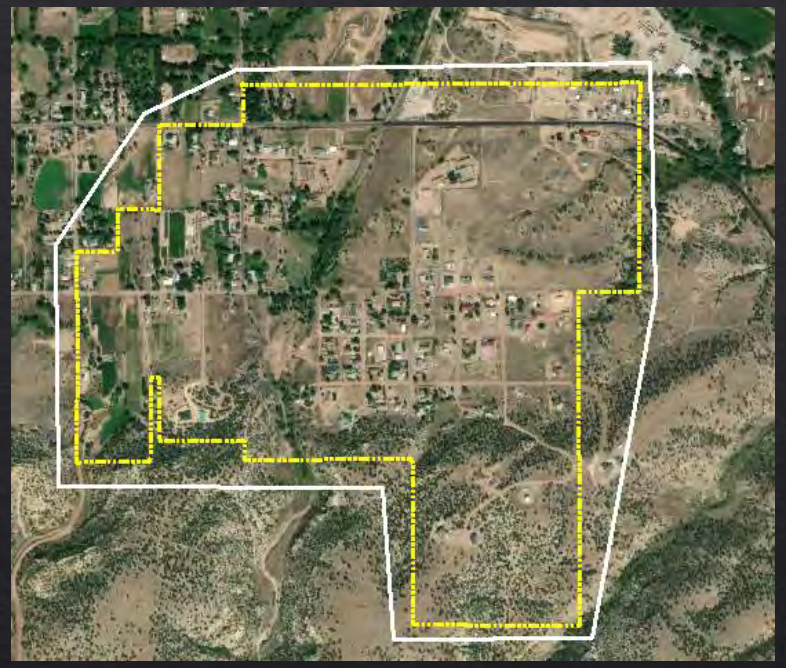
Refinement Regions



Channel Refinement Regions



Floodplain Refinement Regions

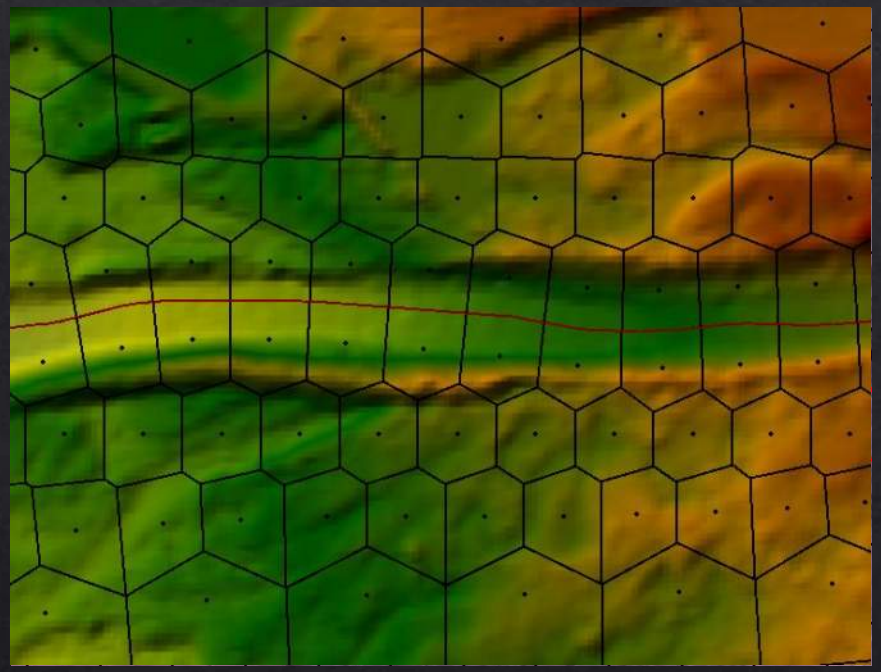


Urban Refinement Regions

Automate generation of refinement regions by buffering flow accumulation grid lines or hydroflattened areas of DEM

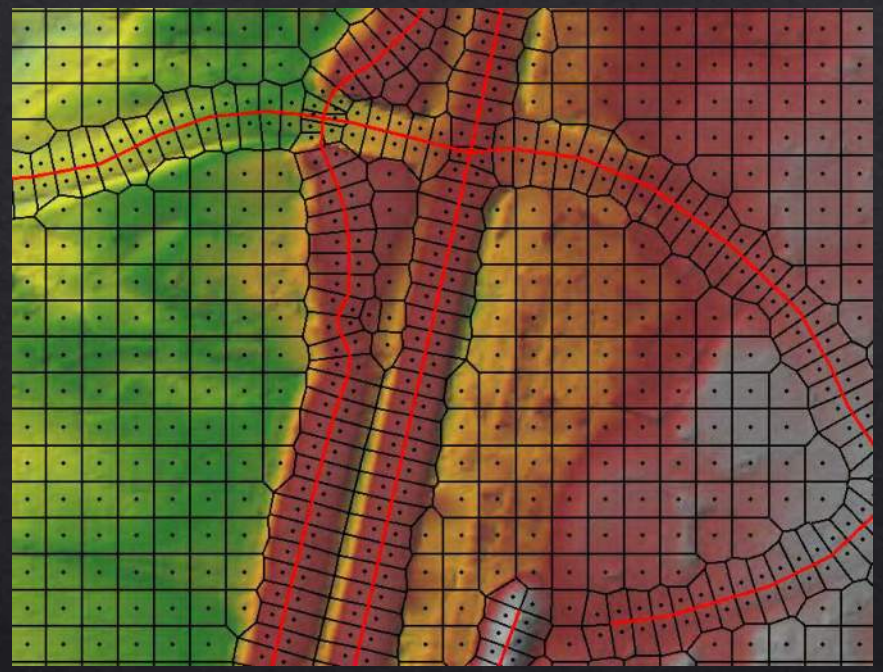
Model Detail & Refinements

Breaklines



Stream Banks/Centerline

- Mapped Streams → Use Stream Bank Breaklines
- Unmapped Streams → Can use Stream Centerline
- Ensure channel cell faces capture channel Manning's n.



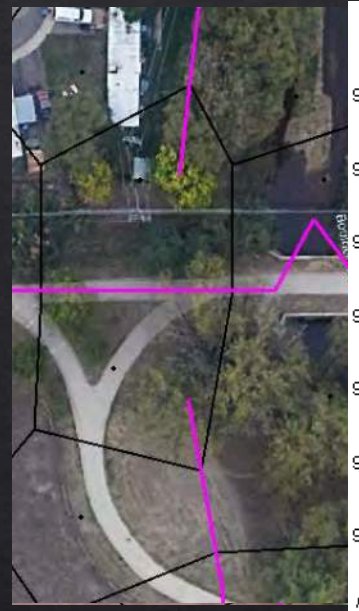
Roadways/Dams/Embankments

- Multiple Sources → Review & Manually Edit.
- Use appropriate cell spacing along overtopping features to properly show continuous inundation.

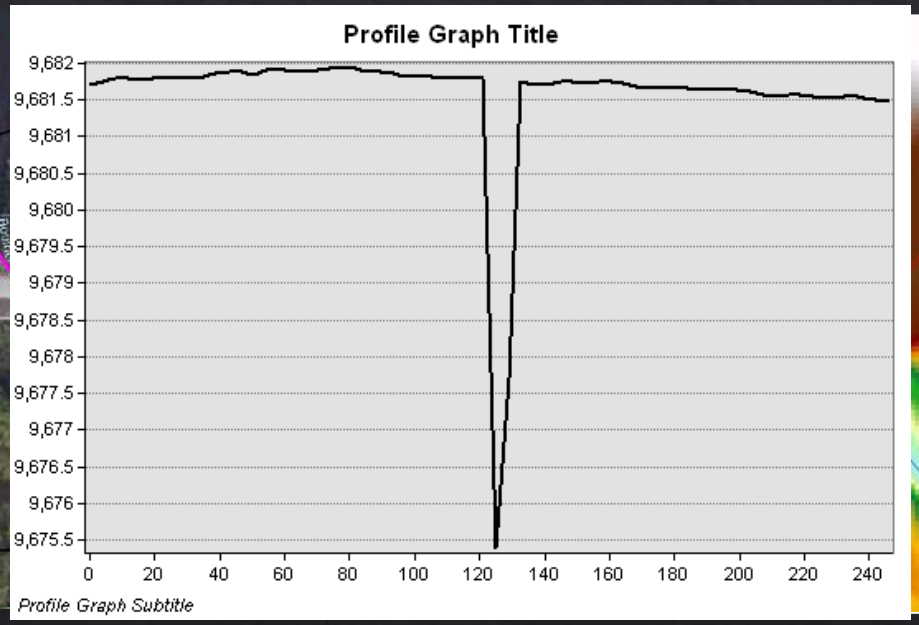
Model Detail & Refinements

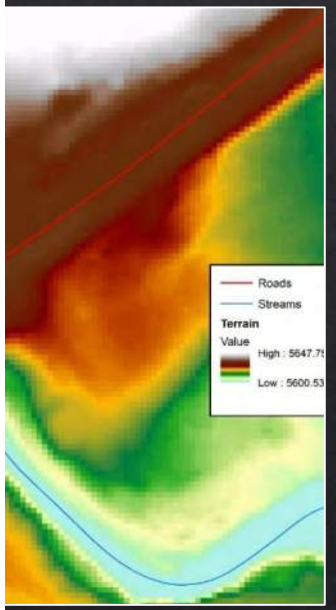
- **Approximating Structures**

~~Offset Breaklines~~
Not Recommended



V-Notch Breaklines



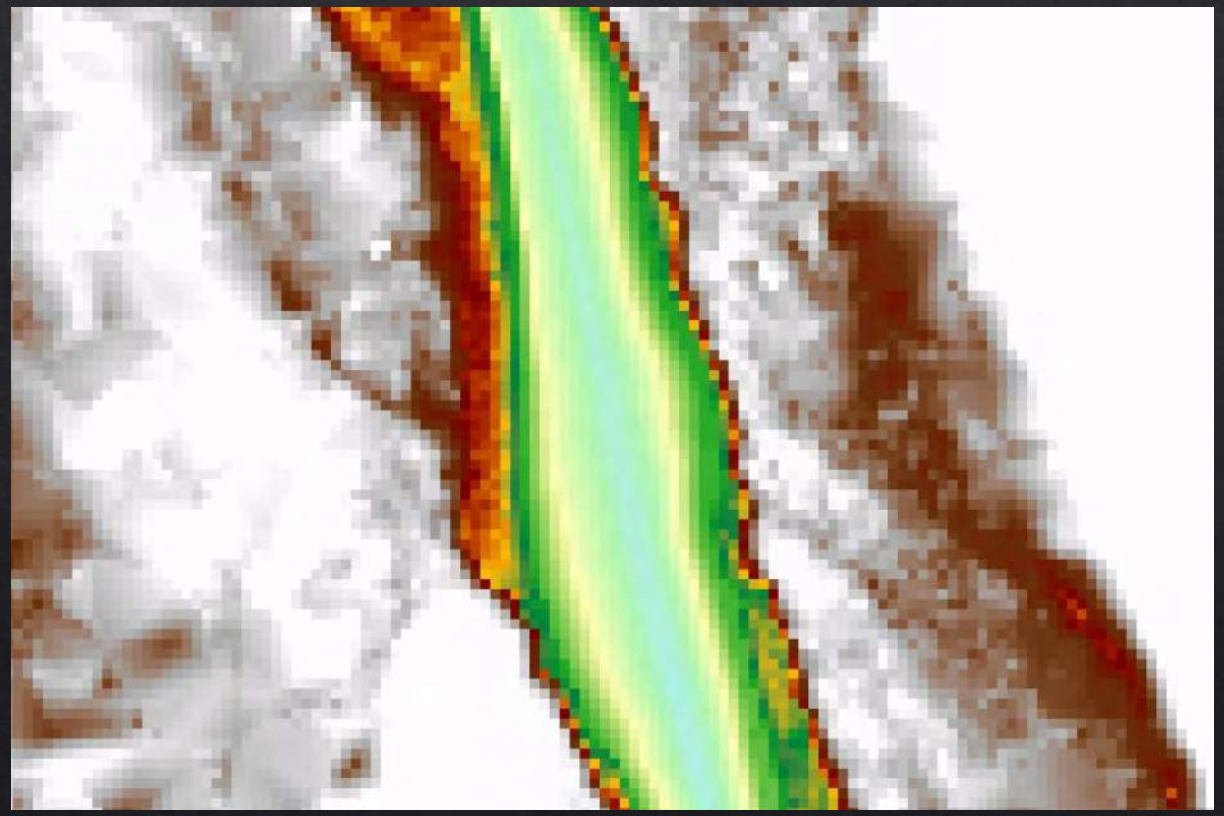


Hydroconnectors

Quickly approximate the hydraulics near structures without defining structure geometry/rating curves.

Terrain Modification

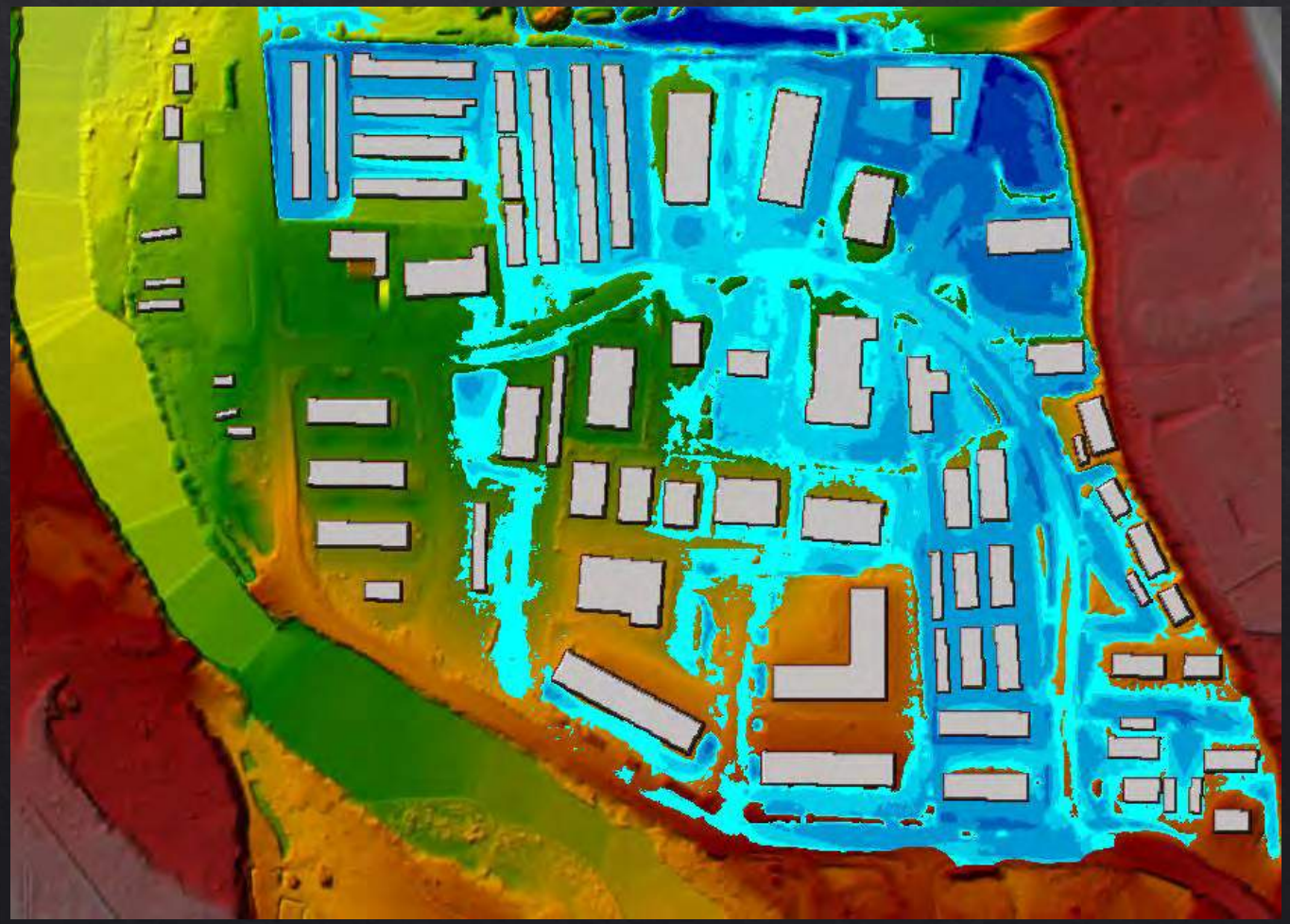
Bathymetry



- Depends on level of study
- Base Flow Considerations
  - Bathymetry Incorporated → Add baseflow using lateral hydrographs (for wholly-contained tributaries)
  - No Bathymetry → Remove baseflow from inflow hydrographs

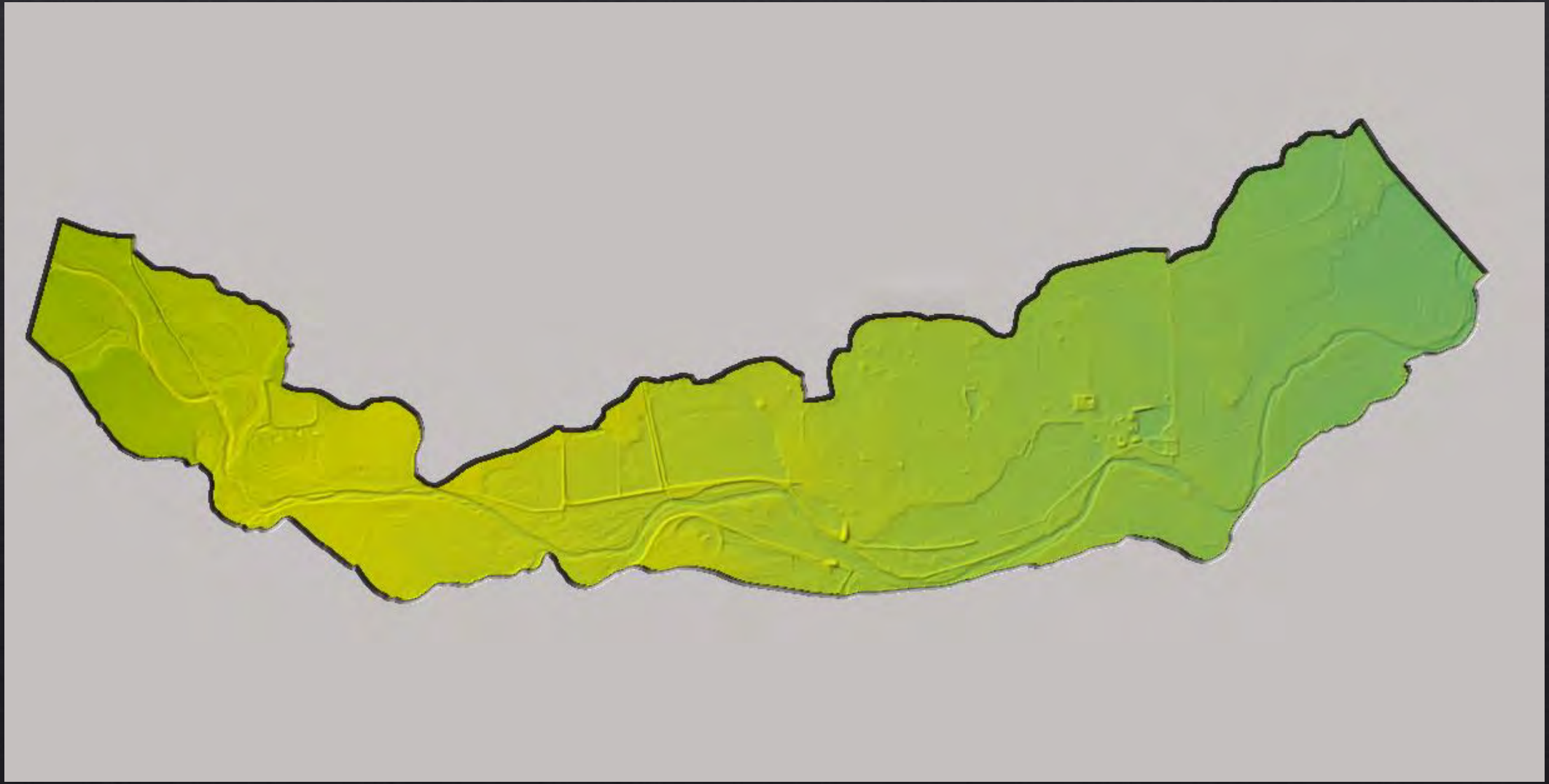
Terrain Modification

Building Footprints

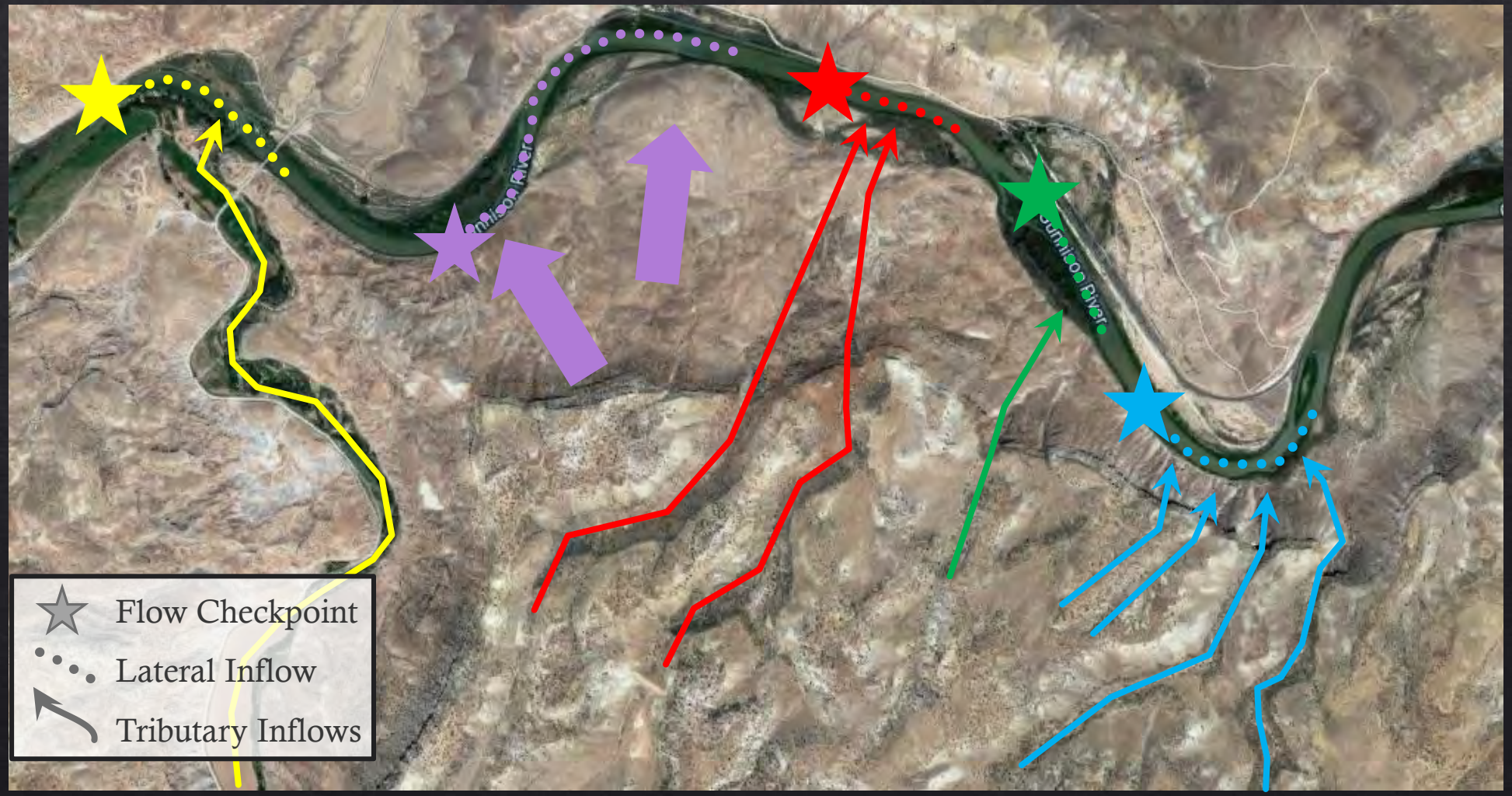


- Default Approach → Increase Manning's n
- If flow direction matters, enforce building footprints.
  - Enforce footprints as breaklines
  - Plot floodplains through buildings

2D Floodway



2D Floodway



Model Calibration & Validation

Hierarchy of Sources

1. Mining Recent Events

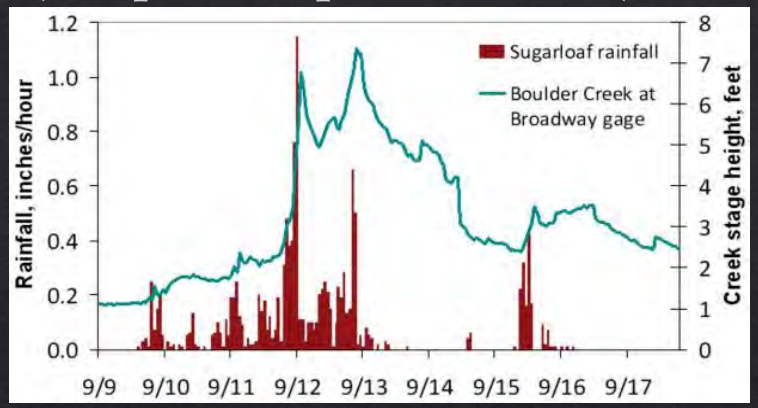
aerial coverage/lateral extent

people capture notable events

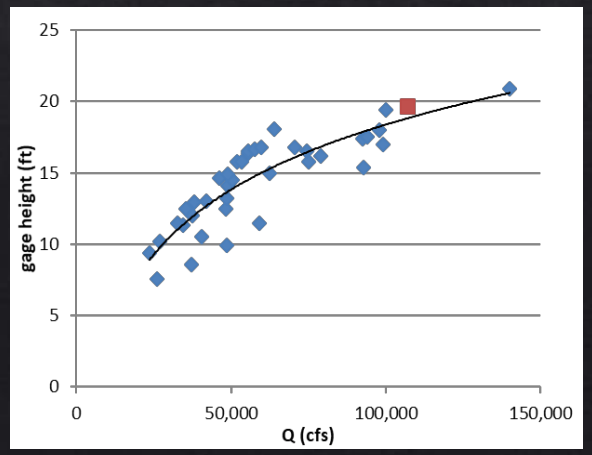
(examples later)

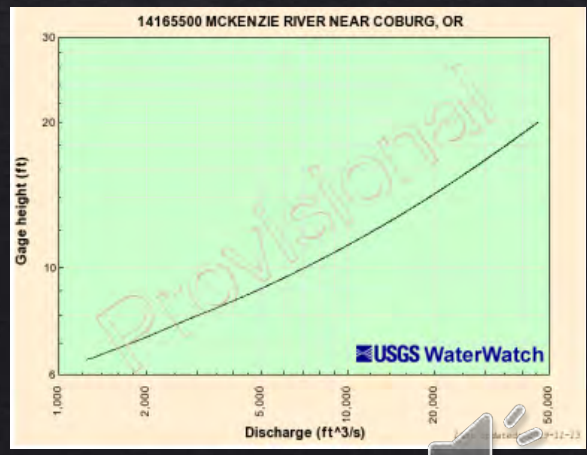
2. Gauge Data (stage & discharge)

A) Replicate specific event (rain & flow)



B) Matching Rating Curve





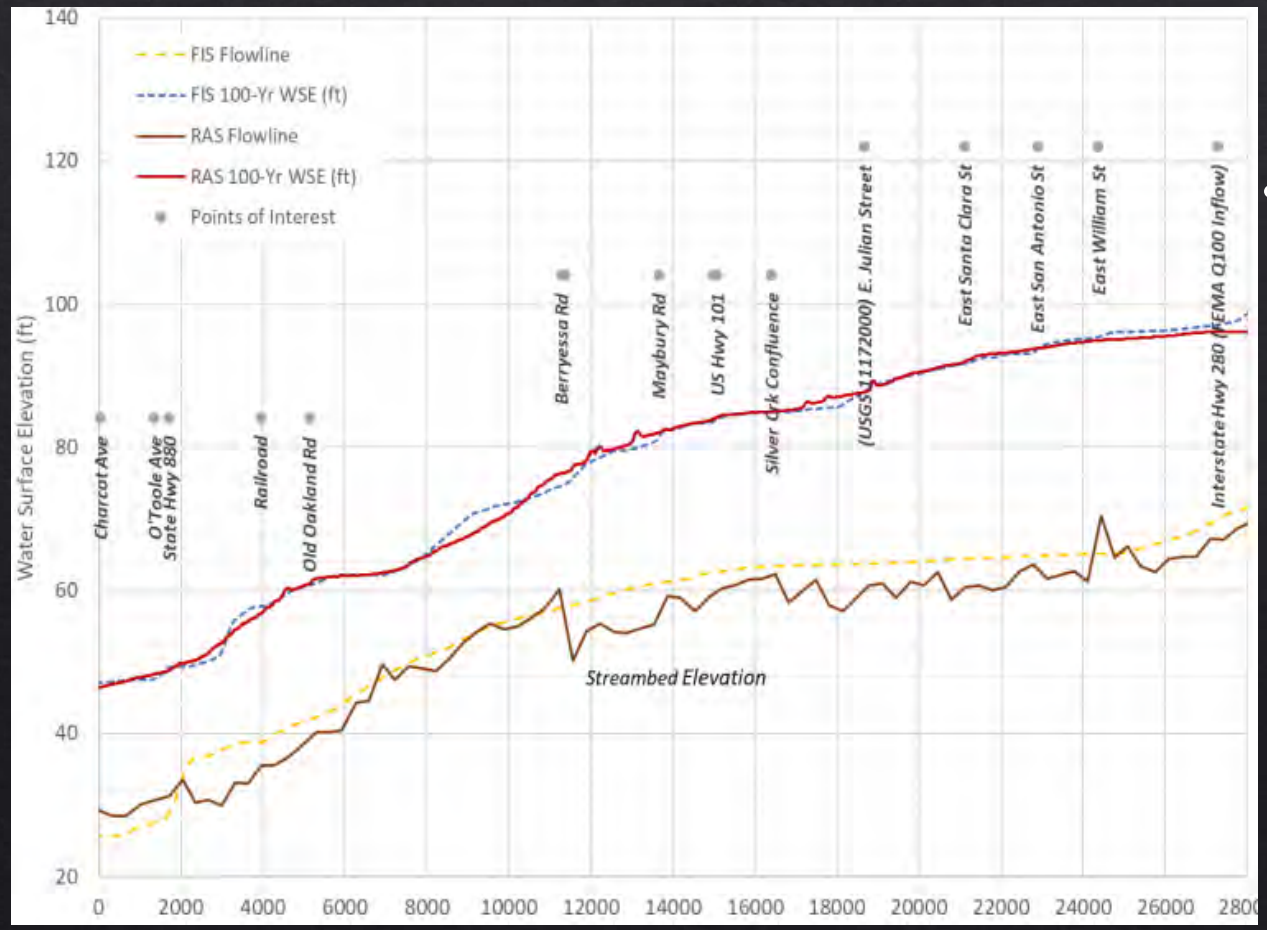
C) X% NOAA ≈ X% LP-III

Model Calibration & Validation

Hierarchy of Sources

3. Effective Data (stage & discharge)

A) Along a full reach



B) Fixed Locations (crossings)

4. Regional Comparison

gauged unit discharges

5. Regression Eqns

last resort - check within band

do not force to median

Discharge +

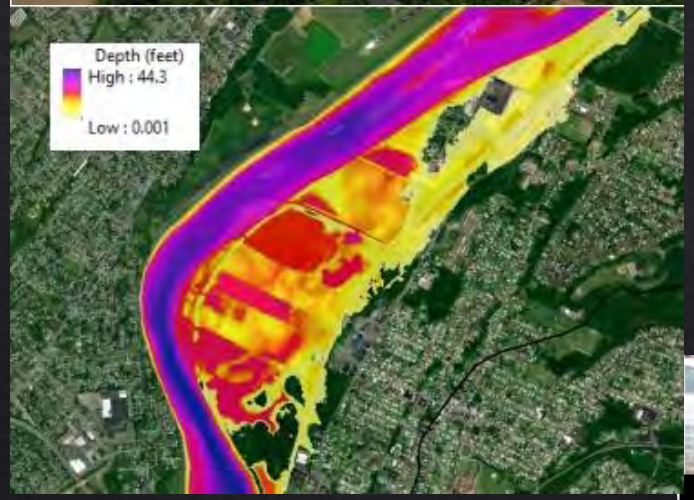
Stage +

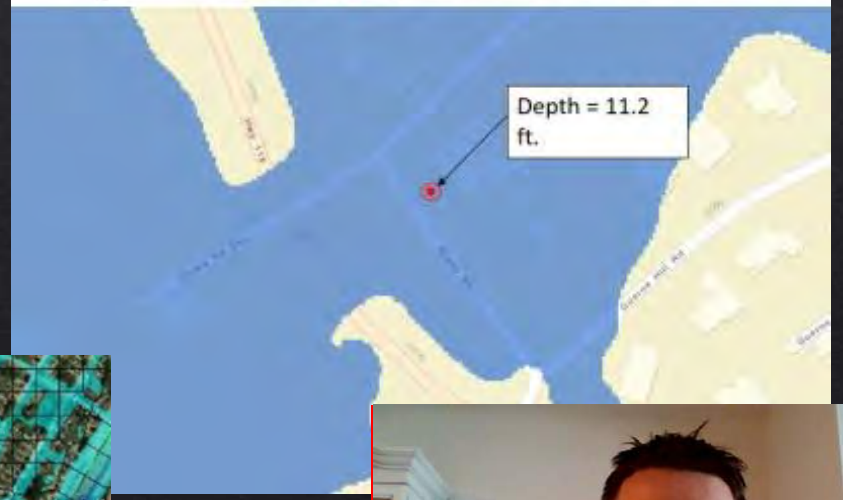
		Duration Distribution CN
Mesh Alignment	**Restart Files**	**Cell Size**
Normal Depth	**Manning's N Crossing Types**	

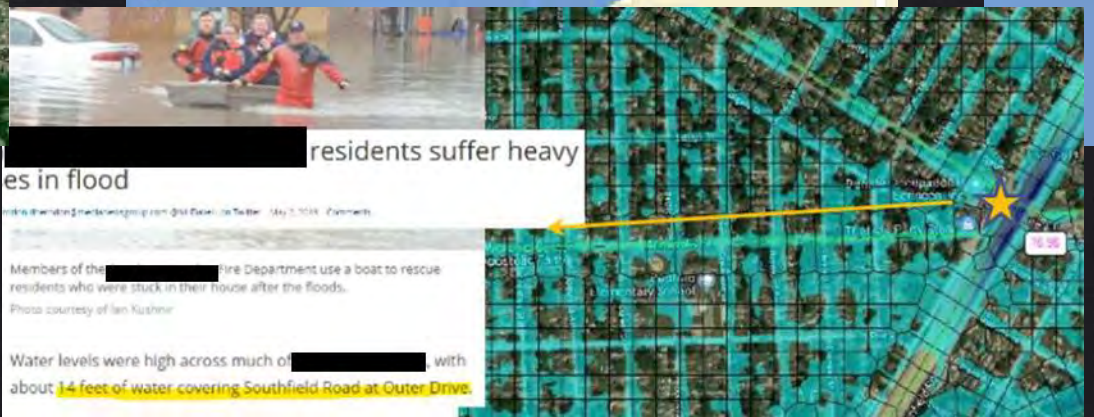
Knobs to turn

Model Calibration & Validation

Aerial Validation with Social Media







2D Mapping & Rendering

Mapping Approaches

Figure 5-5. Comparison of Sloping and Horizontal water surface rendering for steep terrain.

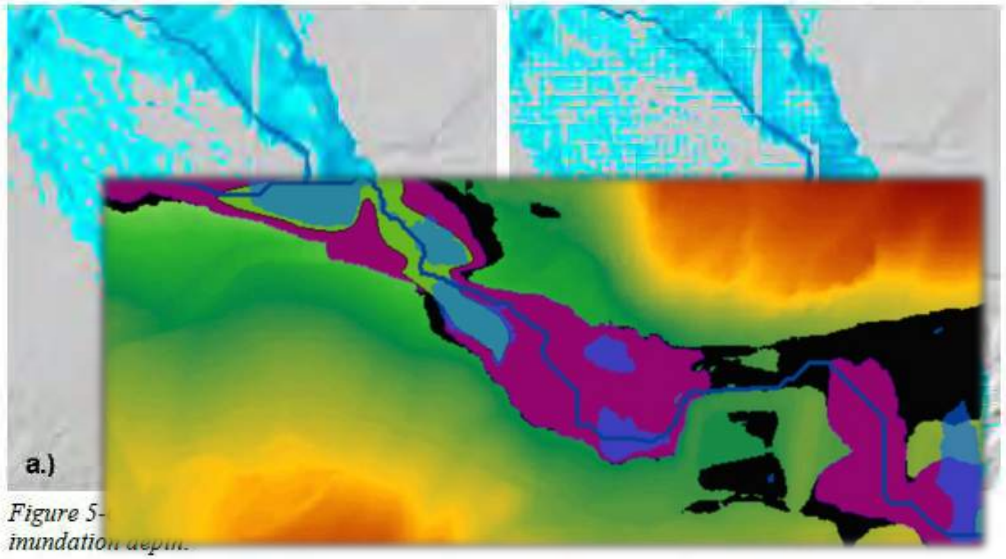
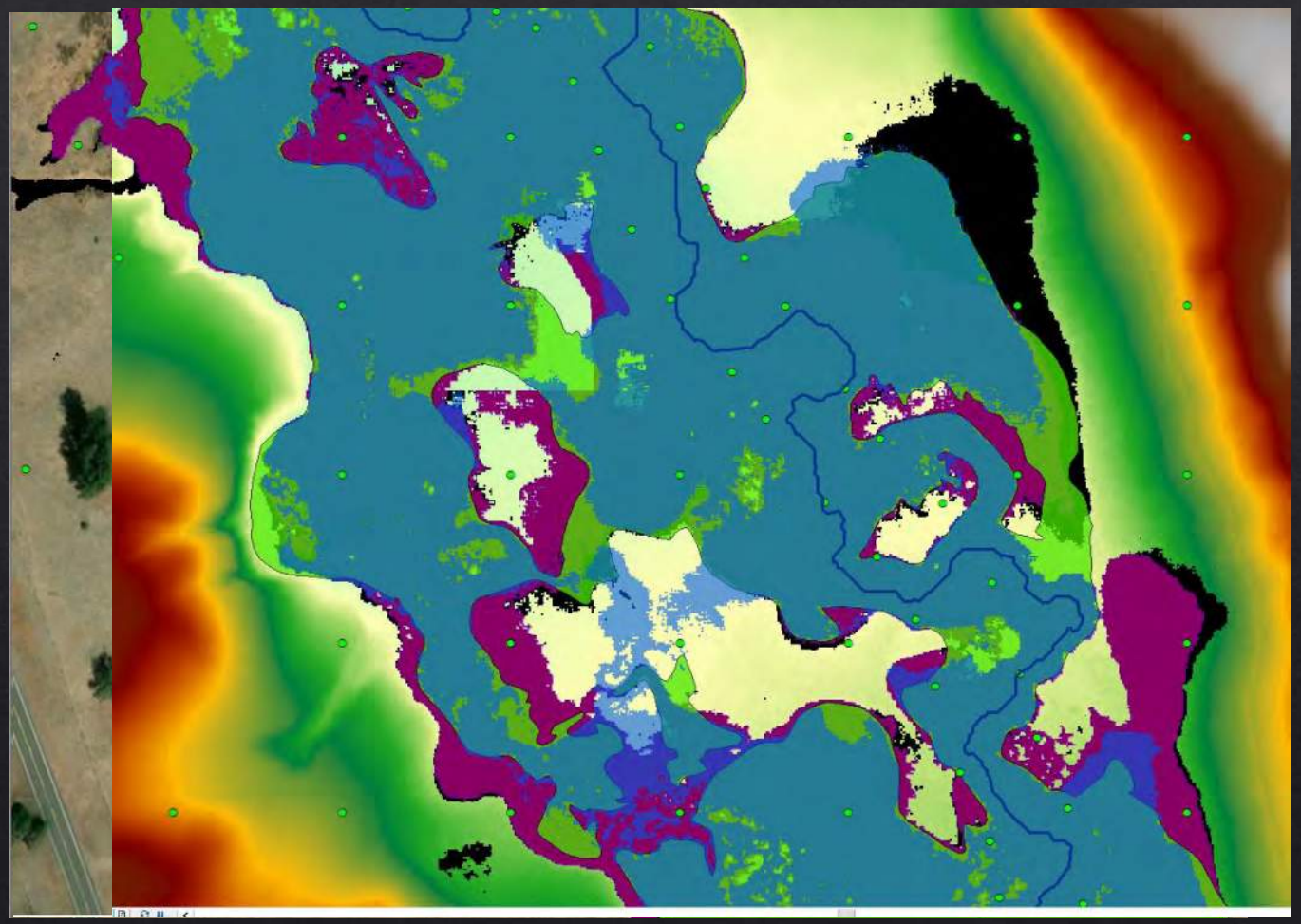


Figure 5-
inundation depth.



Many thanks to Many engineers!

Contact: Geoff.Uhlemann@mbakerintl.com
720.653.5928

2D RESULT COMMUNICATION AND USE

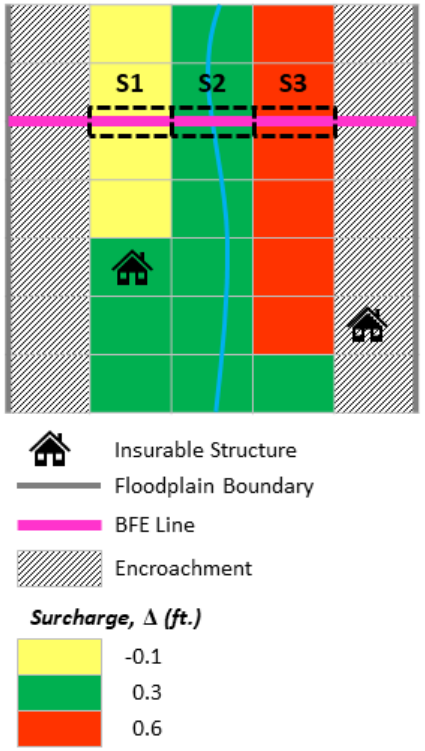
CASFM 2020

Thuy Patton, CFM
Terri Fead, PE, CFM
Rigel Rucker, PE, CFM

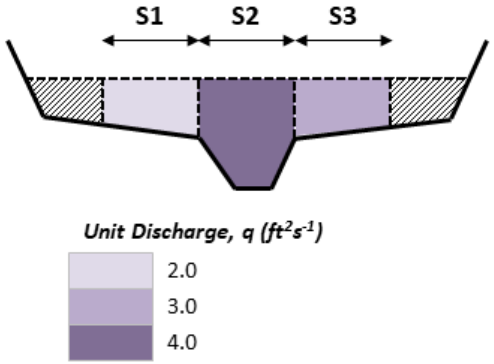
THE START

- 2D Floodways are difficult to produce and manage
- New technology should be utilized if it creates a better understanding of risk
- FEMA's Standards were cumbersome for 2D product development and effective use
- Needed more consistency with surcharge calculation approach

1 Calculate surcharge at each cell, and divide BFE line into segments



2 Calculate unit discharge for each segment



3 Calculate unit discharge weighted surcharge average ($\bar{\Delta}_{BFE}$) for all segments along BFE line

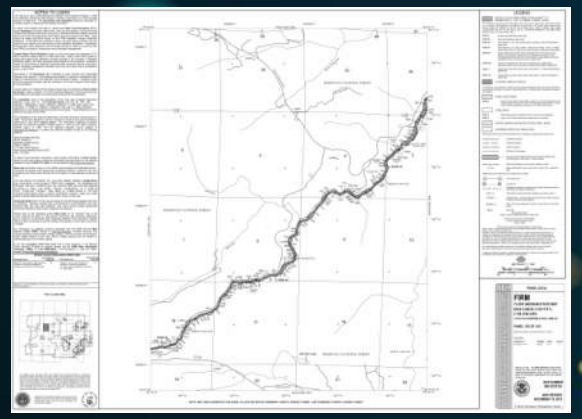
$$\bar{\Delta}_{BFE} = \frac{\Delta_{S1} q_{S1} + \Delta_{S2} q_{S2} + \Delta_{S3} q_{S3}}{q_{S1} + q_{S2} + q_{S3}}$$

$$\bar{\Delta}_{BFE} = \frac{(-0.1)(2.0) + (0.3)(3.0) + (0.6)(4.0)}{2.0 + 3.0 + 4.0}$$

$$\bar{\Delta}_{BFE} = \mathbf{0.14}\ \boldsymbol{ft}.$$

1 Evaluate weighted surcharge average and individual cell surcharges against criteria. Adjust criteria where more restrictive state surcharge requirements exist.

