IMPROVING PUBLIC SAFETY AT LOW HEAD DAMS IN COLORADO

by: Andrew Earles, Ph.D., P.E., D.WRE, Karl Kingery, P.E. and Sarah Zimmer, Wright Water Engineers, Inc.

Bill McCormick, P.E., P.G., Head Dam Safety Branch, Colorado Division of Water Resources

Alex Alma and Amy Moyer, Colorado Parks and Wildlife

CASFM 2020 Annual Conference

Introduction

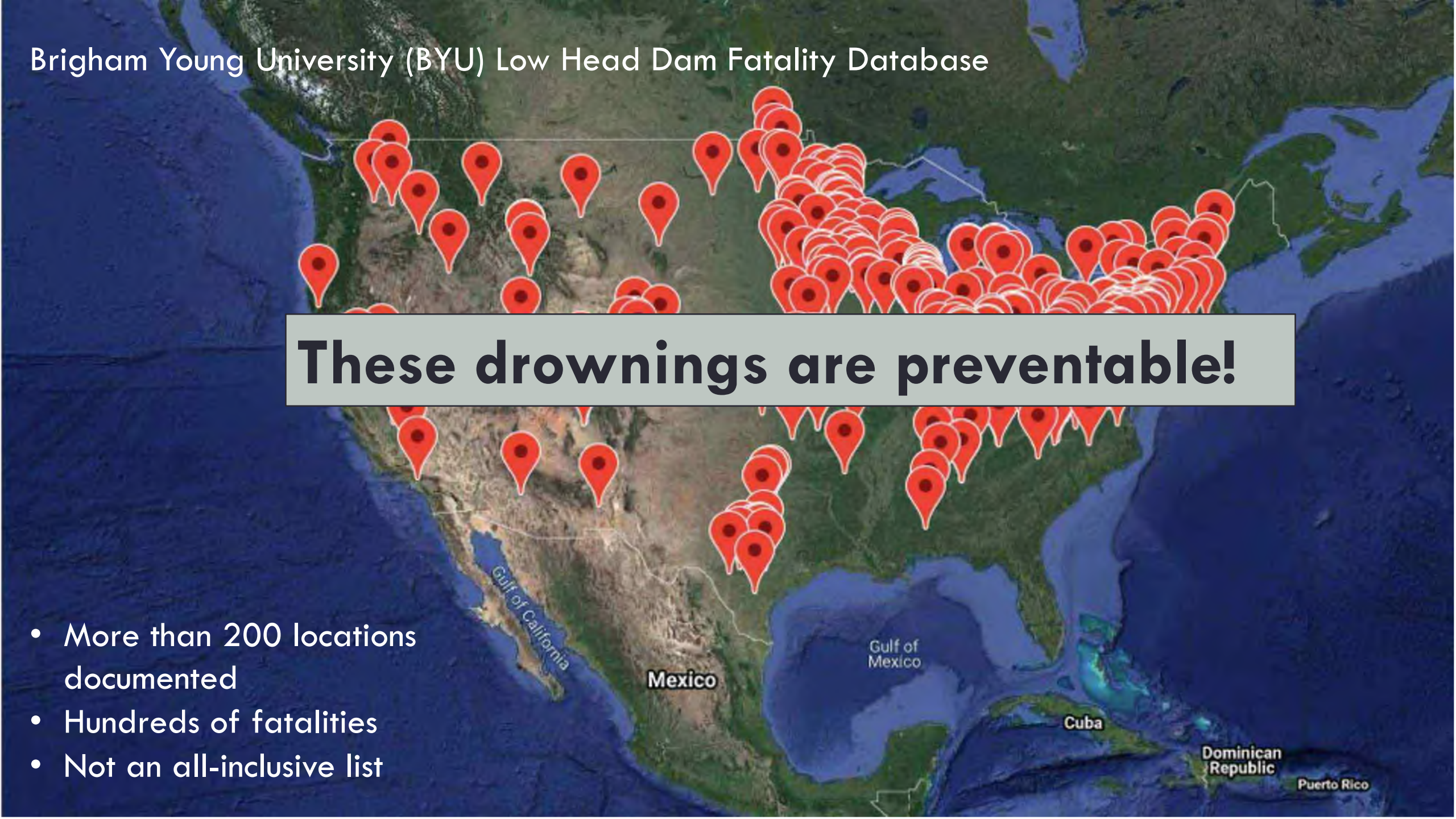
Presentation Overview

- Introduction
- Hydraulic Hazards of Low Head Dams
- Colorado's Low Head Dam Safety Initiative
- Conclusions & Next Steps

Low Head Dam – Stoner Creek (KY)

Video by Karl Kingery, P.E., WWE

Brigham Young University (BYU) Low Head Dam Fatality Database



These drownings are preventable!