Criteria	Description	Pass	Fail
1	BFE average is within allowable surcharge range of 0.0 to 1.0 feet.	✓	
2	All cells overlapping insurable structures are within the allowable surcharge range of 0.0 to 1.0 feet.	✓	
3	All cells considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✓	
4	All cells ***not*** considered in the BFE average are within the allowable surcharge range ± 0.5 feet (-0.5 to 1.5 feet)	✓	



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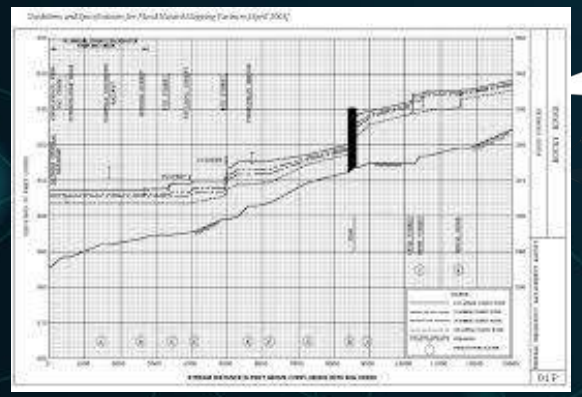

or

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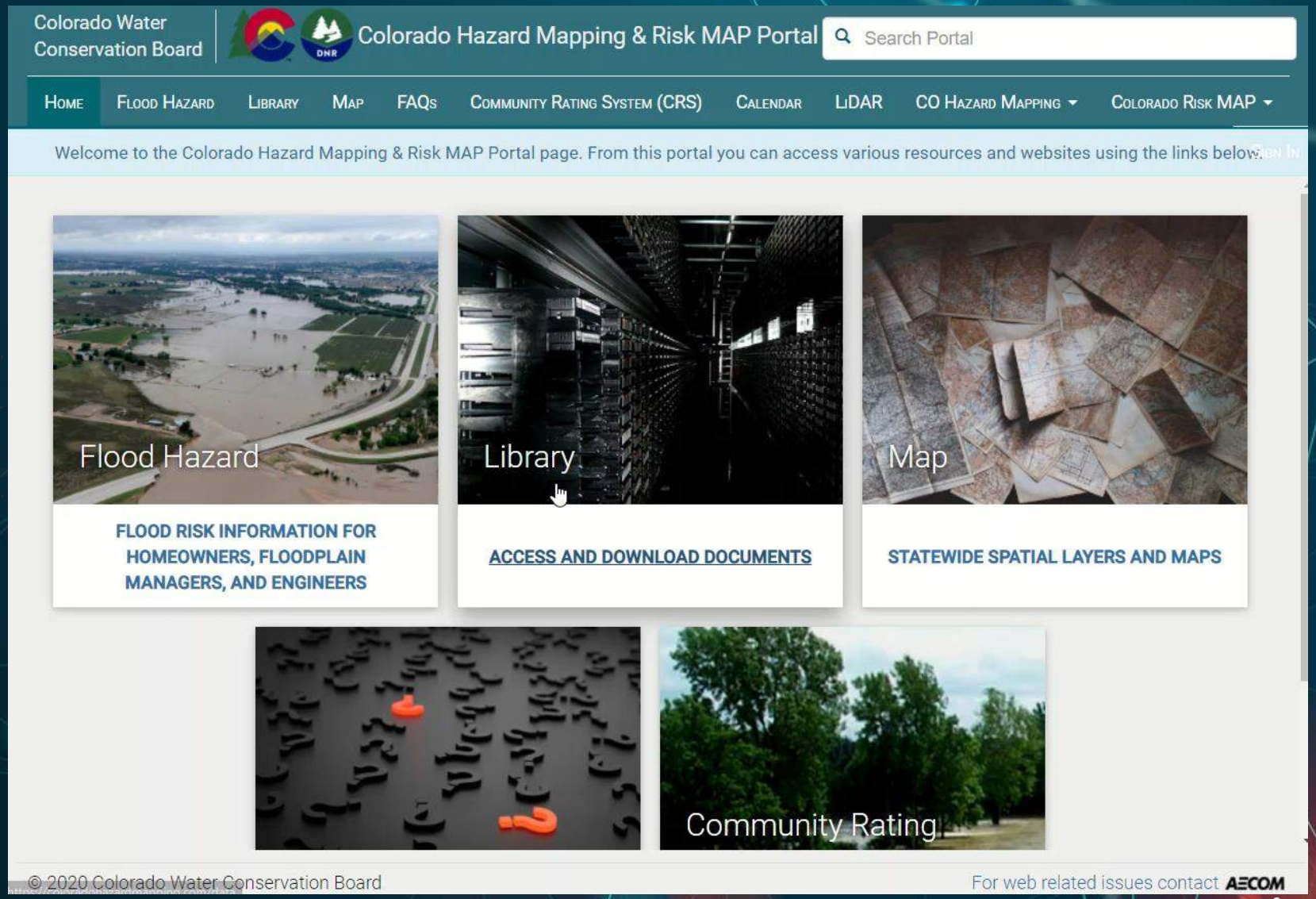


Some Slide Graphics by Slidesgo

01 Water Surface Elevation Grids

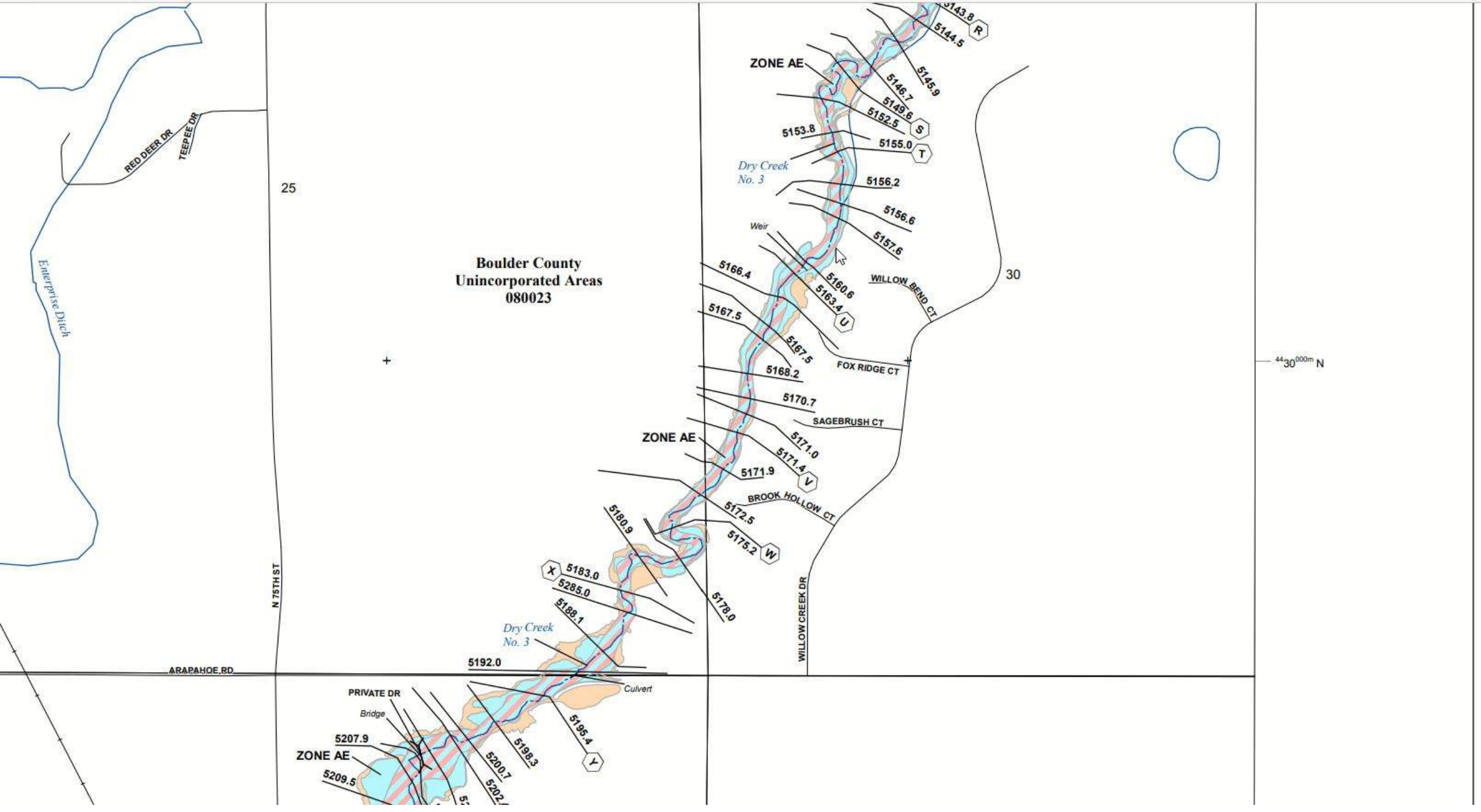
02 Conversion to Digital FIRM

03 Interim Guidance for Managers and Engineers

04 Training

WATER SURFACE ELEVATION GRIDS

- Graphical representation of model results
- Benefits and needs for floodplain managers
  - One click for BFEs
  - Will need outreach and training on online viewers and data interpretation
  - Will allow cataloging of historic info
- Benefits and needs for FEMA and partners
  - Eliminate FIS Profiles, FWDT in most cases
  - Eliminates graphical BFEs/labeling, etc. (some may still be used for evaluation)
  - FIS becomes narrative, could be digital
  - Grids will need more detailed review process
  - Need LOMC Process


Boulder County
Unincorporated Areas
080023
ZONE AE
ZONE AE
ZONE AE
Dry Creek
No. 3
Dry Creek
No. 3
Enterprise Ditch
RED DEER DR
TEEPEE DR
25
30
N 75TH ST
ARAPAHOE RD
WILLOW BEND CT
FOX RIDGE CT
SAGEBRUSH CT
BROOK HOLLOW CT
WILLOW CREEK DR
PRIVATE DR
Bridge
Weir
Culvert
5143.8
5144.5
5145.9
5146.7
5149.6
5152.5
5153.8
5155.0
5156.2
5156.6
5157.6
5160.6
5163.4
5166.4
5167.5
5167.5
5168.2
5170.7
5171.0
5171.4
5171.9
5172.5
5175.2
5178.0
5180.9
5183.0
5285.0
5188.1
5192.0
5195.4
5198.3
5200.7
5202.
5207.9
5209.5
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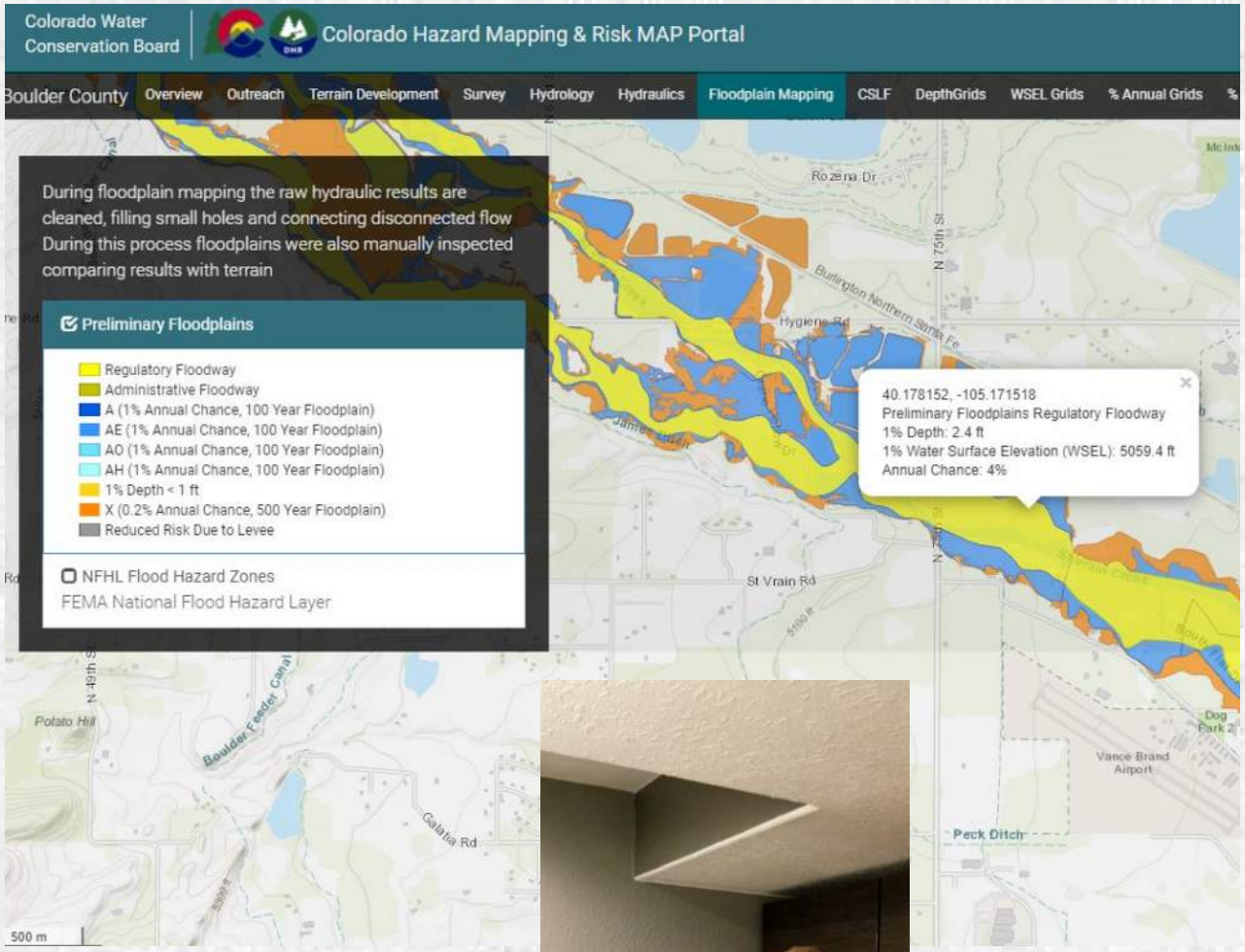
44 30 000m N



FULL CONVERSION TO DIGITAL FIRM

- FEMA converting would help with consistency
- Will eliminate need for paper FIRM products
  - Panel creation cost reduction
  - Can have draft/prelim/effective available on similar viewers
  - Move to a nationwide format
  - Reduce discrepancies between panels
- Make access easier and improve resolution
- Communities without web capabilities could be worked with one on one

FEMA's National Flood Hazard Layer (NFHL) Viewer with Web AppBuilder for ArcGIS

boulder county colorado

Show search results for boulder coun...

NFHL Print Tool

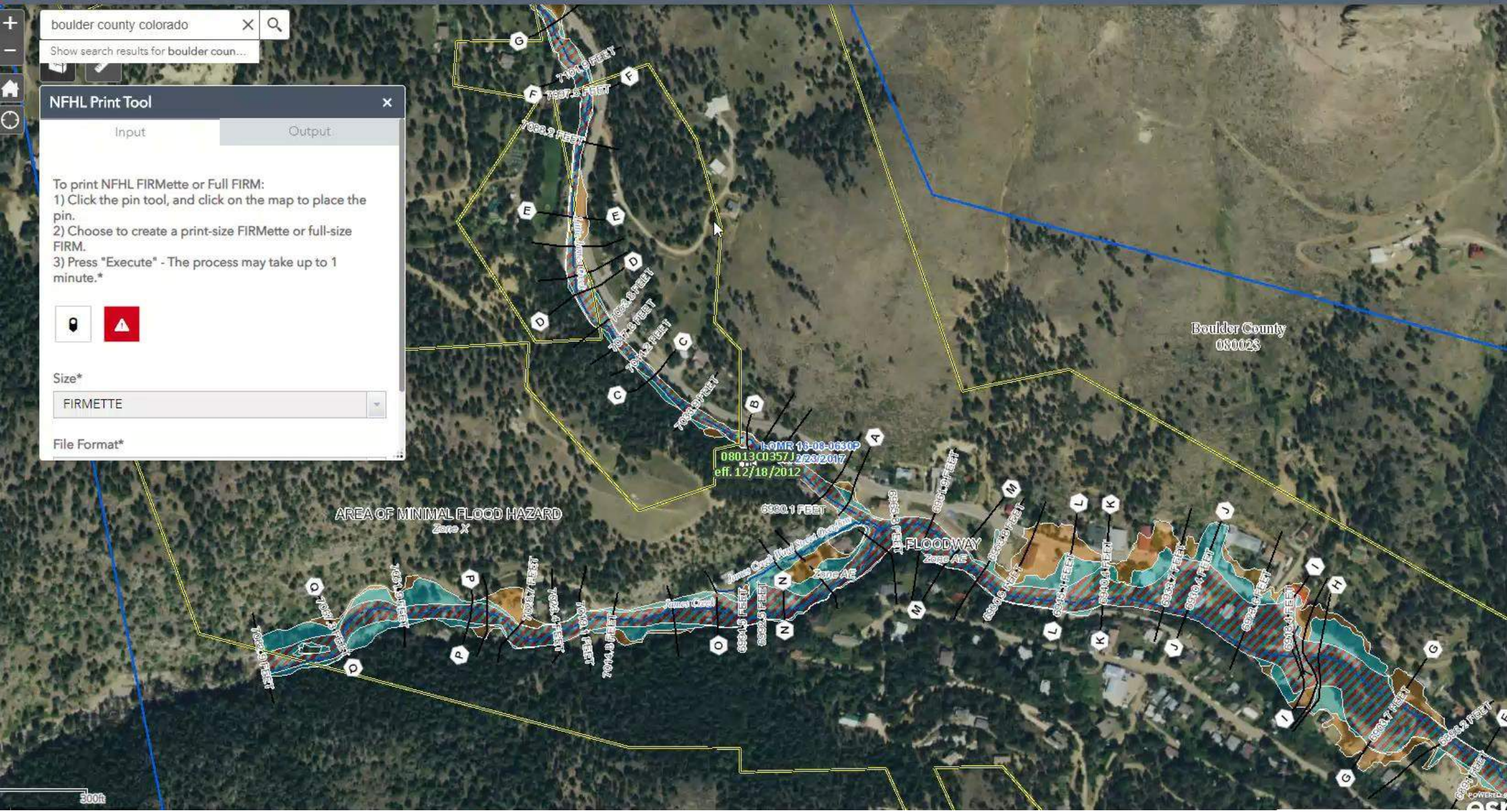
Input | Output

To print NFHL FIRMette or Full FIRM:
1) Click the pin tool, and click on the map to place the pin.
2) Choose to create a print-size FIRMette or full-size FIRM.
3) Press "Execute" - The process may take up to 1 minute.*

Size*

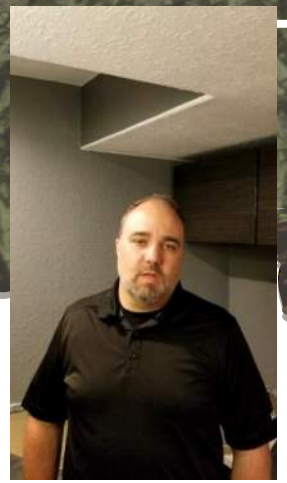
FIRMETTE

File Format*



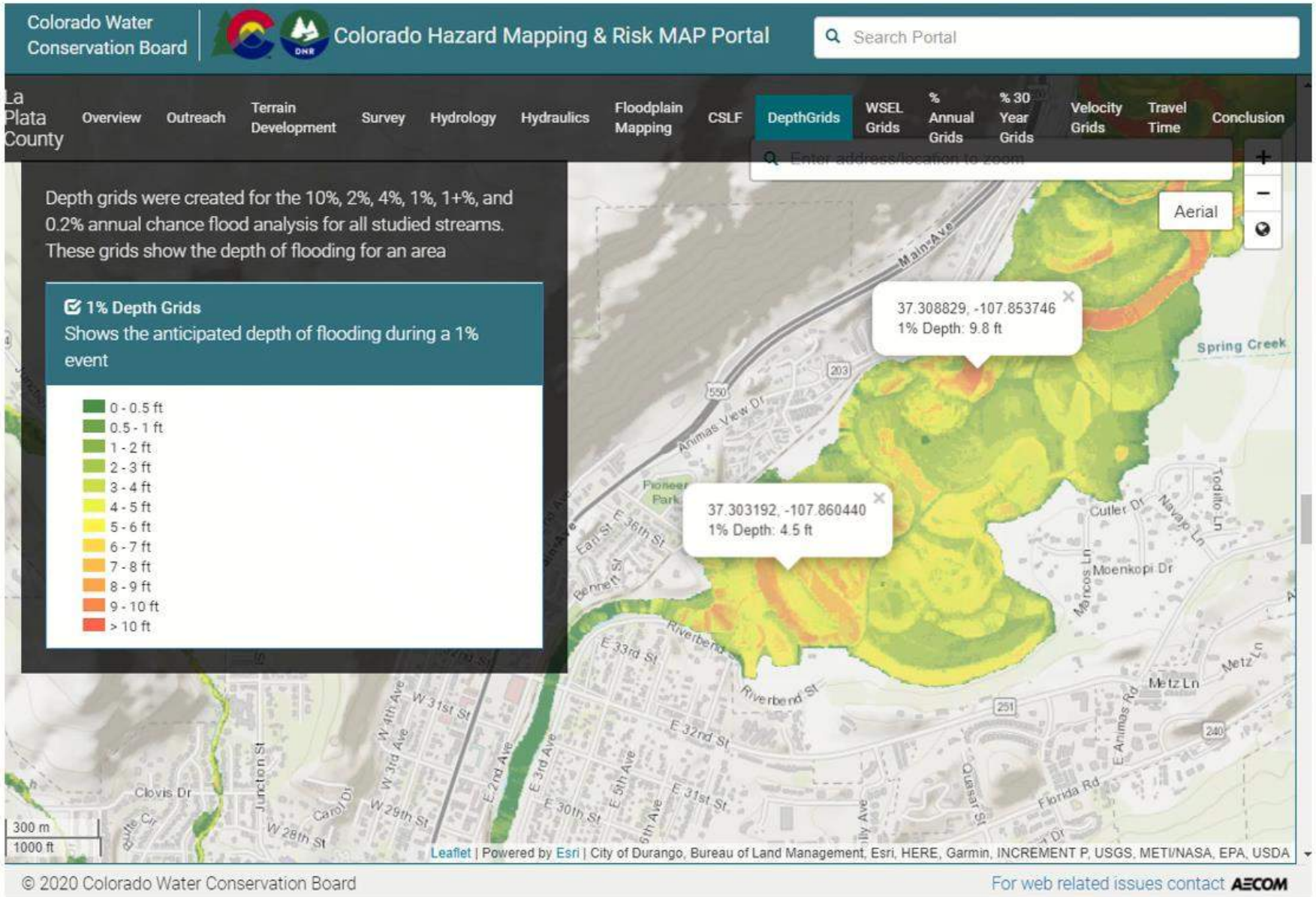
INTERIM DIGITAL DATA FOR FLOODPLAIN MANAGERS AND ENGINEERS

Interim Recommendation



RECOMMENDATIONS UNTIL NATIONAL DATASET DIGITAL

- WSE grids, Depth Grids, DxV Requested
  - Best on web viewer
  - Second Option Map Package
  - WSE Grid standalone for local GIS
- Floodway surcharge grid and floodplain changes for LOMR, and Effective method for 1D interface
- Comparison of pre and post project
- Model stability report
- Effective and revised model with versioning
- Typical spatial data
- GIS map packages


Colorado Water Conservation Board
Colorado Hazard Mapping & Risk MAP Portal
Search Portal
La Plata County
Overview
Outreach
Terrain Development
Survey
Hydrology
Hydraulics
Floodplain Mapping
CSLF
DepthGrids
WSEL Grids
% Annual Grids
% 30 Year Grids
Velocity Grids
Travel Time
Conclusion
Enter address/location to zoom
Aerial
Depth grids were created for the 10%, 2%, 4%, 1%, 1+%, and 0.2% annual chance flood analysis for all studied streams. These grids show the depth of flooding for an area
1% Depth Grids
Shows the anticipated depth of flooding during a 1% event
0 - 0.5 ft
0.5 - 1 ft
1 - 2 ft
2 - 3 ft
3 - 4 ft
4 - 5 ft
5 - 6 ft
6 - 7 ft
7 - 8 ft
8 - 9 ft
9 - 10 ft
> 10 ft
37.308829, -107.853746
1% Depth: 9.8 ft
37.303192, -107.860440
1% Depth: 4.5 ft
Main Ave
Spring Creek
Animas View Dr
Pioneer Park
Riverbend St
Cutler Dr
Navajo Ln
Moenkopi Dr
Metz Ln
Florida Rd
E Animas Rd
Clovis Dr
Juncton St
W 28th St
W 29th St
W 31st St
E 33rd St
E 32nd St
E 31st St
E 30th St
300 m
1000 ft
Leaflet | Powered by Esri | City of Durango, Bureau of Land Management, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA
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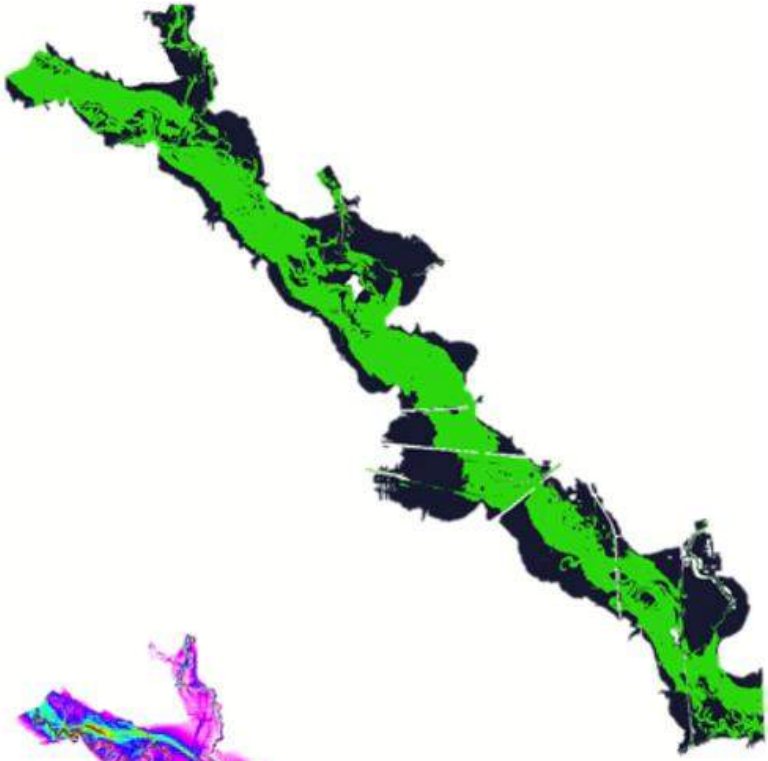
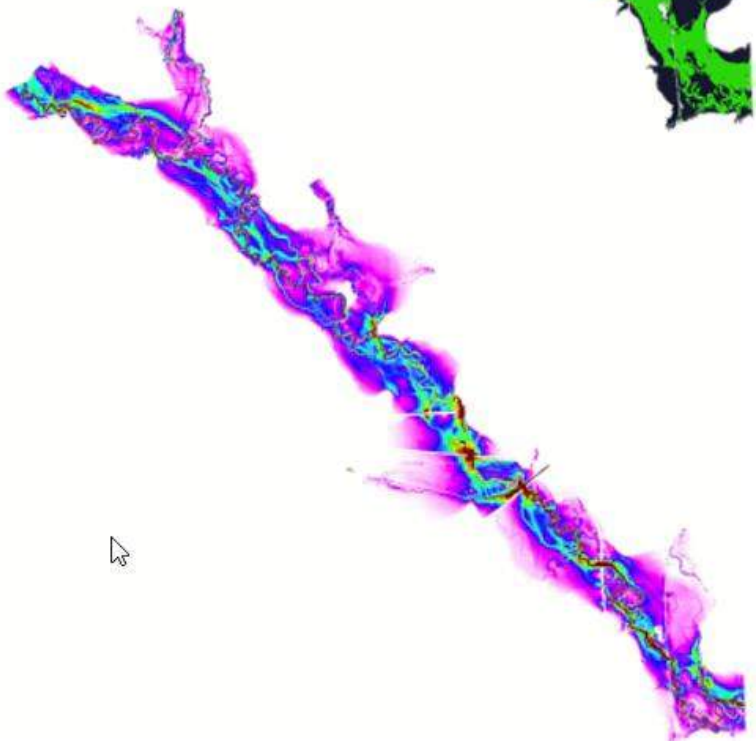
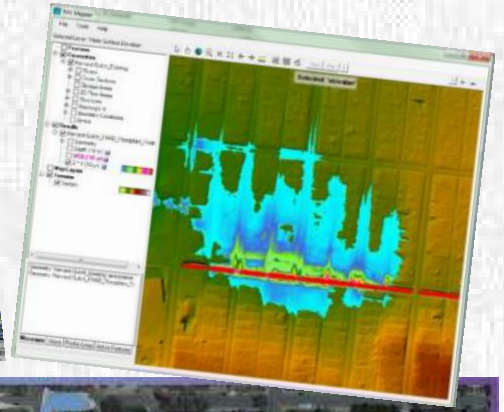
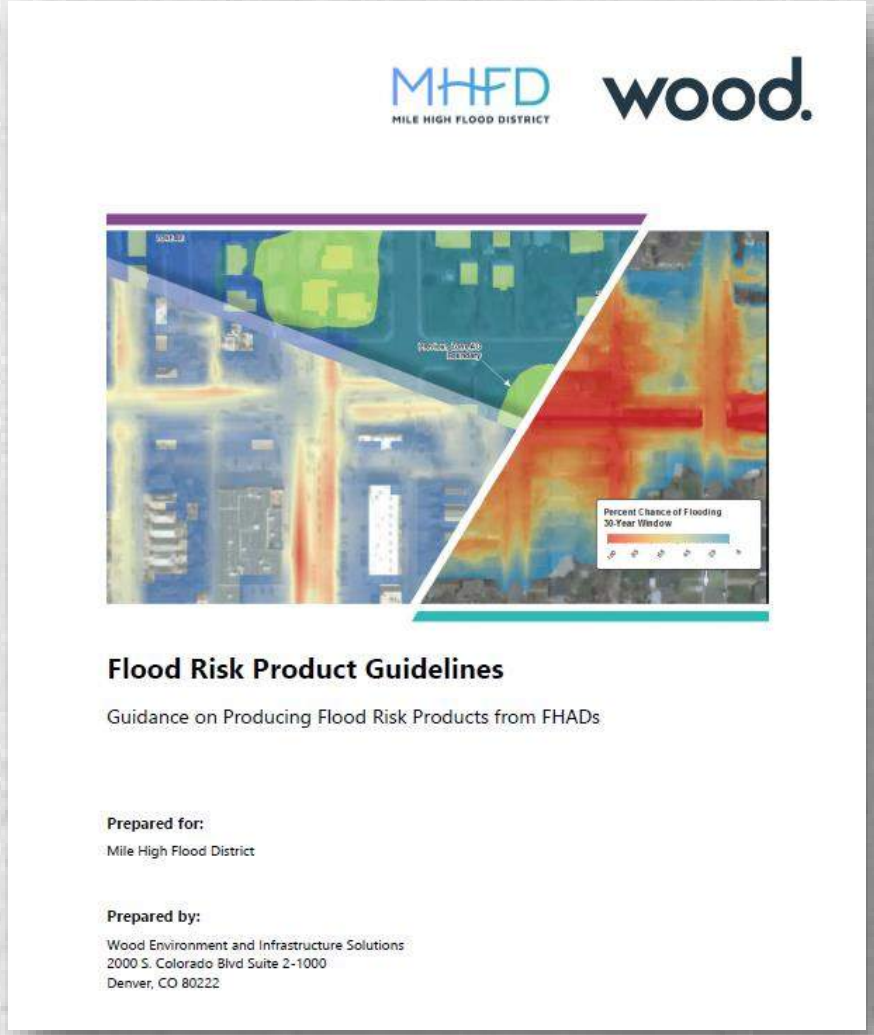




Flood Risk Products for Effective 1D Floodplain Studies





MHFD MILE HIGH FLOOD DISTRICT

wood.

Flood Risk Product Guidelines

Guidance on Producing Flood Risk Products from FHADs

Prepared for:

Mile High Flood District

Prepared by:

Wood Environment and Infrastructure Solutions
2000 S. Colorado Blvd Suite 2-1000
Denver, CO 80222

Figure 1 – FHAD to Flood Risk Products

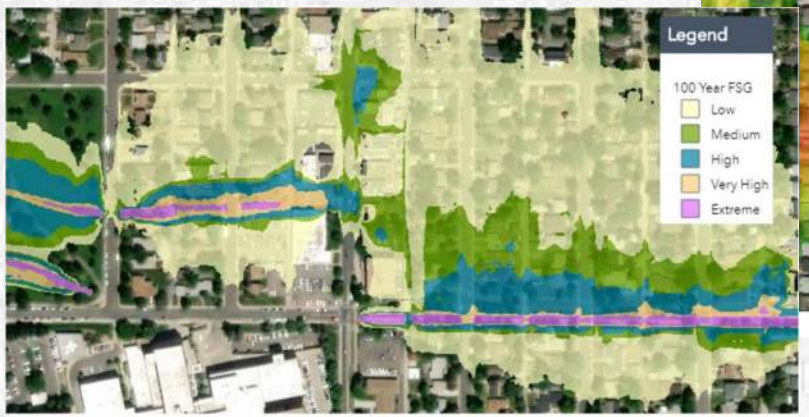


Figure 12 – Mapped Flood Severity Grid

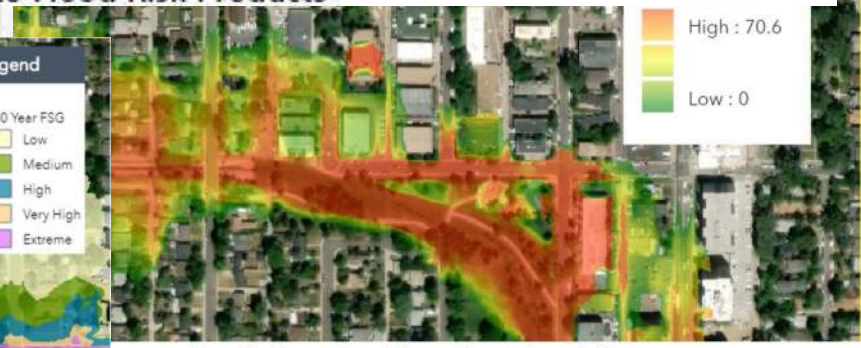


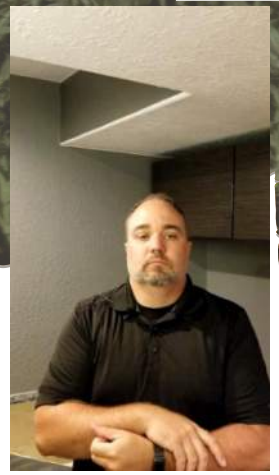
Figure 19 – Percent Annual Chance Output - Example View

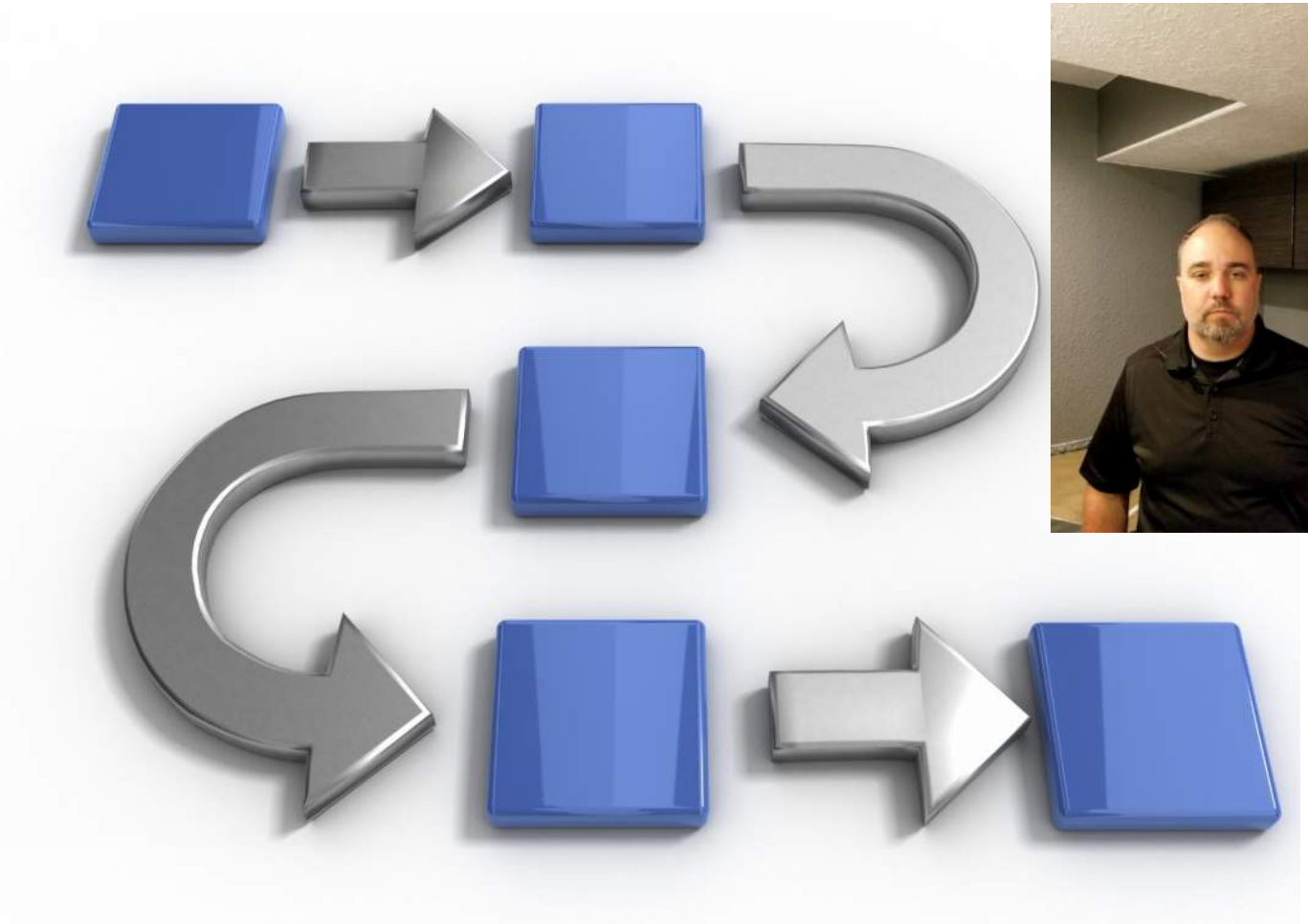
DIGITAL DATA USE BY ENGINEERS

- Trainings for output manipulation of required grids.
- Ability to “check out” part of a large model still an issue.
- Transitioning from effective 1D models and floodways

SUGGESTED APPROACH AND TRAINING

Recommendation





APPROACH

- WSE grids as regulatory products is recommended as an immediate step.
  - This change does not require a revision to current regulatory products, it is just an addition of a new one.
  - This will create a mandatory tool that will help with all of the items identified in the analysis above.
  - Will need to be generated in many areas.
  - C2DC asks that FEMA allow the publication of WSE grids in addition to or instead of water surface profiles based on floodplain manager preference.
- Move toward regulatory digital flood hazard layers instead of FIRMs.
  - Access to a universal platform, such as the NFHL, for information is recommended.
  - A method to view historic and superseded information is also recommended. Create revised quality standards, such as floodplain boundary standards, that can be applied to 2D results.
- Pursue outreach and develop training documentation and references related to the use of all digital products
- Develop a more effective check in/check out and quality assurance processes for model and map revisions. This needs to include storage and size considerations

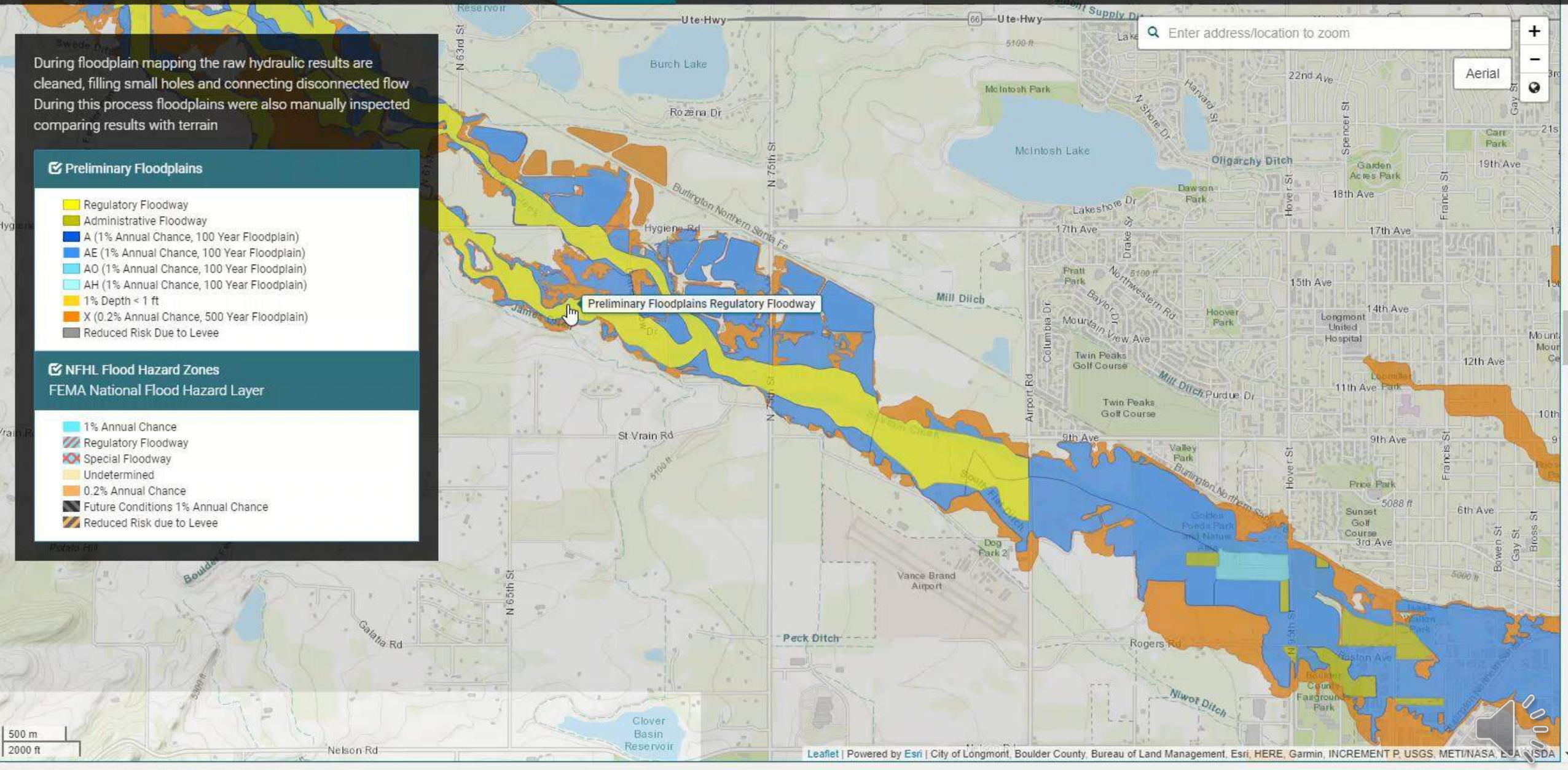
During floodplain mapping the raw hydraulic results are cleaned, filling small holes and connecting disconnected flow. During this process floodplains were also manually inspected comparing results with terrain

Preliminary Floodplains

- Regulatory Floodway
- Administrative Floodway
- A (1% Annual Chance, 100 Year Floodplain)
- AE (1% Annual Chance, 100 Year Floodplain)
- AO (1% Annual Chance, 100 Year Floodplain)
- AH (1% Annual Chance, 100 Year Floodplain)
- 1% Depth < 1 ft
- X (0.2% Annual Chance, 500 Year Floodplain)
- Reduced Risk Due to Levee

NFHL Flood Hazard Zones
FEMA National Flood Hazard Layer

- 1% Annual Chance
- Regulatory Floodway
- Special Floodway
- Undetermined
- 0.2% Annual Chance
- Future Conditions 1% Annual Chance
- Reduced Risk due to Levee



Trainings

When is 2D Beneficial?
What to review for 2D?

Best Practices for FPMs.
Determine a BFE with no profile.

GIS data, use and symbology.
Insurance.

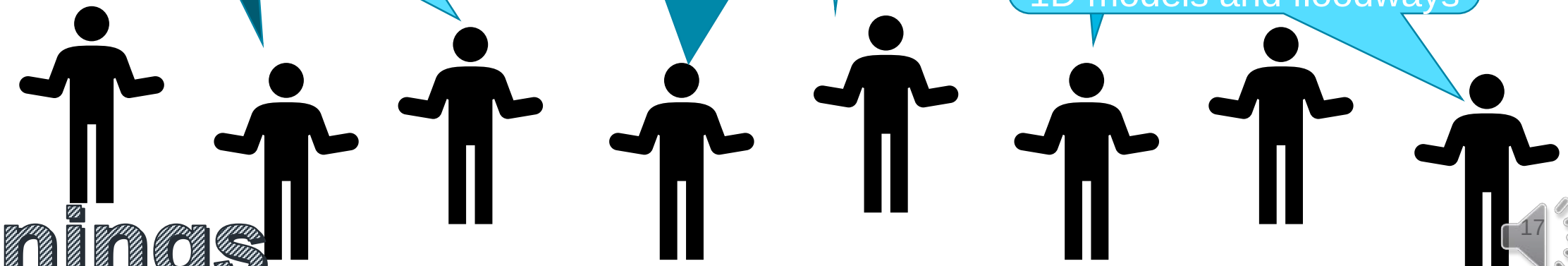
What to request for 2D?
What non-regulatory Products are used for?

Common pitfalls/issues to look for before signing MT2
Review of model stability/convergence.

How to read a BFE from 2D results?
How to fill out elevation certs or permit using 2D results?

How to manage without a floodway.
General Floodway Training.
How effective data is filed

How to transition or interface 2D with effective 1D models and floodways



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Colorado Hazard Mapping & Risk MAP Portal

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Welcome to the Colorado Hazard Mapping & Risk MAP Portal page. From this portal you can access various resources and websites using the links below.

FLOOD RISK INFORMATION FOR HOMEOWNERS, FLOODPLAIN MANAGERS, AND ENGINEERS

ACCESS AND DOWNLOAD DOCUMENTS

STATEWIDE SPATIAL LAYERS AND MAPS

VIEW FREQUENTLY ASKED QUESTIONS

LEARN MORE ABOUT CRS FOR COLORADO COMMUNITIES

For web related issues contact AECOM

Thank You!