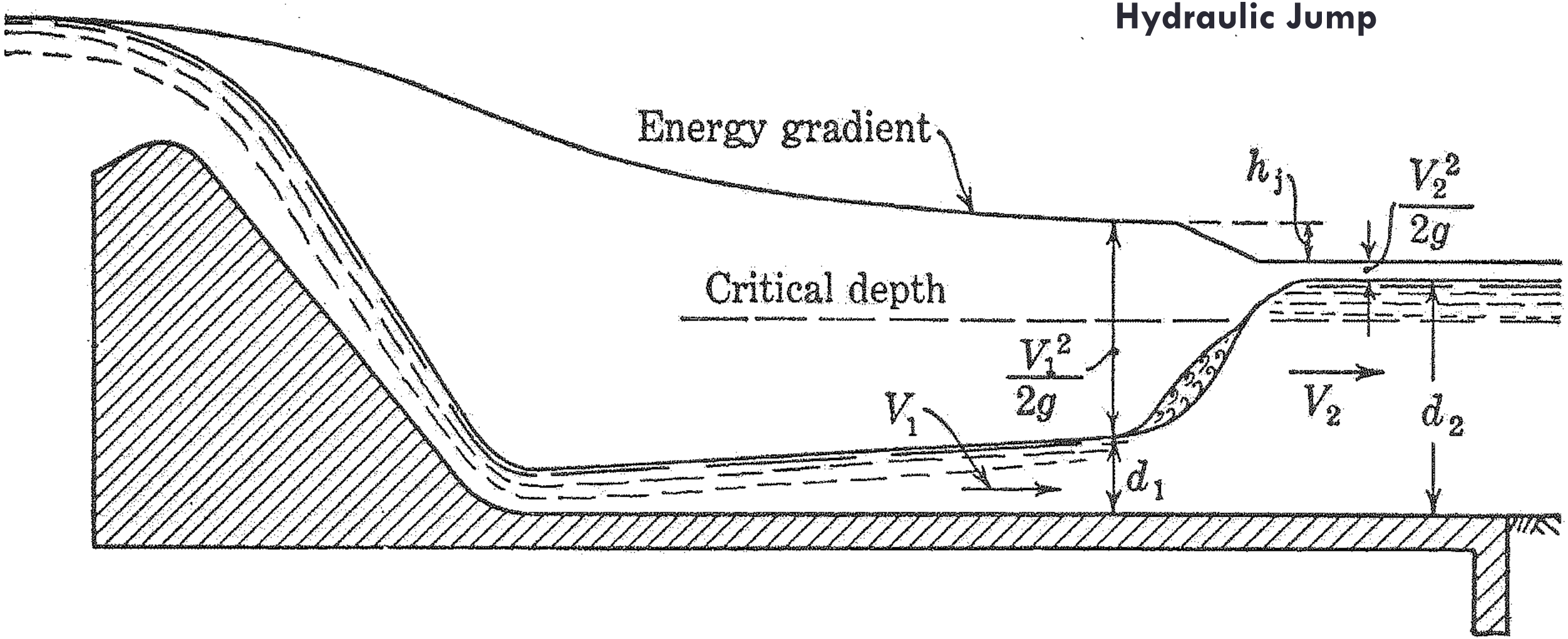
- More than 200 locations documented
- Hundreds of fatalities
- Not an all-inclusive list