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

Thuy Patton, CFM
Thuy.patton@state.co.us

MILE HIGH FLOOD DISTRICT

Terri Fead, PE, CFM
tfead@udfcd.org

AECOM

Rigel Rucker, PE, CFM
Rigel.rucker@aecom.com

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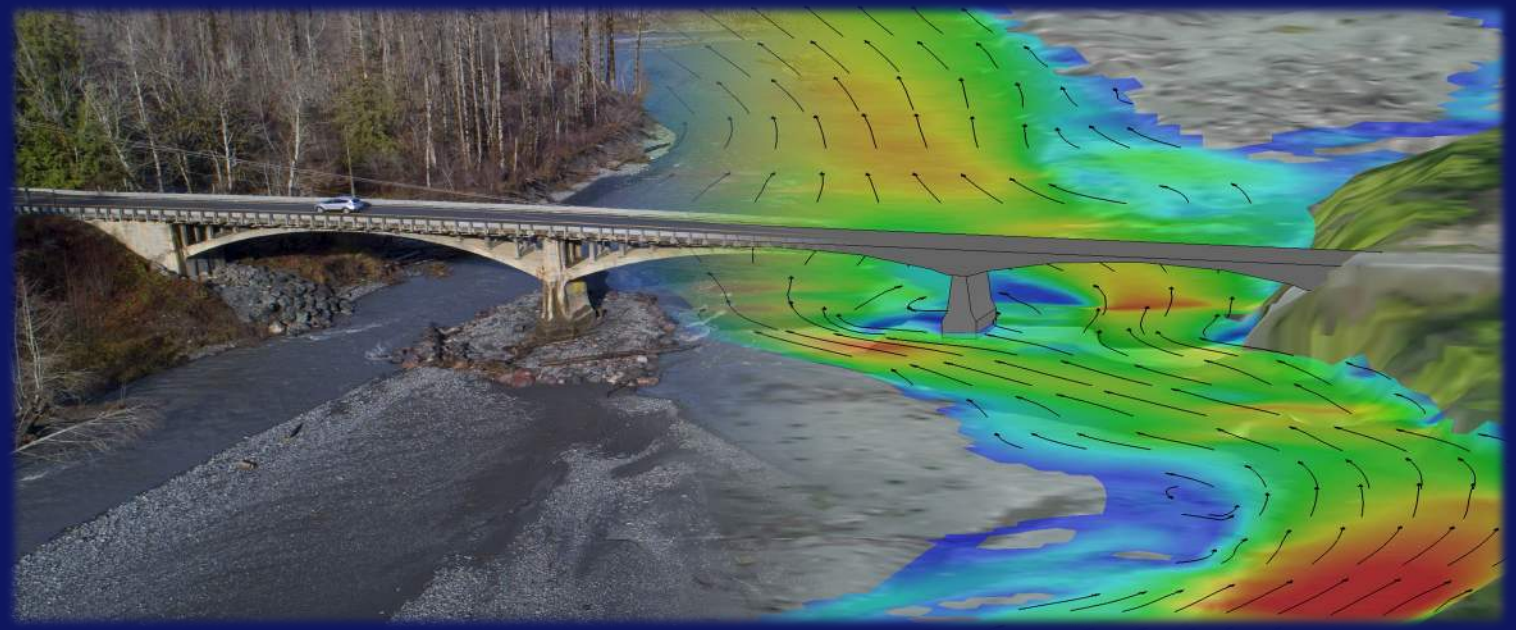

Federal Highway Administration RESOURCE CENTER | 20 YEARS OF SERVICE

Methods for Delineating and Evaluating Floodways in 2D Models

2020 CASFM Virtual Conference

Technical Session: 2D Modeling

September 30, 2020

Scott Hogan, P.E., Federal Highway Administration

Image by John Gussman

On-Ramp to Innovation
every day counts

Background

- FHWA started using 2D modeling for complex bridge hydraulics in 1988
- In 2012 FHWA's reference documents (HEC-18, HDS-7) recommended 2D modeling for bridge hydraulics and scour analysis
- FHWA partnered in 2013 with the US Bureau of Reclamation in the ongoing development of SRH-2D for transportation hydraulics and initiated a graphical user interface in SMS (by Aquaveo)
- The application of 2D models for floodway delineation and assessment was not clearly defined.
- In 2018, a Colorado floodway workgroup was initiated and ultimately provided recommendations to FEMA
- In 2019, FEMA formed and Interagency Project Team (IPT) to update the standards and guidelines for 2D modeling

Overview

- 1D versus 2D modeling assumptions that affect floodway development
- Evaluating surcharges in a 2D model
- Two methods for delineating floodways in 2D models

1D versus 2D Modeling Assumptions

Hydraulic Variables	One-dimensional (1D) Modeling	Two-dimensional (2D) Modeling
Flow direction	Assumed by user	Computed
Flow paths	Assumed by user	Computed
Water surface elevation	Assumed constant across cross sections	Computed at each element
Flow velocity	Averaged at each cross section Assumed in one direction	Magnitude and direction Computed at each element
Flow distribution	Computed based on conveyance	Computed based on continuity
Channel roughness	Assumed constant between cross sections	Represented at each element
Ineffective (blocked) flow areas	Assumed by user	Computed
Flow contraction and expansion through bridges	Assumed by user	Computed

Case Study Project Example: Elkhorn River NE

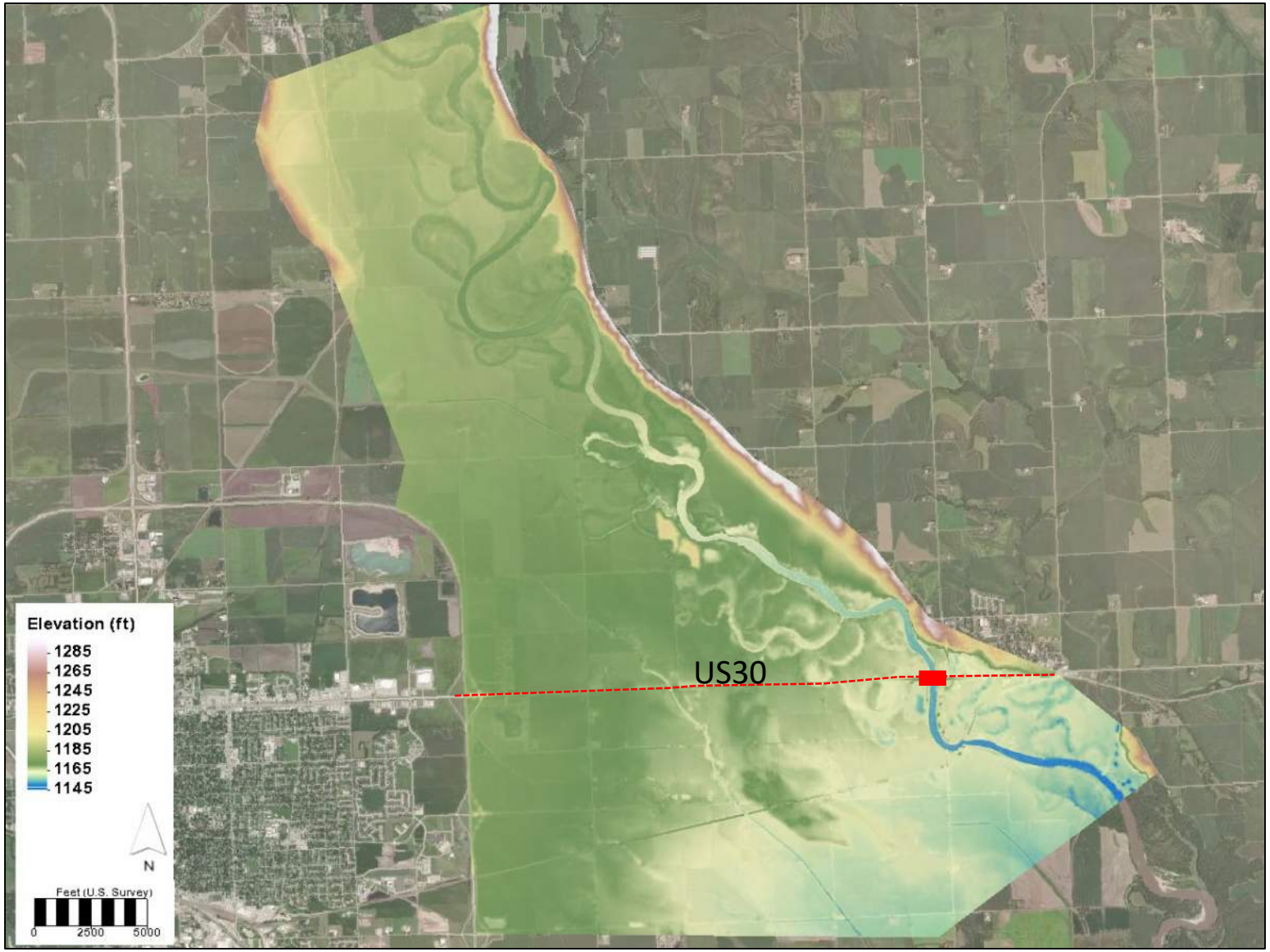

Image Source: Nebraska Department of Highways

- Q_{100} = 86,000 cfs
- ~9 mile reach
- Floodplain is 1.5 – 3 miles wide
- Project objective: US30 road/bridge improvements

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Case Study Project Example: Elkhorn River NE

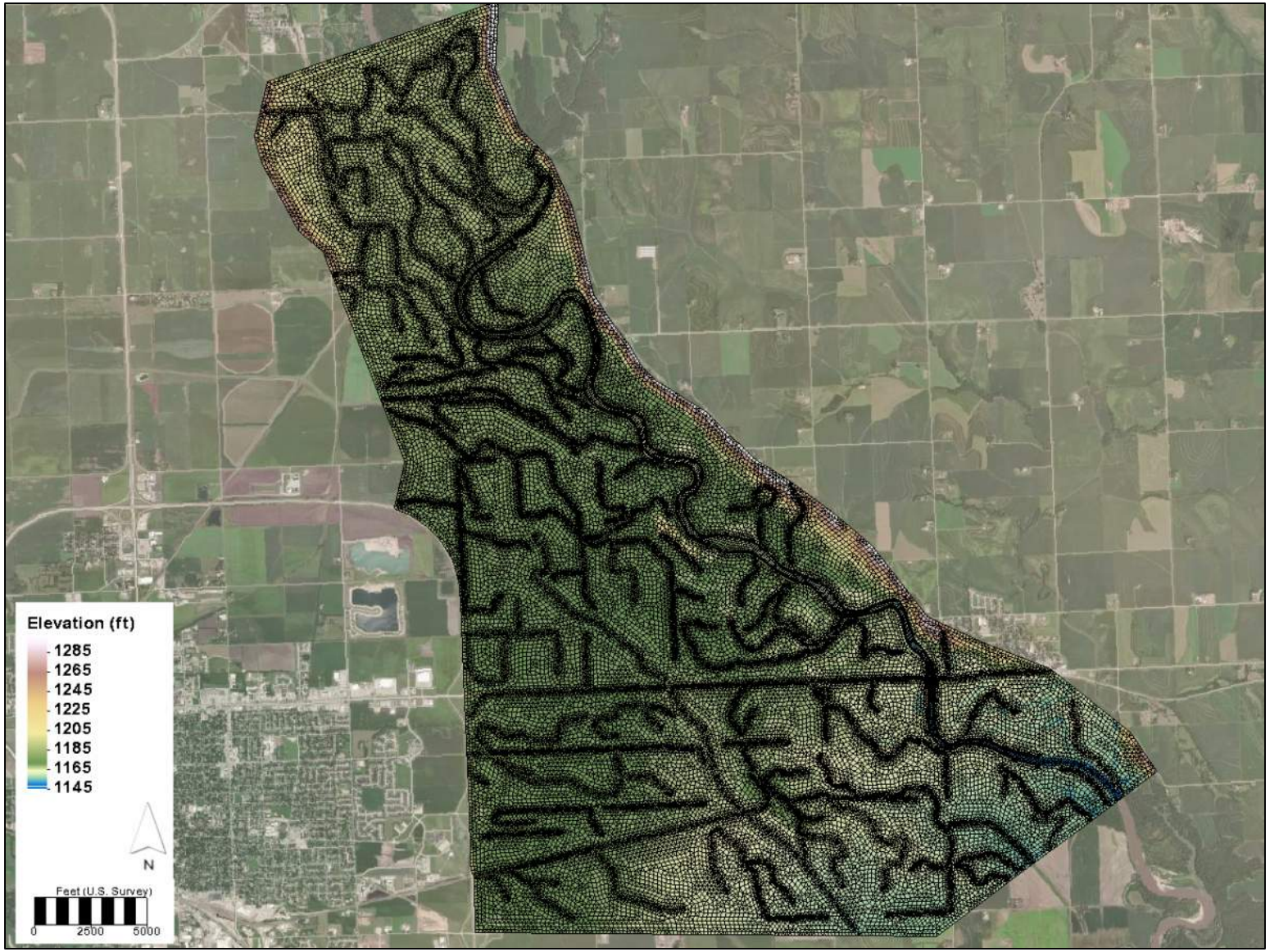

Image Source: Nebraska Department of Highways

- Q_{100} = 86,000 cfs
- ~9 mile reach
- Floodplain is 1.5 – 3 miles wide
- Project objective: SR30 roadway/bridge improvements
- Mesh developed using new feature delineation tools in SMS
- ~87,000 elements (3 ft – 200 ft)
- Calibrated to HWM data
- Model runtime (CPU) = 12 minutes (20 hour steady state sim)

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Evaluating Surcharges with Evaluation Lines

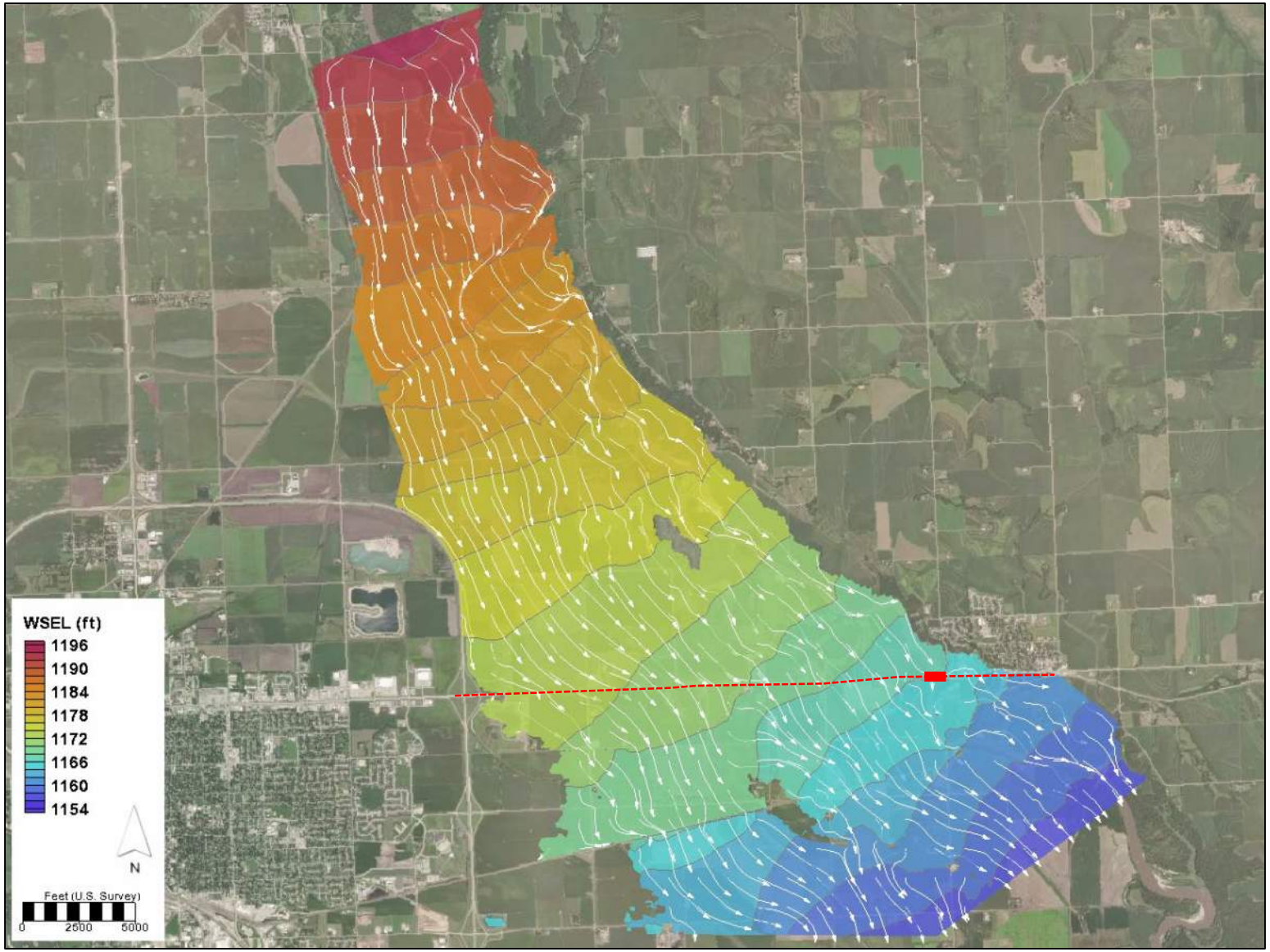

Image Source: Nebraska Department of Highways

SMS Tools / Process

- Display linear WSEL Contours at desired spacing
- Save As .shp file (Mesh Contours -> Arc Shapefile
- Open new shapefile and convert it to a 1D XS coverage
- Define a centerline (for stationing)
- Generate a Summary Table of average WSELs for each scenario
- Compare results

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Current Effective 1D Floodway Modeled in 2D

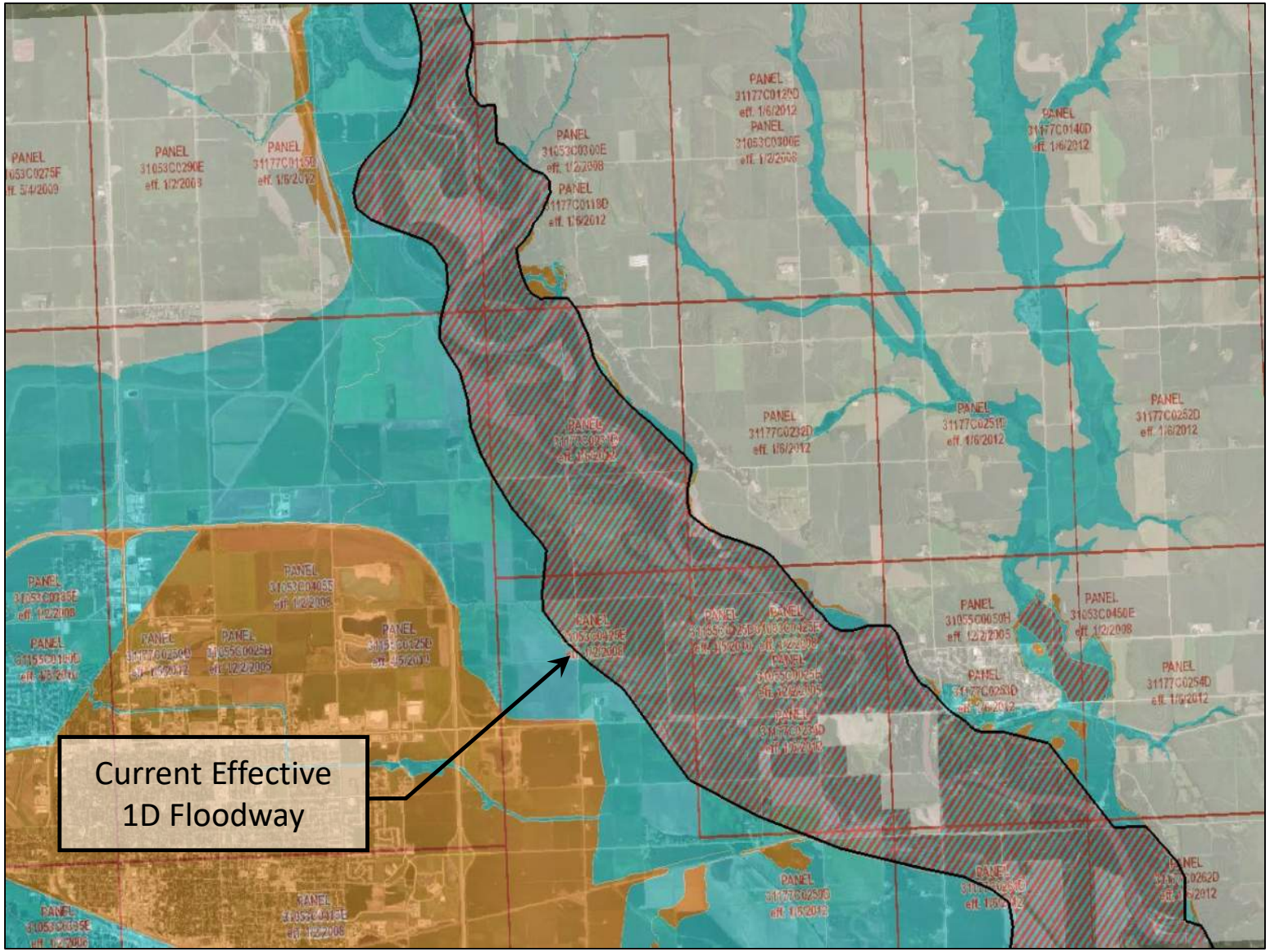

Image Source: Nebraska Department of Highways / FEMA Flood Hazard Map

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Current Effective 1D Floodway Modeled in 2D

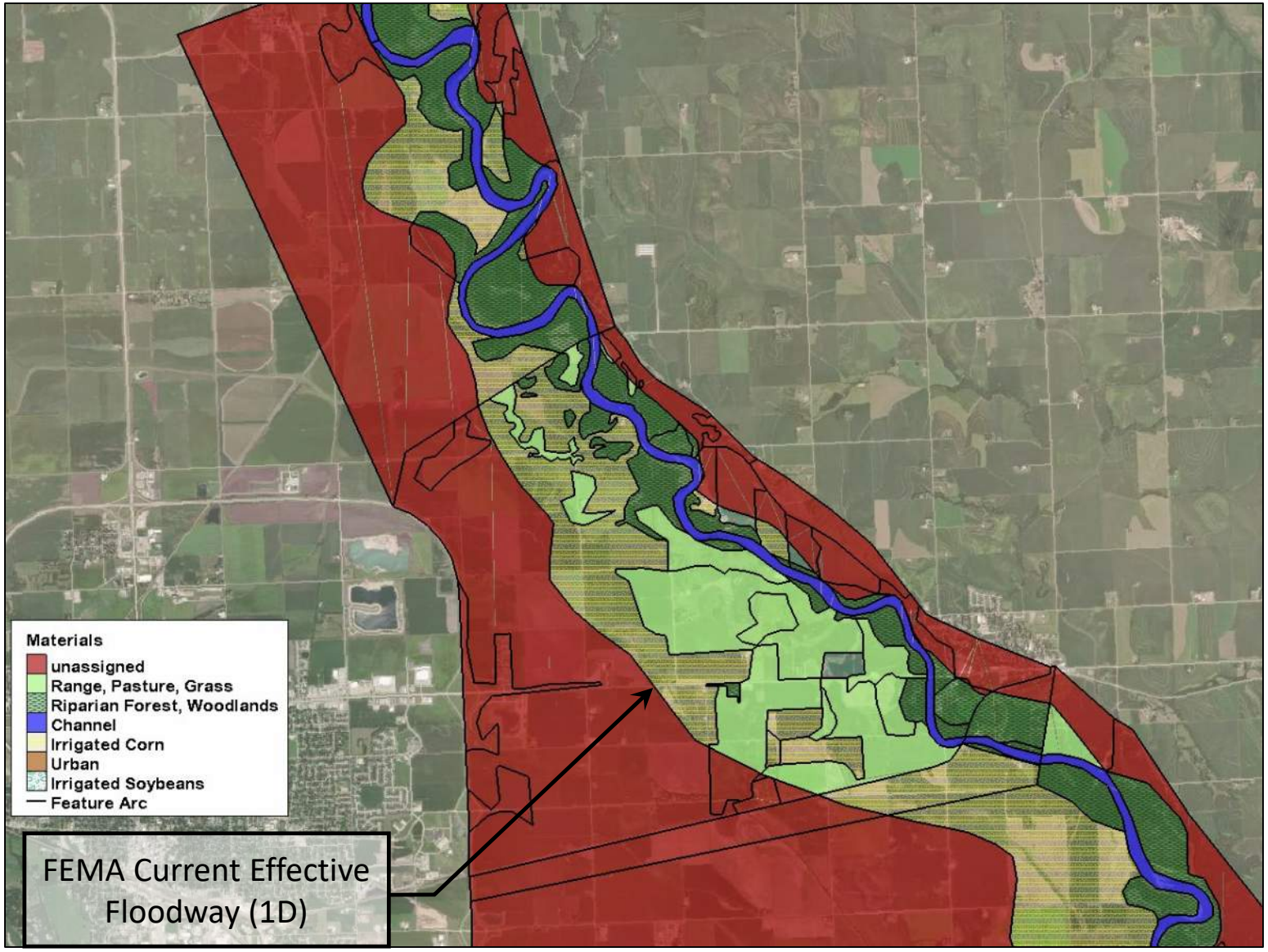

Image Source: Nebraska Department of Highways

SMS Tools / Process

- Floodway corridor defined in materials coverage
- The materials outside of floodway boundary are 'disabled' using an unassigned material type
- Simulation is rerun
- Results are compared

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Current Effective 1D Floodway Modeled in 2D

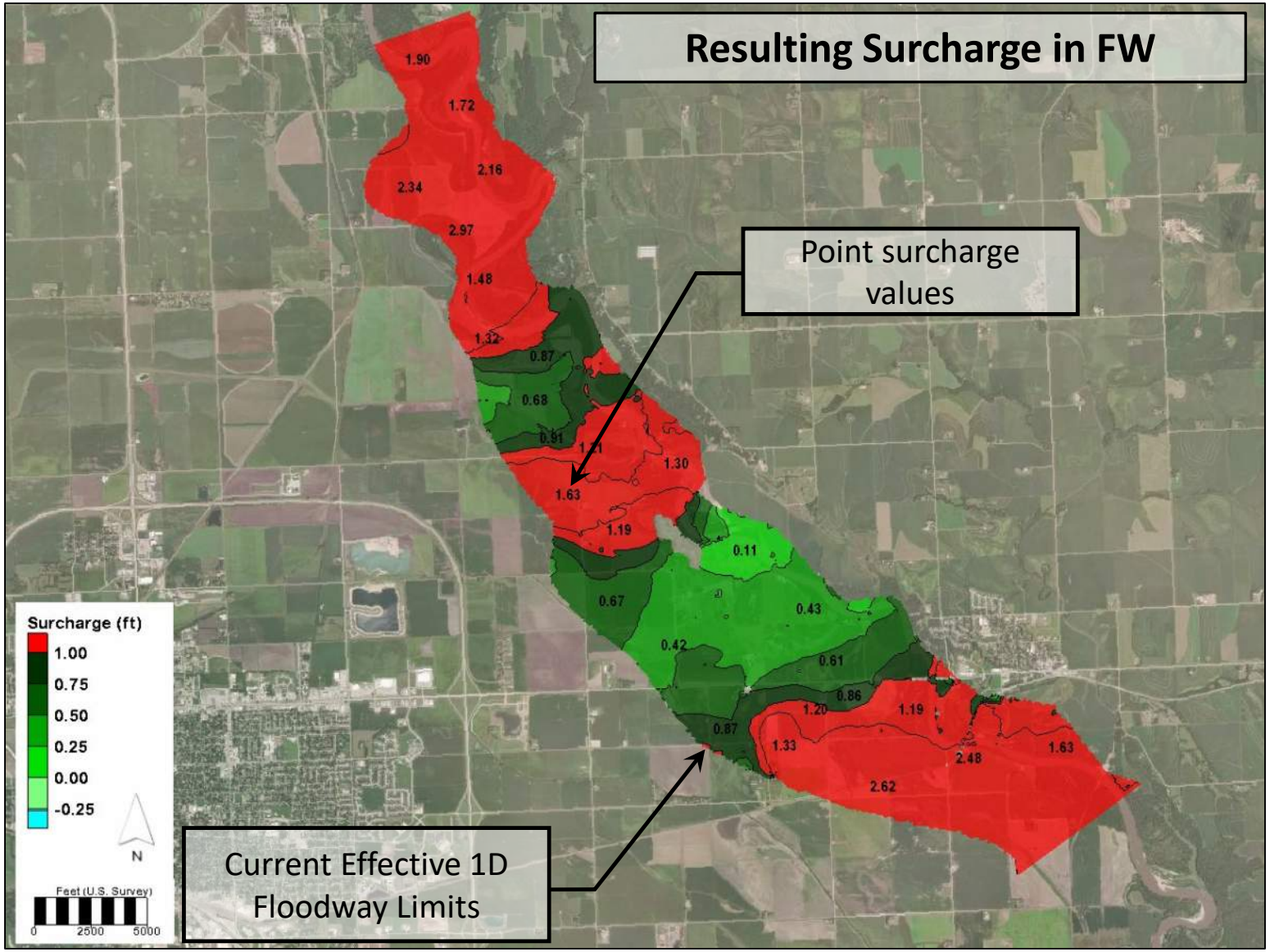

Image Source: Nebraska Department of Highways

- In many cases the floodway surcharges estimated with a 2D model for current effective 1D floodways are higher than predicted with the 1D model

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Evaluating Surcharges in a 2D Model (1D Floodway)

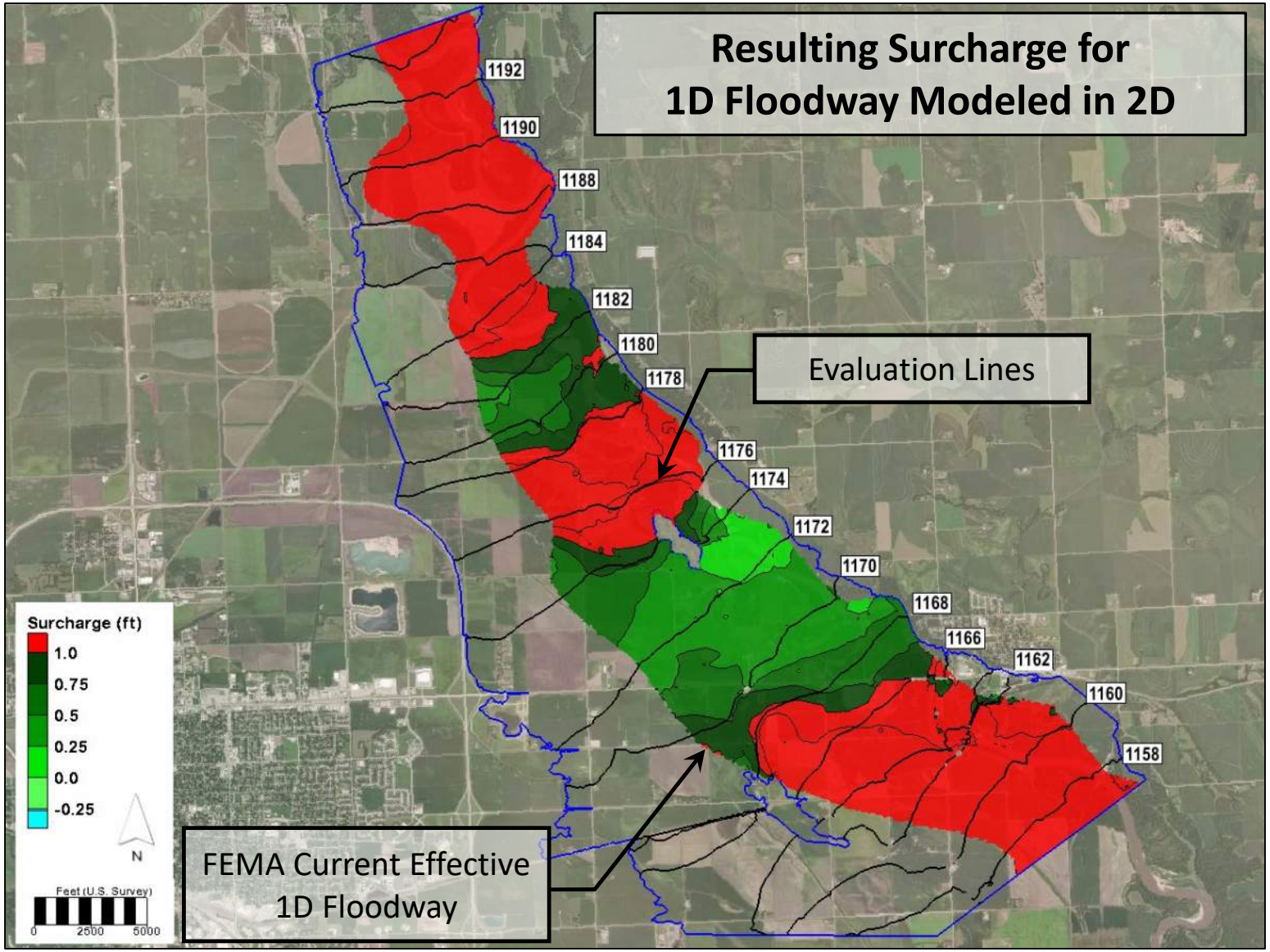

Image Source: Nebraska Department of Highways

Floodway Surcharge Summary

Q100 Base Flood Evaluation Lines	Current Effective 1D Floodway in 2D	
WSEL Ave	WSEL Ave	Surcharge
(ft)	(ft)	(ft)
1158.00	1159.82	**1.82**
1160.00	1162.08	**2.08**
1162.00	1163.28	**1.28**
1164.00	1165.72	**1.72**
1166.00	1166.96	0.96
1168.00	1168.75	0.75
1170.00	1170.45	0.45
1172.00	1172.27	0.27
1174.00	1174.42	0.42
1176.00	1177.36	**1.36**
1178.00	1179.13	**1.13**
1180.00	1180.89	0.89
1182.00	1182.79	0.79
1184.00	1185.44	**1.44**
1186.00	1188.25	**2.25**
1188.00	1190.62	**2.62**
1190.00	1191.75	**1.75**
1192.00	1193.80	**1.80**

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Two Methods for Delineating 2D Floodways

1. Equal Discharge Reduction
2. Unit Discharge (Depth x Velocity)

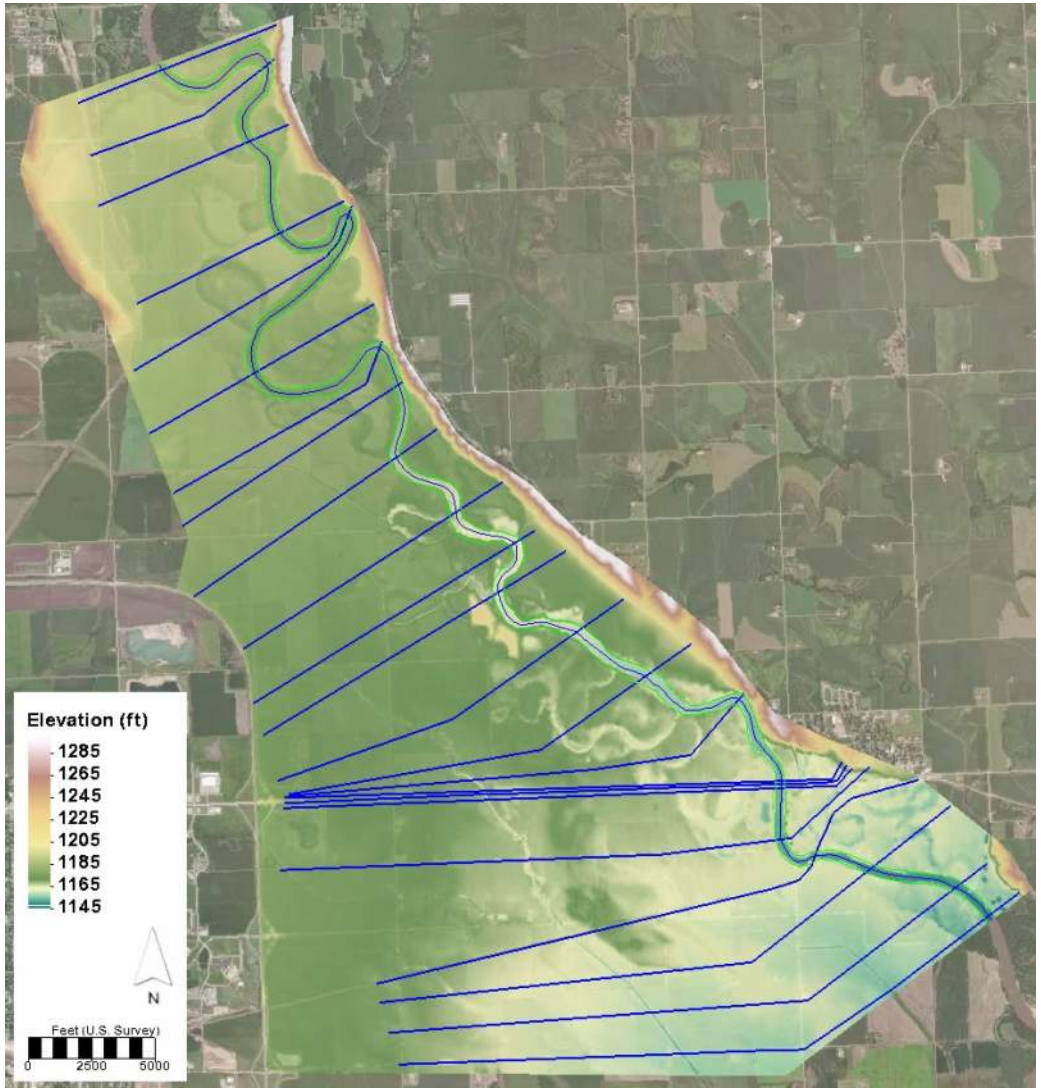

Image Source: Nebraska Department of Highways

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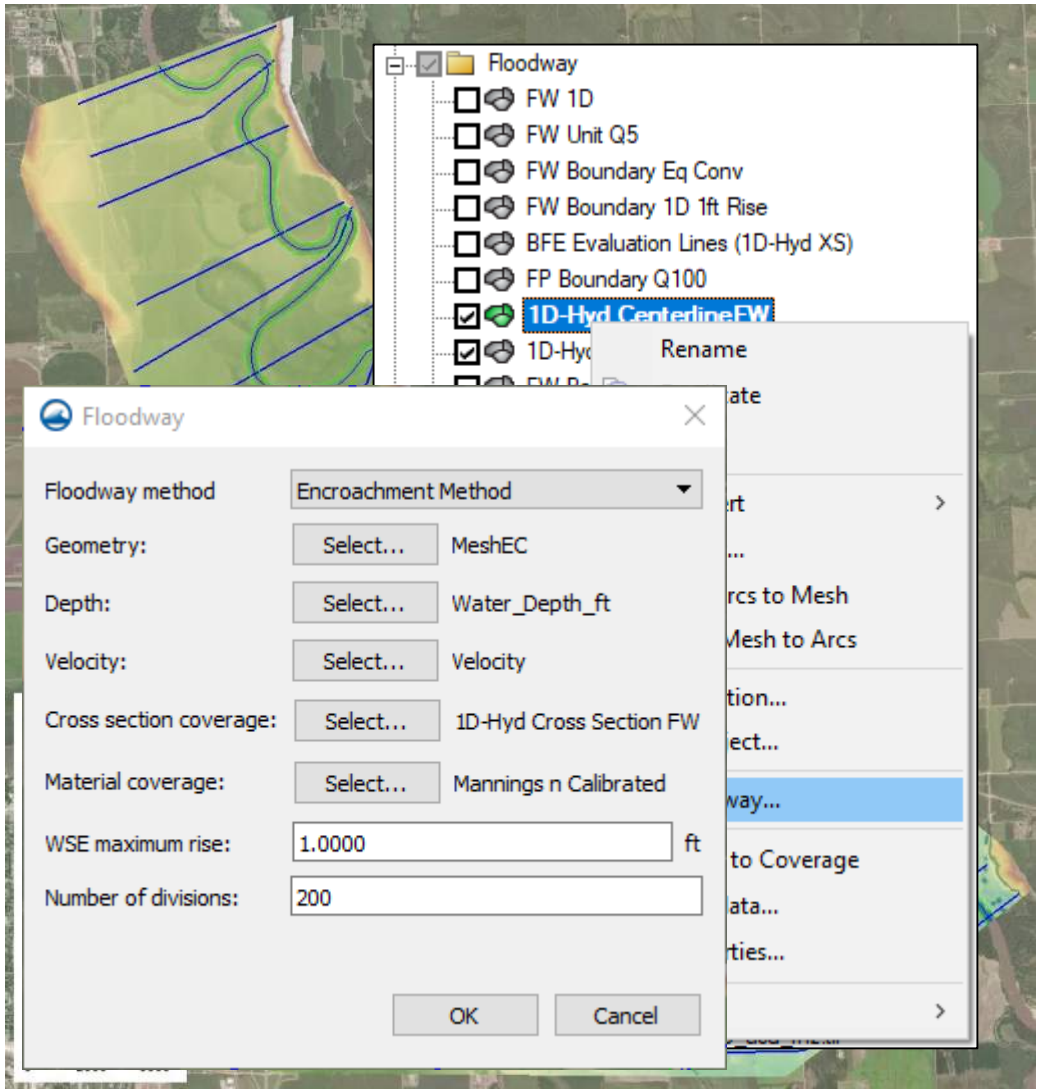
Equal Discharge Reduction Floodway Delineation

- Most consistent with 1D Equal Conveyance method
- Flow area is removed from either floodplain limit, based on equal discharge reduction, until a target rise is achieved
- Cross sections are required for evaluation, but alignment is not critical

SMS/SRH-2D Tools and Process

- Define channel centerline and banks
- Add reference cross sections
- Select Encroachment Method and appropriate data set and target surcharge
- An initial FW boundary and materials coverage are automatically generated
- Run encroachment simulation
- Review/compare results



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Equal Discharge Reduction Method Results

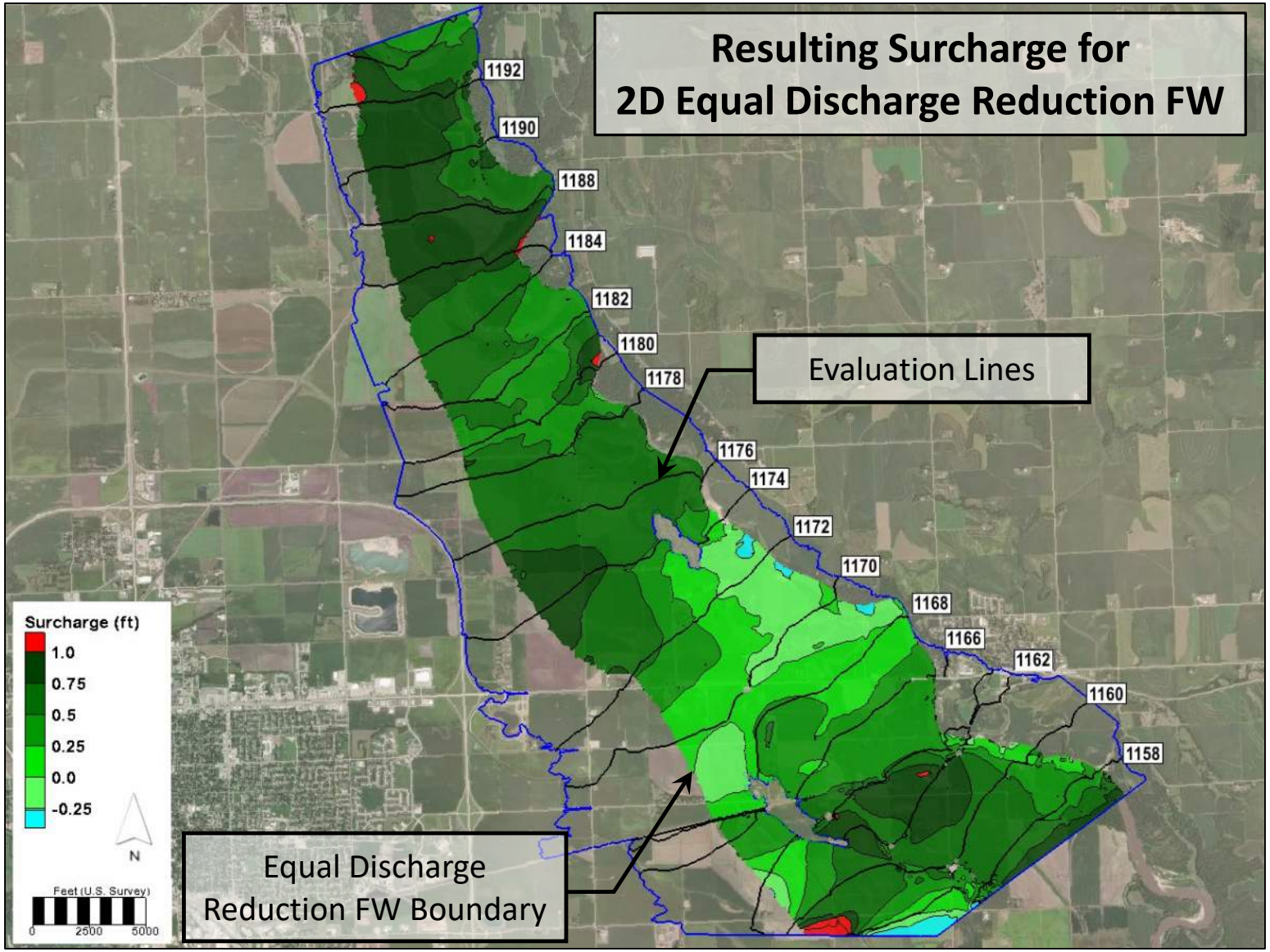

Image Source: Nebraska Department of Highways

Floodway Surcharge Summary

Q100 Base Flood Evaluation Lines	Equal Discharge Reduction Floodway	
WSEL Ave	WSEL Ave	Surcharge
(ft)	(ft)	(ft)
1158.00	1158.70	0.70
1160.00	1160.55	0.55
1162.00	1161.92	-0.08
1164.00	1164.48	0.48
1166.00	1166.43	0.43
1168.00	1168.11	0.11
1170.00	1170.00	0.00
1172.00	1172.09	0.09
1174.00	1174.21	0.21
1176.00	1176.66	0.66
1178.00	1178.56	0.56
1180.00	1180.69	0.69
1182.00	1182.47	0.47
1184.00	1184.58	0.58
1186.00	1186.83	0.83
1188.00	1188.77	0.77
1190.00	1190.76	0.76
1192.00	1192.80	0.80

Unit Discharge Floodway Delineation

- Based on a user specified depth*velocity (DxV) threshold
- A specific unit discharge does not correspond to a specific rise
- Internal DxV 'Islands' are excluded
- An iterative process is needed to identify the unit discharge that corresponds with the desired rise

<u>SMS Tools / Process</u>

- Select Unit Discharge Method and appropriate data sets
- Set target Unit Discharge threshold
- An initial FW boundary and materials coverage are automatically generated
- Run encroachment simulation
- Review/compare results

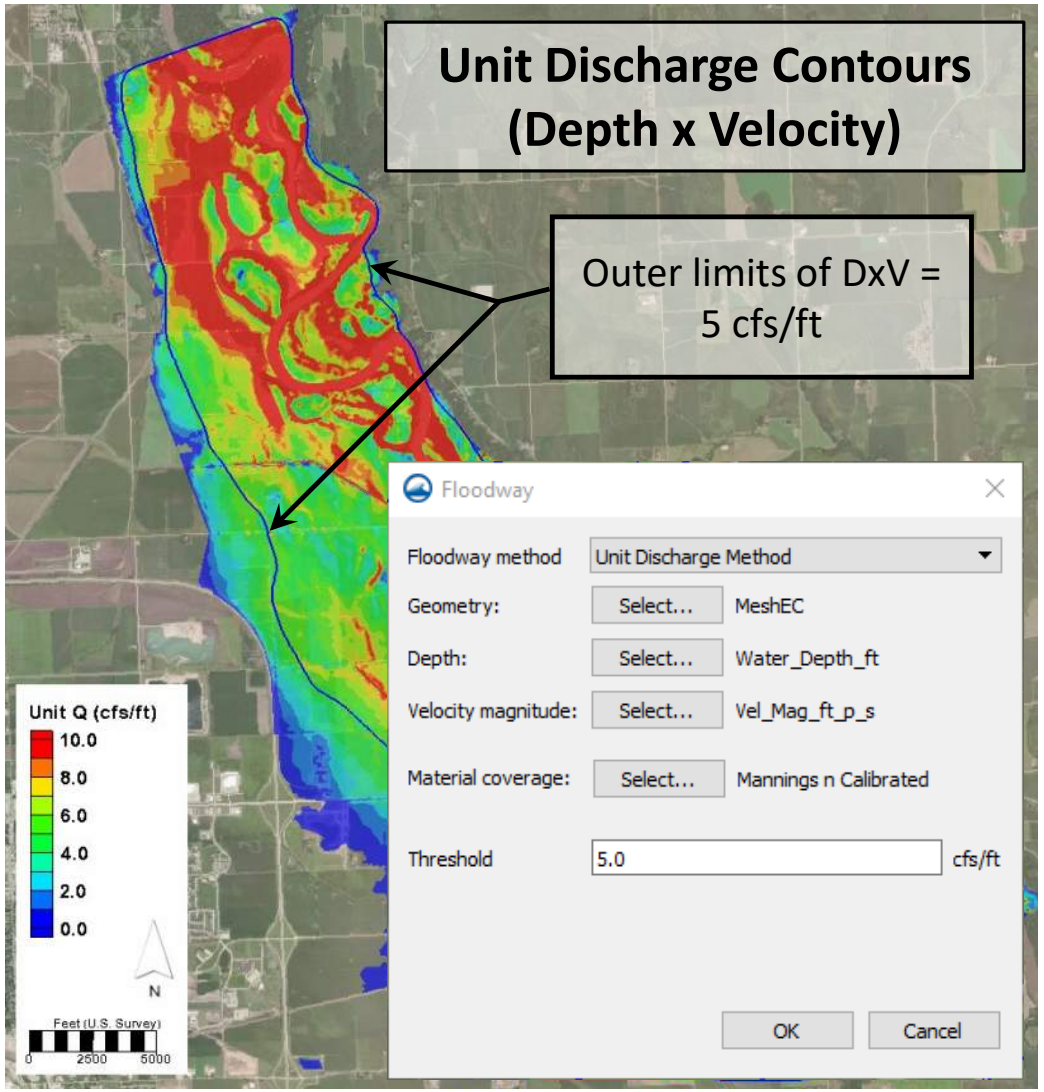

Image Source: Nebraska Department of Highways

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Unit Discharge Floodway Delineation Method

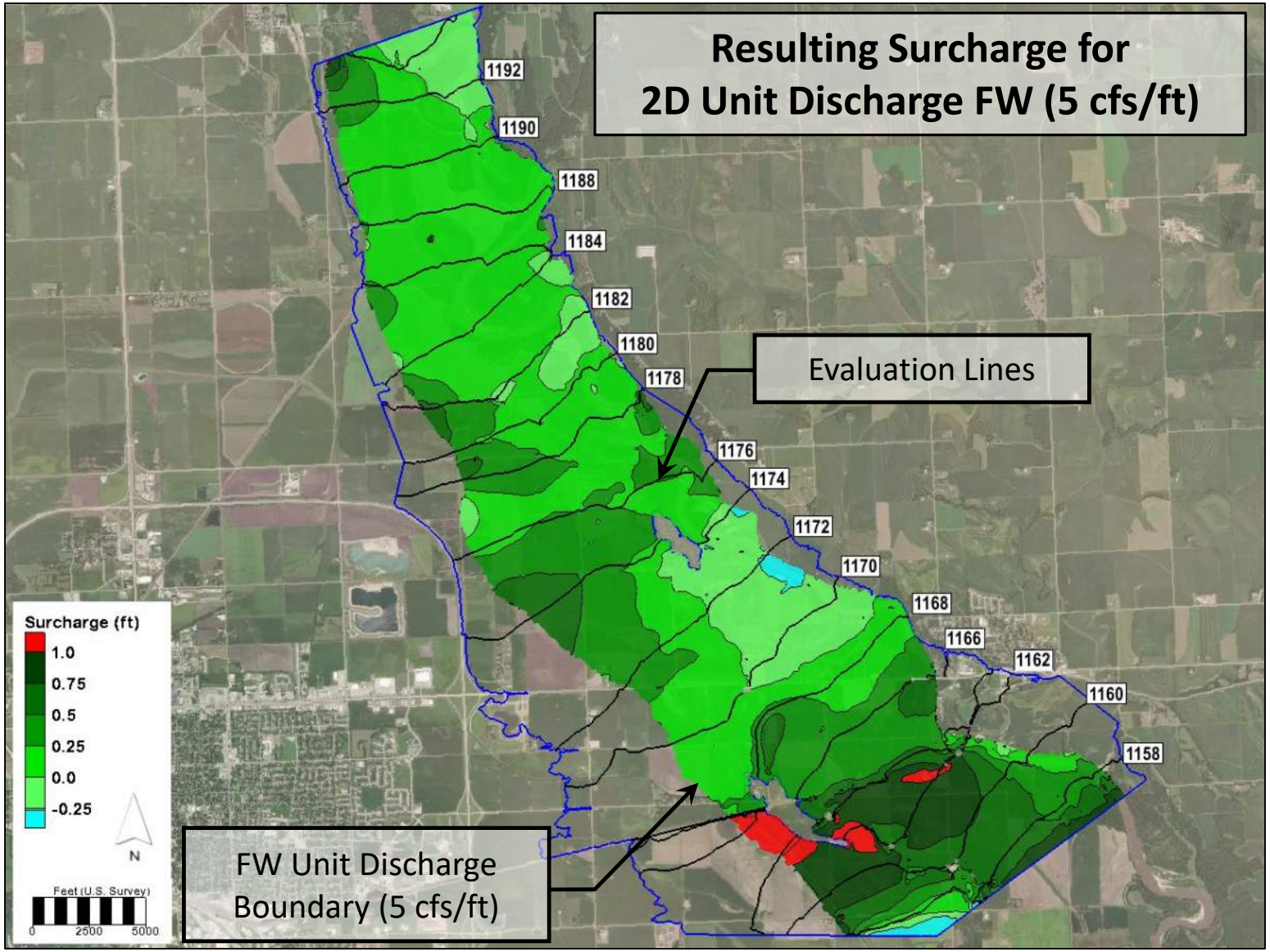


Image Source: Nebraska Department of Highways

Floodway Surcharge Summary

Q100 Base Flood Evaluation Lines	Unit Discharge 2D Floodway (q=5cfs/ft)	
WSEL Ave	WSEL Ave	Surcharge
(ft)	(ft)	(ft)
1158.00	1158.73	0.73
1160.00	1160.52	0.52
1162.00	1162.19	0.19
1164.00	1164.53	0.53
1166.00	1166.48	0.48
1168.00	1168.16	0.16
1170.00	1169.90	-0.10
1172.00	1171.95	-0.05
1174.00	1173.97	-0.03
1176.00	1176.26	0.26
1178.00	1178.24	0.24
1180.00	1180.11	0.11
1182.00	1182.06	0.06
1184.00	1184.07	0.07
1186.00	1186.12	0.12
1188.00	1188.14	0.14
1190.00	1190.08	0.08
1192.00	1192.08	0.08

Comparison of Floodway Delineation Methods

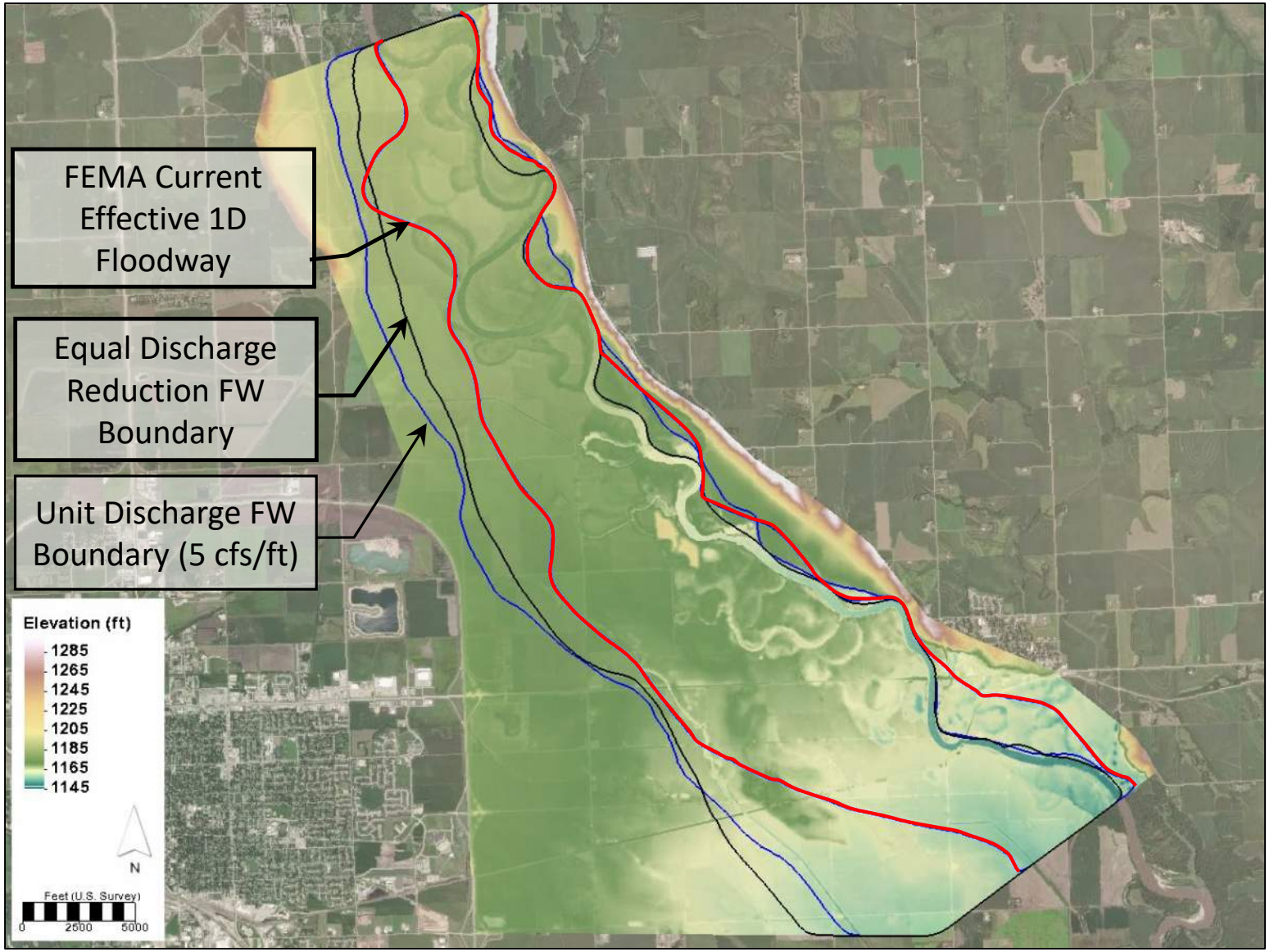


Image Source: Nebraska Department of Highways

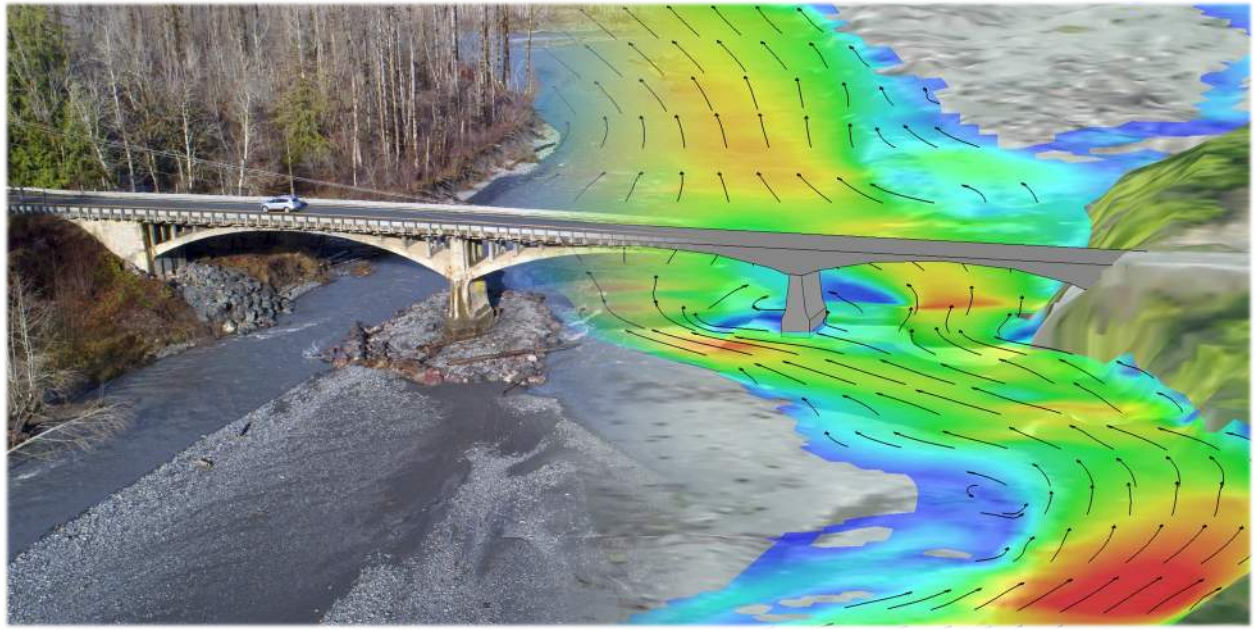


Image by John Gussman

THANK YOU!

Scott Hogan
FHWA Resource Center
Scott.hogan@dot.gov
(720) 575-6026

Please contact me if you are interested in the following resources:

- 2D hydraulic modeling bi-monthly webinars on 2D modeling best practices
- Floodway modeling updates
- Two-Dimensional Hydraulic Modeling for Highways in the River Environment - Reference Document (FHWA 2019)
- Training resources
- Tutorials and videos

www.fhwa.dot.gov/engineering/hydraulics/bridgehyd/bridge.cfm

2D NATIONAL EFFORTS

CASFM Virtual Conference

September 30th, 2020

Two-Dimensional Floodway Updates

FEMA Updates

compass

Identify Hazards, Interpret Risks, Integrate Mitigation

Integrated Project Team (IPT)

MEMBERSHIP

Executive Sponsor:
Luis Rodriguez, FEMA Risk Management Directorate

Executive Sponsor:
Rachel Sears, FEMA Mitigation Directorate

Vice-Chair:
Laura Algeo, FEMA Risk Management Directorate

Membership:
Production and Technical Services (PTS)
Cooperating Technical Partners (CTP)
FEMA Regions
Federal Highway Administration (FHWA)
Colorado 2-Dimensional Consortium (C2DC)
United States Army Corps of Engineers (USACE)
Community Engagement and Risk Communication (CERC)

PURPOSE

- Define how FEMA will evaluate regulatory compliance for floodways developed from 2D models.

OUTCOME

- Define recommendations for short-term changes and additions to existing standards and guidance.
- Define additional recommendations in the long-term for senior leadership on CFR changes.

Slide Source: FEMA, *Two-Dimensional Floodway Modeling* Presentation, ASFPM 2020

compass
Identify, Interpret, Integrate

IPT Goals

Short-Term (Phase 1)

Allowable Approaches

Determine allowable approaches to define floodway when base analysis has been performed in 2D (1D floodway, steady state equivalent, 2D unsteady only, etc.)

Surcharge Compliance Criteria

Identify floodway surcharge compliance criteria (new floodways and no-rise) that will ensure we meet regulatory descriptions of compliance

Guidance & Standards

Other 2D guidance/standards updates needed for how to display the results; such as profiles, Floodway Data Tables (FDT), Base Flood Elevation (BFE) on Flood Insurance Rate Maps (FIRM), etc.

Training Needs

Identify training needs for floodplain managers to effectively administer and manage floodplains and floodways developed from 2D models

Long-Term (Phase 2)

Revisiting Encroachment-Based Floodway

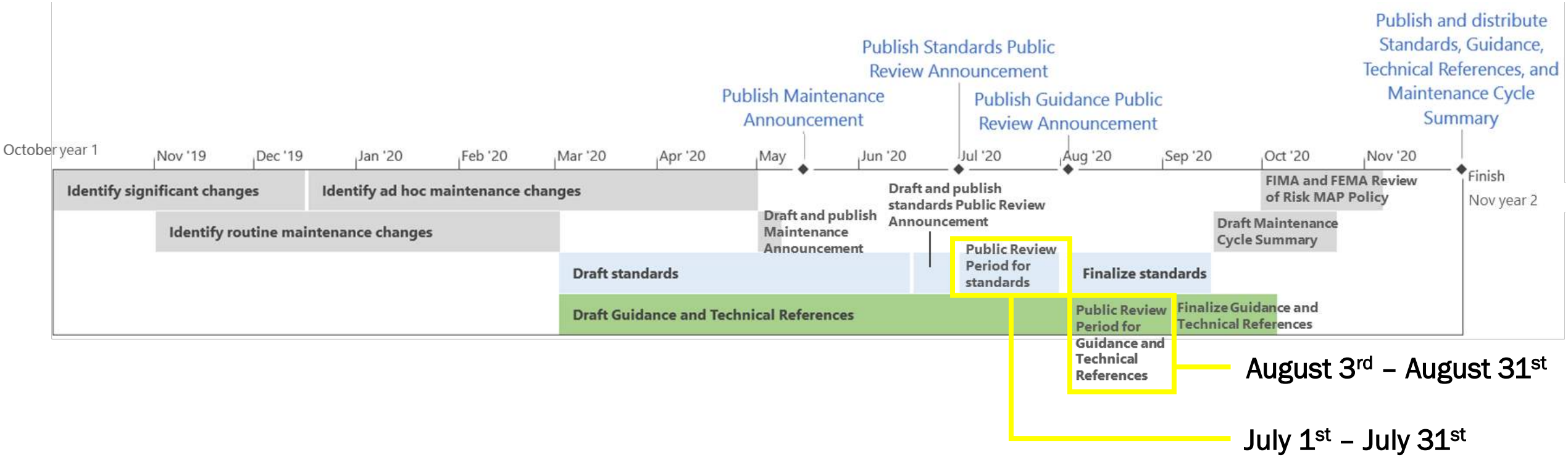
Alternatives to encroachment-based floodway that still help effectively manage floodplain development

Code of Federal Regulations (CFR)

Definition of path to accomplish CFR changes

Slide Source: FEMA, *Two-Dimensional Floodway Modeling* Presentation, ASFPM 2020

Timeline



- The monthly FEMA **Engineering and Mapping Community of Practice** meetings will announce the **Public Review Periods** to highlight internal/external comment collection on proposed revisions to identified **Guidance & Standards**

Slide Source: FEMA, *Two-Dimensional Floodway Modeling* Presentation, ASFPM 2020

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IPT Future Considerations

Testing Floodway Alternatives

Pushing New Tools to Expediate 2D Floodway Analysis

Continue identifying needed long term updates and best practices

Slide Source: FEMA, *Two-Dimensional Floodway Modeling* Presentation, ASFPM 2020

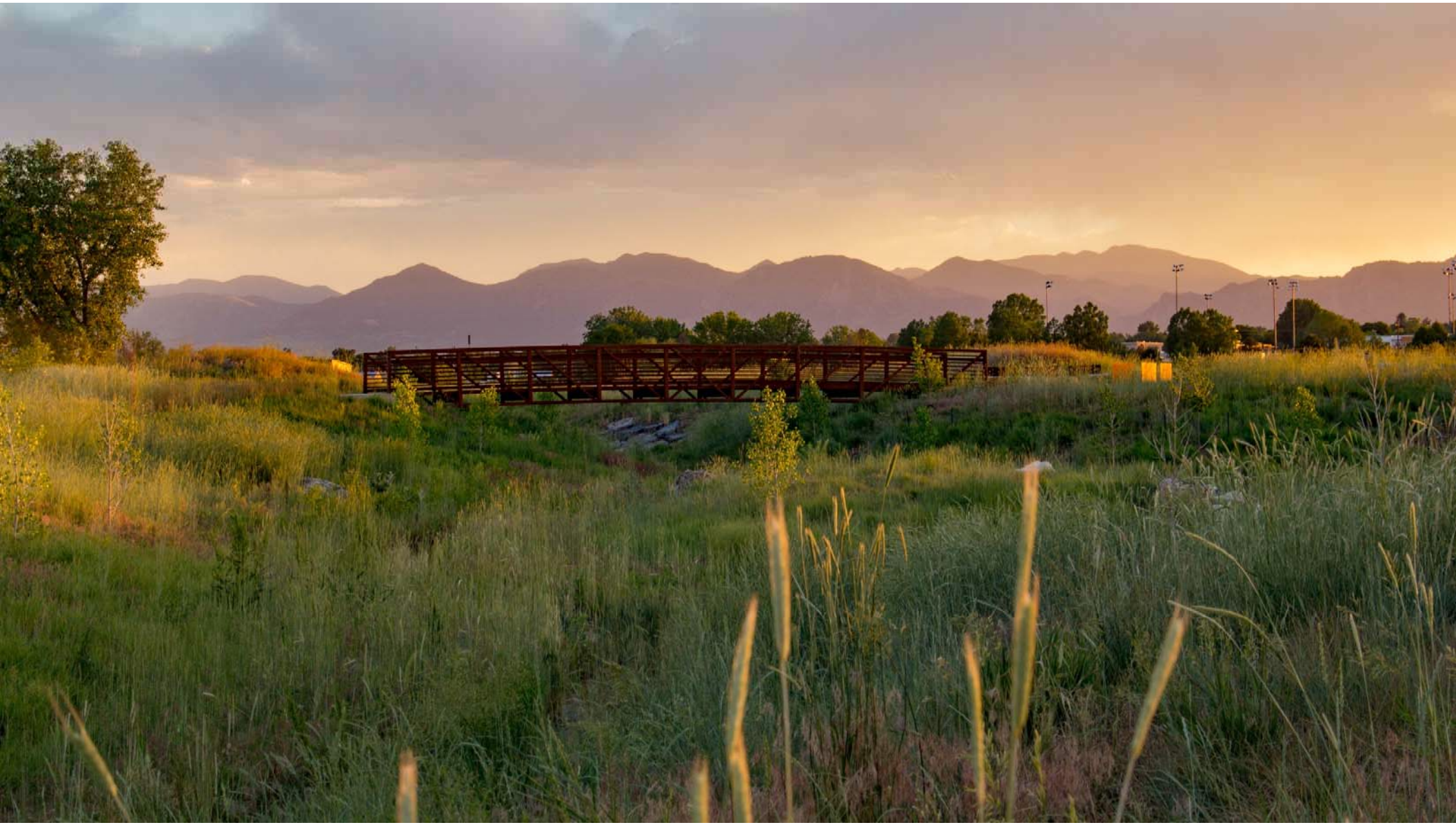
compass
Identify, Interpret, Integrate

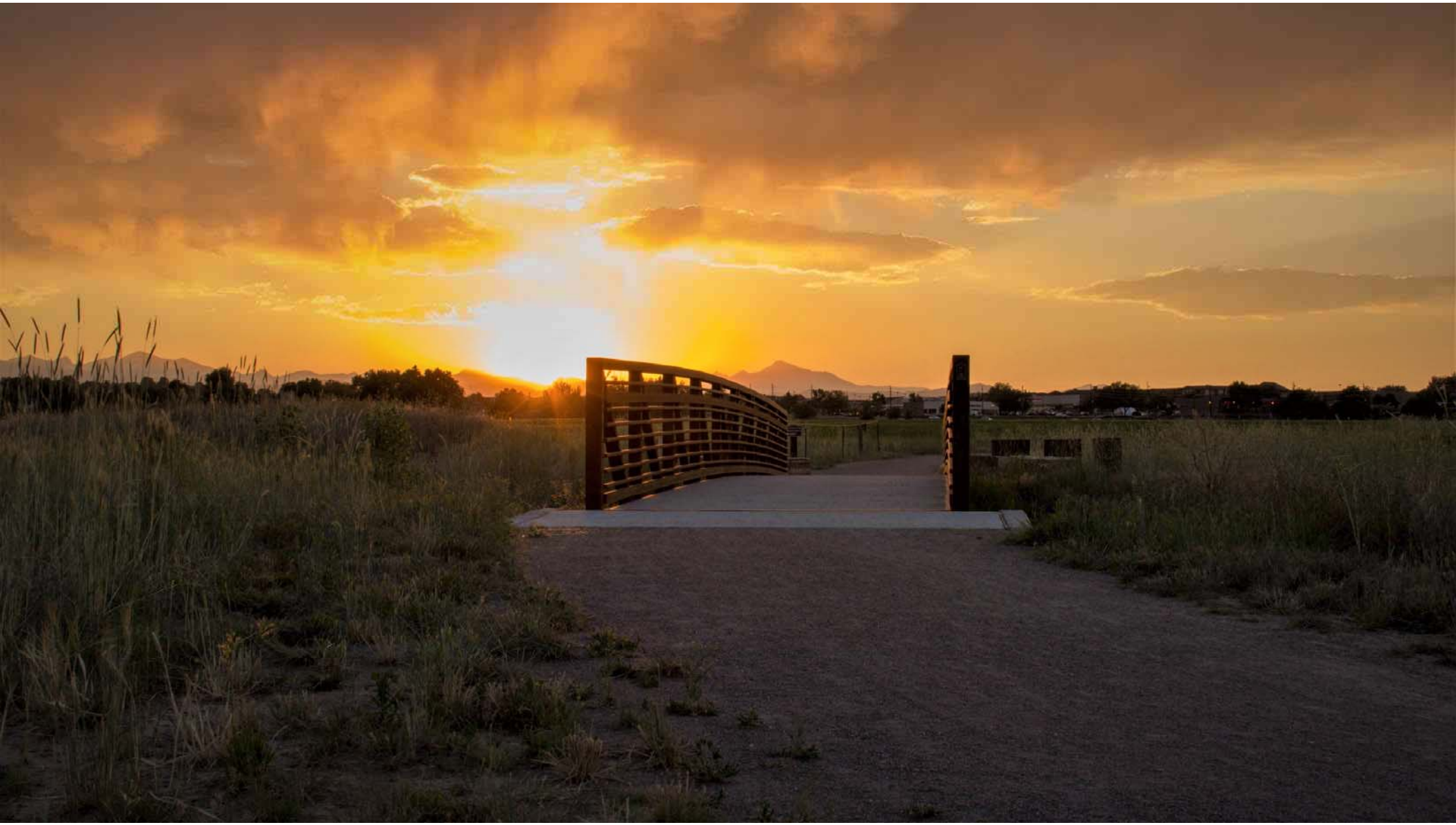
THANK YOU!

QUESTIONS?

Isaac Allen
Water Resources Engineer
AECOM, a member of the **Compass PTS JV**
Isaac.allen@aecom.com

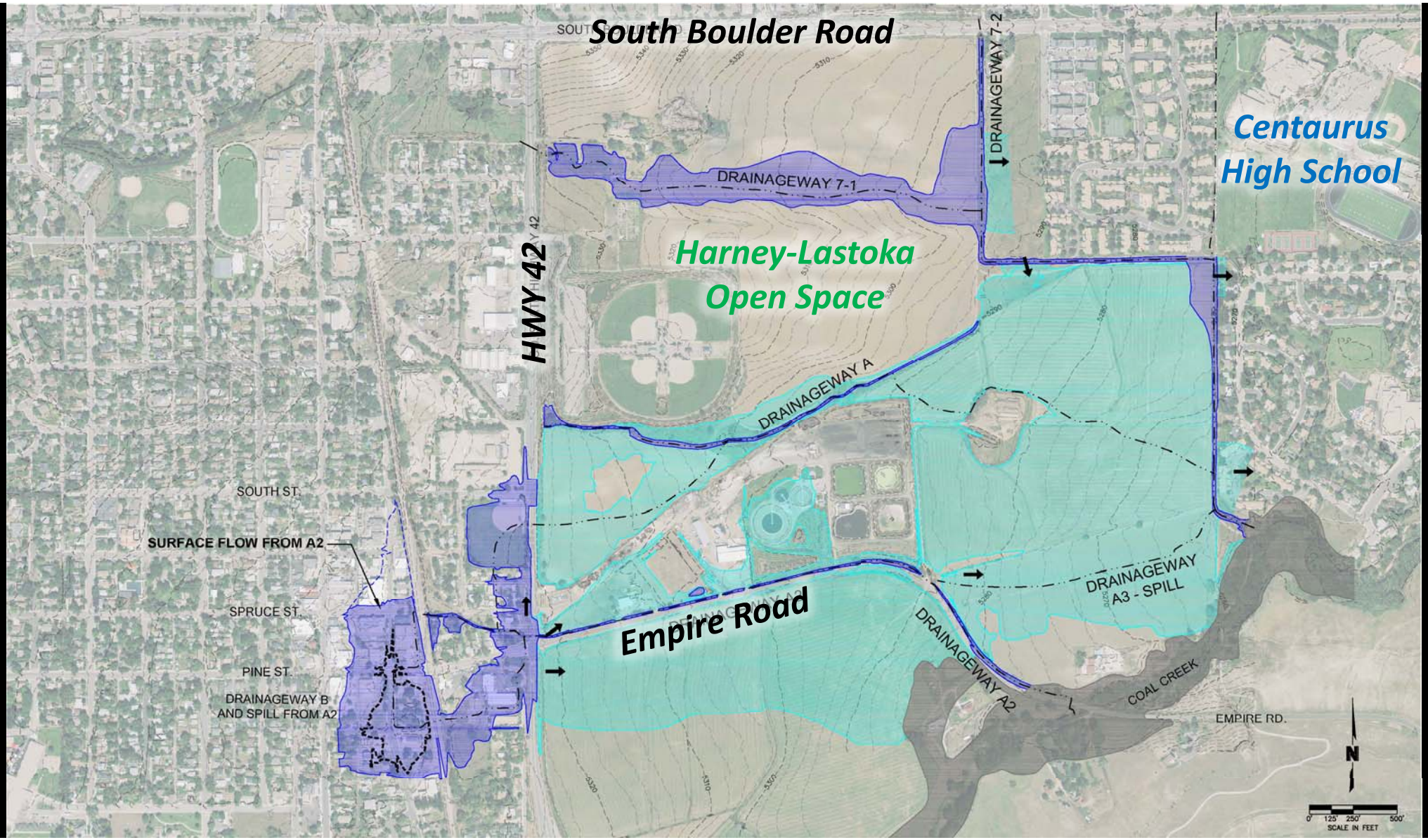
compass
Identify, Interpret, Integrate

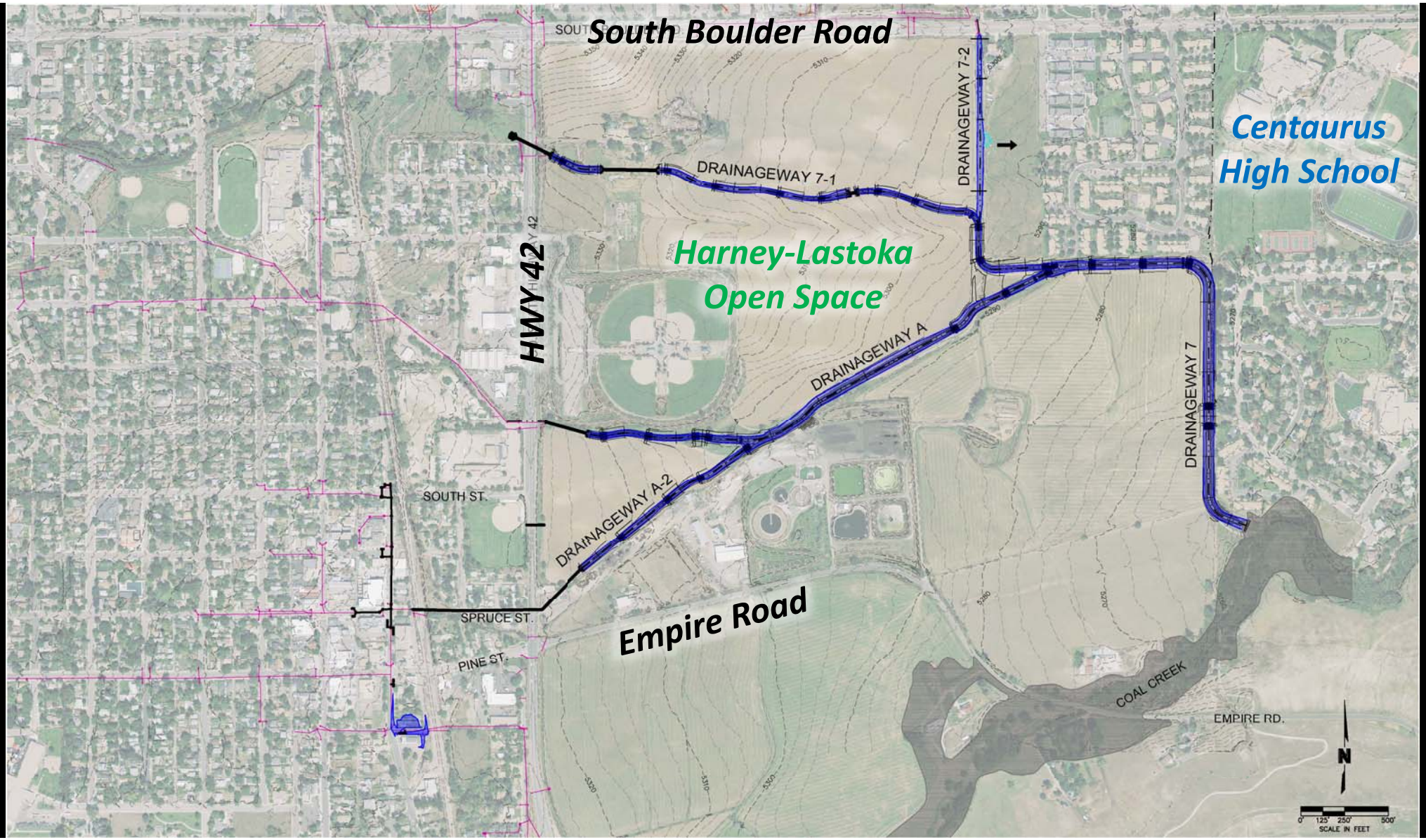





Contractor I


Contractor II
18


South Boulder Road
DRAINAGEWAY 7-2
Centaurus High School
DRAINAGEWAY 7-1
Harney-Lastoka Open Space
HWY 42
DRAINAGEWAY A
SOUTH ST.
SURFACE FLOW FROM A2
SPRUCE ST.
PINE ST.
DRAINAGEWAY B AND SPILL FROM A2
Empire Road
DRAINAGEWAY A3 - SPILL
DRAINAGEWAY A2
COAL CREEK
EMPIRE RD.
N
0' 125' 250' 500'
SCALE IN FEET


South Boulder Road
Centaurus High School
Harney-Lastoka Open Space
HWY 42
DRAINAGEWAY 7-1
DRAINAGEWAY 7-2
DRAINAGEWAY A
DRAINAGEWAY A-2
DRAINAGEWAY 7
SOUTH ST.
SPRUCE ST.
PINE ST.
Empire Road
COAL CREEK
EMPIRE RD.
N
SCALE IN FEET

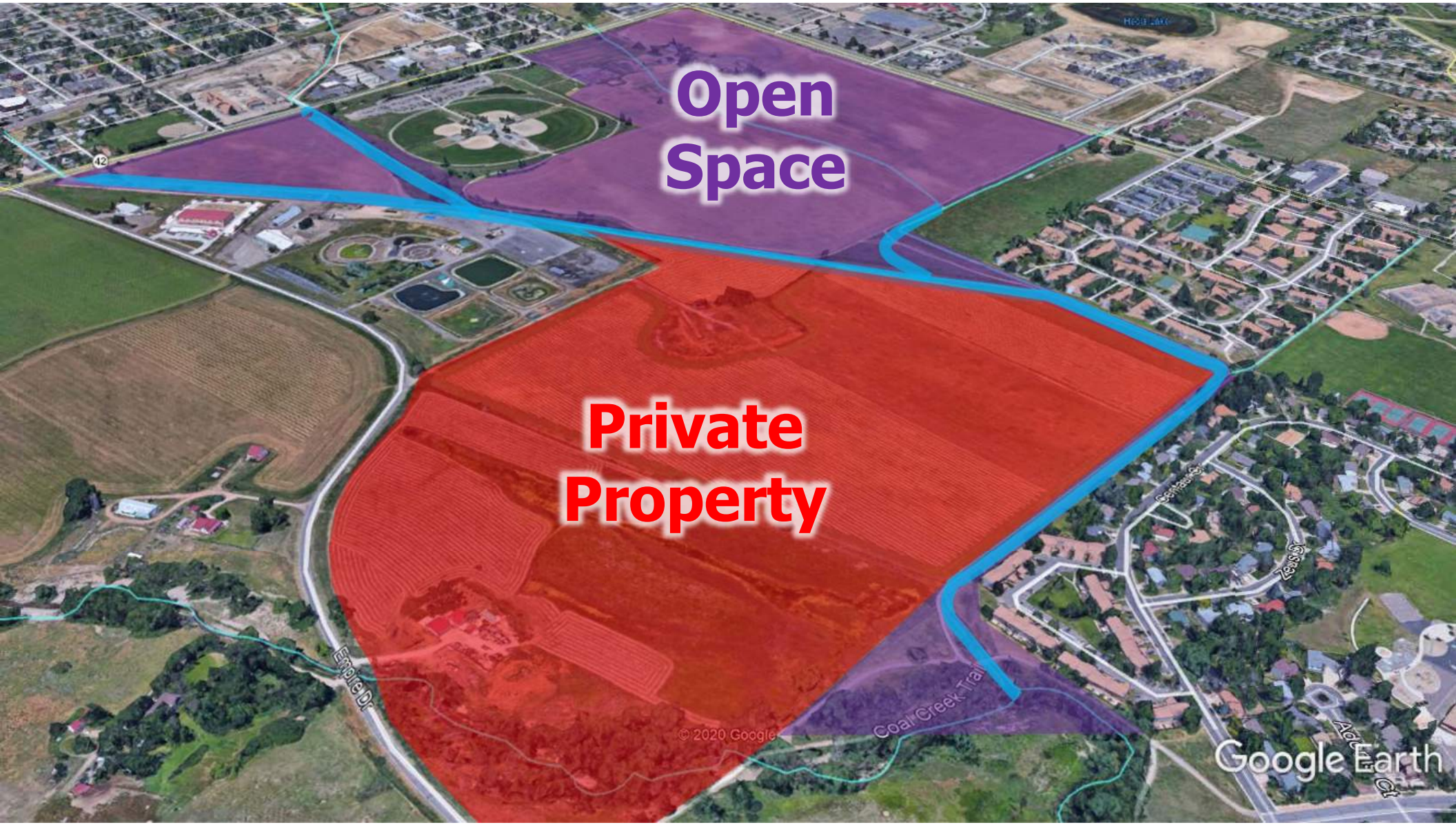

HWY 42
Pine Street
South Street
Main Street
Walnut St
Main St
Spruce St
© 2020 Google
Google Earth

CASFM

2017 Project Awards Presentation


KOMATSU
PC 360

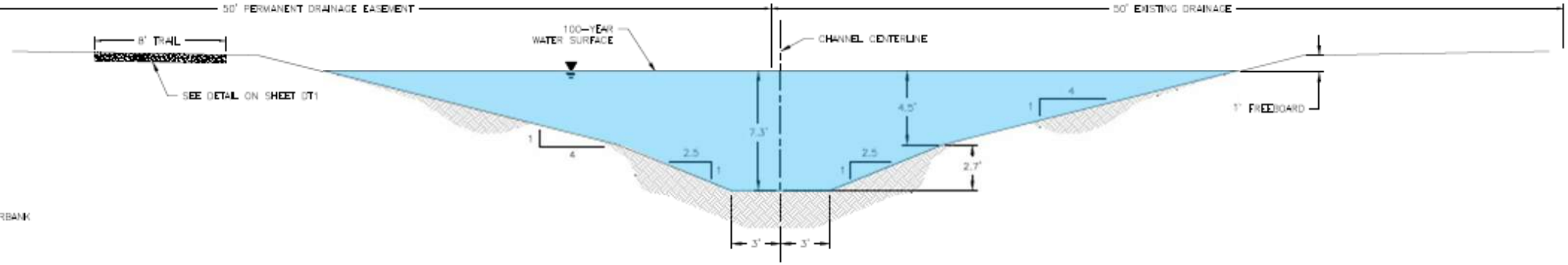

NATIONAL
TRUNCH SAFETY


Open Space
Private Property
Eagle Dr
Coal Creek Trail
© 2020 Google
Google Earth


Pre-Project
Google Earth

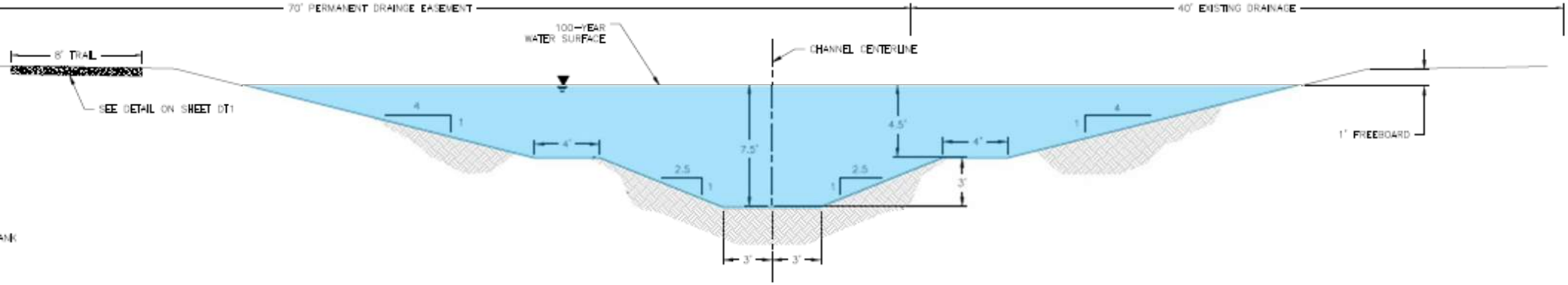

Pre-Project


Post-Project
New Drainage Easement
Temp. Construction Easement
Google
Google Earth



RBANK

SECTION



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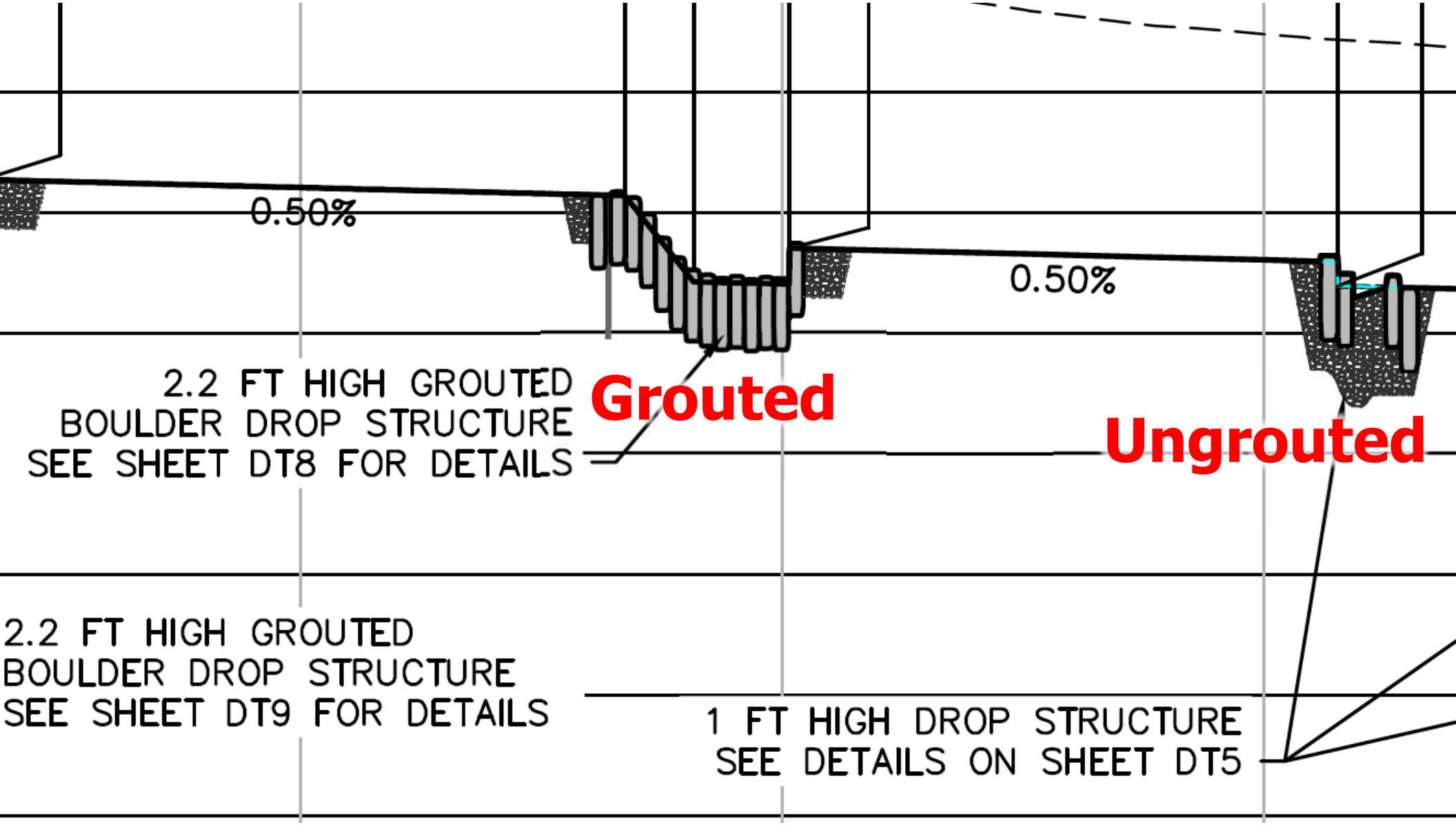
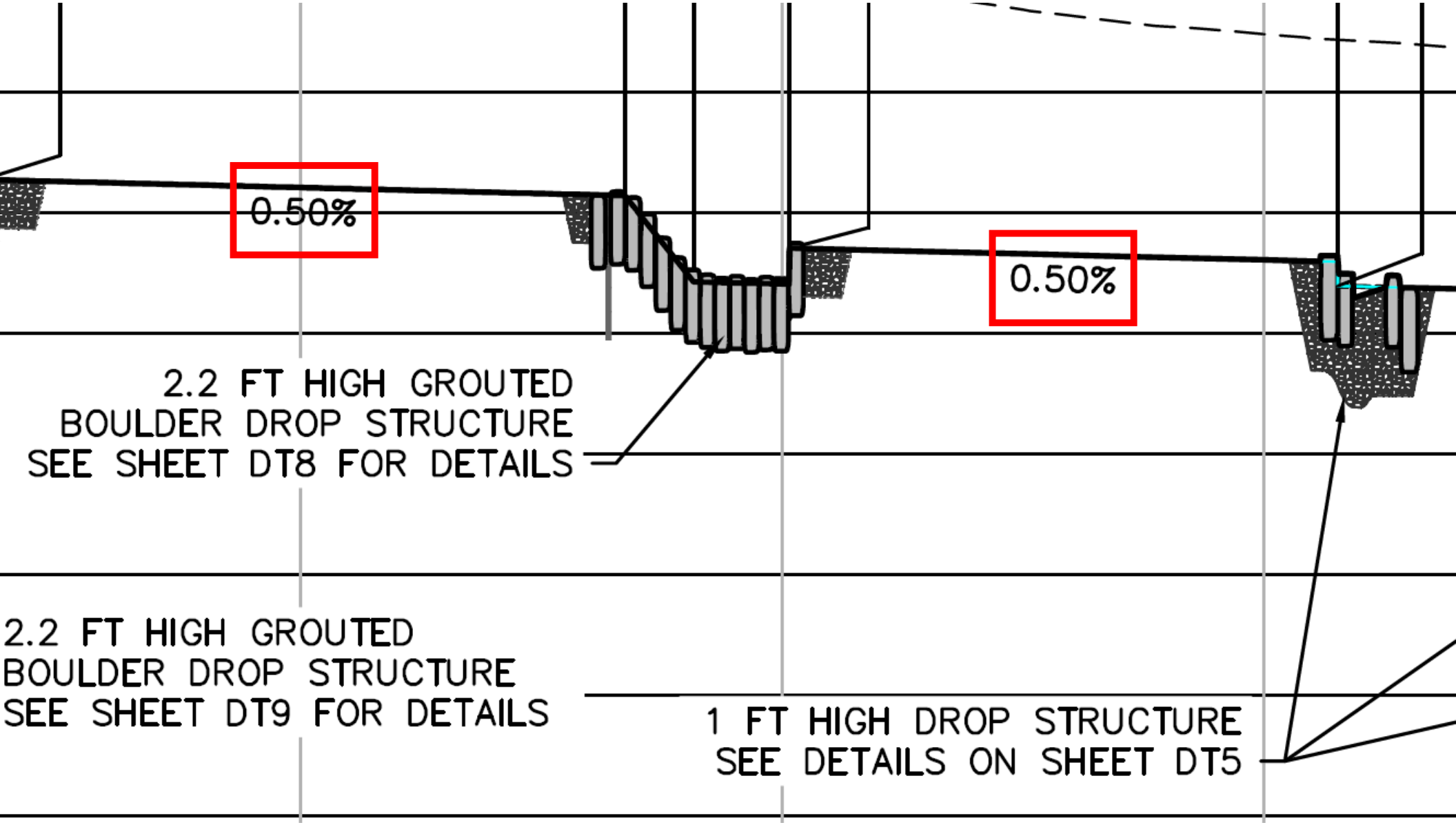

0.50%
0.50%
2.2 FT HIGH GROUTED
BOULDER DROP STRUCTURE
SEE SHEET DT8 FOR DETAILS
Grouted
Ungrouted
2.2 FT HIGH GROUTED
BOULDER DROP STRUCTURE
SEE SHEET DT9 FOR DETAILS
1 FT HIGH DROP STRUCTURE
SEE DETAILS ON SHEET DT5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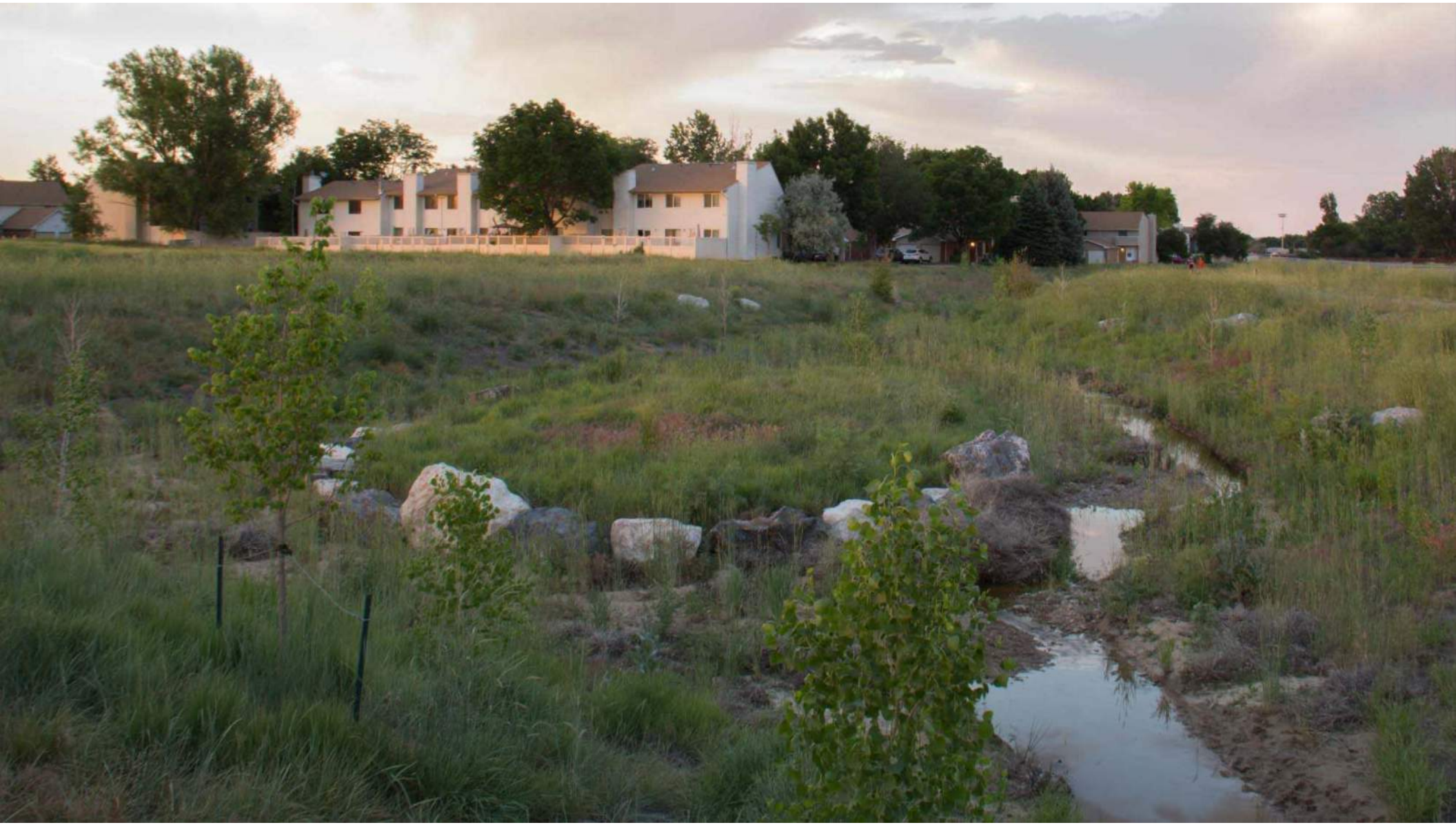
2.2 FT HIGH GROUTED
BOULDER DROP STRUCTURE
SEE SHEET DT8 FOR DETAILS
2.2 FT HIGH GROUTED
BOULDER DROP STRUCTURE
SEE SHEET DT9 FOR DETAILS
1 FT HIGH DROP STRUCTURE
SEE DETAILS ON SHEET DT5


ervoir
Reservoir Number 1
Hecla Lake
Project Site
Louisville
© 2020 Google
Google Earth