Hydraulic Hazards of Low Head Dams

LOW HEAD DAMS OFTEN HAVE SMOOTH WATER ABOVE THE DAM AND BOILS BELOW THE DAM

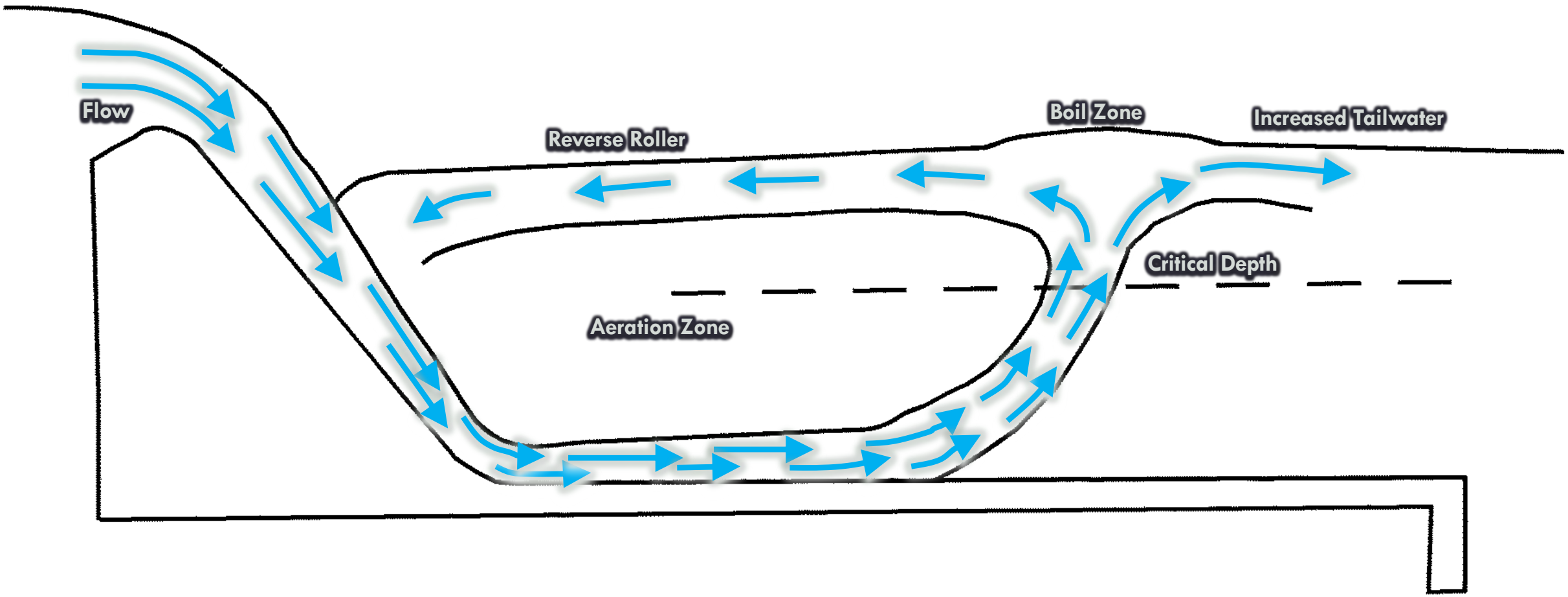

PLEASE
STAY
OFF
THE
DAM

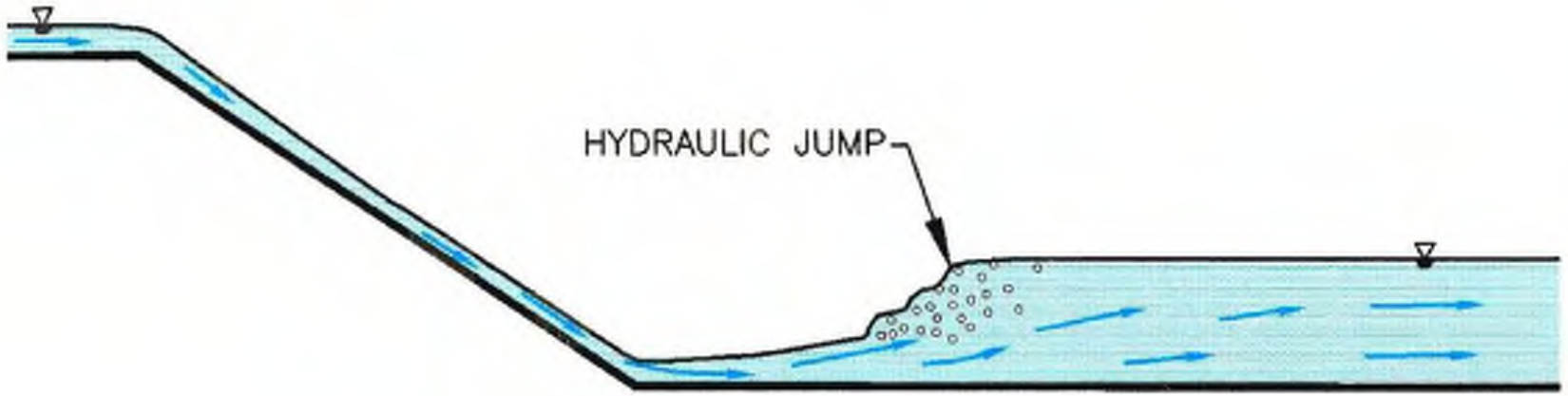
Hydraulic Jump



King, H.W., Wisler, C.O., Woodburn, J.G. 1948. Hydraulics. 5th edition. New York: John Wiley & Sons. Page 278.