Over 1 mile
Hecla Lake
Empire Dr
Coal Creek
© 2020 Google
Google Earth

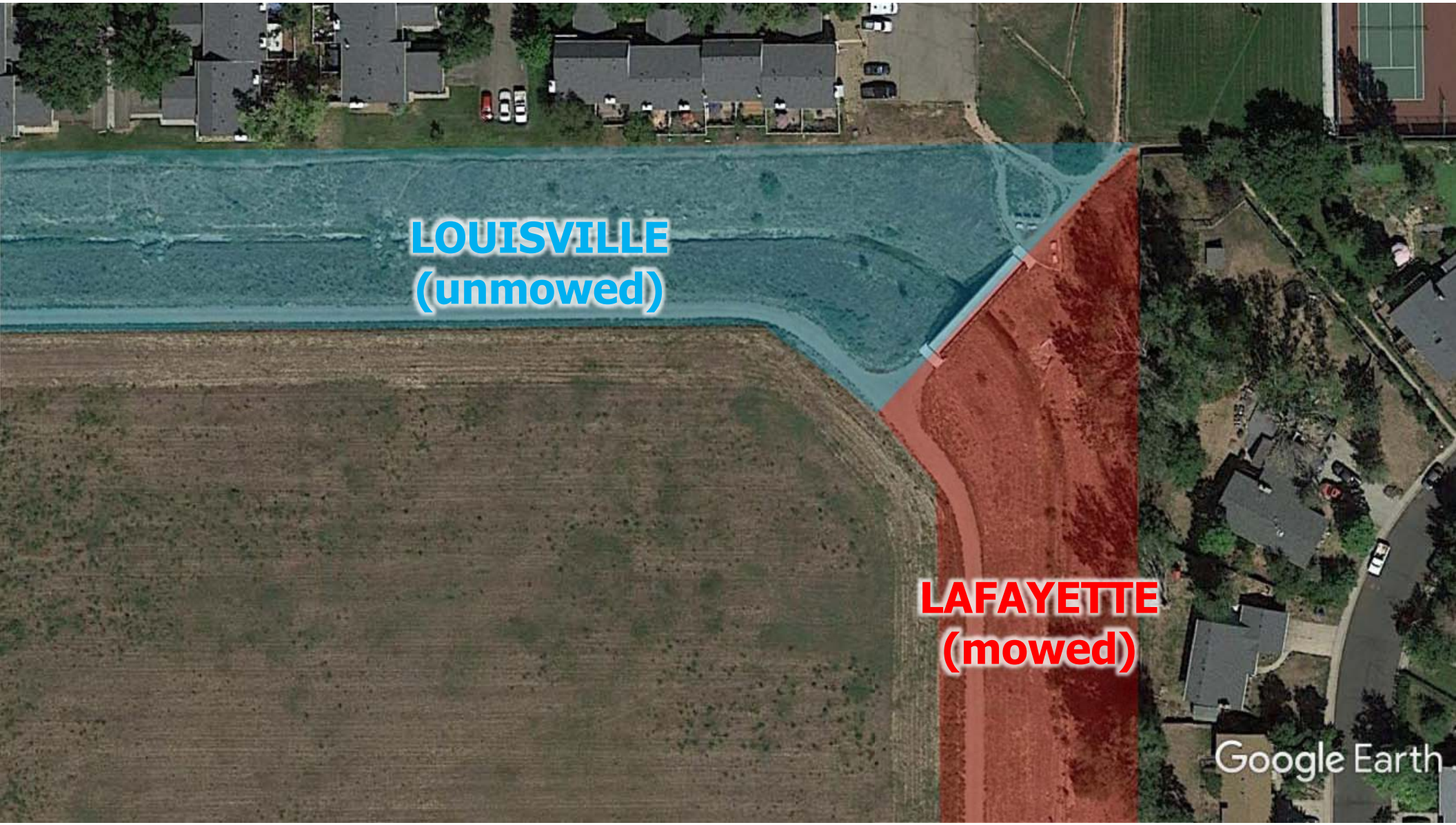

Fines

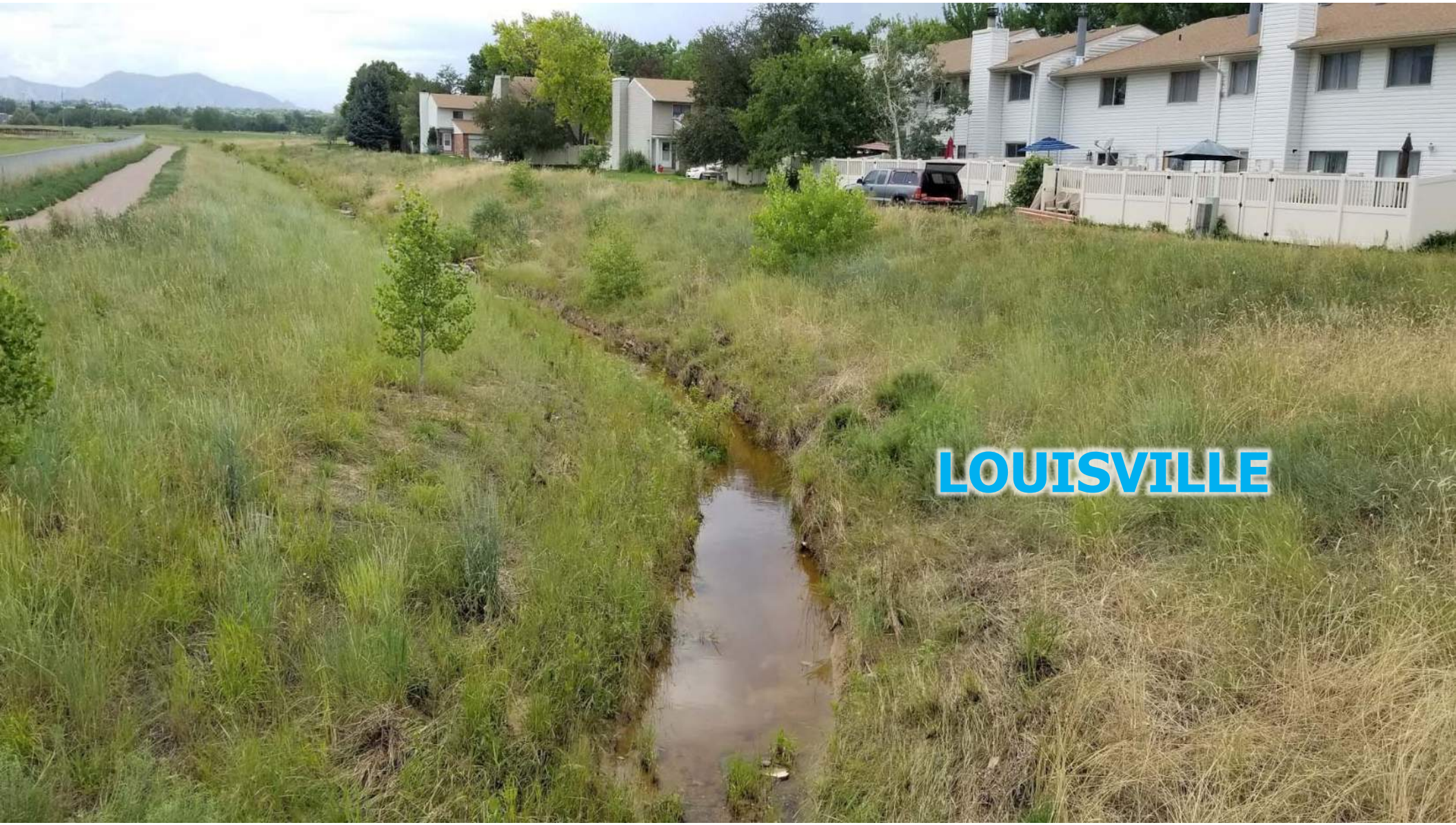



LAFAYETTE
LOUISVILLE


LOUISVILLE


LAFAYETTE


LOUISVILLE
(unmowed)
LAFAYETTE
(mowed)
Google Earth


LOUISVILLE

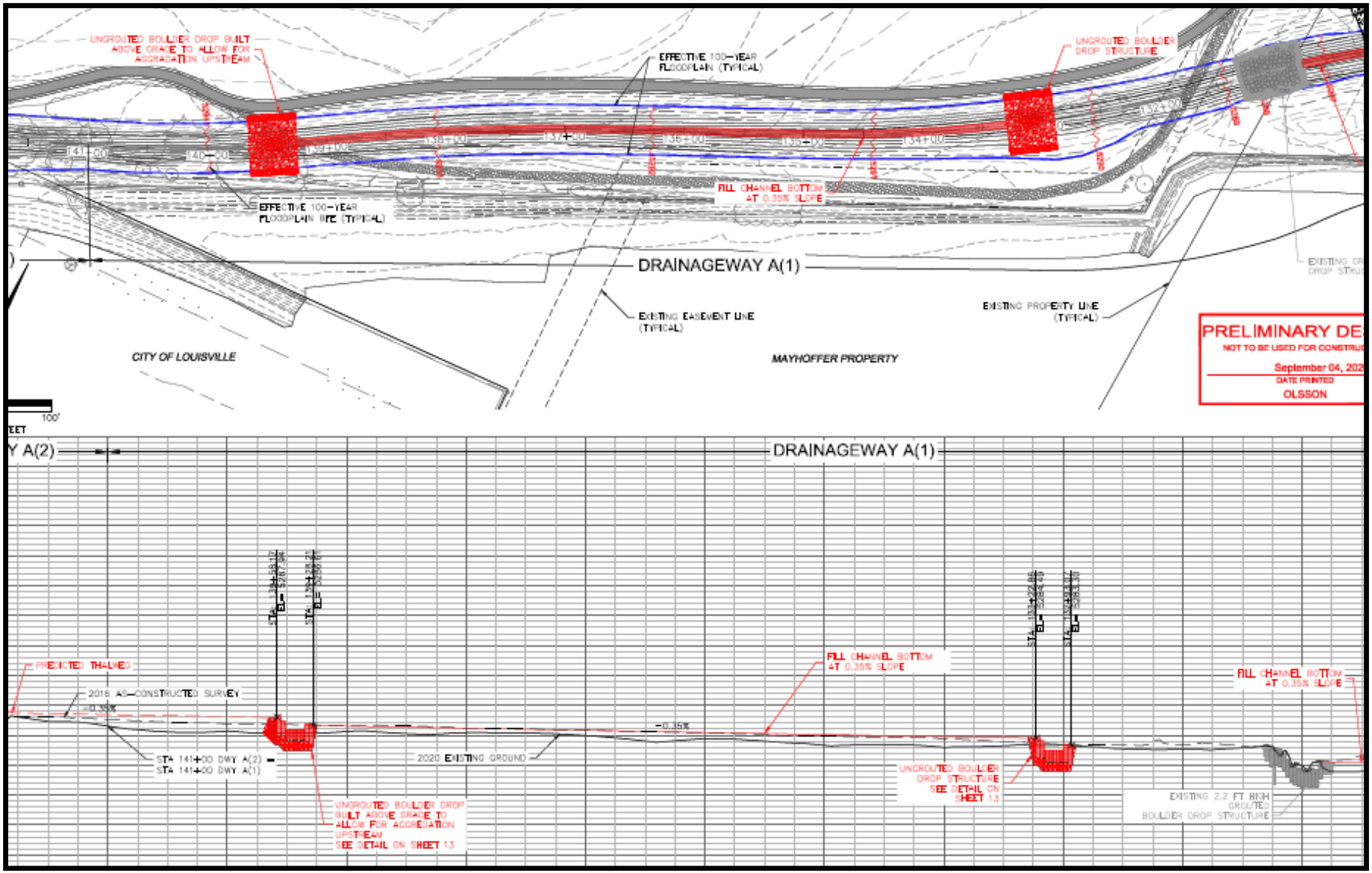

LAFAYETTE

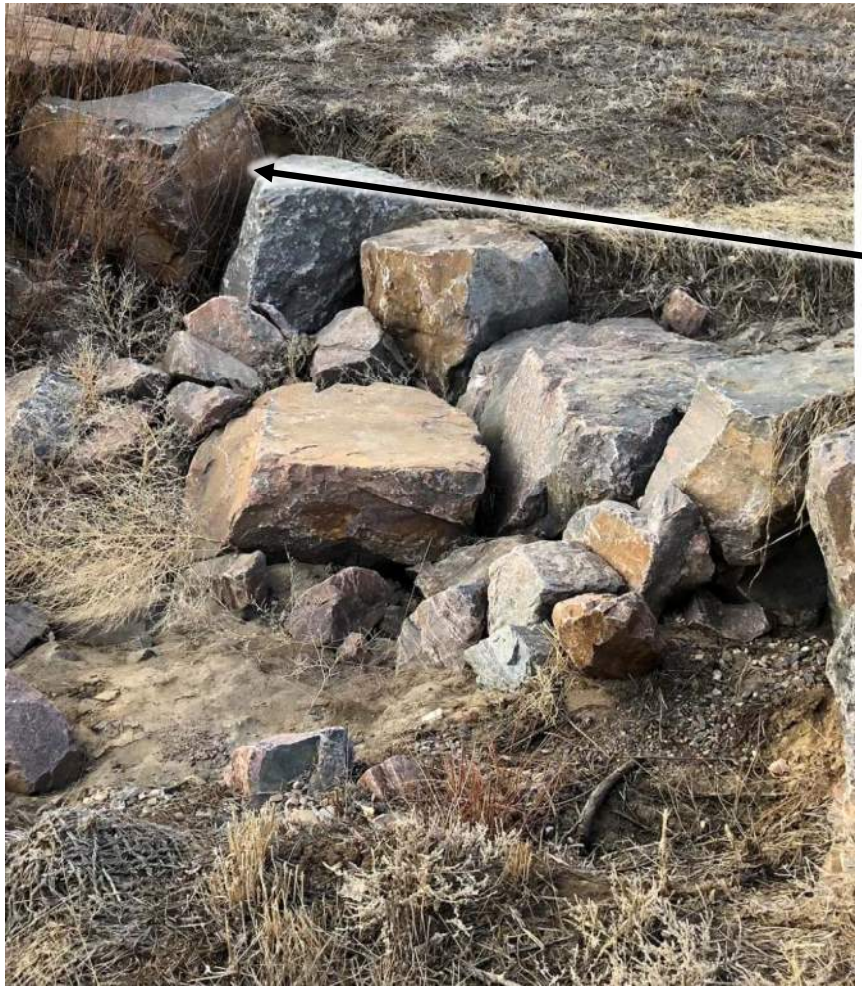

LOUISVILLE

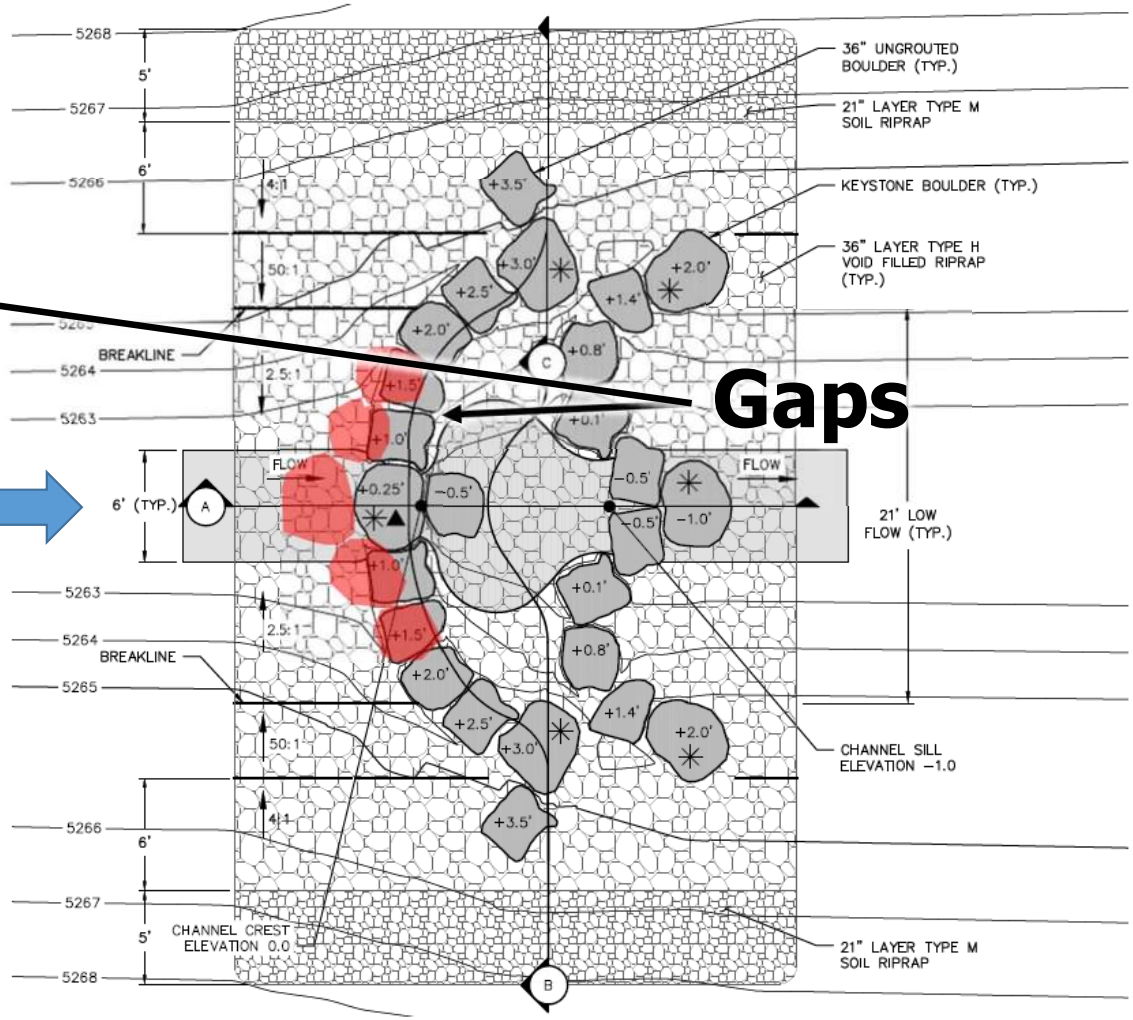

LAFAYETTE


Unmowed


Mowed

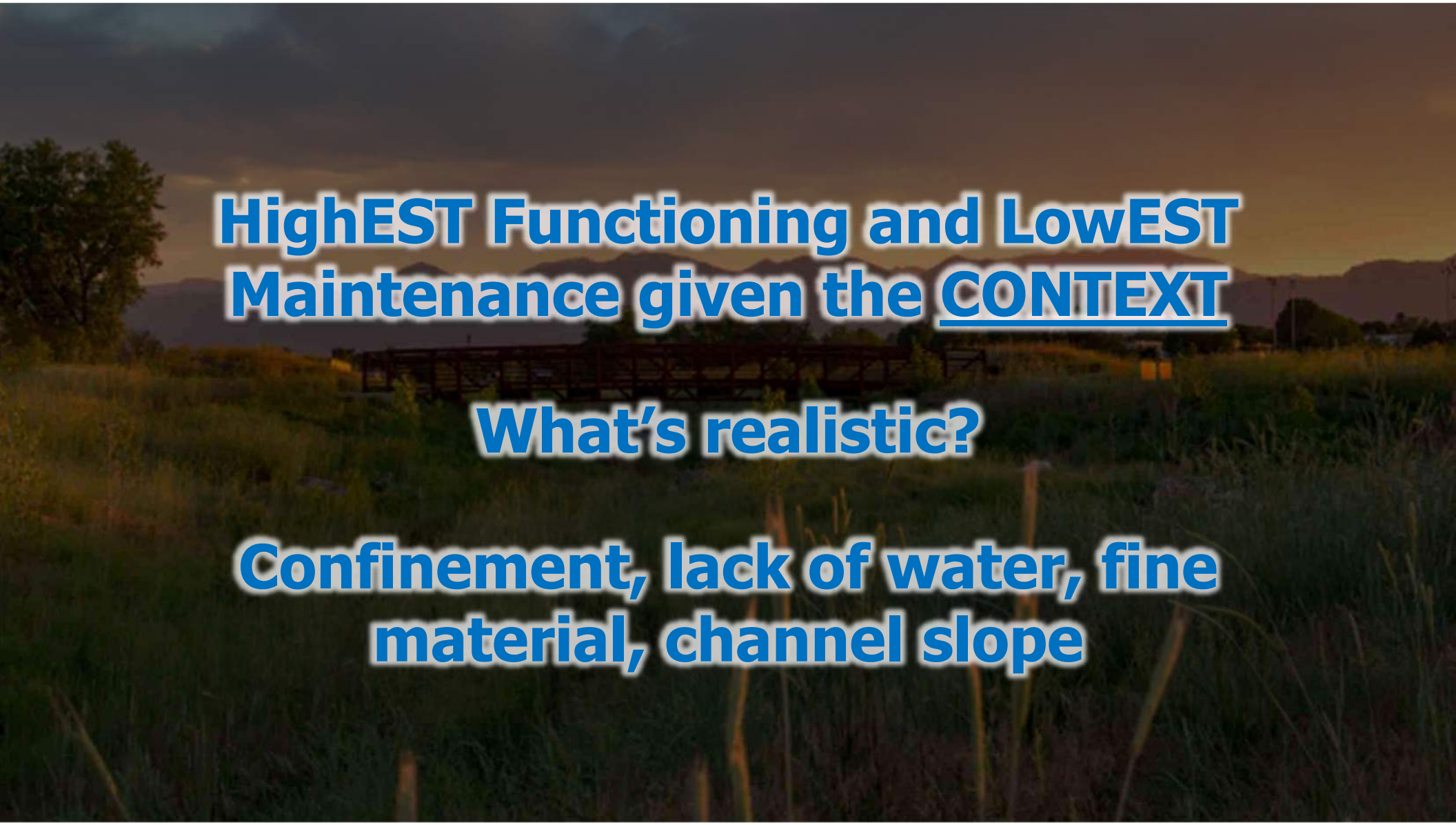

UNGROUTED BOULDER DROP BUILT ABOVE GRADE TO ALLOW FOR AGGRADATION UPSTREAM
EFFECTIVE 100-YEAR FLOODPLAIN (TYPICAL)
UNGROUTED BOULDER DROP STRUCTURE
141+00
140+00
139+00
138+00
137+00
136+00
135+00
134+00
132+00
EFFECTIVE 100-YEAR FLOODPLAIN LINE (TYPICAL)
FILL CHANNEL BOTTOM AT 0.35% SLOPE
DRAINAGEWAY A(1)
EXISTING EASEMENT LINE (TYPICAL)
EXISTING PROPERTY LINE (TYPICAL)
CITY OF LOUISVILLE
MAYHOFFER PROPERTY
PRELIMINARY DE
NOT TO BE USED FOR CONSTRU
September 04, 202
DATE PRINTED
OLSSON
100'
DRAINAGEWAY A(2)
DRAINAGEWAY A(1)
PREMOTED THALWEG
2016 AS-CONSTRUCTED SURVEY
-0.35%
STA 141+00 DWY A(2)
STA 141+00 DWY A(1)
2020 EXISTING GROUND
UNGROUTED BOULDER DROP BUILT ABOVE GRADE TO ALLOW FOR AGGREDATION UPSTREAM SEE DETAIL ON SHEET 13
FILL CHANNEL BOTTOM AT 0.35% SLOPE
UNGROUTED BOULDER DROP STRUCTURE SEE DETAIL ON SHEET 13
FILL CHANNEL BOTTOM AT 0.35% SLOPE
EXISTING 2.2 FT HIGH GROUTED BOULDER DROP STRUCTURE





1 DT6 TYPICAL DROP STRUCTURE PLAN

0' 2.5' 5' 10'



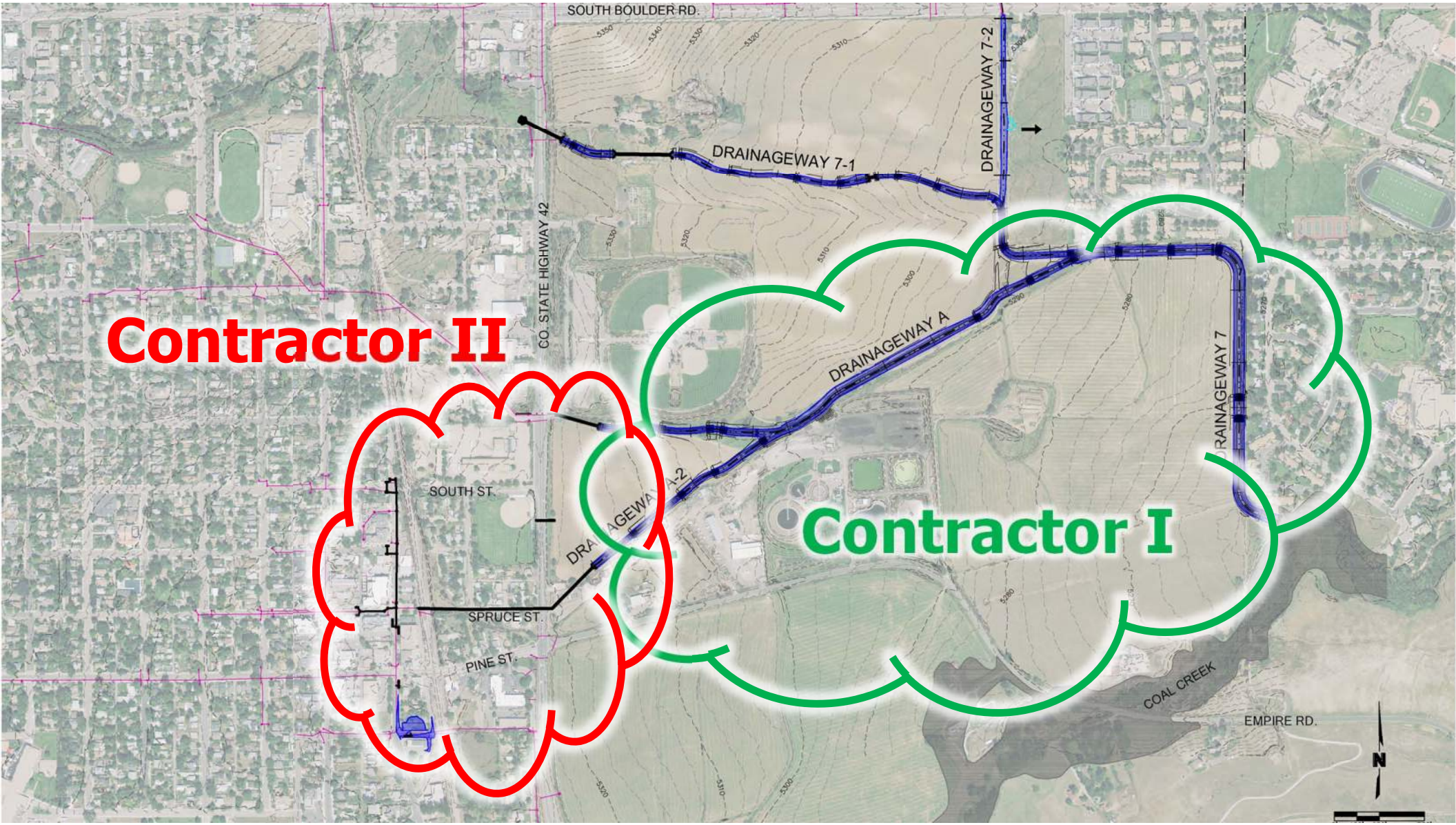
HighEST Functioning and LowEST Maintenance given the CONTEXT

What's realistic?

Confinement, lack of water, fine material, channel slope


Contractor I


Contractor II
18


SOUTH BOULDER RD.
DRAINAGEWAY 7-1
DRAINAGEWAY 7-2
CO. STATE HIGHWAY 42
DRAINAGEWAY A
DRAINAGEWAY 7
Contractor II
Contractor I
SOUTH ST.
SPRUCE ST.
PINE ST.
COAL CREEK
EMPIRE RD.
N

A Tale of Two Contractors:
Lessons Learned from a $9 Million Drainage Project

OLSSON ASSOCIATES

A Tale of Two Contractors: Lessons Learned from a $9 Million Drainage Project

Introduction

The City of Louisville, along with the Urban Drainage and Flood Control District (UDFCD) and City of Lafayette, undertook a drainage improvements project with the purpose of significantly reducing the 100-year floodplain in downtown Louisville. Olsson Associates provided design and construction engineering services for the drainage improvement project. The project enlarged the storm drain system in downtown Louisville, conveyed stormwater under the BNSF railroad, across Highway 42, through the Harney Lastoka open space and into Coal Creek. The open space is jointly owned by Louisville, Lafayette, and Boulder County. The project included construction of over 3,000 feet of storm sewer pipe and box culvert, and 1.3 miles of open channel and grade control. Due to the anticipated timing of reviews by regulatory entities, the project was split into two phases for bidding and construction.

Each phase had its own unique issues and obstacles. Each contractor dealt with inclement weather, deadlines, and sometimes zealous residents. However, it was clear that one Contractor performed their work in a fair, honest, and timely manner, while the other mismanaged their project, and caused considerable stress and aggravation for the sponsors. This is their story.

Project Overview

The map below shows the general project extents for each phase. Phase I was located in primarily open space and farmland to the east of Highway 42; Phase II was located in residential and downtown areas in the heart of Louisville.

1 OLSSON ASSOCIATES

Lafayette-Louisville Boundary Area Drainage Improvements: A Tale of Two Contractors — February 2017

Phase I: Contractor I – Project Overview

- Construction of 7,200 linear feet of open channel system to convey the 100-year storm from downtown Louisville to Coal Creek, pedestrian trail, and three pedestrian bridge crossings
- Coordination among the City of Louisville, the City of Lafayette, Boulder County Open Space, and private landowner
- Over 72,000 cubic yards of earthwork and 23 grouted and ungrouted boulder drop structures

Phase II: Contractor II – Project Overview

- Construction of 1,800 linear feet of storm pipe, inlets, and manholes in downtown Louisville, and 1,400 linear feet of box culvert under a City street and state highway
- 100 linear feet of 72-inch storm pipe tunneled below a railroad
- Extensive coordination with dry utilities including approximately 40 utility adjustment
- Tight deadline to end construction prior to start of summer downtown street fair

Bid Process

During the bid process, Contractor I stood out as the top choice for Phase I. Contractor I was the low bidder, had a history of quality work in Colorado, and the sponsors were familiar with their work.

Bids for Phase II came in higher than expected, with Contractor II being the only bidder lower than the engineer's estimate for Phase II. Neither the project sponsors nor Olsson staff were aware of other Colorado projects completed by Contractor II. Despite the lack of history of quality work, Contractor II was selected due to the low bid.

Bid Statistics

	Contractor I	Contractor II
Initial bid	$ 3,569,146	$ 3,434,558
Next closest bidder	$ 3,983,111	$ 3,632,942
Amount below engineer's estimate	$600,000	$8,000

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Contractor II, in contrast, did not handle work or work-related questions in an acceptable manner; issues became "crises" that required immediate answers. There was little forethought. In addition, Contractor II changed project managers twice, superintendents once, and foremen once within the first three months. This lack of continuity required previous discussions to be repeated and, subsequently, items were missed in the process. Overall, Contractor II had double the number of field orders and RFIs as Contractor I. These numbers highlight the

2 OLSSON ASSOCIATES

Contractor Comparison Summary
Lafayette-Louisville Boundary Area Drainageway Improvement Project

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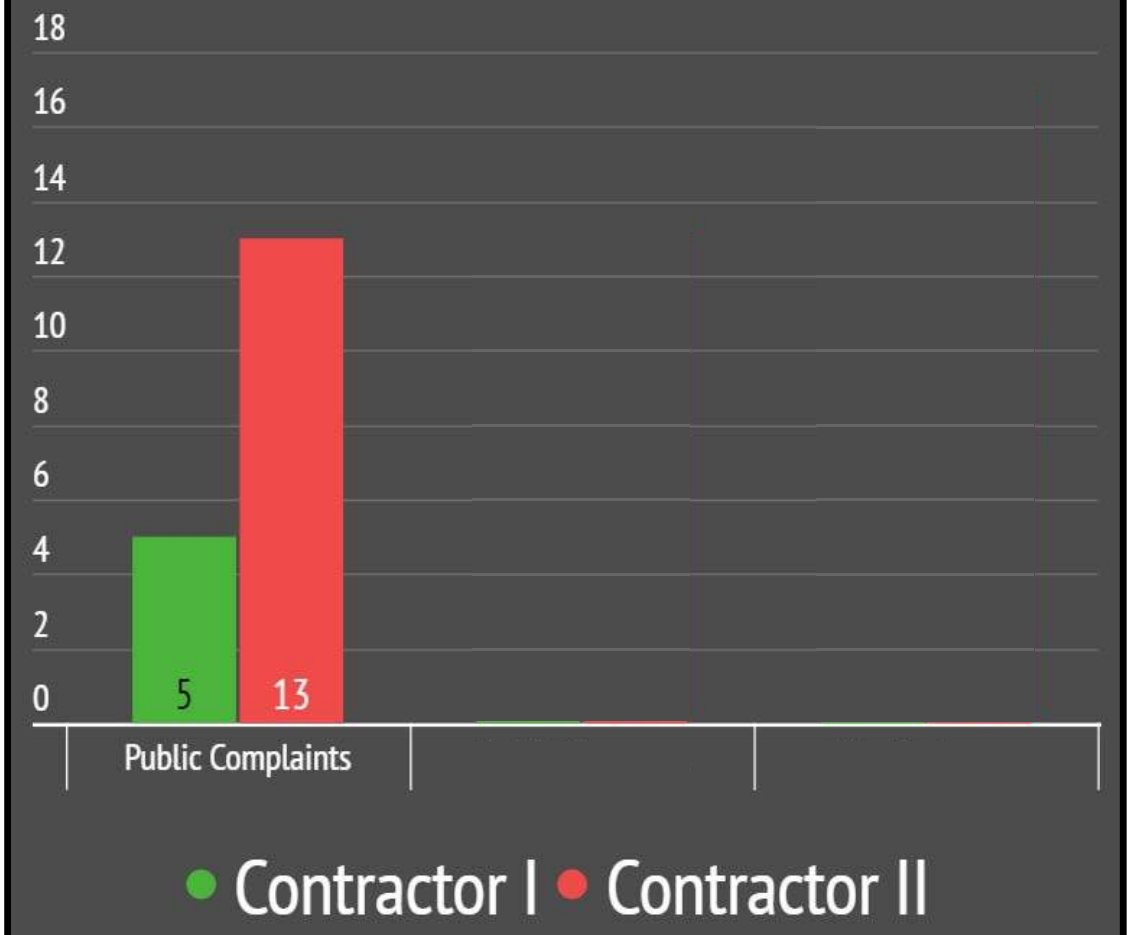
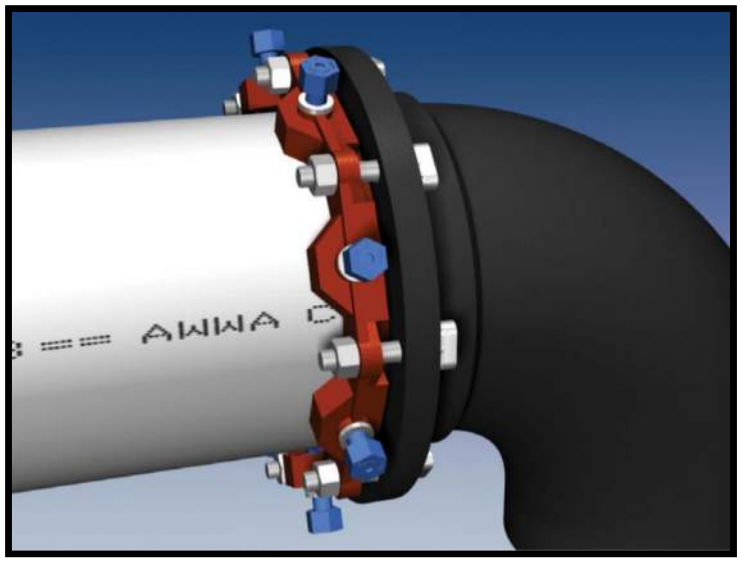
Increase in Cost from Change Orders	$95,381	$143,689
Total Cost After Contract Changes	$3,664,527	$3,578,247
Final Cost	$3,664,527	$3,122,921
Value of Removed and Uncompleted Work	$0	($455,326)
Notice to Proceed	1/20/2016	2/8/2016
Original number of contract work days	160	130
Number of days contract was extended	43	31
Weather Days	64	8
Field Orders	5	11
Overtime Requests	0	2
Requests for Information	6	20
Submittals	35	32
Avg. Reviews/Submittal	1.2	1.6
Change Orders/Work Change Directives	10	34
Average Cost/Contract Change	$8,542	$2,307
Pay Applications	12	8
Avg. Reviews/Pay Application	1.5	4.1
Number of Project Manager Changes	0	2
Number of Superintendent Changes	0	3
Number of Foreman Changes	0	3
Progress Meetings	34	31
Total Meetings	40	38
Number of Email Correspondence	2,148	3,158
Number of Emails per day	6.4	14.0
Public Complaints	5	13
Safety Concerns	2	13
Quality Issues	3	17
Punchlist Items	57	86
Total Engineer's Time Spent	1,318	1,739
Average Engineer's Time Spent/Day	4	8
Total Value of Engineer's Time	$135,348	$175,235
Average Value of Engineer's Time/Day	$403	$776

Personnel Changes

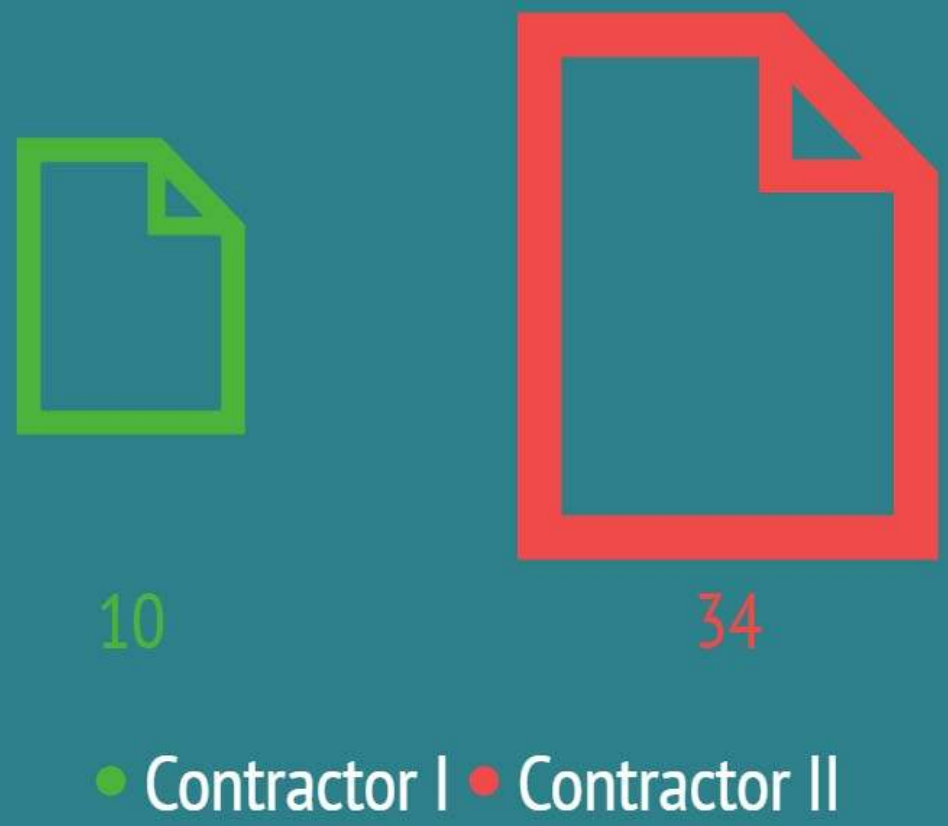
2 Project Manager Changes

Safety & Quality Issues

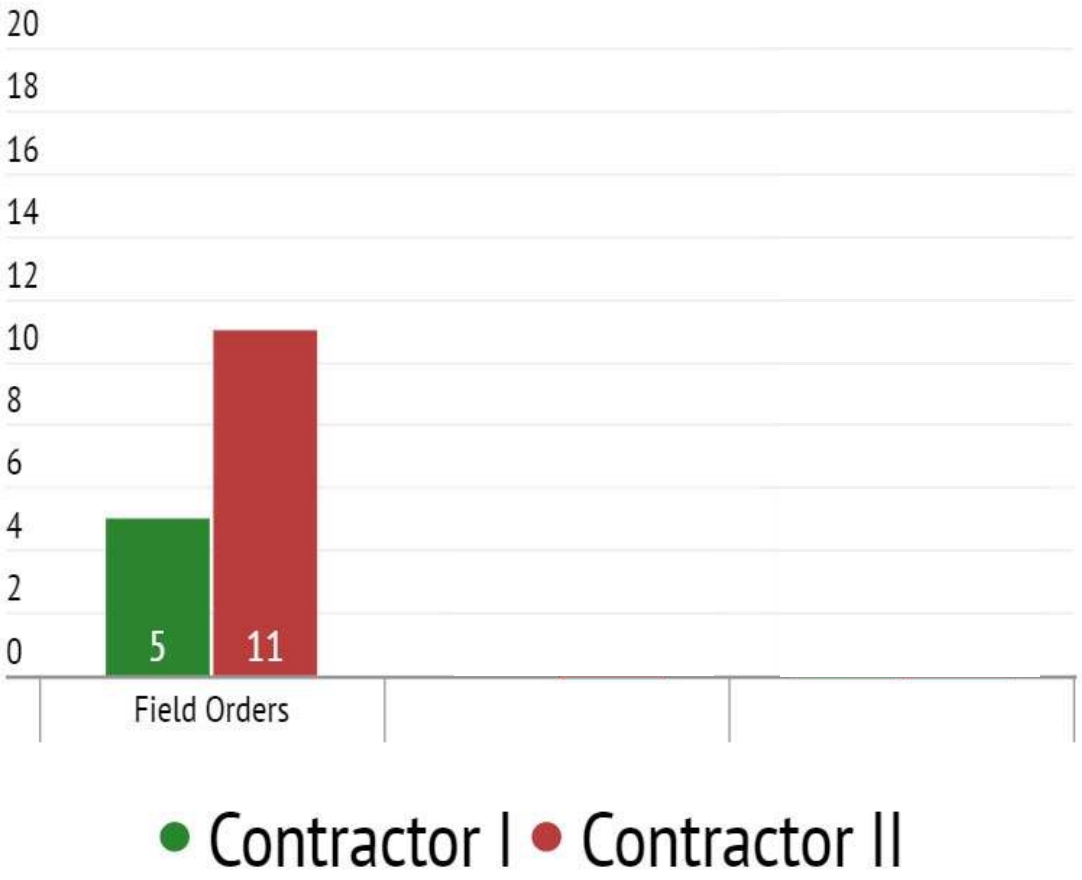




Change Order Requests



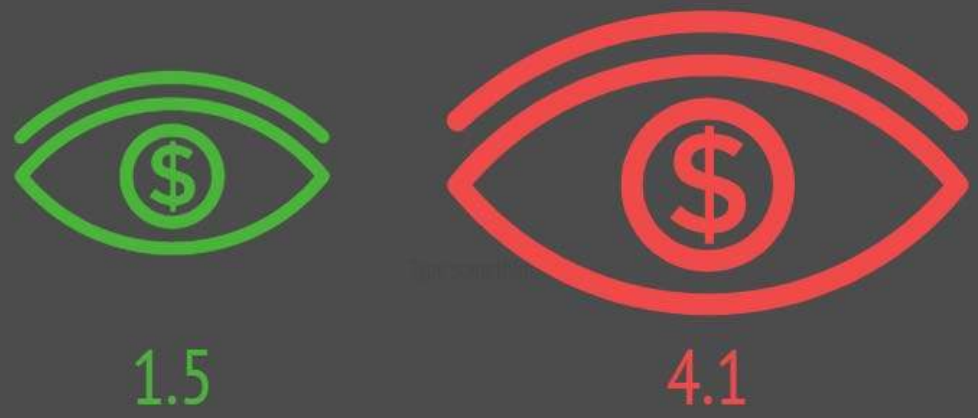
Contractor Requests




ROAD
CLOSED
TO
THRU TRAFFIC
HITACHI


MAPLE SYRUP
ASPARAGUS
ORGANIC
CERTIFIED
LOCAL
$5

Reviews per Pay App



• Contractor I • Contractor II

Emails per Day

Engineering Cost per Day

• Contractor I • Contractor II

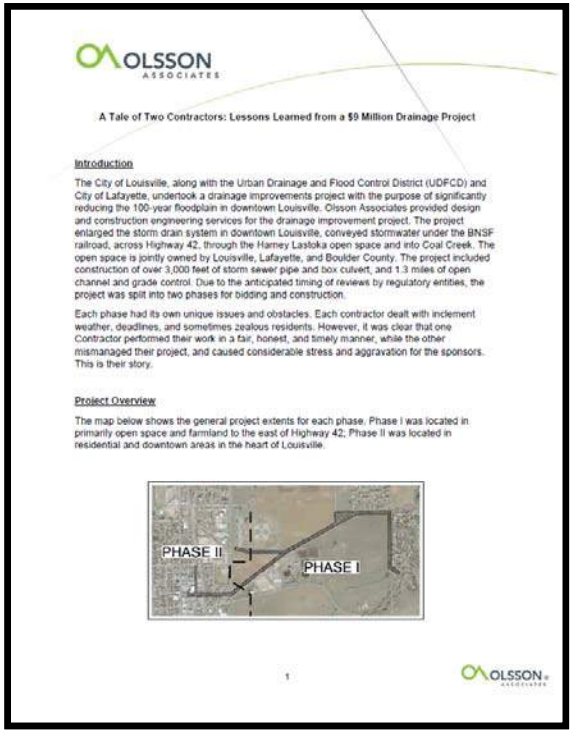
$455,326

Value of removed and uncompleted work for Contractor II

From: [redacted]
Sent: Friday, January 27, 2017 9:43 AM
To: [redacted]
Subject: [redacted] Trucking release form

[redacted],

A Tale of Two Contractors:
Lessons Learned from a $9 Million Drainage Project



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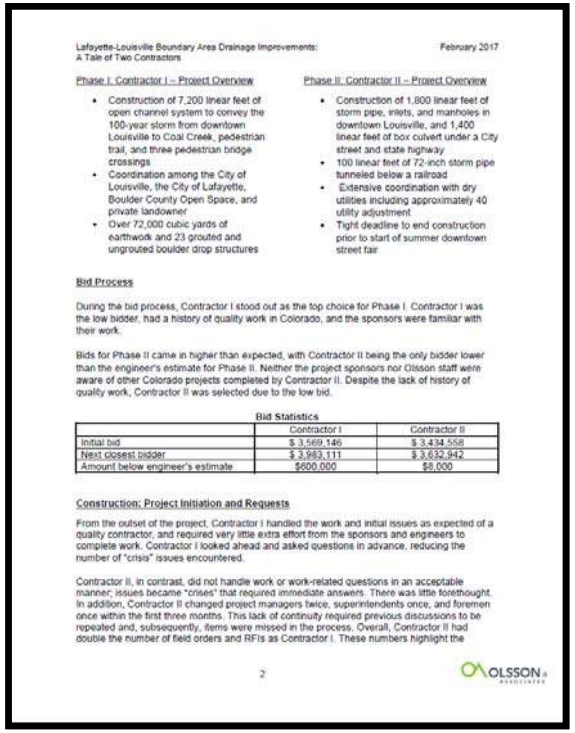
PHASE II
PHASE I

1



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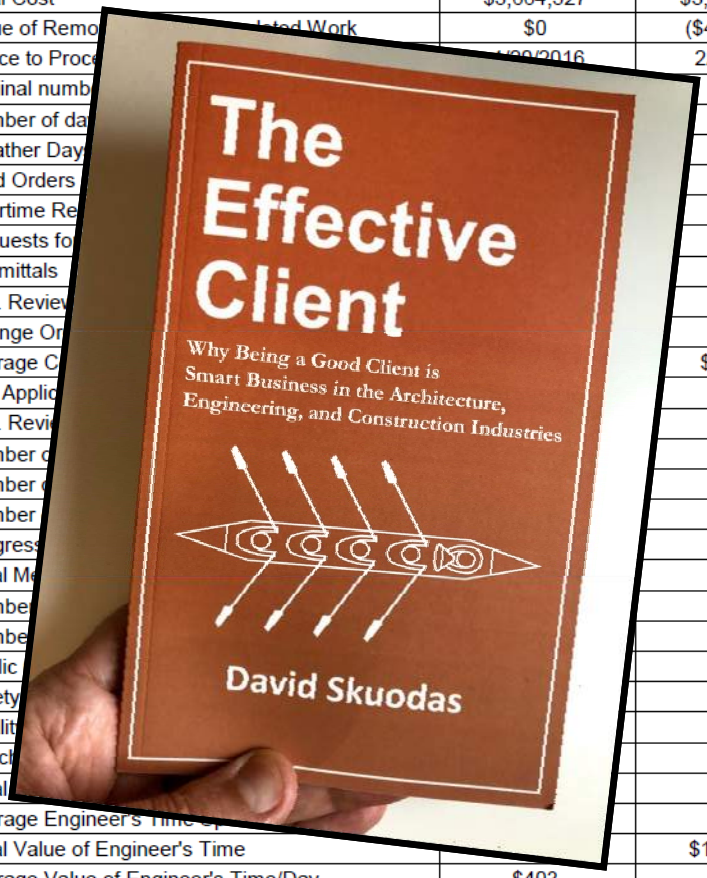
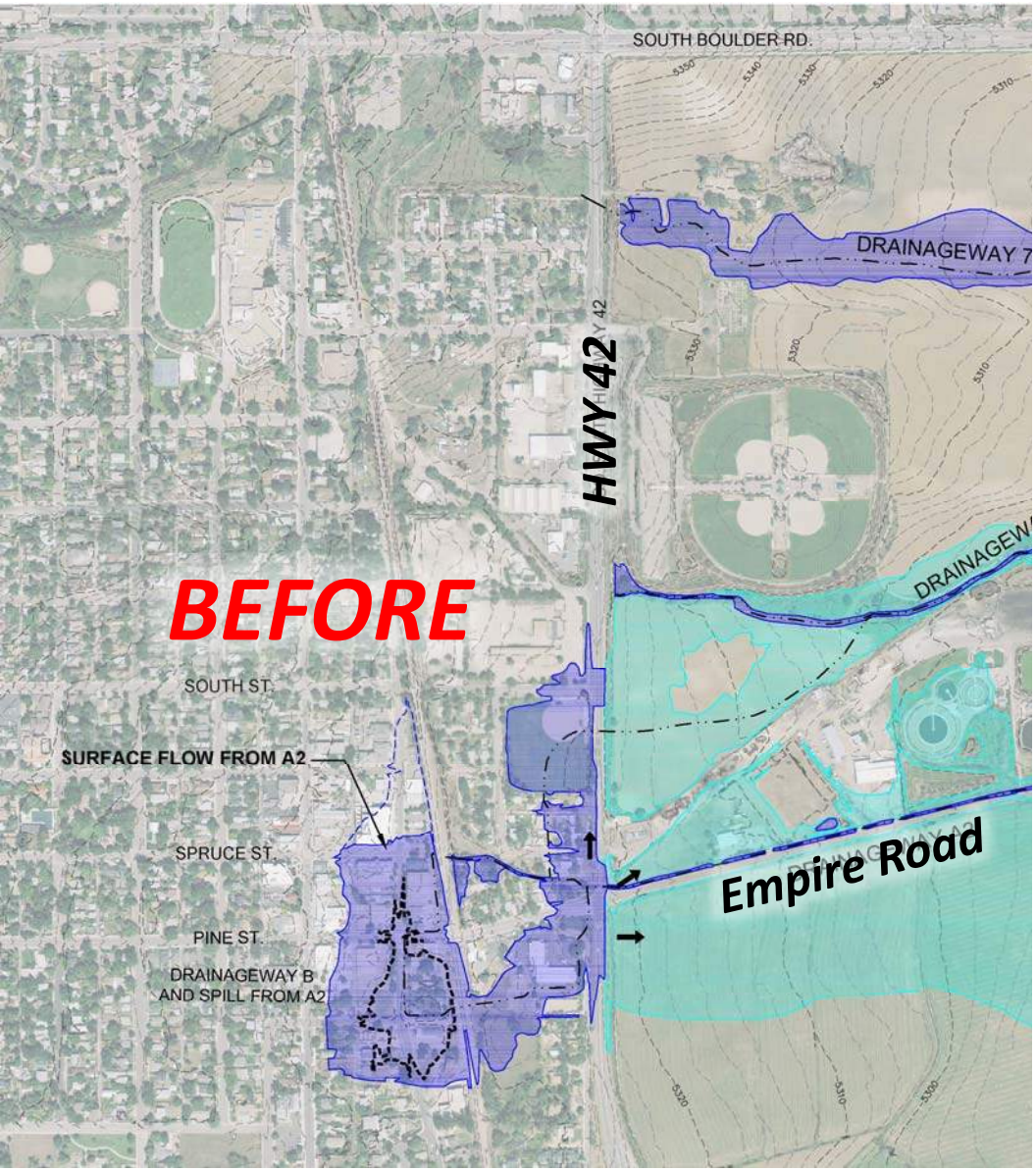
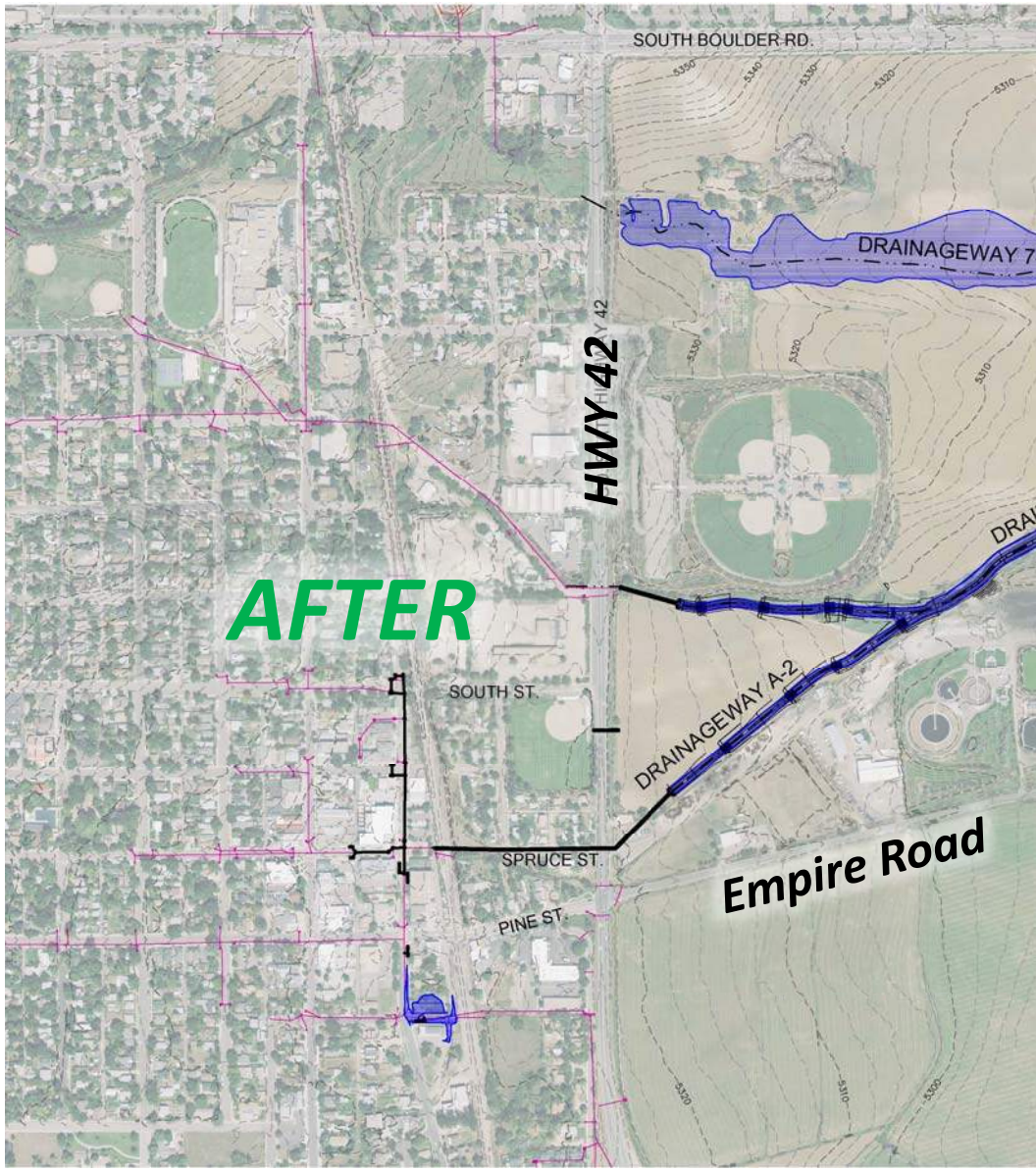
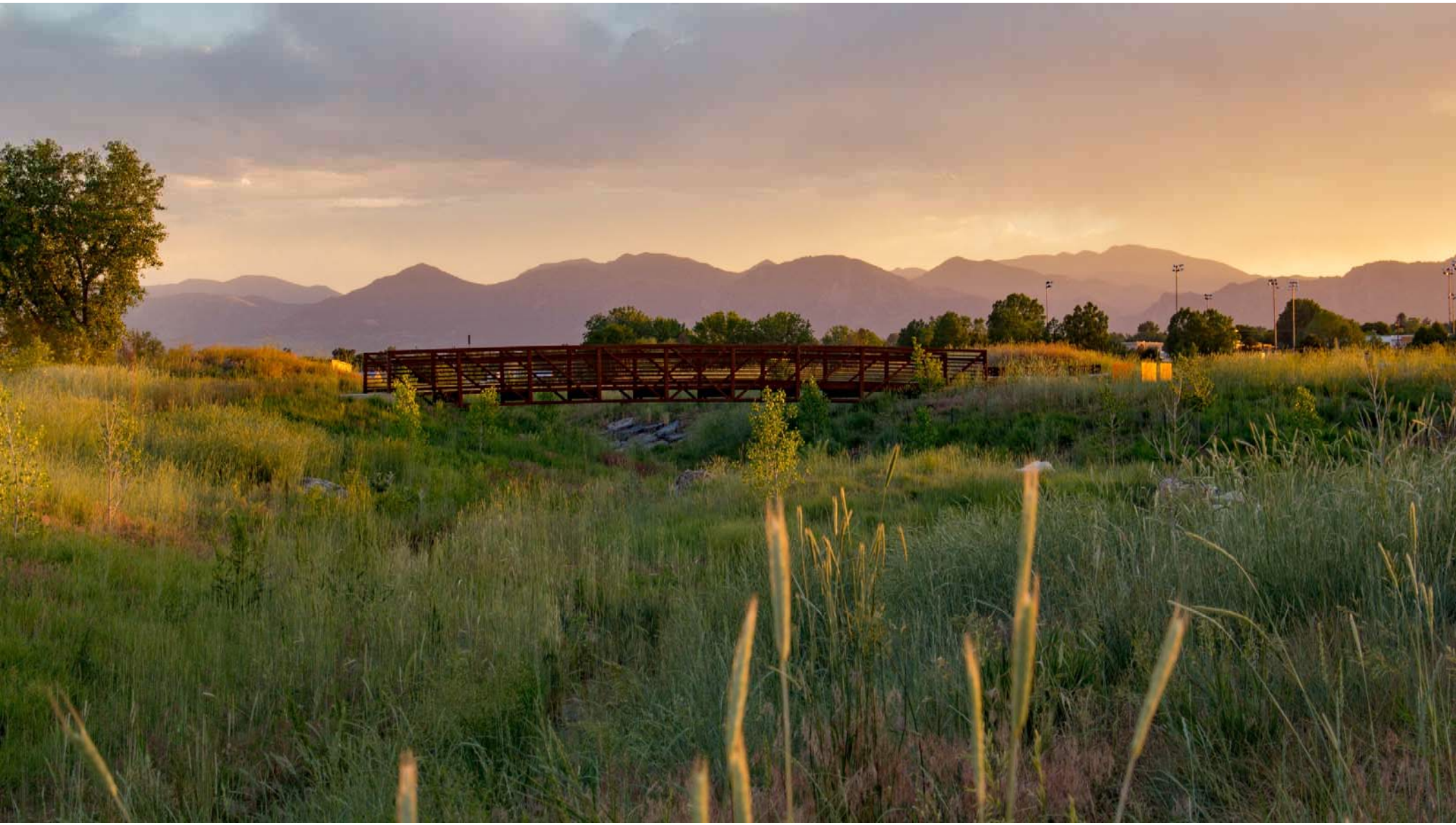
Notice to Proc	/20/2016	2/8/2016
Original numb		130
Number of da		31
Weather Day		8
Field Orders		11
Overtime Re		2
Requests fo		20
Submittals		32
Avg. Revie		1.6
Change Or		34
Average C		$2,307
Pay Applic		8
Avg. Revi		4.1
Number c		2
Number c		3
Number		3
Progress		31
Total M		38
Numbe		3,158
Numbe		14.0
Public		13
Safety		13
Qualit		17
Punch		86
Total		1,739
Average Engineer's Time		8
Total Value of Engineer's Time		$175,235
Average Value of Engineer's Time/Day	$403	$776




BEFORE
SOUTH BOULDER RD.
DRAINAGEWAY 7
HWY 42
DRAINAGEW
SOUTH ST.
SURFACE FLOW FROM A2
SPRUCE ST.
PINE ST.
DRAINAGEWAY B
AND SPILL FROM A2
Empire Road


AFTER
SOUTH BOULDER RD.
DRAINAGEWAY 7
HWY 42
SOUTH ST.
DRAINAGEWAY A-2
SPRUCE ST.
PINE ST.
Empire Road



Lessons Learned from a “Small Project”

House flooded seven times in 17 years, records show house was built 12” lower than it should have been based on the original drainage study

Crawl space constructed below grade but with vapor barrier, garage and living room slab on grade and less than required 18” inches above gutter flow line

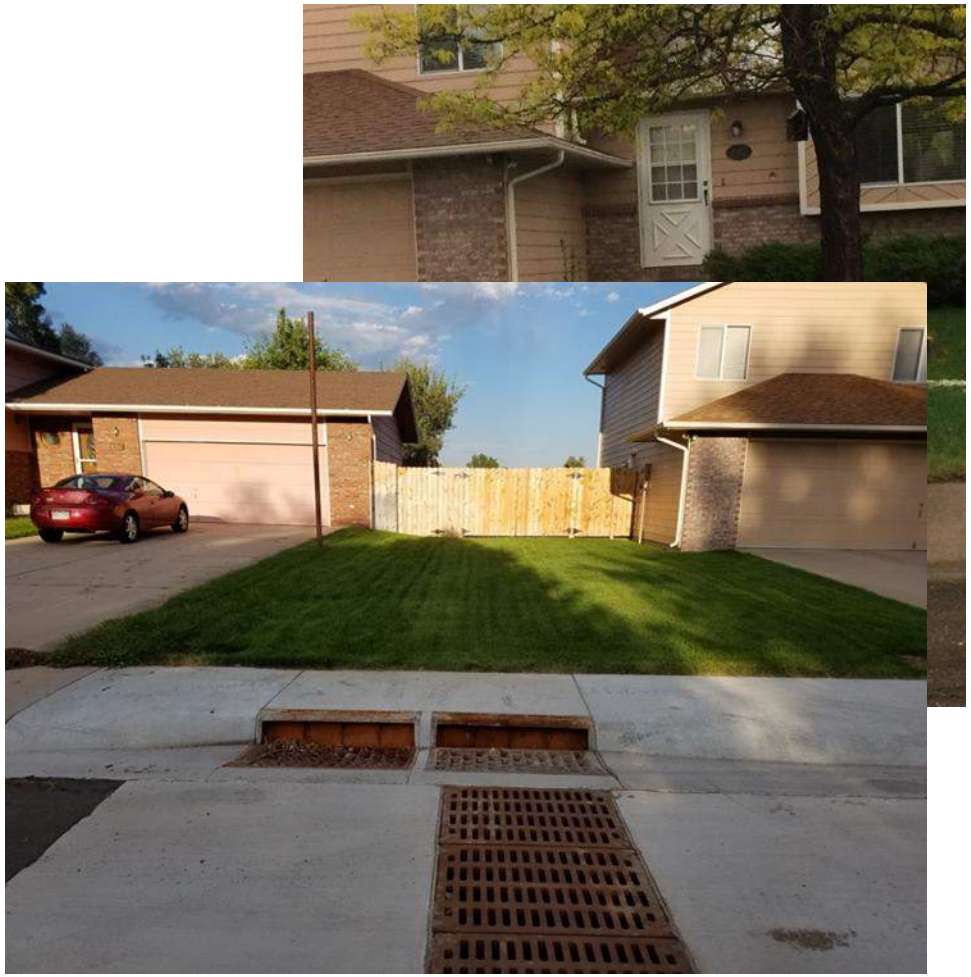
Nearly 100 acres drained to a single inlet and 24” pipe

Design, Construction and Success!?

Project designed street-width gallery inlets and new 34” elliptical pipe threaded between other utilities

Design took just a few months and construction took just over seven weeks including several weather days

After a large rain in early July, the homeowner called us to say how pleased she was with the improvements and the project.

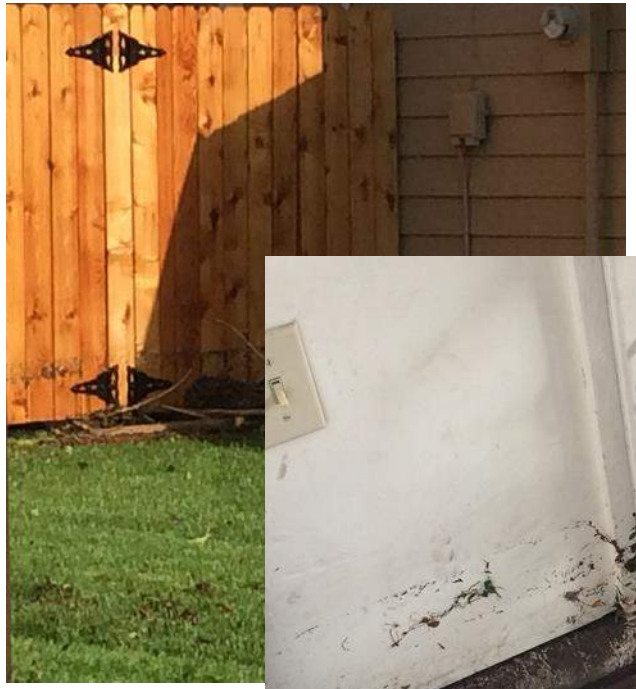


A Little Rain Must Fall

An afternoon storm on August 10th brought 1.5” rain in the first 15 minutes, 2” overall

Floatable debris at fence, high water line in garage and homeowner stated water in living room. Neighbors said water knee/thigh deep in street and they cleared debris from inlets.

I shifted to forensic engineer mode, trying to gather information and determine cause. Neighbors and homeowners were upset and needed to vent.



The Aha Moment

Further investigation found construction per plan except for fence, bottom designed 18” above grade, constructed at 6”. Homeowner request to fence sub, City inspector and prime may have known, no engineers were aware

One design flaw was exposed in the review, the back fence should have also had an opening to allow water to continue to flow and not pond in the yard.

Post-storm flow modeling showed changes to fence would allow a 10-year flow in pipe, and up to 100-year flow in swale through yard before water would impact the house. This was the original level of protection intended

Design engineering firm, prime contractor and City each paid 1/3 of cost to repair damages

Takeaways

Take the time to explain design to ALL who are impacted long term, and ALWAYS get an agreement in writing

Don’t forget your sympathy/empathy, be able to take some venting and still be kind

Solutions don’t have to be perfect, know when to say good enough


Google Earth


Thanks for sending me an email asking me to do something for you that it would have taken less time for you to do than it took for you to send me an email.
your ecards
someecards.com

Long email so I included a couple summary comments at the start. We definitely are sensitive to the costs and inconvenience of excessive routine maintenance so it is being considered as we go through the design. While it is impossible to entirely eliminate some types of maintenance that are connected to a multi-purpose facility such as the Little Dry Creek Park, it's also unrealistic to compare the required level of maintenance to a park that is located entirely outside of 100-year floodplains. Additionally, there are recreational benefits to consider that can be achieved in multi-purpose facilities that can't be achieved elsewhere. We have an intelligent and experienced design team that is supported by intelligent and experienced City, County, and UDFCD staff. I suggest we schedule a few meetings over the next 3 months to specifically discuss operations and maintenance so we can collectively identify site specific concerns and develop solutions which minimize the anticipated level of maintenance. Let us know how we can help to get those discussions started.

I also provided some detailed responses to items Nate and Brad have identified. Ultimately we recognize that we need to get to a place where the staff responsible for maintenance is comfortable with the design that is being proposed. I just wanted to assure you that many of the problems Nate and Brad are dealing with are already being evaluated by our design team and we continue to work towards acceptable solutions.

- High water debris rings have to be expected, there is no way around them in a detention facility. Within landscaped areas it will require raking, removal, and disposal. Within native areas you may be able to selectively decide when to remove the debris and when to leave it in place. We view this as a minor level of maintenance effort. ?
- Routine trash and debris. We've seen several storms pass through the site over the last few summers and with it comes a high level of trash and debris. This debris will attach to trees, shrubs, railings, structure grates, etc. and will occur even if the detention pond is not storing water. There is very little that can be done to correct the problem outside of controlling the trash and debris at the source or upstream of the project. Within our design we are trying to route all piped storm flows from onsite and offsite basins through a water quality treatment system. This will isolate the trash to several specific locations within the park for collection and removal. It does not address trash and debris from the upstream portion of Little Dry Creek though. On both Federal Boulevard culverts we are not installing trash racks subsequently less trash and debris will be retained on site than the current condition and the pond is less likely to fill due to the result of clogging on the inlet which stress on the vegetation should be avoided. Again, we view having to collect and dispose of trash and debris after a storm event to be a minor level of maintenance.
- With regard to structures. We know that all structures within the flood pool will be subjected to buoyant forces and will need special design attention. Most will need to be fixed, including trash cans, benches, irrigation boxes, and so on. We should be able to address many of these concerns with proper design.
- Landscape materials. We aren't planning to propose widespread use of floatable surface cover treatments within the lower portions of the ponding limits. Especially mulch. We recognize it floats and will get washed away. There may be a few isolated cases where we may recommend the use of mulch around the station but we could design those to be relatively small and high within the ponding limits and design channel flows. The majority of these concerns can be minimized or eliminated through proper design.
- Sediment on trails. Most trails are being designed to run parallel to the Creek and be higher on the banks. In locations where direct flows will pass over the trails we will incorporate a toe wall design along the edge of the trail to reduce the potential of trail loss during larger events. We also are designing major sumps within the trail layout where large amounts of sediment could accumulate. That said, some sediment deposition should be expected during ponding events.
- Lower flatwork adjacent to the station. We think it is important to include design elements that provide access to the Creek. In the case around the station this means that after larger flow events, portions of the flatwork will need to be swept or washed clean. We don't view this to be a high level of maintenance compared to the recreational value provided, but if City staff believe otherwise we can easily eliminate the access near the lower portions of the Creek.
- Irrigated turf maintenance. This concern is tough to quantify ? a couple of things we have going for us. We should be able to achieve good infiltration within the turf grass areas. The borings indicate the turf grass elevations are within the range of interlayered clay/sand and sands and gravel. During construction if we encounter more clay than sand we can easily over excavate the areas by 6-12 inches and replace it with onsite sands and gravels. Also consider that the lower elevations of the turf grass are roughly 5 feet above the normal permanent pool water surface level of the fishing pond so frequent ponding over the turf grass connected to smaller storm events won't be an issue, but sediment deposition connected to flows that breach the channel banks do need to be considered. This area will be irrigated so we could integrate quick couplers into the system so that manageable levels of sediment can be easily washed into the turf grass. Some sediment loading shouldn't be harmful, if's deep deposits over poor draining soils that could cause problems. Again, we believe there are things we can do to minimize ? level of maintenance of these turf zones and still be able to provide the desired recreational value.
- With regard to bank stabilization and around structures, we'll do the best we can to design a reliable system that is generally free erosion.
- Finally the upper flatwork areas within the pond limits such as parking lots, Creekside Drive and the pedestrian underpass. It is true that if the ponding reaches the 50-year and above level, sediment deposition will occur in these areas and need to be removed. For this level of storm, this is minor maintenance that would have to be performed compared to the anticipated much larger flood damage to respond to elsewhere in the basin.

GROUTED RIPRAP

Wait…that is not what I designed!

- Client:
  - Municipal Maintenance Division
  - Self Perform the work
  - Desires Hard Improvement
- Problem
  - Sediment Accumulation
  - Floodplain issues

- Vegetated Void-filled Riprap lining

- NOT Vegetated VFR Lining

August, 2011 Thunderstorm

August, 2011 Thunderstorm

Stuck in the details! ★

Missed the big picture.

Keep it simple.

Missed the big picture.

Keep it simple.

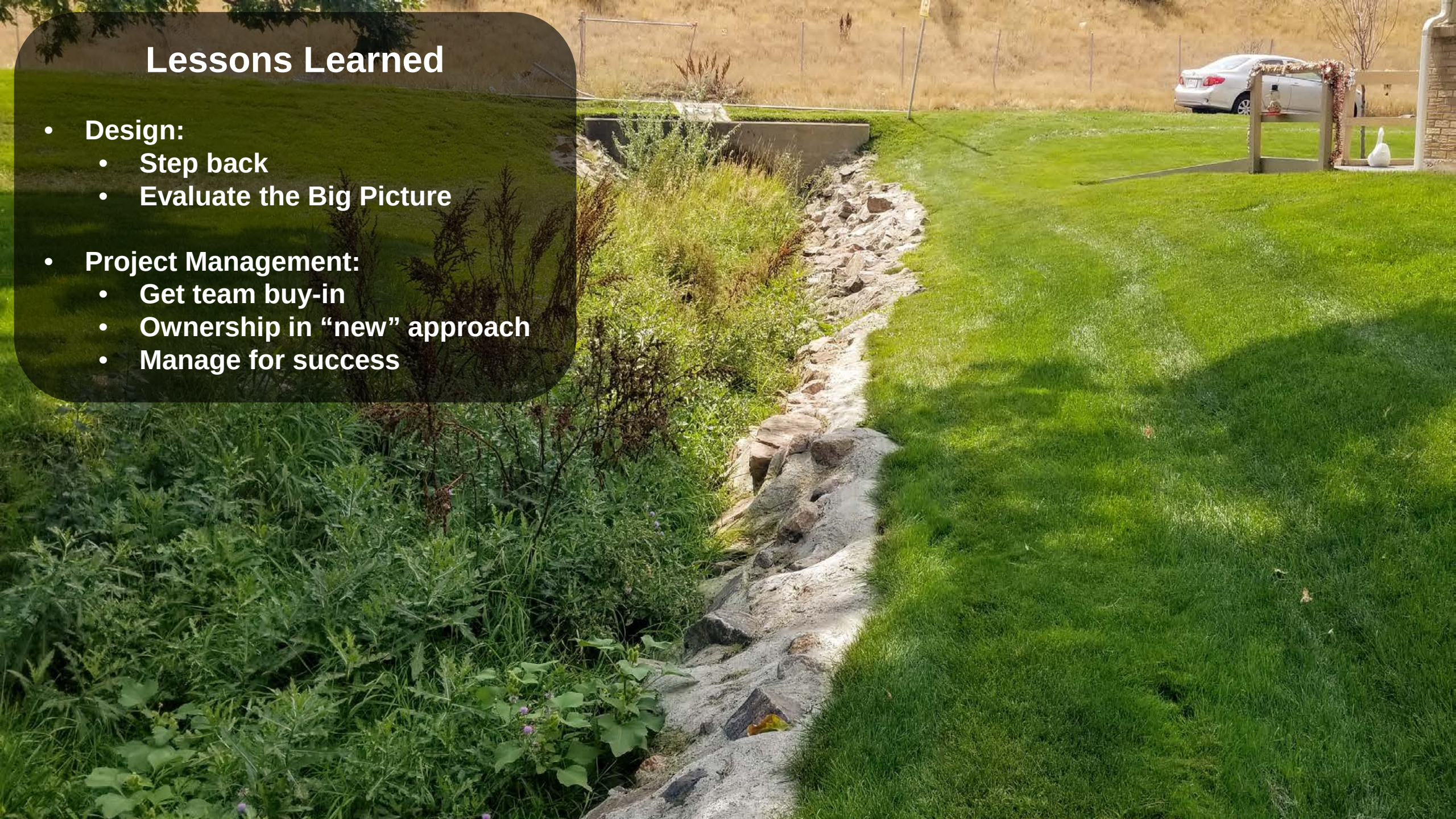
Missed the big picture.

Keep it simple.

Lessons Learned

- Design:
  - Step back
  - Evaluate the Big Picture

- Project Management:
  - Get team buy-in
  - Ownership in “new” approach
  - Manage for success

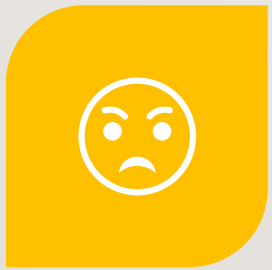


LEGAL ACTIONS

LESSONS LEARNED

EXAMPLE CASE

BACKGROUND



IT WILL FEEL PERSONAL

LEGAL PROCESS

FOCUS ON THE FACTS

CDOT REGION 4 2D MODELING REVIEW AND THE D-27-G BRIDGE REPLACEMENT

Steven Griffin, PE, CFM
CDOT R4 Hydraulics
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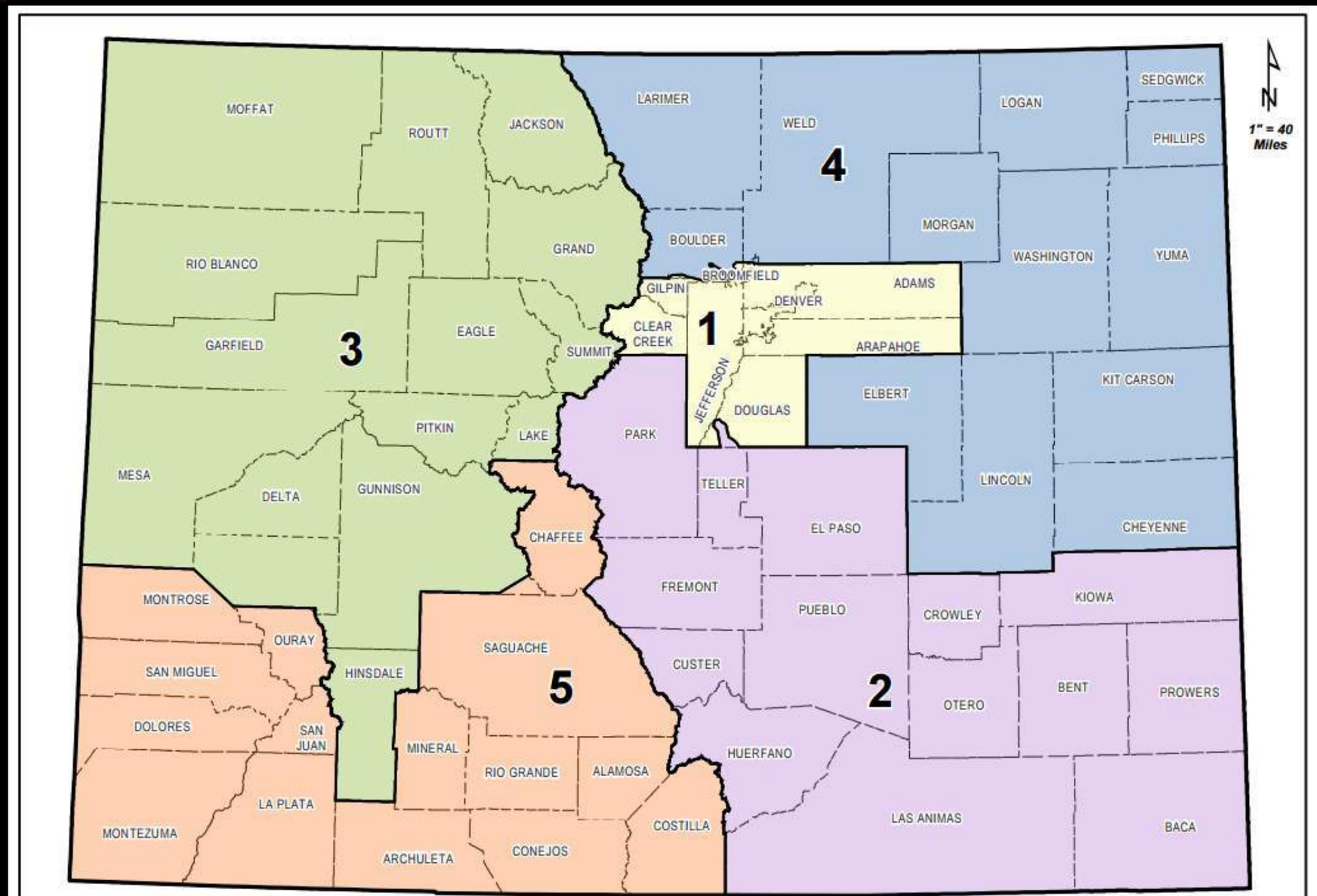
970-350-2338

Anthony Alvarado, PE, CFM
Ayres, Hydraulics
alvaradoa@ayresassociates.com
970-797-3501

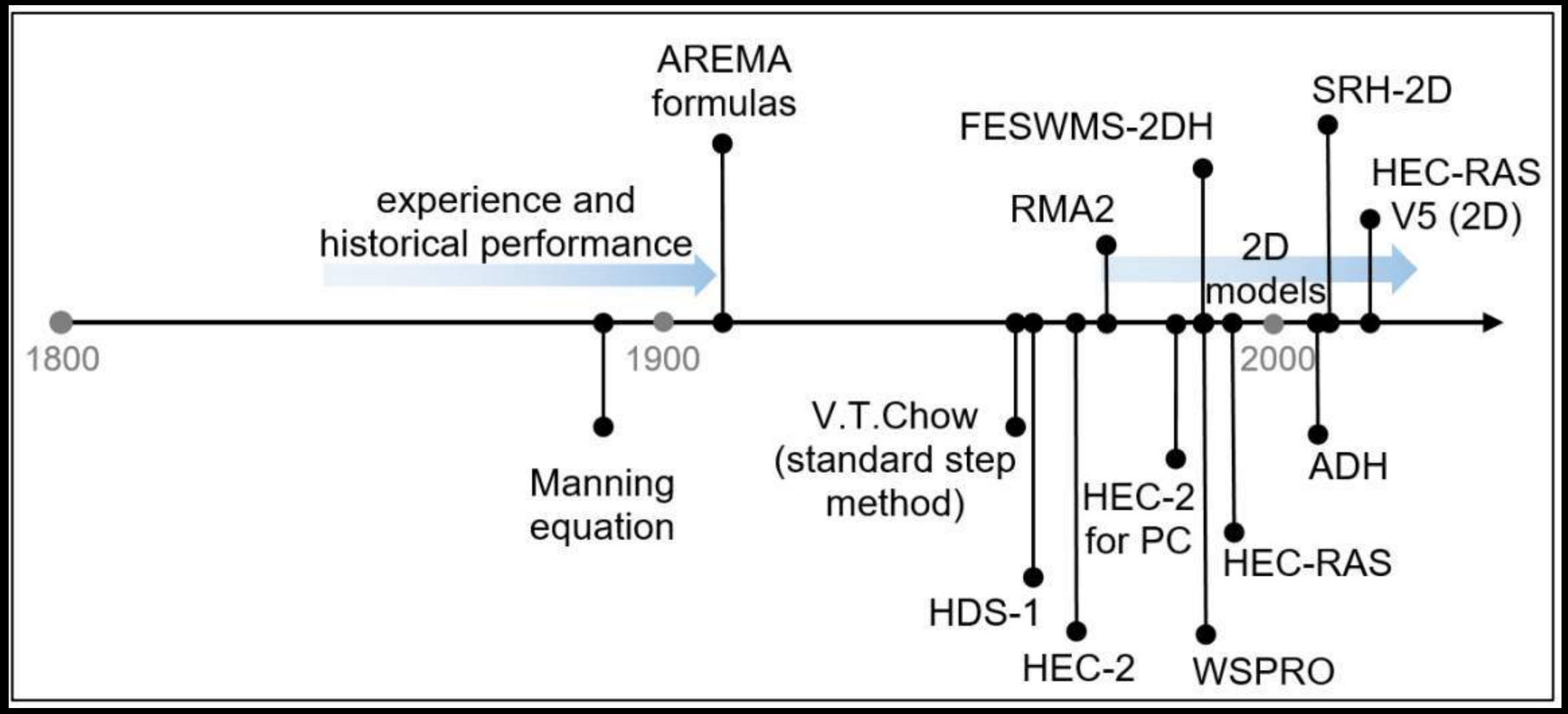
TOUR OF COMING ATTRACTIONS

- History of 2D Models
- 2D Advantages
- 2D Challenges
- Common Pitfalls and the QC Review process
- Case Study – Wray, CO

CDOT REGION 4



HISTORY OF HYDRAULIC MODELING



SOURCE: FHWA TWO-DIMENSIONAL HYDRAULIC MODELING FOR HIGHWAYS IN THE RIVER ENVIRONMENT

THE 2D ADVANTAGE

Hydraulic Variables	1D Modeling	2D Modeling
Flow direction	**Assumed** by user	**Computed**
Flow paths	**Assumed** by user	**Computed**
Channel roughness	**Assumed** constant between cross sections	Roughness values at individual elements used in computations.
Ineffective flow areas	**Assumed** by user	**Computed**
Flow contraction and expansion through bridges	**Assumed** by user	**Computed**
Flow velocity	**Averaged** at each cross section	**Computed** at each element
Flow distribution	**Approximated** based on conveyance	**Computed** based on continuity and momentum
Water Surface Elevation	**Assumed** constant across entire cross section	**Computed** at each element

THE PROBLEM

Powerful New Tech

+

New Users

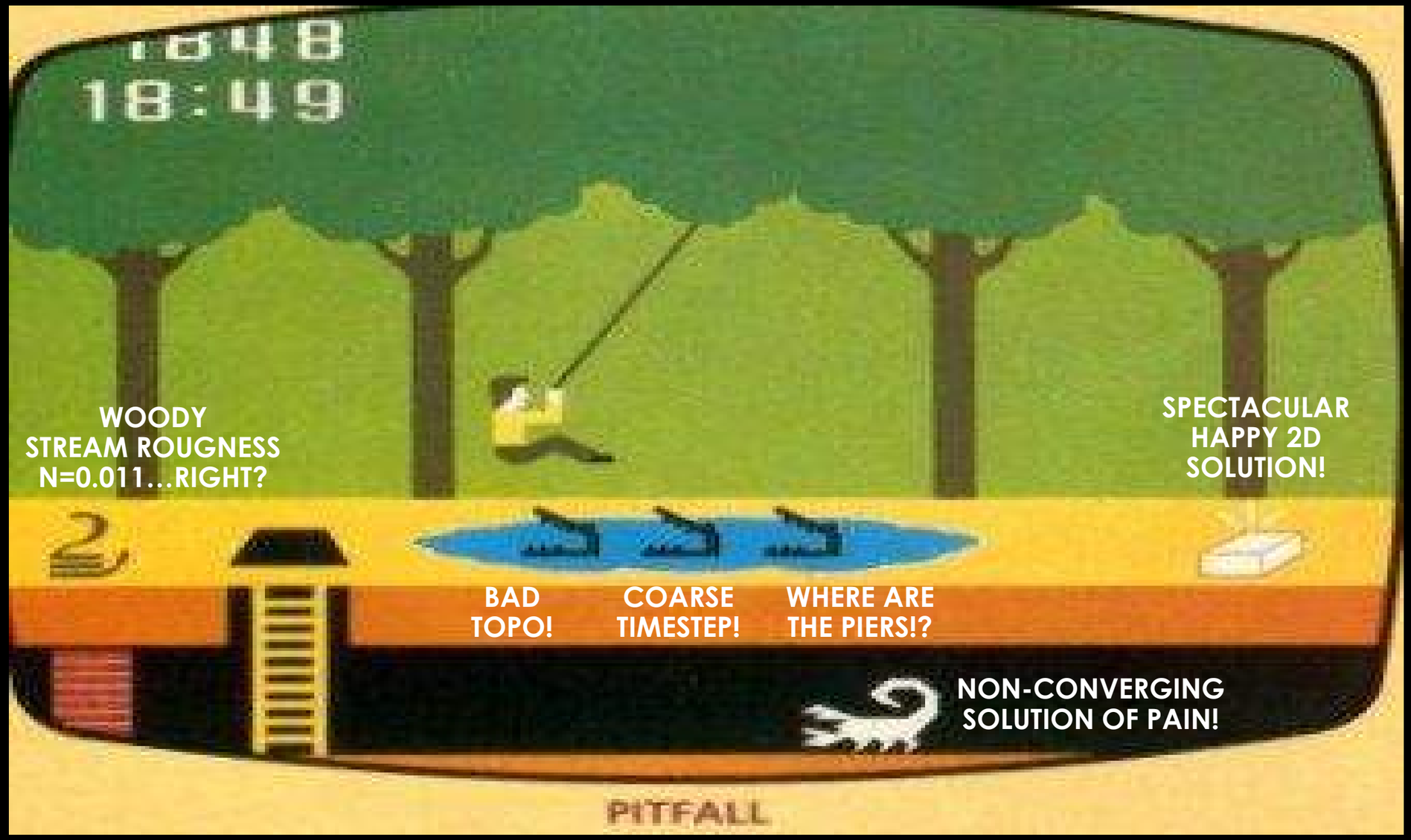
+

New Reviewers

=

What Could Go Wrong?

COMMON PITFALLS!



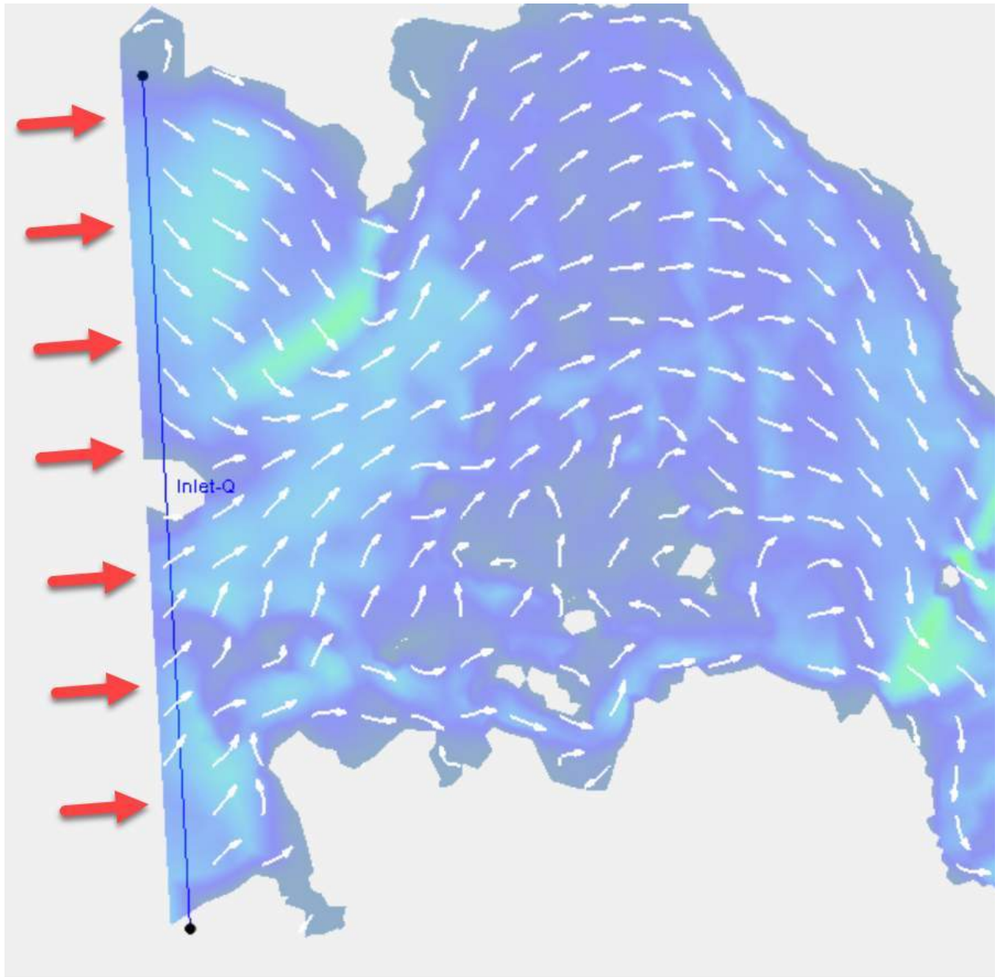
REVIEW GUIDE TO COMMON MISTAKES

Project (Sub-Account and Description)	23010 Eastern Timber BR	COLORADO Department of Transportation		
Model Run	100 yr Existing			
Str # and/or Reach	G-21-A Sand Creek			
Review Date	Nov 11, 2019	**Region 4 Hydraulics Unit**		Original Form (credit): Clark Barlow, Atkins
Reviewer	Steven Griffin, CDOT	**SMS / SRH-2D Quality Check**		Form Revision Number: 1.0
SMS Version	13.0.10			Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
Input Review			**(Date of Response:)**	
Boundary Conditions				
Upstream Boundary Condition				
1	Does the location of the inflow boundary condition seem appropriate?			
2	Does the flowrate match the event being modeled?			
3	Are the flowrate units correct?			
	Do the upstream boundary conditions in the			

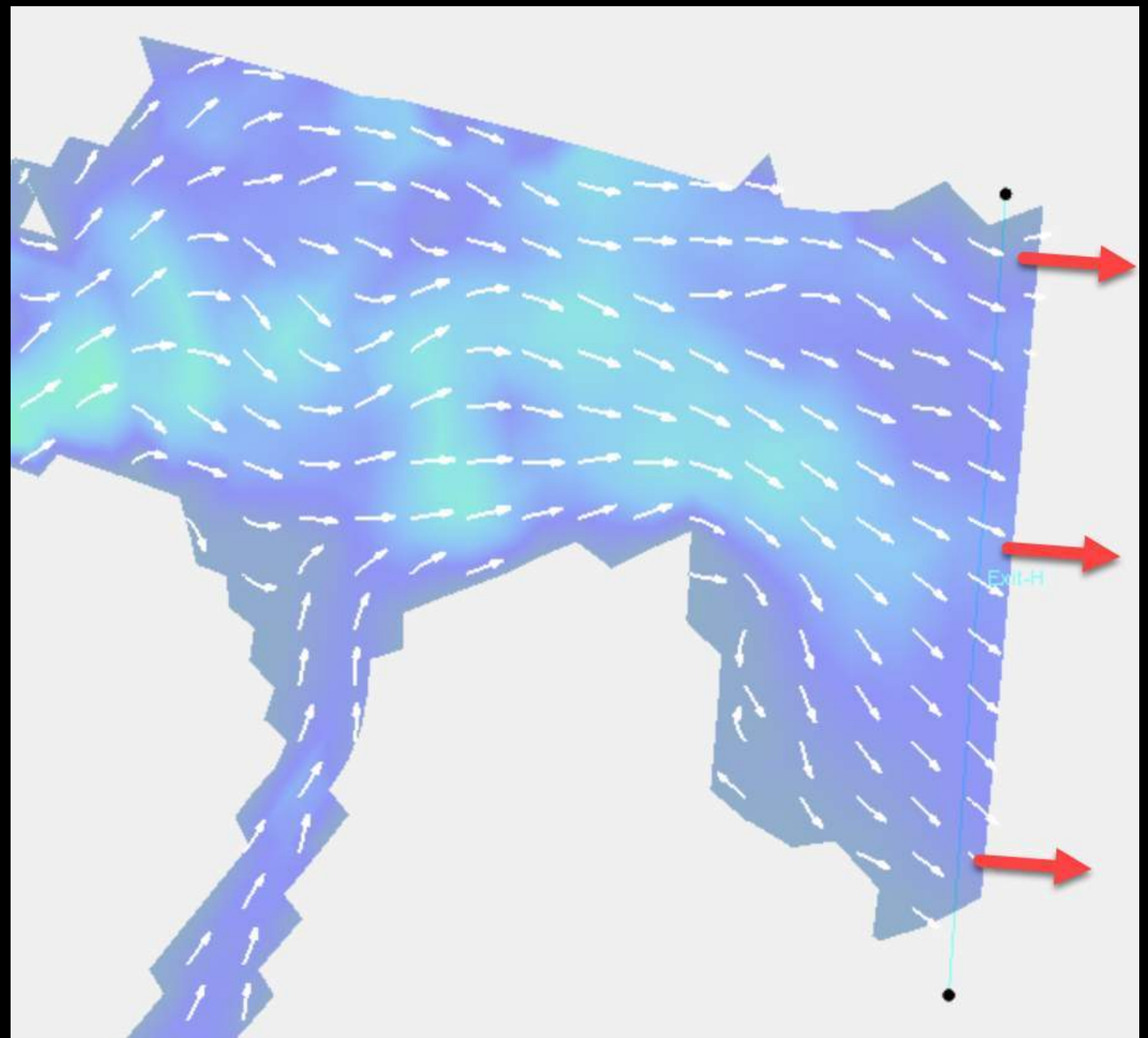
UPSTREAM BOUNDARY

- Where water enters
- Location
- Data source
- Correct numbers
- Impacts to results

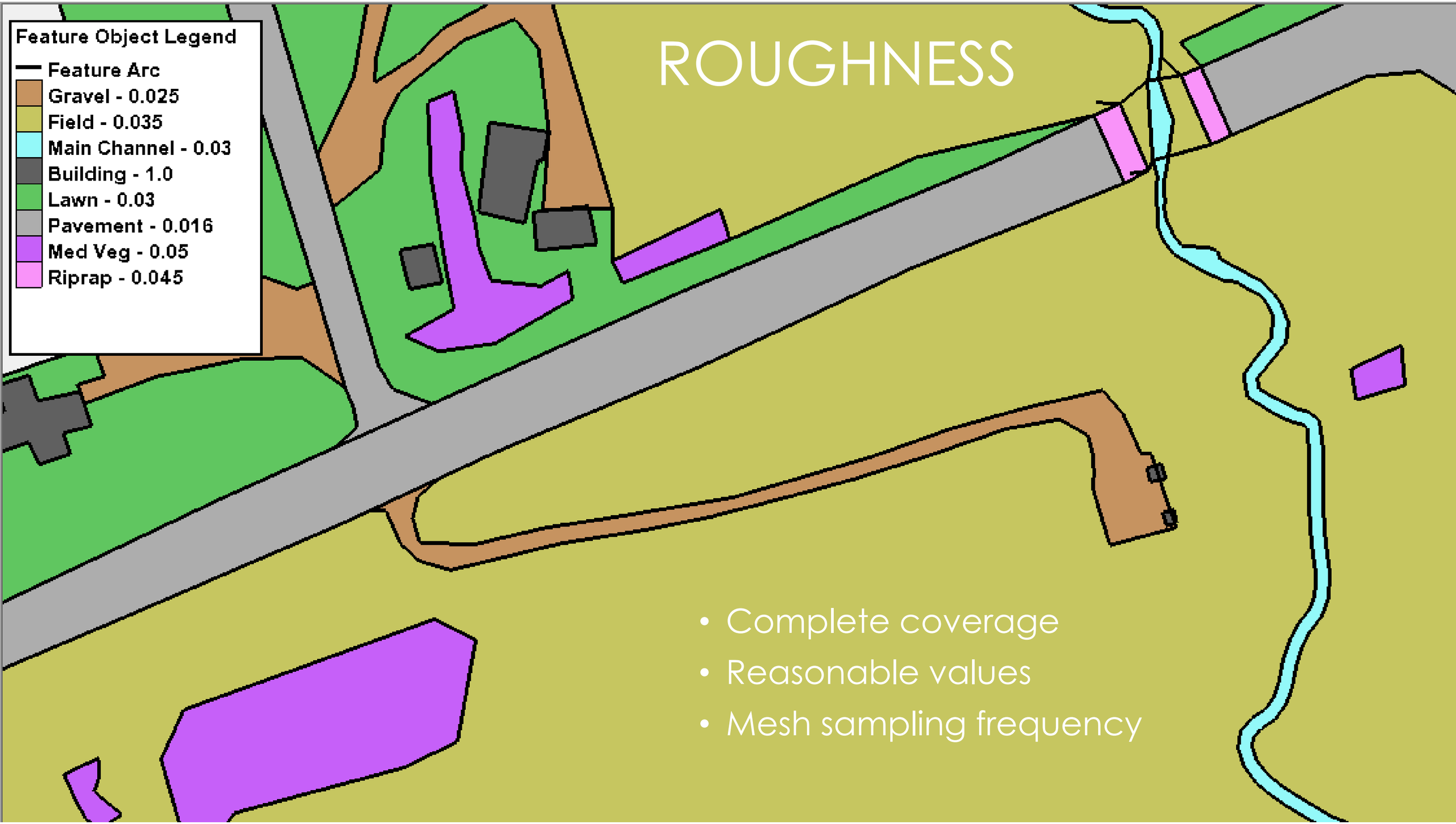


DOWNSTREAM BOUNDARY

- Where water exits
- Location
- Data source
- Elevation Datum
- Correct number
- Impact to results