Submerged Hydraulic Jump

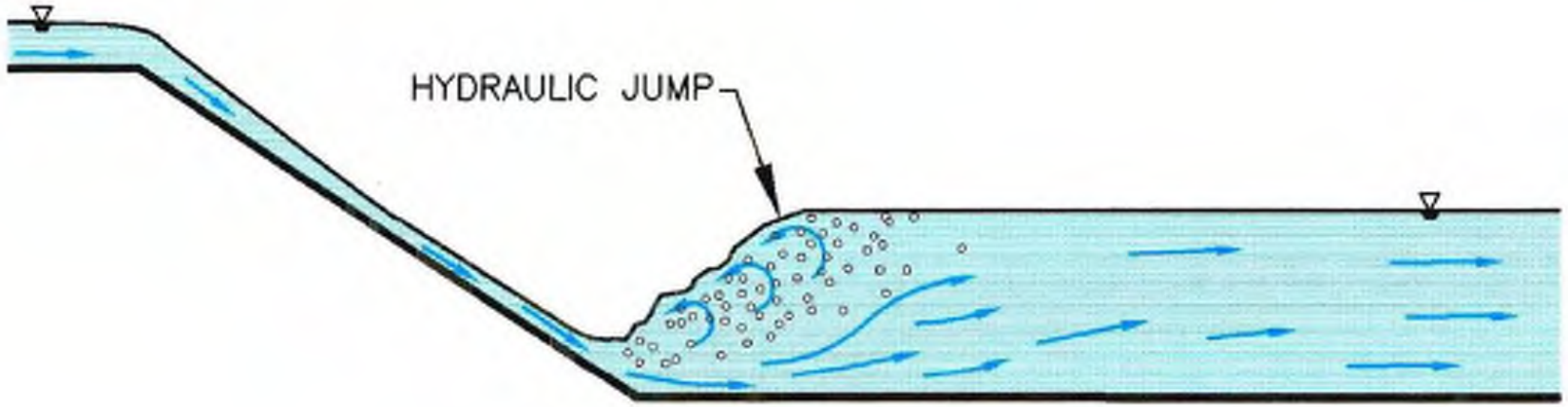




LITTLE ENTRAPMENT POTENTIAL

CASE I

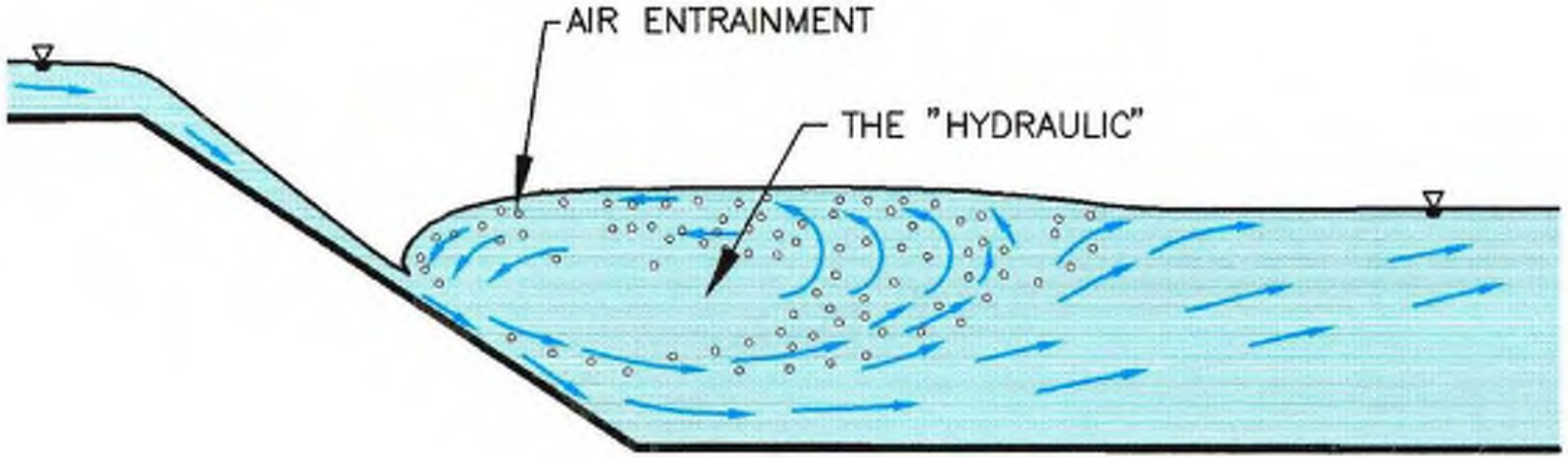
- LOW TAILWATER WITH SWEPT-OUT JUMP
- PERSONS WILL USUALLY BE SWEPT DOWNSTREAM



MODEST ENTRAPMENT POTENTIAL