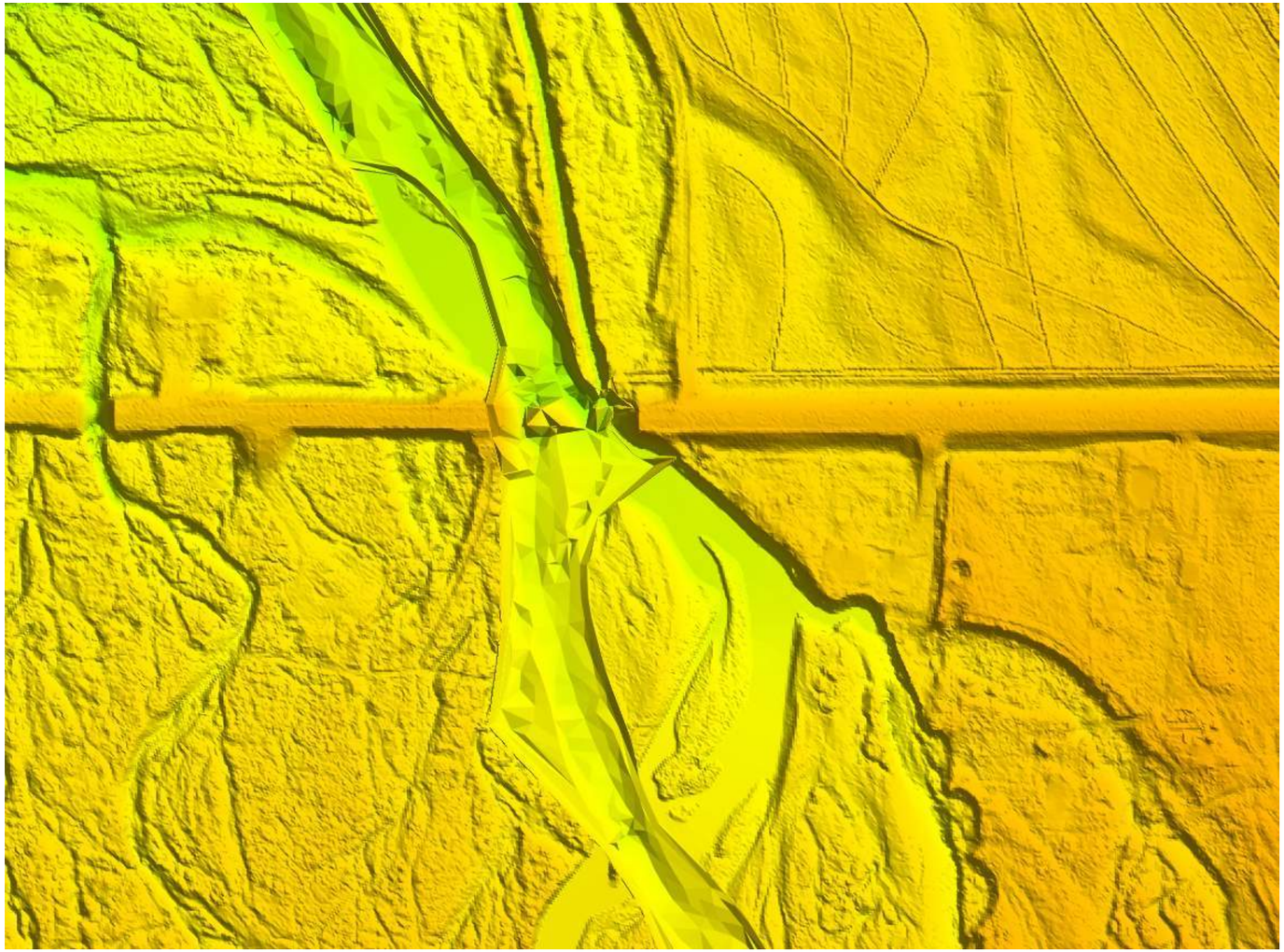
ROUGHNESS



- Complete coverage
- Reasonable values
- Mesh sampling frequency

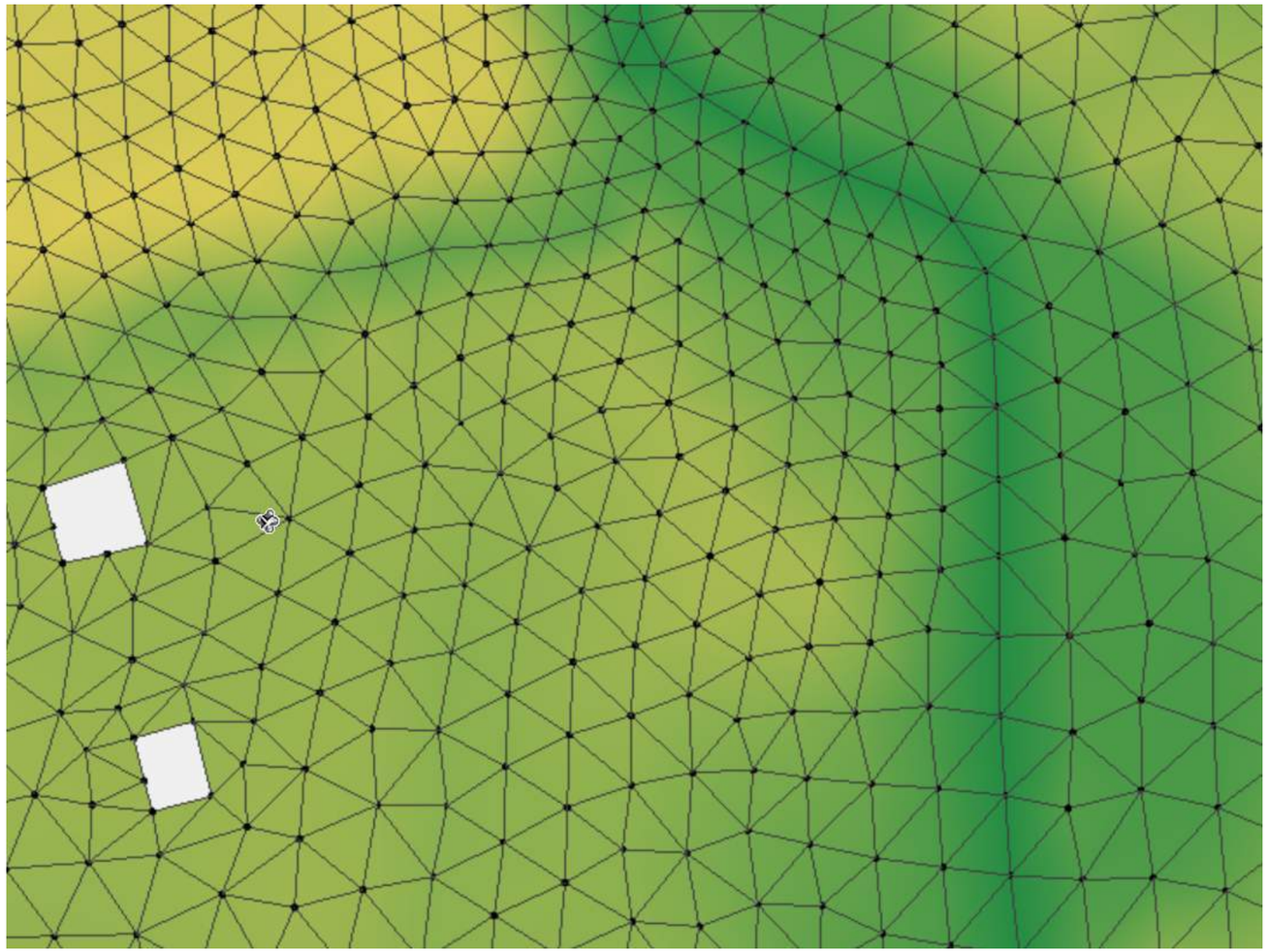
TERRAIN

- Elevation Datum
- Merging data sources
- Necessary resolution
- Dealing with missing data
- Check min/ max



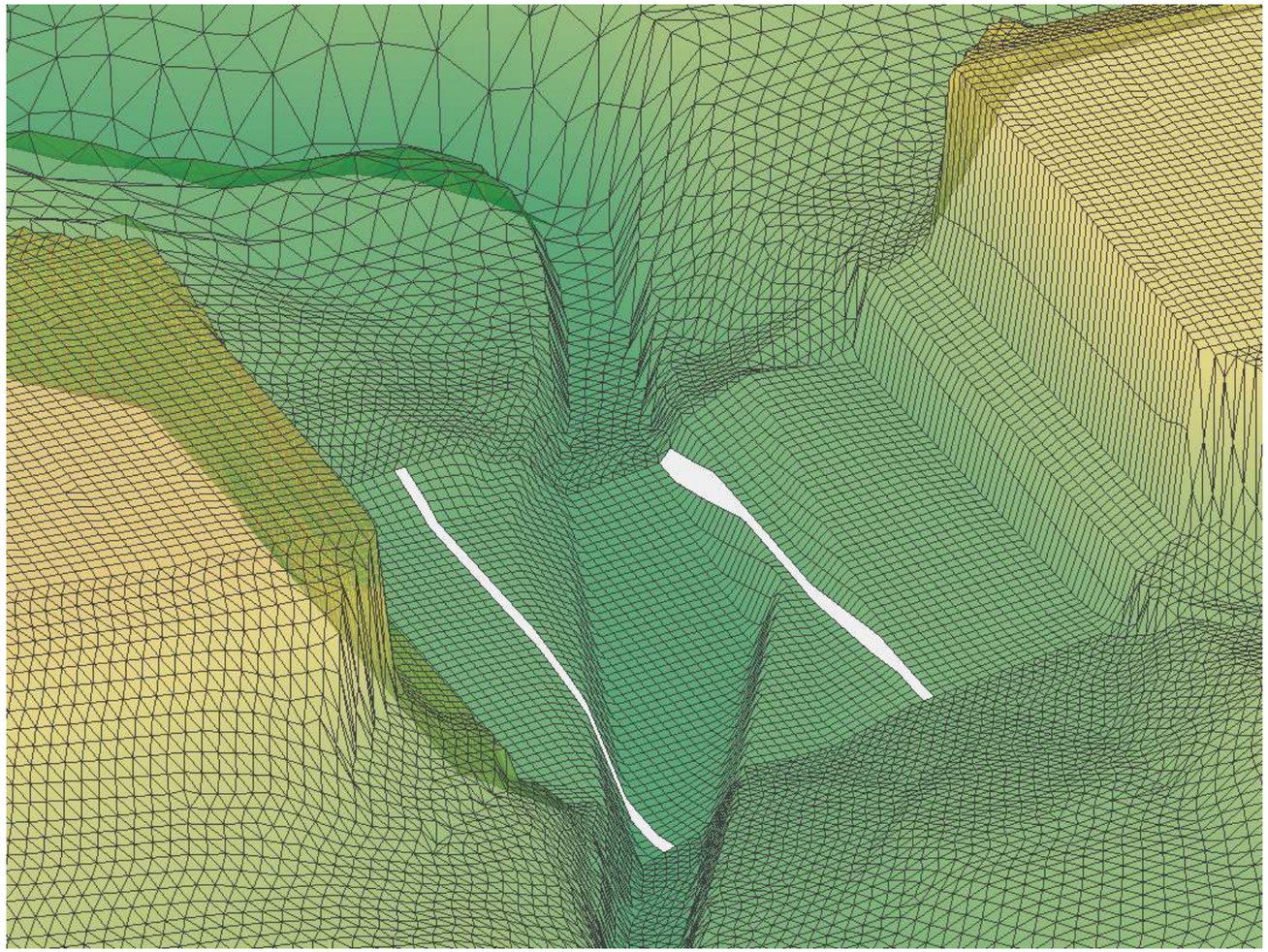
MESH

- Extents
  - Upstream / downstream
  - Inundation
- Resolution
- Number of elements
- Mesh quality
  - Size transitions
  - Angles
- Maximum slope
- Holes in the mesh



STRUCTURES

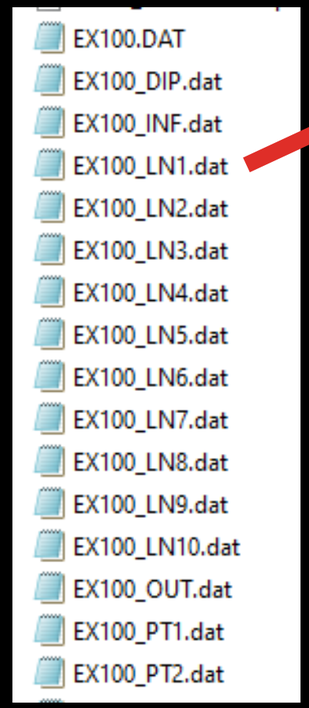
- Vertical faces
- Snapping pressure flow to grid
- Representing piers:
  - Mesh holes (best)
  - Obstructions (ok-ish)
  - Roughness (kind of bad)
  - Neglect (Not OK)
- Culverts and HY-8

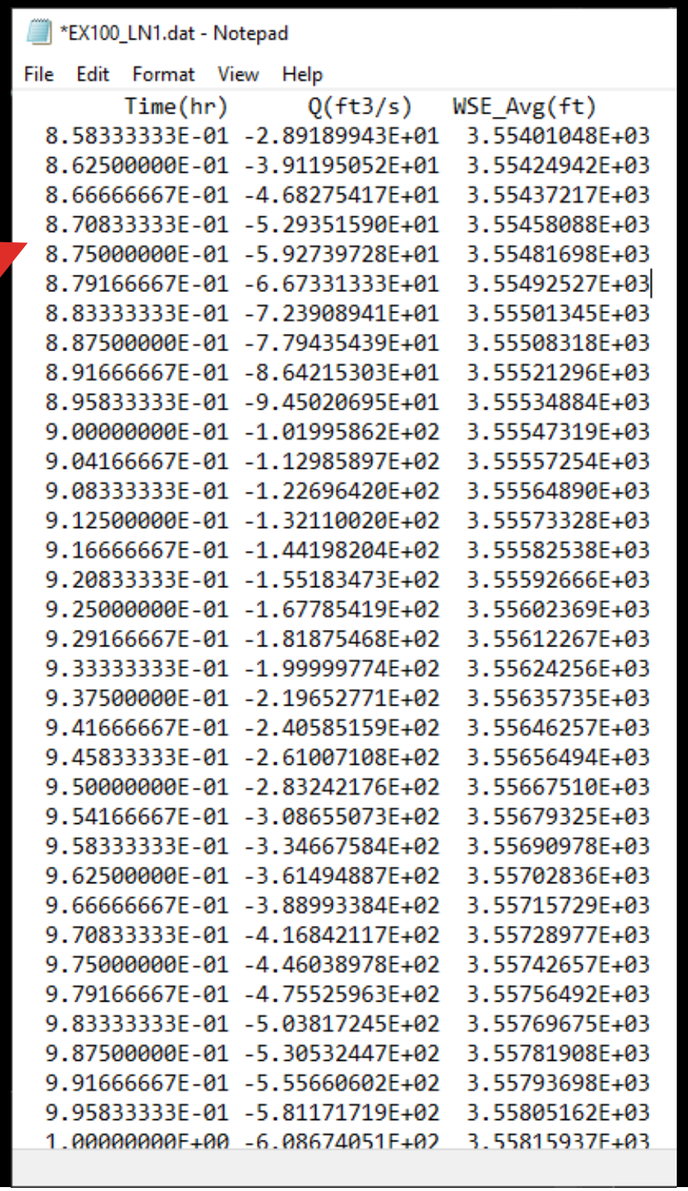


DO RESULTS EQUAL ANSWERS ?

- Stability and Convergence
- Monitor points
- Monitor Line

- Continuity
- Steady state





*EX100_LN1.dat - Notepad

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8.95833333E-01	-9.45020695E+01	3.55534884E+03
9.00000000E-01	-1.01995862E+02	3.55547319E+03
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9.83333333E-01	-5.03817245E+02	3.55769675E+03
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9.95833333E-01	-5.81171719E+02	3.55805162E+03
1.00000000E+00	-6.08674051E+02	3.55815937E+03

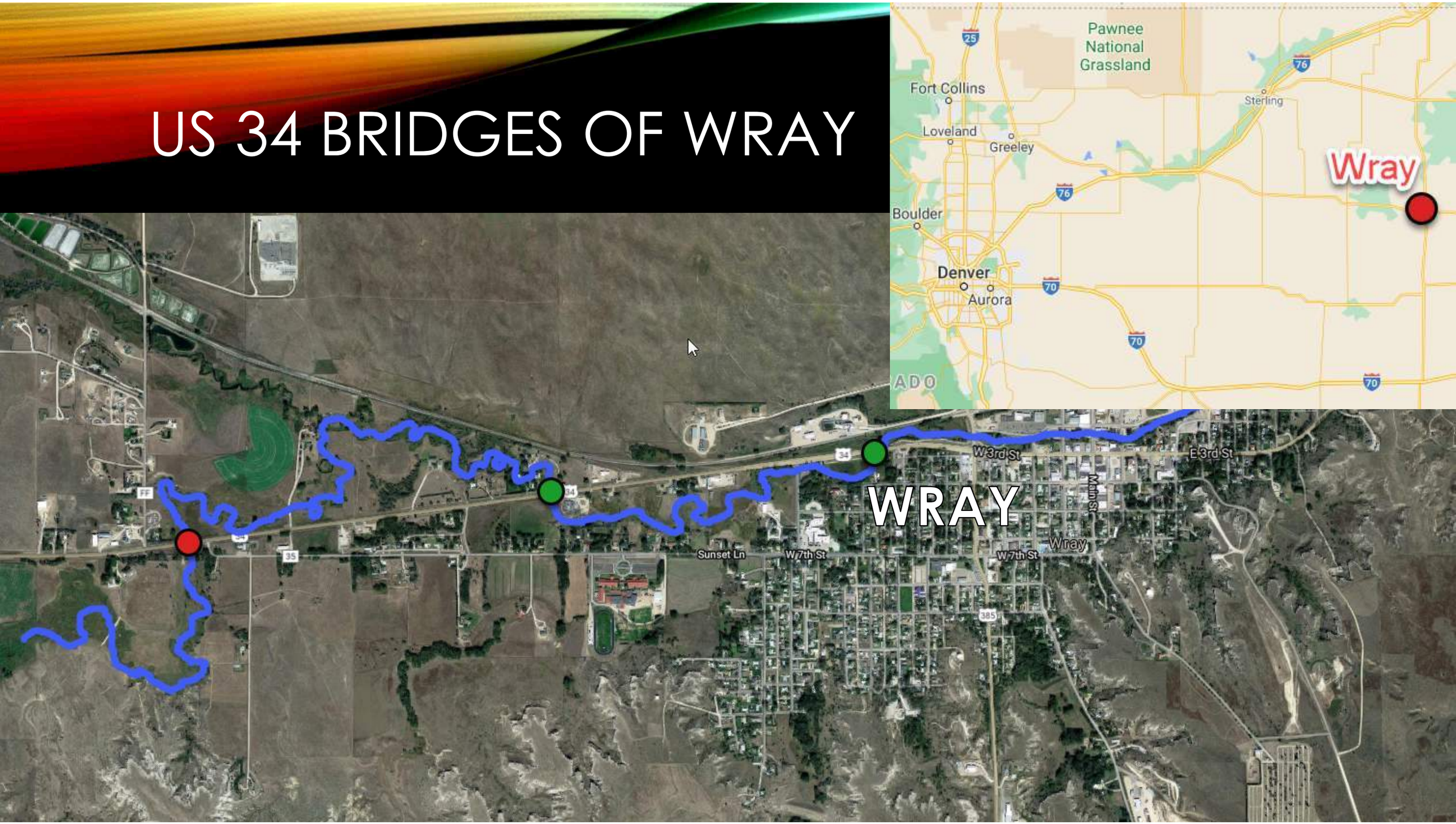
RESOURCES

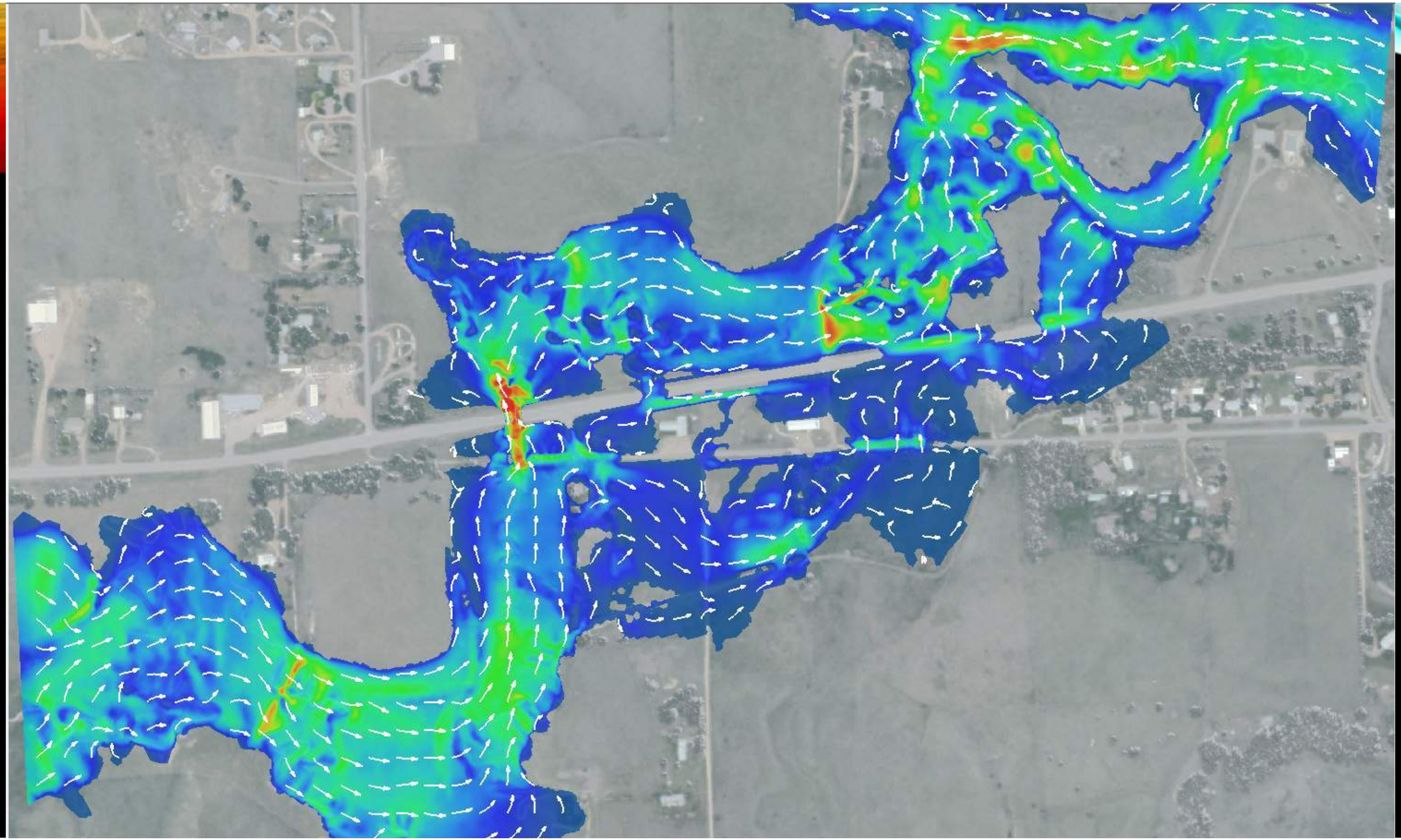
- CDOT Region 4 SRH-2D QC Checklist
- FHWA SRH-2D QC Checklist
- NHI Course 135095
- Bi-Monthy Webinars – Scott Hogan, FHWA
  - https://www.fhwa.dot.gov/engineering/hydraulics/

CASE STUDY: D-27-G

- Timber Bridge replacement
- Wray, CO (Eastern Colorado)
- Assumed Design: Two Span bridge

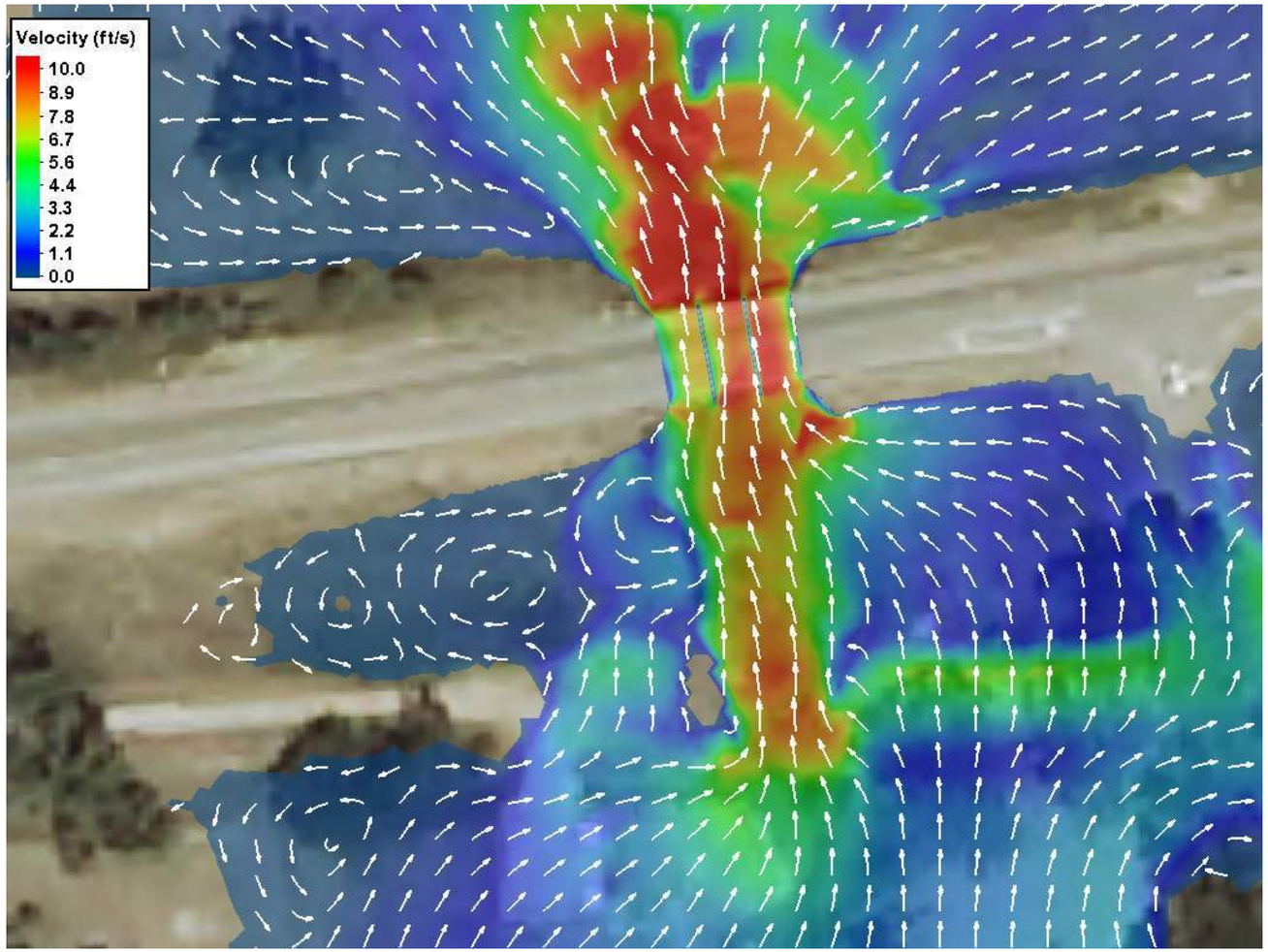
US 34 BRIDGES OF WRAY





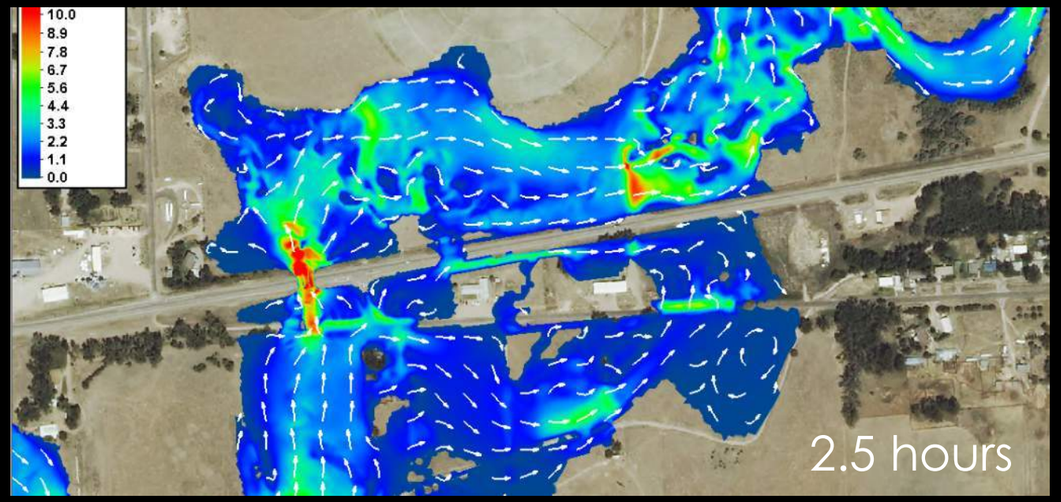
EXISTING CONDITIONS

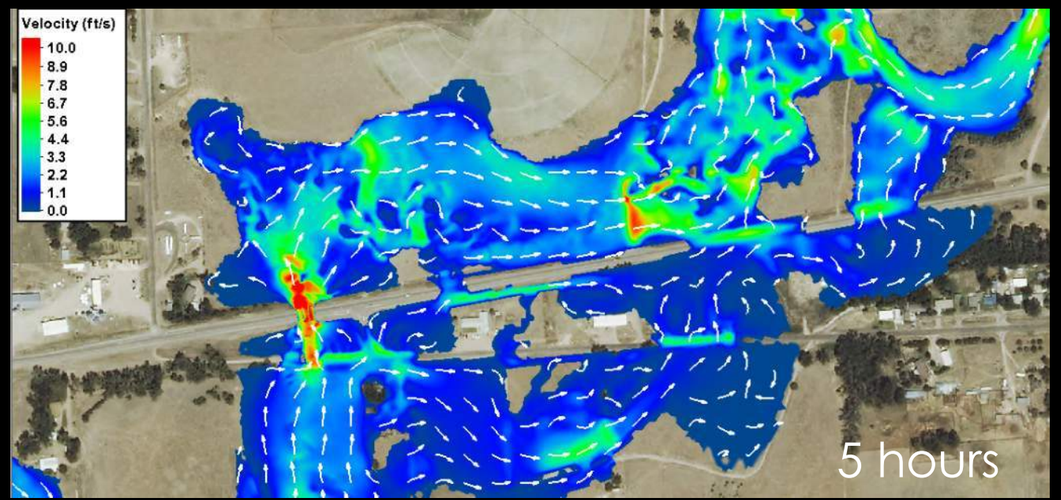
- Timber Bridge
- Three 24-foot spans
- Wall piers



CDOT MODEL REVIEW

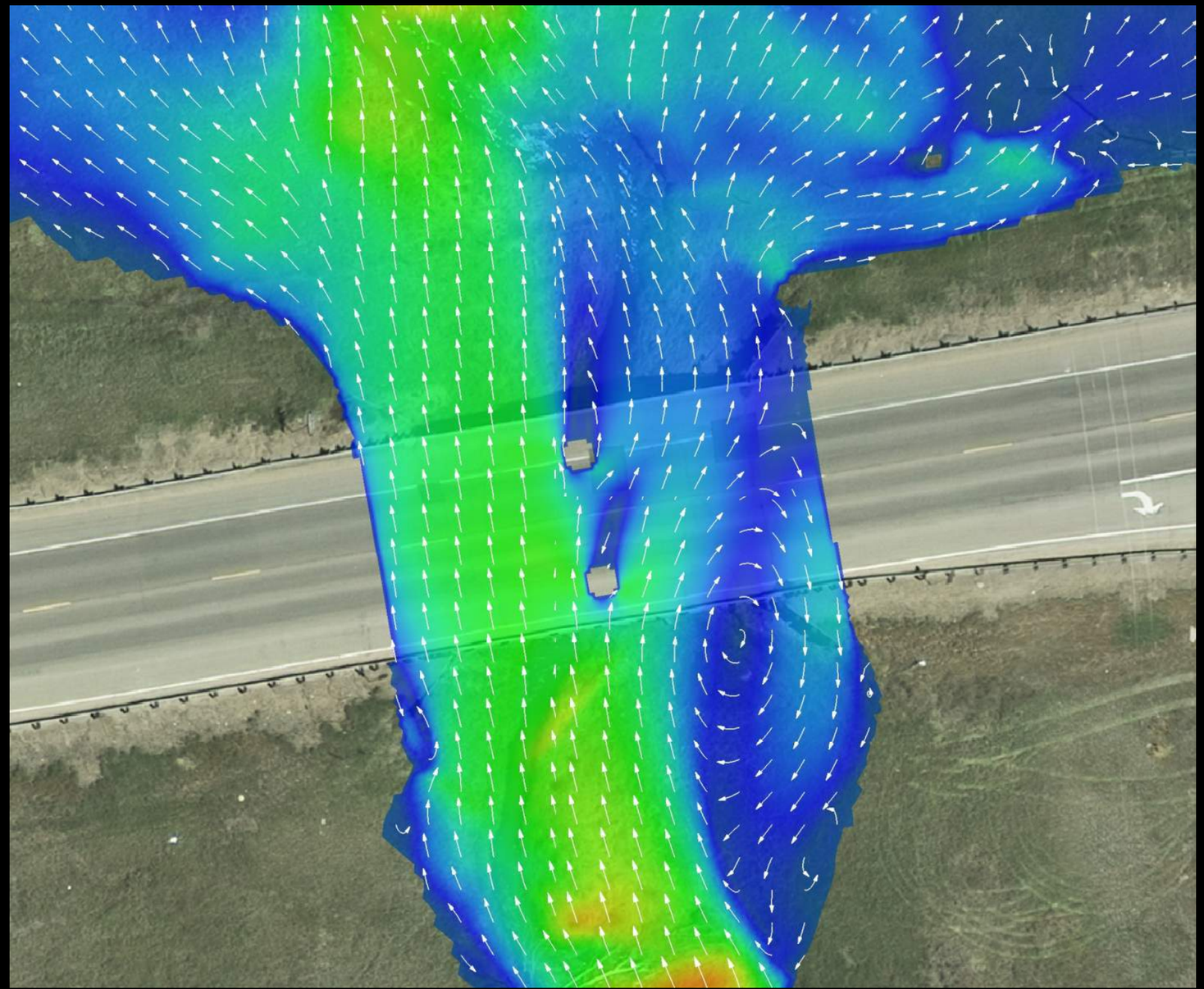
- Questioned source of terrain data
- Minor mesh quality issue
- Water touched model extents
- Questioned roughness
- Duration of 2.5-hour insufficient→ Caught additional overtopping in 500-year event → 8-hour simulation
- Recommended additional monitor lines





2D MODEL RESULTS

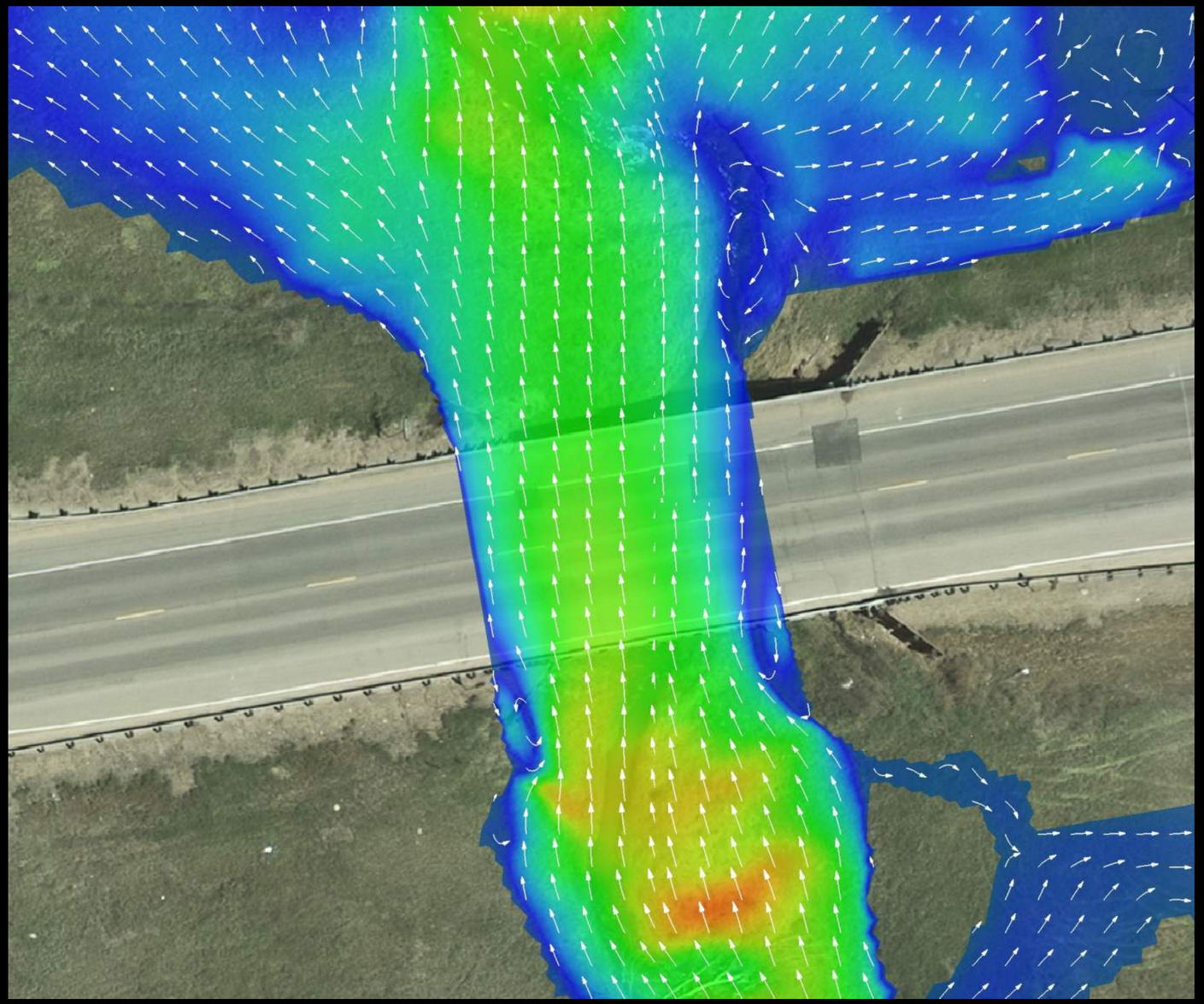
- Passes the QA Checklist
- No adverse impact
- The 112ft Two span bridge works!
- So what's wrong?



Velocity Map of 112ft, two span bridge

2D MODEL RESULTS

- Single Span, 80ft bridge
- Passes the QA Checklist
- No adverse impact
- → $400k Lower Cost



Velocity Map: 80ft single span bridge

SUMMARY

- Review checklist
- Avoid mistakes
- Save money

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2-D Hydraulic Model Review Checklist

Project: _____ **Reviewer:** _____

River: _____

Project Purpose: _____ **Date:** _____

#	Item	Comment	Action Needed	Screen Shot
1	**Data**			
2	Project Vertical Datum			X
3	Project Horizontal Datum			X
4	Does final surface accurately represent site (are hydraulic controls represented)			
5	**Topography**			
6	Source/Date			
7	Stated Accuracy			
8	Datums verified			
9	**Bathymetry**			
10	Source/Date			
11	Datums verified			
12	**Additional Survey**			
13	Source/Date			
14	Datums verified			
15	**Bridge/Culvert/Structure Data**			
16	Source/Date			
17	Datums verified			
18	**Mesh**			
19	Is the upstream mesh limit sufficient			
20	Is the downstream mesh limit sufficient			
21	Are the lateral extents sufficient			
22	Does mesh accurately represent the site (are hydraulic controls represented)			
23	Is mesh quality sufficient			
24	Source of material types (imagery)			
25	Are material types correctly assigned			
26	Are appropriate n values used			
27	Is mesh size reasonable (element count)			
28	Appropriate monitor lines (# and location)			
29	**Boundary Conditions**			
30	Upstream Boundary - Verify correct inflow(s) amount and type			
31	Downstream Boundary - Verify correct stage and type			
32	**Structures**			
33	**Bridge**			
34	Is bridge geometry correct			
35	Are pier locations correct			
36	Are piers modeled correctly			
37	Is pressure flow accounted for correctly			
38	**Culvert**			
39	Is culvert correctly represented			
40	**Other Structures**			
41	Is structure correctly represented			
42	**Hydraulic Analysis**			
43	Are simulation settings reasonable			
44	Verify steady state conditions			
45	Verify continuity			
46	Do results contain any oddity's			

47	Does model calibrate to known data			
48	**General Comments**			
49				
50				
51				
52				
53				

Project (Sub-Account and Description)	23010 Eastern Timber BR
Model Run	100 yr Existing
Str # and/or Reach	G-21-A Sand Creek
Review Date	Nov 11, 2019
Reviewer	Steven Griffin, CDOT
SMS Version	13.0.10

COLORADO
Department of Transportation

Region 4 Hydraulics Unit

SMS / SRH-2D Quality Check

Original Form (credit): Clark Barlow, Atkins
Form Revision Number: 1.0
Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
Input Review			**(Date of Response:)**	
Boundary Conditions				
Upstream Boundary Condition				
1	Does the location of the inflow boundary condition seem appropriate?			
2	Does the flowrate match the event being modeled?			
3	Are the flowrate units correct?			
4	Do the upstream boundary conditions in the BC coverage match the computed flowrates in the model as evidenced by monitoring lines, monitoring points, etc.?			
Downstream Boundary Condition				
5	Does the location of the outflow boundary condition seem appropriate?			
6	Does the input downstream water level match the event being modeled?			
7	Are the water level elevation units correct?			

Model Run	100 yr Existing
Str # and/or Reach	G-21-A Sand Creek
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Department of Transportation

Region 4 Hydraulics Unit

SMS / SRH-2D Quality Check

Original Form (credit): Clark Barlow, Atkins
Form Revision Number: 1.0
Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
8	Does the downstream boundary condition in the BC coverage match the water surface elevation shown in the model at the model boundary? (As evidenced by the output data)			
9	Are the locations of the Monitor Lines and Monitor Points sufficient and appropriate?			
Hot Start File				
10	Is the correct hot start file being used?			
11	Is the hot start file working?			
Terrain				
12	Are the correct scatter sets or terrain image data being interpolated to the mesh?			
13	Are there any outliers in the scatter data (e.g. zero value elevations, high or low values relative to surroundings)?			

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SMS / SRH-2D Quality Check

Original Form (credit): Clark Barlow, Atkins
Form Revision Number: 1.0
Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
14	Does the scatter set triangulation seem reasonable?			
15	Have breaklines been employed where necessary?			
16	Was the correct priority assigned when merging scatter sets (if applicable)?			
17	Does the merged surface contain any artificial artifacts from the merge? Significant "ledges" or drops in elevation across the merging boundary, etc.?			
18	Is the terrain extent sufficient to cover the modeling domain?			
19	Are the elevation units in the terrain data correct?			
Mesh/Geometry				
20	Are all significant mesh quality checks satisfied?			

Model Run	100 yr Existing
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SMS / SRH-2D Quality Check

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Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
21	Are minimum and maximum element sizes appropriate throughout the model?			
22	Is the model domain sufficiently large to contain the computational extent and the desired reach?			
23	Are the roadway toes of slope, centerlines, edge of pavement, and other pertinent features correctly captured by the mesh?			
Roughness				
24	Do manning's roughness values seem reasonable?			
25	Do the boundaries and extent of material polygons seem reasonable?			
Model Control Inputs				
26	Do model control settings, particularly the time step, seem reasonable?			
27	Have other settings been introduced to maximize model run efficiency? Setting the Inflow BC to "steady" if a steady simulation etc.			

Model Run	100 yr Existing
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SMS / SRH-2D Quality Check

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Form Revision Number: 1.0
Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
Structures				
28	Is the bridge deck included, and pressurized if necessary?			
29	Are bridge abutments, retaining walls, and other bridge features represented appropriately?			
30	Are the bridge piers correctly represented in the mesh and materials coverage?			
31	Are all pertinent insurable structures blocked out within the mesh and unassigned via the materials coverage?			
32	Are all culverts accounted for in the model, and has the culvert definition (arcs, HY-8 input) been verified?			
33	Have other hydraulic structures (irrigation ditches, offtake gates or weirs, other features) been appropriately modeled?			
Model Calibration				
34	Are any external references to aid in calibration and tie-ins present? Cross-section locations, previous model results, observed WSE, etc.			
Output Review				
Numerical Health				
35	Are there any warnings/messages in the SRH-2D output file?			
36	Has a steady state solution been reached? Do the INF file, monitor line/point files, HY output file, demonstrate convergence of the model?			
Depths/Water Surface Elevations				

Model Run	100 yr Existing
Str # and/or Reach	G-21-A Sand Creek
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Region 4 Hydraulics Unit

SMS / SRH-2D Quality Check

Original Form (credit): Clark Barlow, Atkins
Form Revision Number: 1.0
Form Revision Date: November 2019 by Steven Griffin

Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item
37	Are there any abnormally high or negative depth values?			
38	Are extracted water surface elevations accurate?			
Flowrates				
39	Are extracted flowrates accurate?			
Velocities				
40	Are there any abnormally high velocities? Any negative velocities?			
Froude Number				
41	Do Froude Numbers appear reasonable?			
Data Set Comparisons				
42	Is there good "data hygiene" in the model? (Are different data sets easily distinguished from one another, are there old model runs that need to be cleaned up or deleted, etc.)			
43	Are pertinent data sets (i.e. Existing vs. Proposed) able to be directly compared via the data calculator or other appropriate method?			
Other Notes				

Model Run	100 yr Existing
Str # and/or Reach	G-21-A Sand Creek
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Region 4 Hydraulics Unit

SMS / SRH-2D Quality Check

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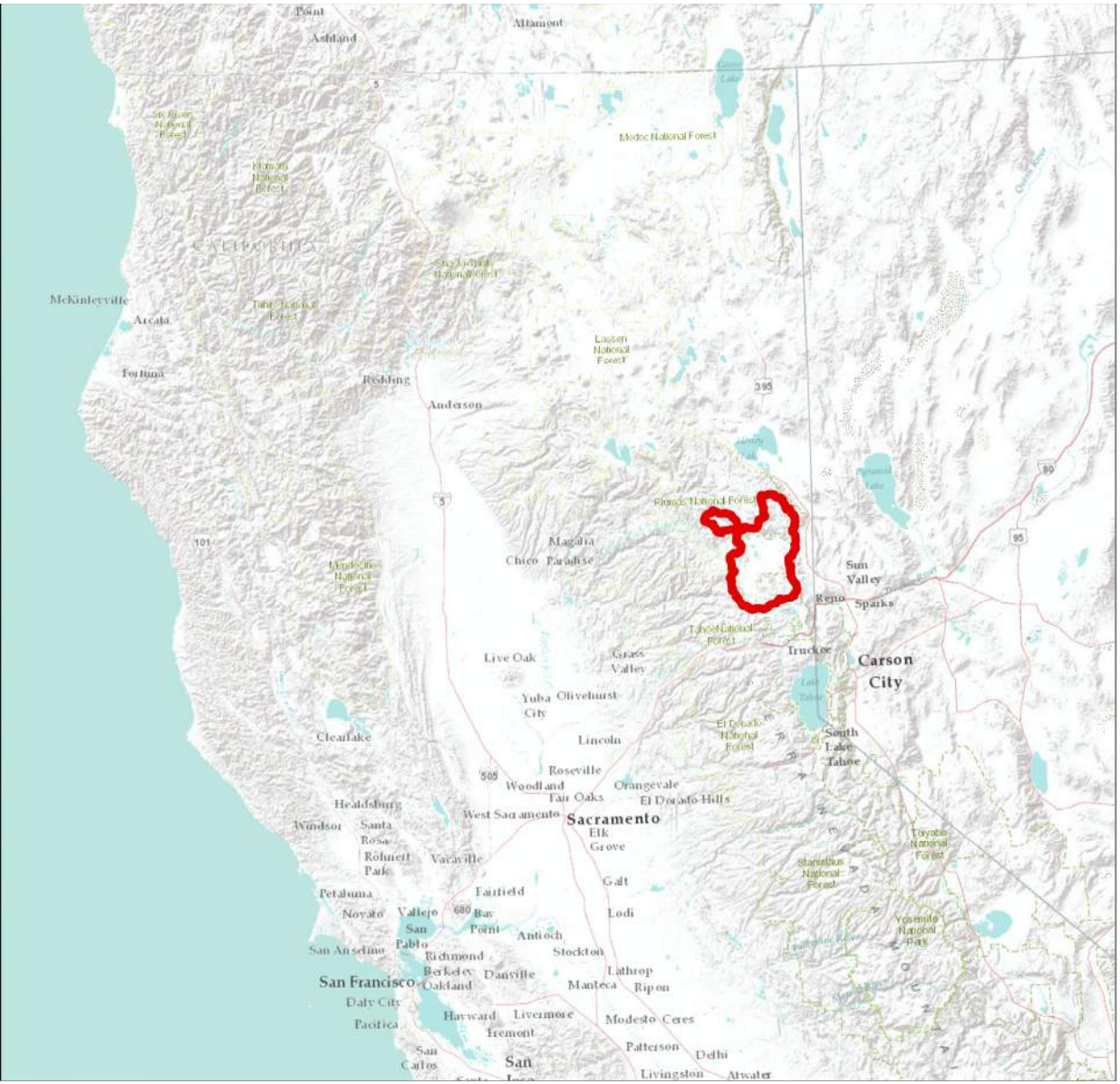
Comment Number	Review Item	QC Comments	Designer Response	Follow Up Review Item

AECOM Imagine it. Delivered.

HEC-HMS + HEC-RAS 2D for Rain-on-Snow-on-Grid with Uplands, too!

Case Study in the Sierra Valley, CA

September 30, 2020



Sierra Valley?

- Approximately 50 miles NW of Reno, NV & 140 miles NE of Sacramento, CA
- Leeward slope of the Sierra Nevada range, mountains on all sides
- Surrounded by National Forests
- Headwaters of the Middle Fork Feather River
- 586 sq. mile watershed

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Flooding History

- Driven by rain-on-snow from atmospheric rivers during Pineapple Express events from the Pacific Ocean
- Flood of record: February 10, 2017

Annual Peak Flows for Middle Fork Feather River CDWR Gage MFP at Portola, CA

Water Year	Date	Peak Flow (cfs)
2017	February 10, 2017	12,891
2007	November 16, 2006	6,918
2018	March 23, 2018	6,108
2019	March 1, 2019	5,652
2011	March 17, 2011	4,851
2016	March 15, 2016	1,649
2008	March 16, 2008	1,382
2012	March 19, 2012	1,342
2013	December 5, 2012	942
2009	March 5, 2009	881
2010	February 28, 2010	775
2015	February 10, 2015	706
2014	February 12, 2014	394

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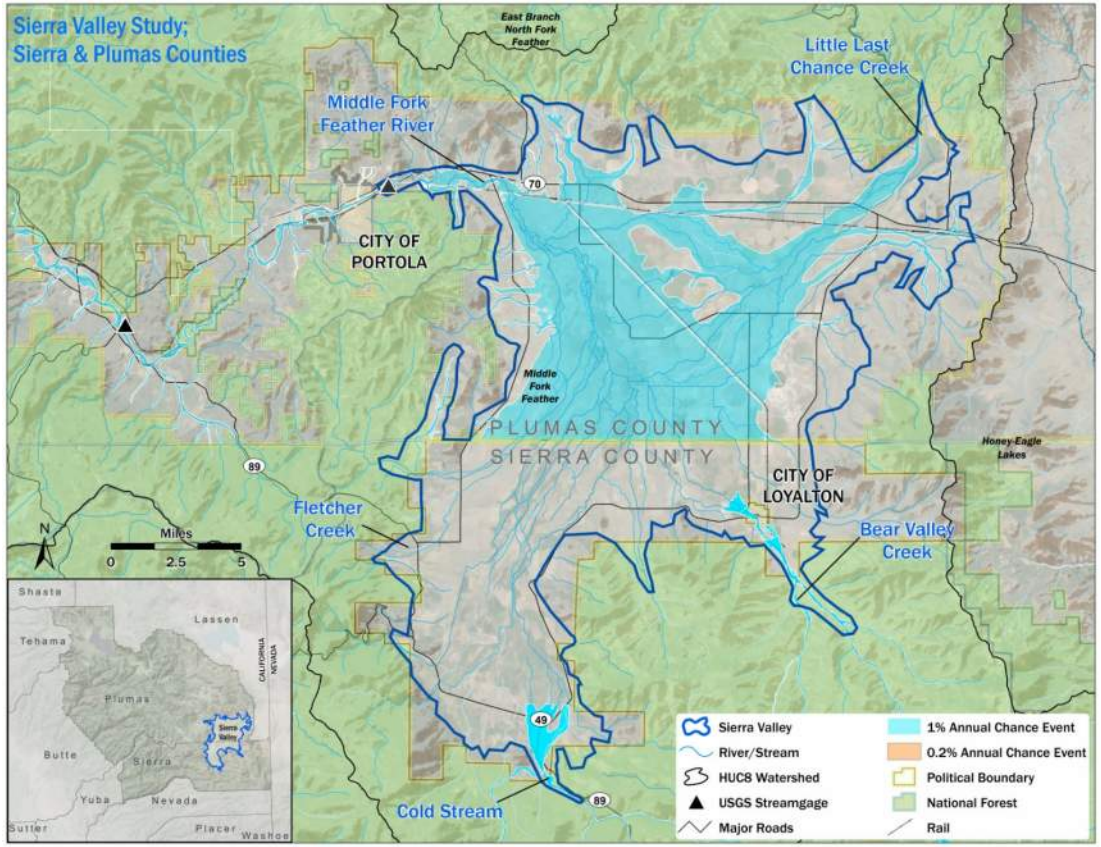
Restudy Need

Significant Community Feedback:

- “Rain-on-snow assessment in earlier study did not sufficiently represent observed floods of record.”
- SNODAS predictive snow data could not be calibrated.
- Outdated Rainfall



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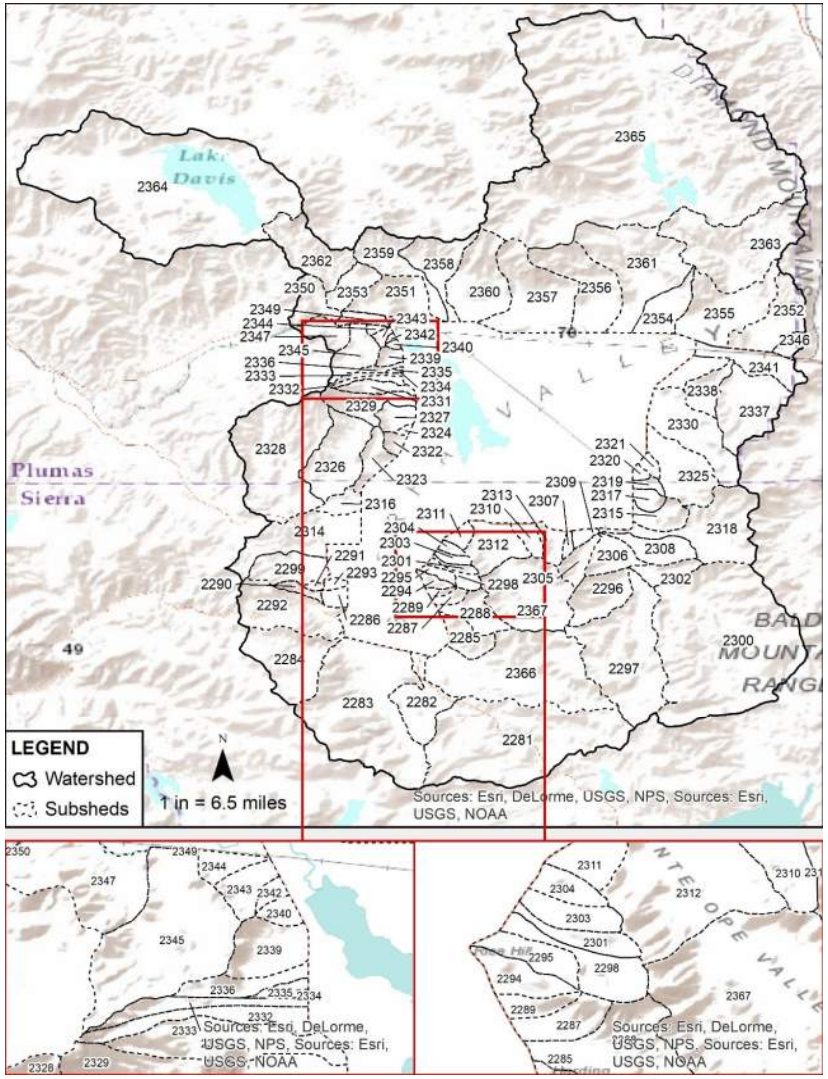
Hydrology – HEC-HMS Parameters

Uplands Hydrology

- 86 Sub-Basins
- 36% above 6,000 feet
- NOAA Atlas 14, 24-hour Gridded Rainfall
- Initial & Constant Loss
- SCS Lag transform
- Constant baseflow
- Temperature Index Snowmelt
- Muskingum-Cunge Channel Routing
- 2 Reservoirs



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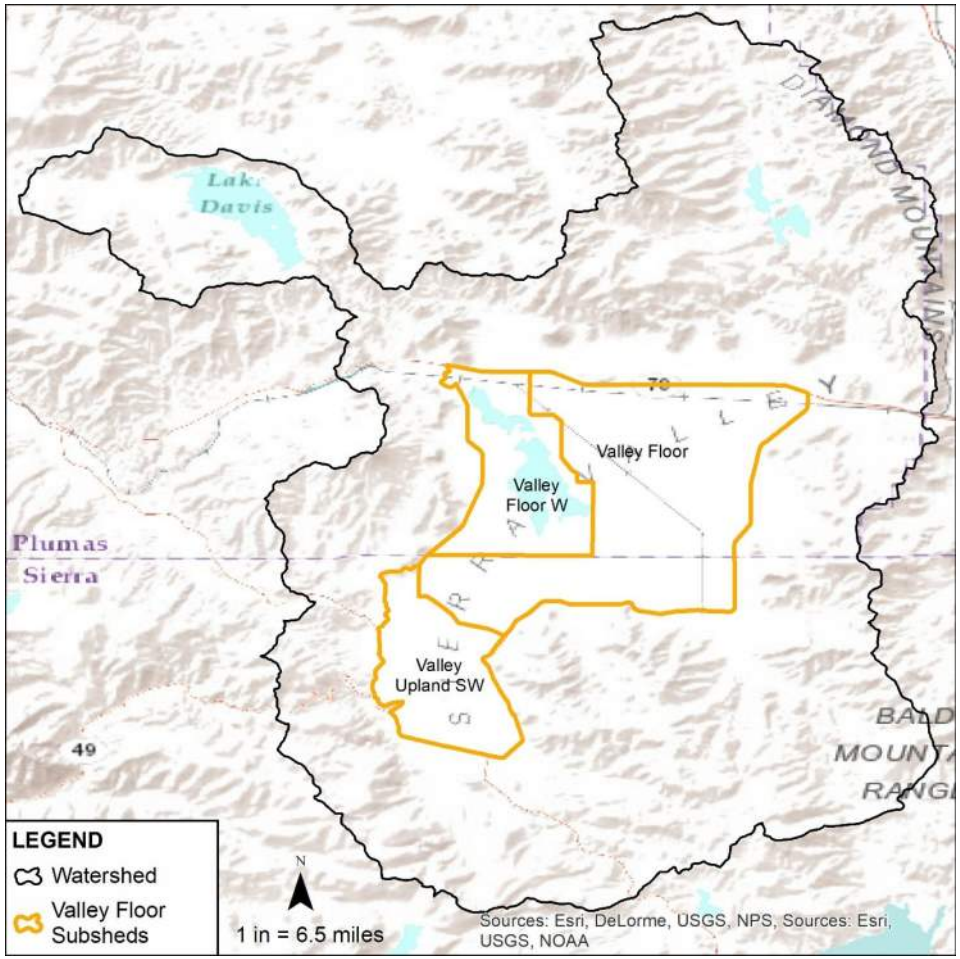
Valley Floor Hydrology

- 3 Subareas
- Very Flat topography
- NOAA Atlas 14 24-hour Gridded Rainfall
- Initial & Constant Loss
- Constant Baseflow
- Temperature Index Snowmelt
- No Routing



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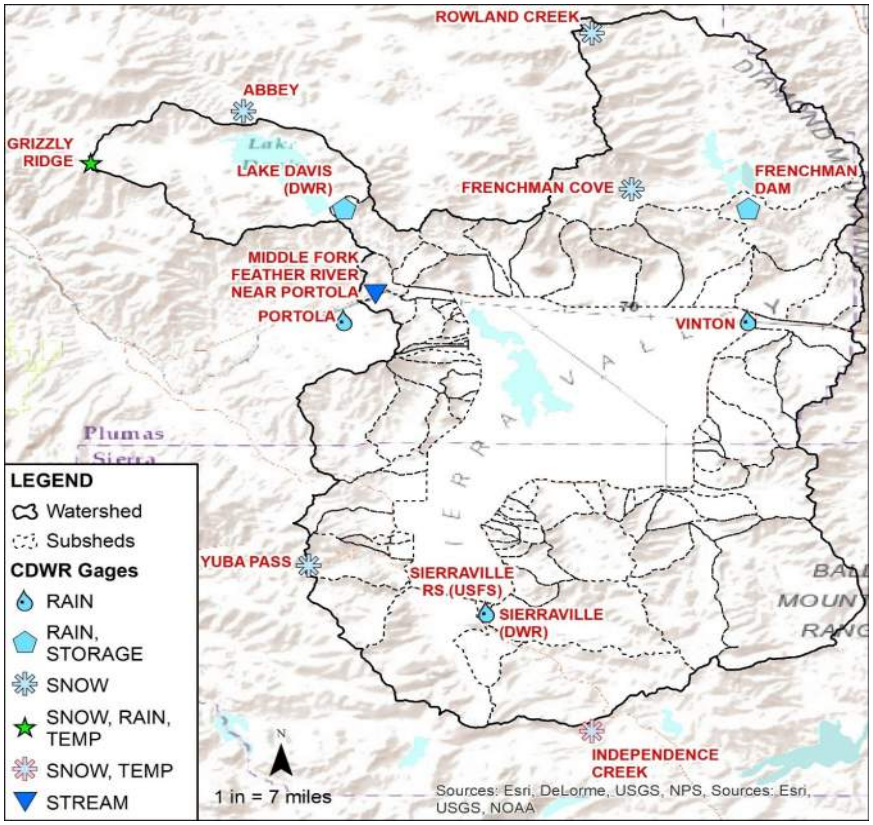
Source Data – 13 CDWR Gages!



Gage Name	Gage ID	Elevation (feet)	Rain, Incremental (inches, daily)	Rain, Accumulated (inches, hourly)	Snow, Depth (inches, monthly)	Snow, Water Content (inches, monthly)	Reservoir Storage (acre-feet, hourly & daily)	Reservoir Elevation (feet, hourly & daily)	Air Temperature (deg. F, hourly)	Flow, River Discharge (cfs, 15 minute)
Abbey	ABY	5,560	--	--	1963-Present	1963-Present	--	--	--	--
Lake Davis (DWR)	DAV	5,768	1987-Present	--	--	--	1984-Present	1984-Present	--	--
Frenchman Cove	FCV	5,800	--	--	1963-Present	1963-Present	--	--	--	--
Frenchman Dam	FRD	5,517	1987-Present	--	--	--	1984-Present	1984-Present	--	--
Grizzly Ridge	GRZ	6,900	1987-Present	1984-Present	1965-Present	1965-Present			1999-Present	
Independence Creek	INN	6,500	--	1999-Present	1937-1995	1937-1995	--	--	1999-Present	--
Middle Fork Feather River Near Portola	MFP	4,850	--	--	--	--	--	--	--	2006-Present
Portola	PRT	4,850	1989-Present	--	--	--	--	--	--	--
Rowland Creek	RWL	6,700	--	--	1950-Present	1950-Present	--	--	--	--
Sierraville (USFS)	SRR	4,975	1989-Present	--	--	--	--	--	--	--
Sierraville (DWR)	SVL	4,975	1987-Present	1984-Present	--	--	--	--	--	--
Vinton	VNT	4,944	1989-Present	--	--	--	--	--	--	--
Yuba Pass	YBP	6,700	--	--	1937-Present	1937-Present	--	--	--	--

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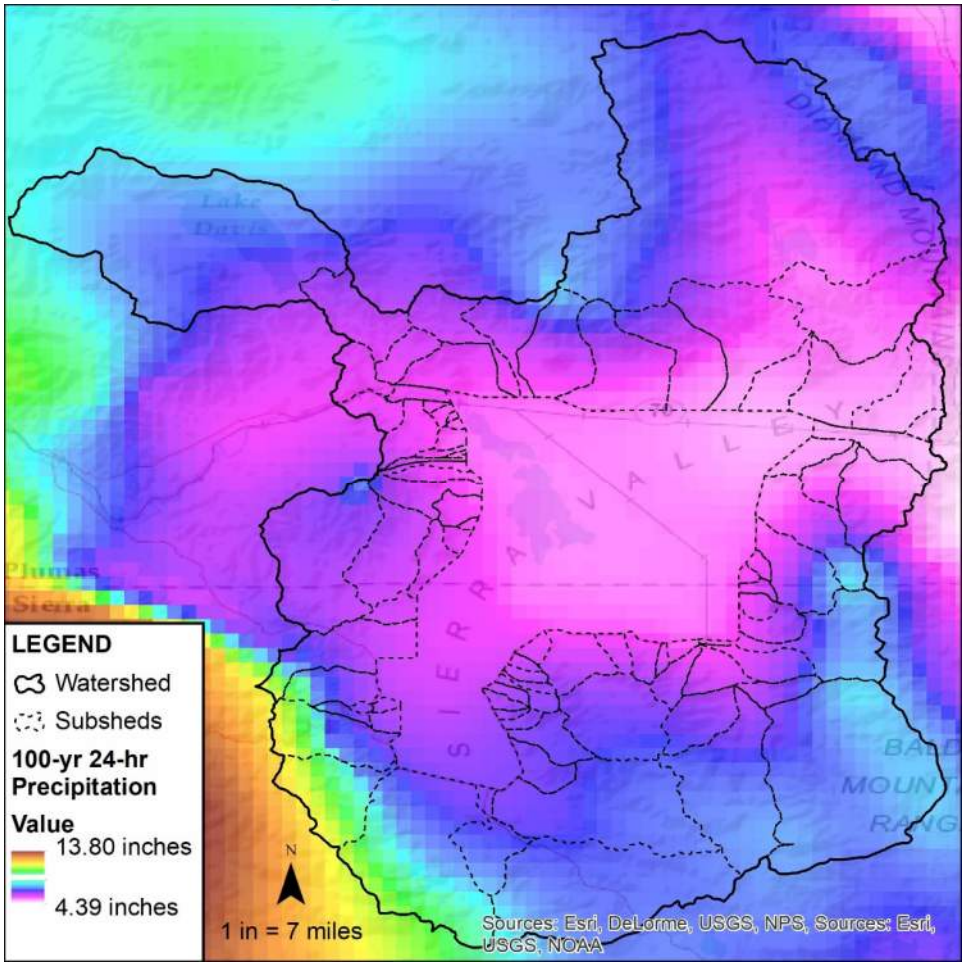
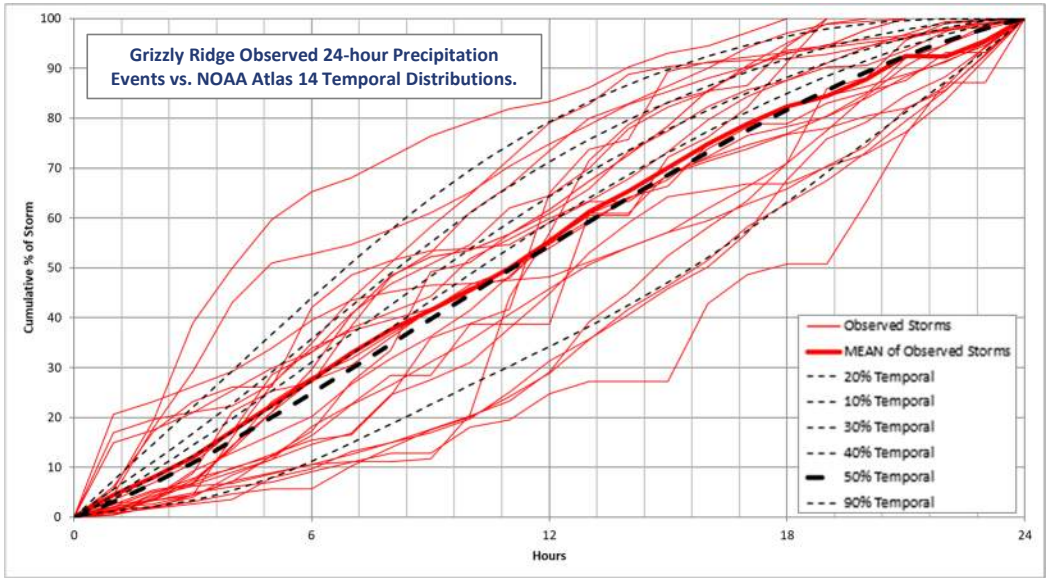
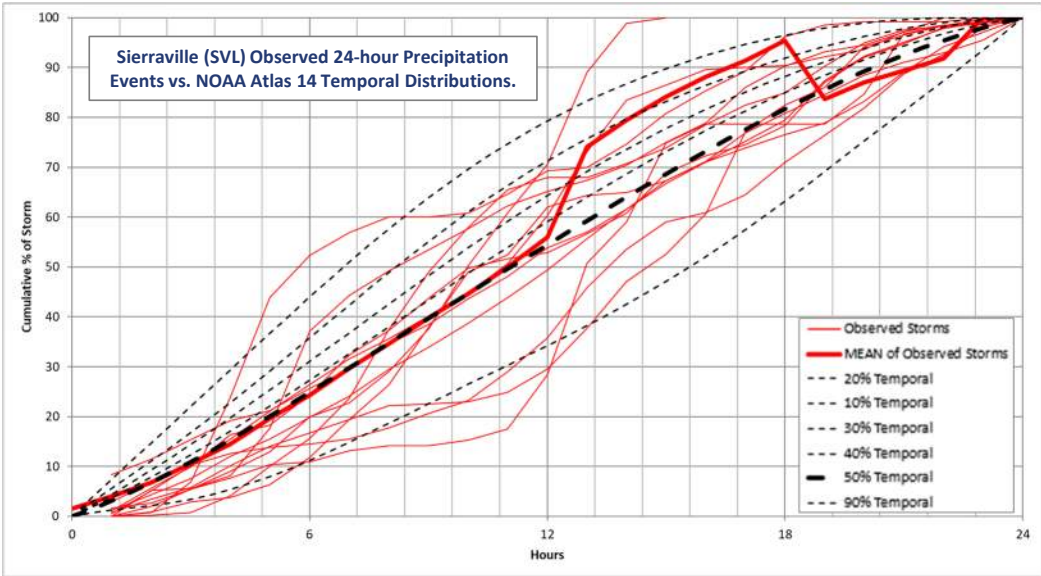
Rainfall Temporal Distribution

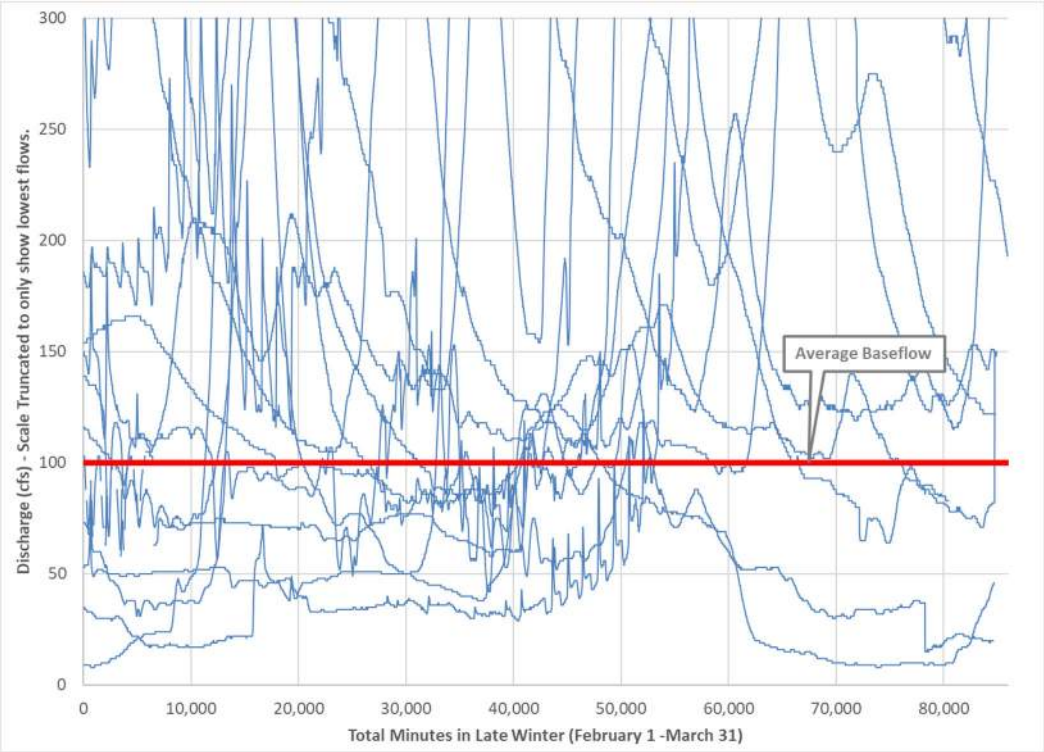


100-year, 24-hour Precipitation from NOAA Atlas 14, Volume 6.





Baseflow



- Field observations and review of stream gage record showed baseflow in the watershed
- Earlier study included it, but provided no source info
- Middle Fork Portola gage included 15-minute data
- Average baseflow visually interpreted from Late Winter record.
- Unit Baseflow = Average baseflow/watershed area = 0.17 cfs/mi^2

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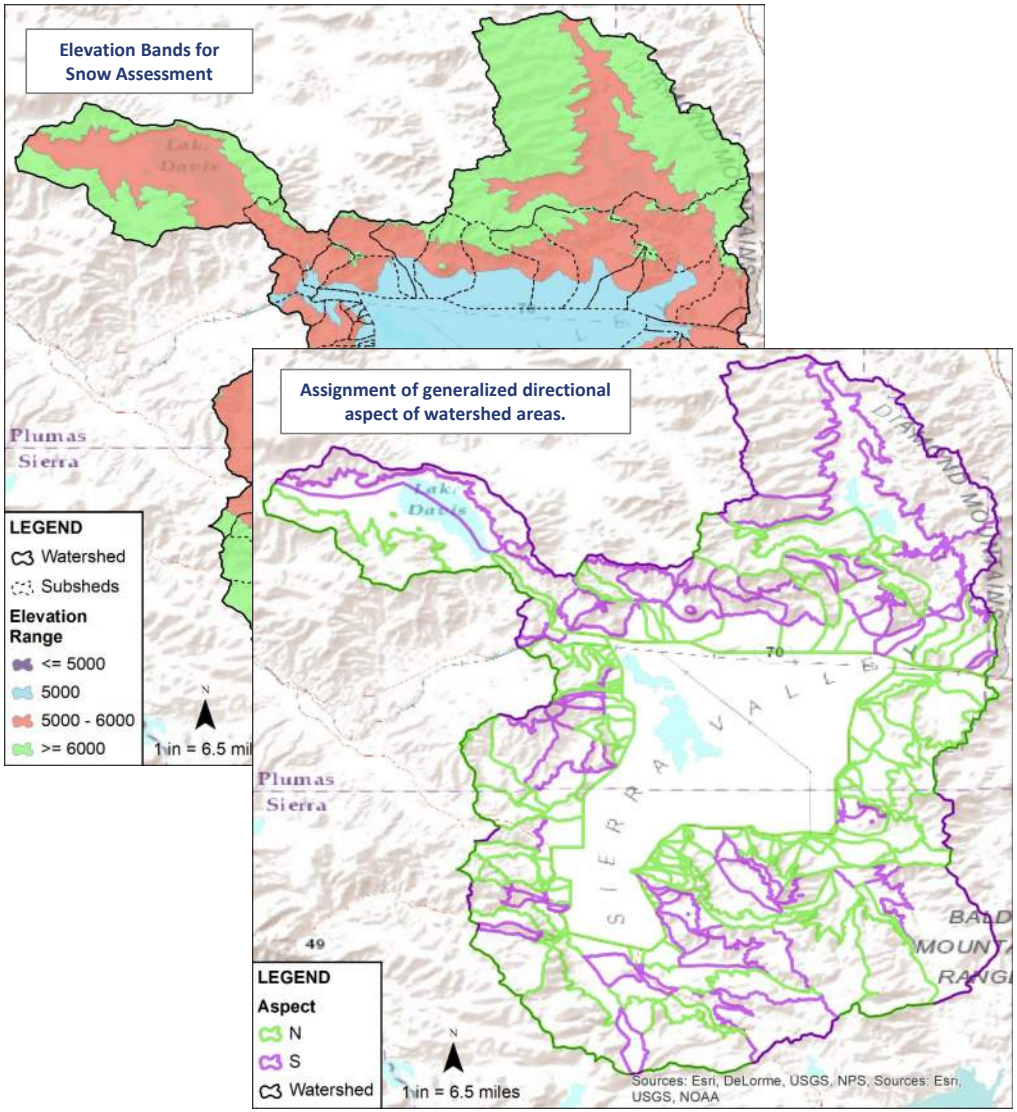
Snowmelt Inputs

Average March Snow Depth and Water Content and Dominant Aspect

Gage Name	Gage ID	Elevation (feet)	Average March Snow Depth (inches)	Average March Snow Water Content (inches)	Dominant Aspect
Abbey	ABY	5,560	31.3	10.1	North
Yuba Pass	YBP	6,700	68.1	24.8	North
Grizzly Ridge	GRZ	6,900	69.9	24.4*	North
Frenchman Cove	FCV	5,800	14.6	4.6	South
Independence Creek	INN	6,500	35.5	12.0	South
Rowland Creek	RWL	6,700	46.2	14.5	South

*Manually adjusted to 24.8 inches for use in the analysis to provide for a consistently increasing interpolation curve.

- 6 gages evenly distributed around watershed, over the elevation range, and across the dominant aspects
- Observed Average March SWE and Depth used to develop rating curves across bands
- GIS methods used to
  - Estimate Snow Water Equivalent by Elevation & Aspect, composited to each band by aspect
  - Locate Basin Centroid
- Initial Liquid Water = 0.4*Initial SWE
- Diurnal temperature series taken from 5-day period in March with widest range



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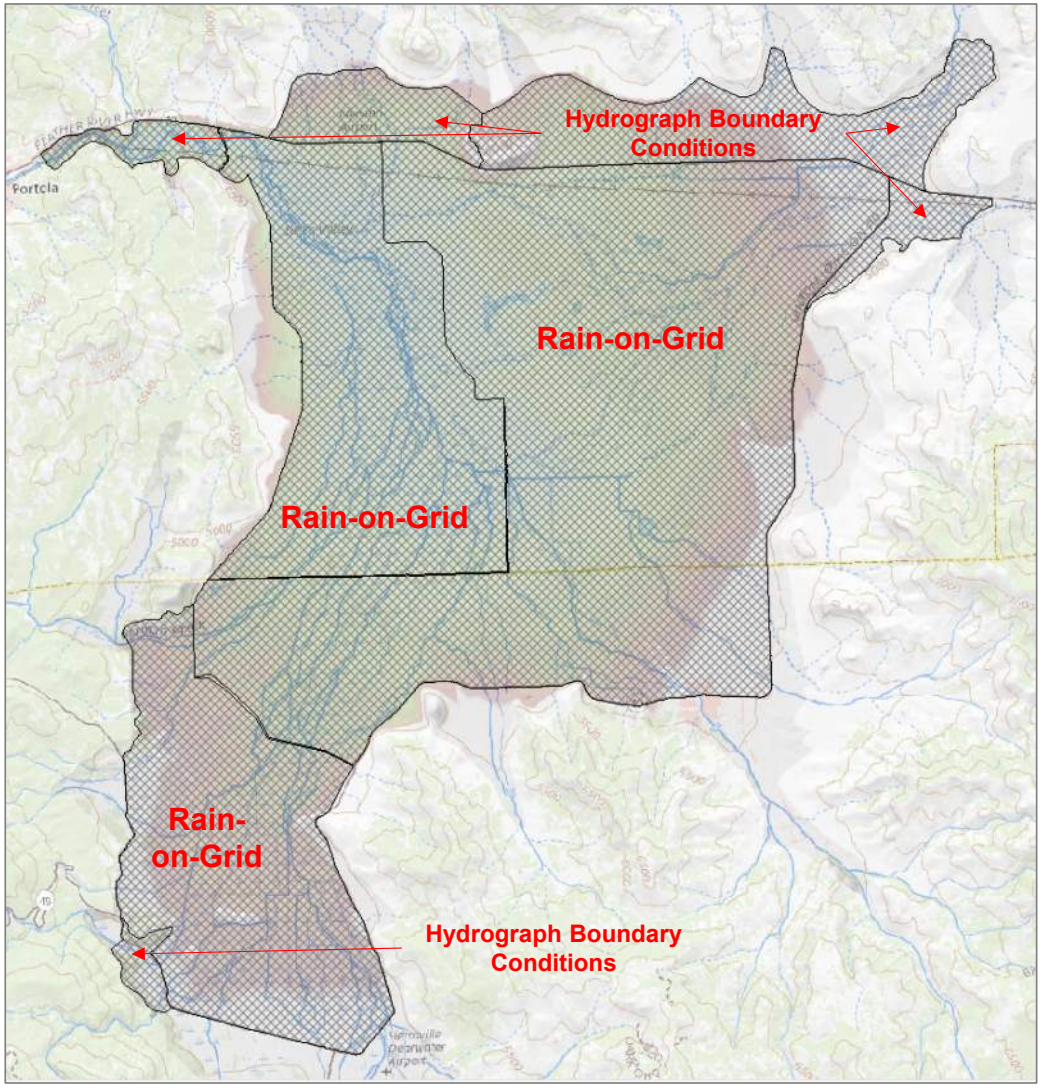
Hydraulics – HEC-RAS 2D Parameters

Mesh, Connections, Flows…

- Mesh
  - Initial 200-ft grid
  - Breaklines placed to refine mesh at channels, ridges, roadways
- Region Connections
  - Physical feature (roadway)
  - Dummy storage areas (to resolve instabilities for direct connections)
- Flows/Boundary Conditions
  - Rain-on-grid on Valley Floor
  - 68 Hydrographs from Upland basins
  - Used DSS file to connect HMS to RAS (Pro tip!)
- Adaptive timestep based on Courant number, 20 iterations
- Diffusion Wave Equation



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Calibration Parameters

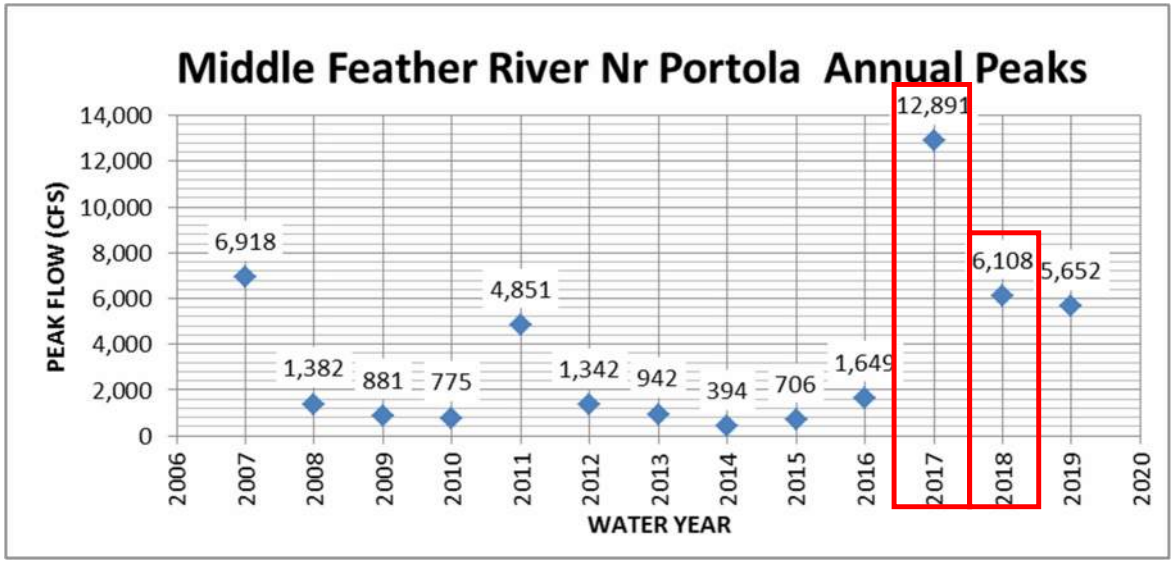
Calibration Events

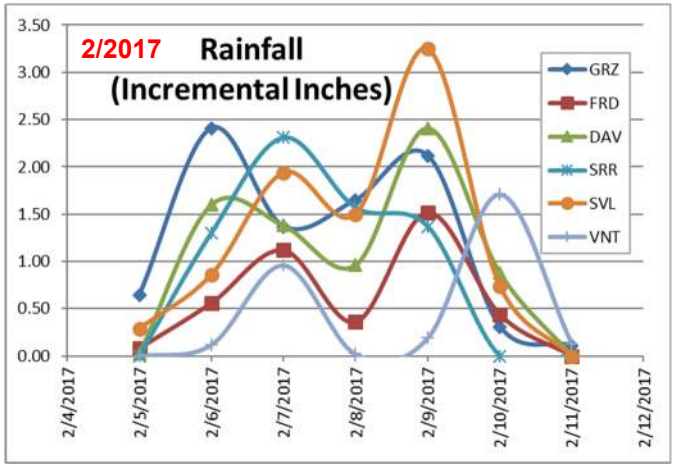
February 10, 2017

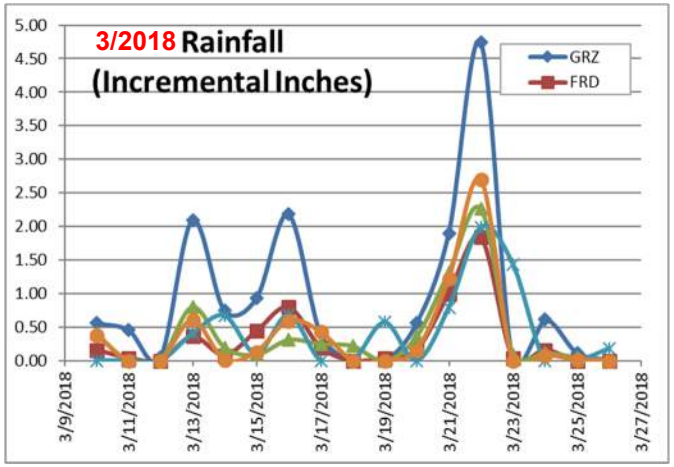
- 12,891 cfs @ MFP
- 4-12 inches total rain over 11 days
- 151-208% of February Average Snowpack
- Max temp above freezing for few days

March 23, 2018

- 6,108 cfs @ MFP
- 5-15 inches total rain over 16 days
- 17-70% of March Average Snowpack
- Max temp above freezing for 8 days







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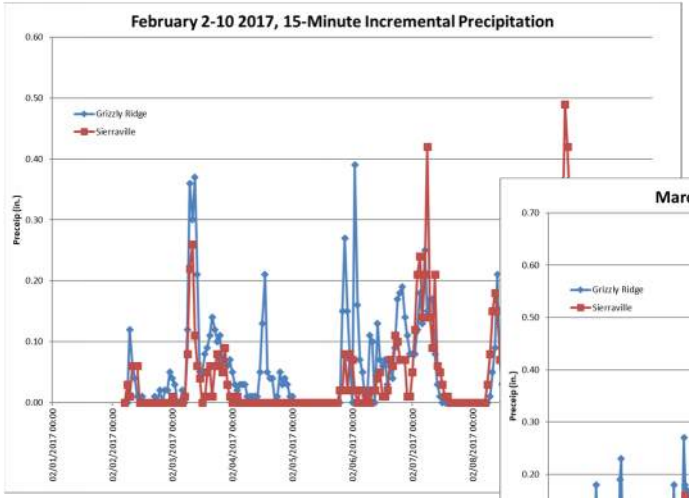
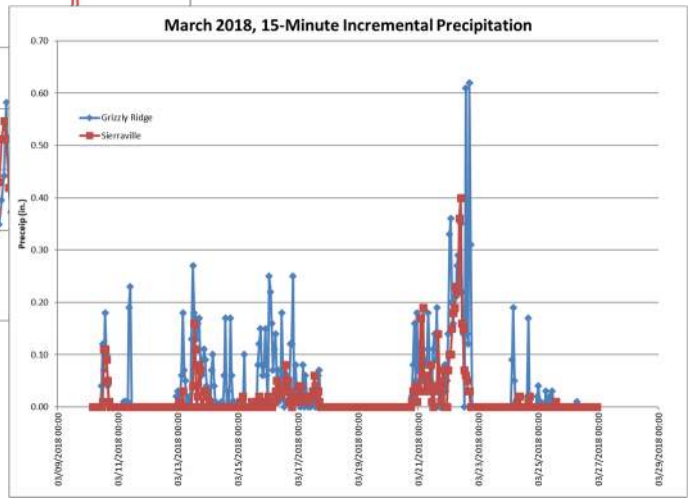
Calibration Rainfall – Unit Hyetographs

- Grizzly Ridge and Sierraville
- Accumulated data converted to incremental

- Selected storm for each calibration event
- Converted to unit hyetograph
- Used NOAA NEXRAD historical radar to review storm tracks and assign basins to gages





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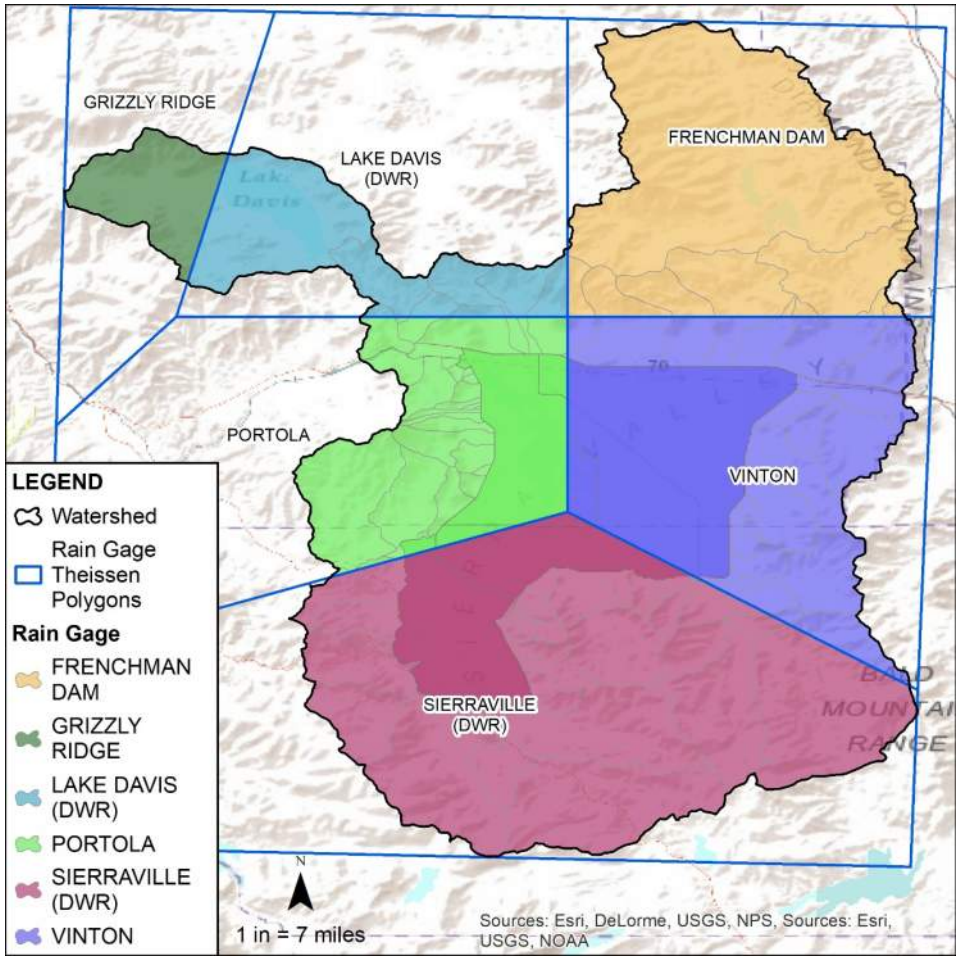
Apply Observed Gage Data

- Rainfall
  - Theissen Polygons used to spatially distribute gages to basins (GIS tool!)
  - Estimate total basin rainfall
  - Develop basin-specific hyetographs
- SWE, temperature applied directly using same methods as frequency events
- Baseflow event unit flow calculated and applied
- Reservoir storage; no outflow



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Run the models! Both of them! Iterate!

- Calibrating to observed flow at MFP Portola
- Use Constant Infiltration, the land-use and soil-based parameter to calibrate

(Everything else from observed info!)

Ultimately…..

- Reduced Constant Infiltration to 20% of original value
- Consistent with literature review for winter conditions

Winner! We're calibrated!

Comparison of Observed Peak Flows (cfs) to Calibrated Model Flows

Calibration Storm	Middle Fork Feather River near Portola (MFP)	Hydraulic Model	Percent Difference
February 2017	12,891	12,255	4.9
March 2018	6,108	5,728	6.2

Comparison of Observed Peak Volumes (ac-ft) to Calibrated Model Volumes

Calibration Storm	Middle Fork Feather River near Portola (MFP)	Hydraulic Model	Percent Difference
February 2017	113,320	103,501	8.7
March 2018	44,963	44,431	1.2

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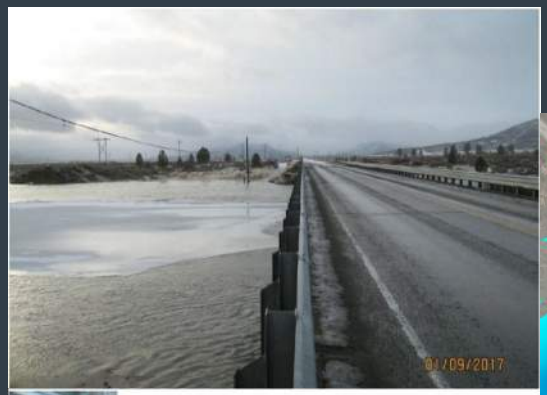
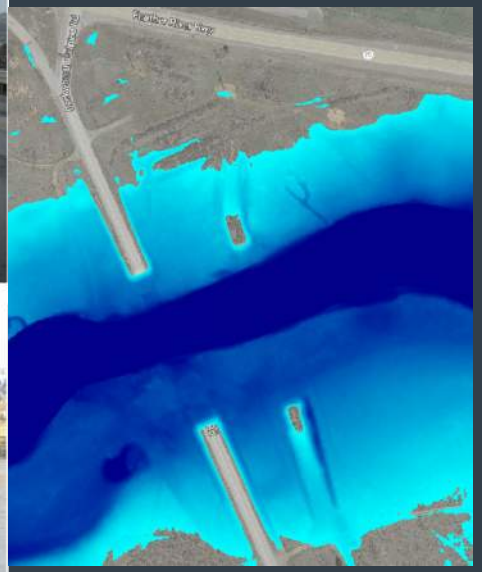
Validation

Flooding at the A-23 Bridge Over the Middle Fork Feather River





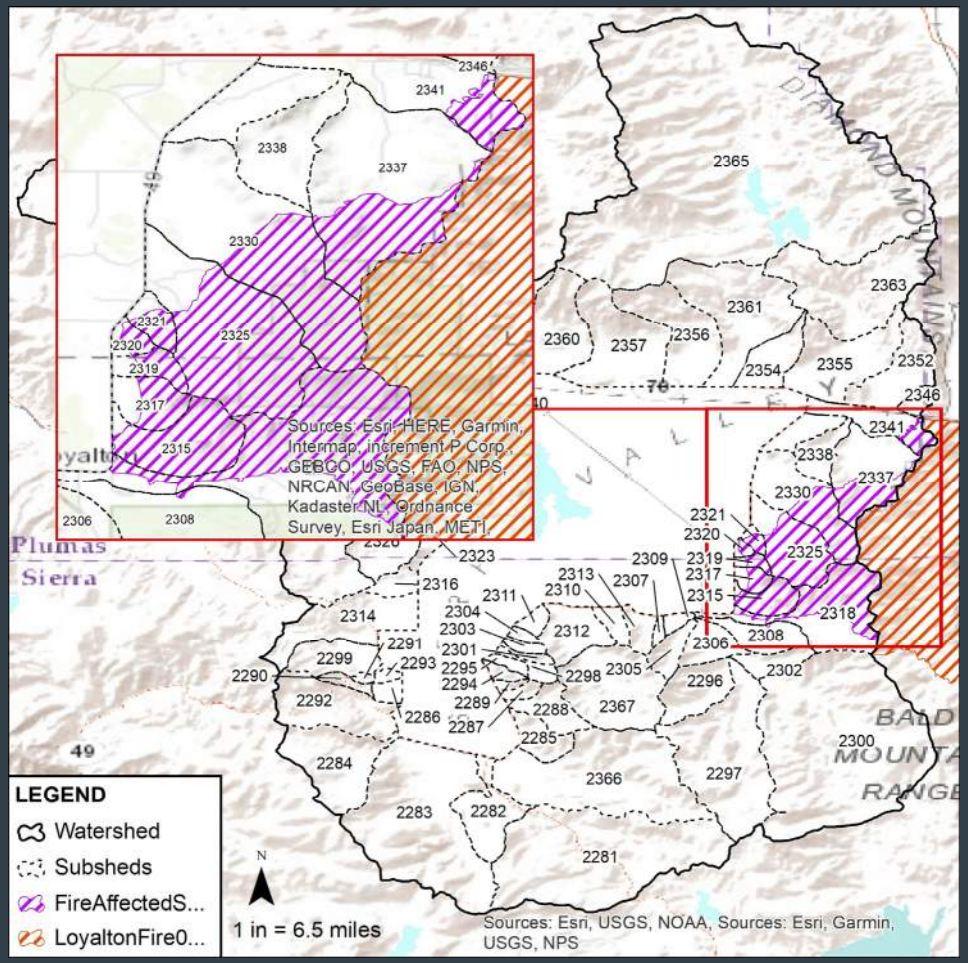
Widespread Flooding at along Harriet Lane

AECOM

What's next?

Possible Post-Fire Analysis…

20 sq. miles burned in the Loyalton fire in August



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Questions?
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Thank you!

Kimberley.Pirri@aecom.com
Lead Hydrologist

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Imagine it.
Delivered.