CASE II

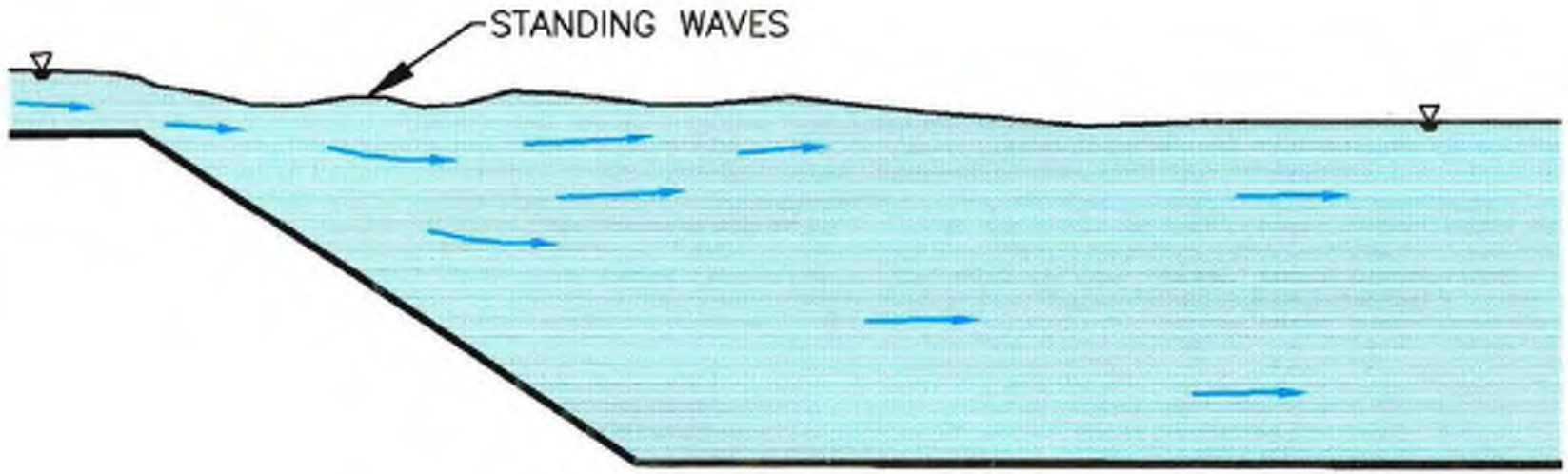
- NORMAL TAILWATER WITH OPTIMUM JUMP.
- MODEST ENTRAPMENT FOR PERSONS, ALTHOUGH LOGS AND SIDEWAYS CANOES CAN GET TRAPPED IN SMALL "HOLE".



HIGH ENTRAPMENT POTENTIAL
EXTREME HAZARD WITH TRANQUIL APPEARENCE

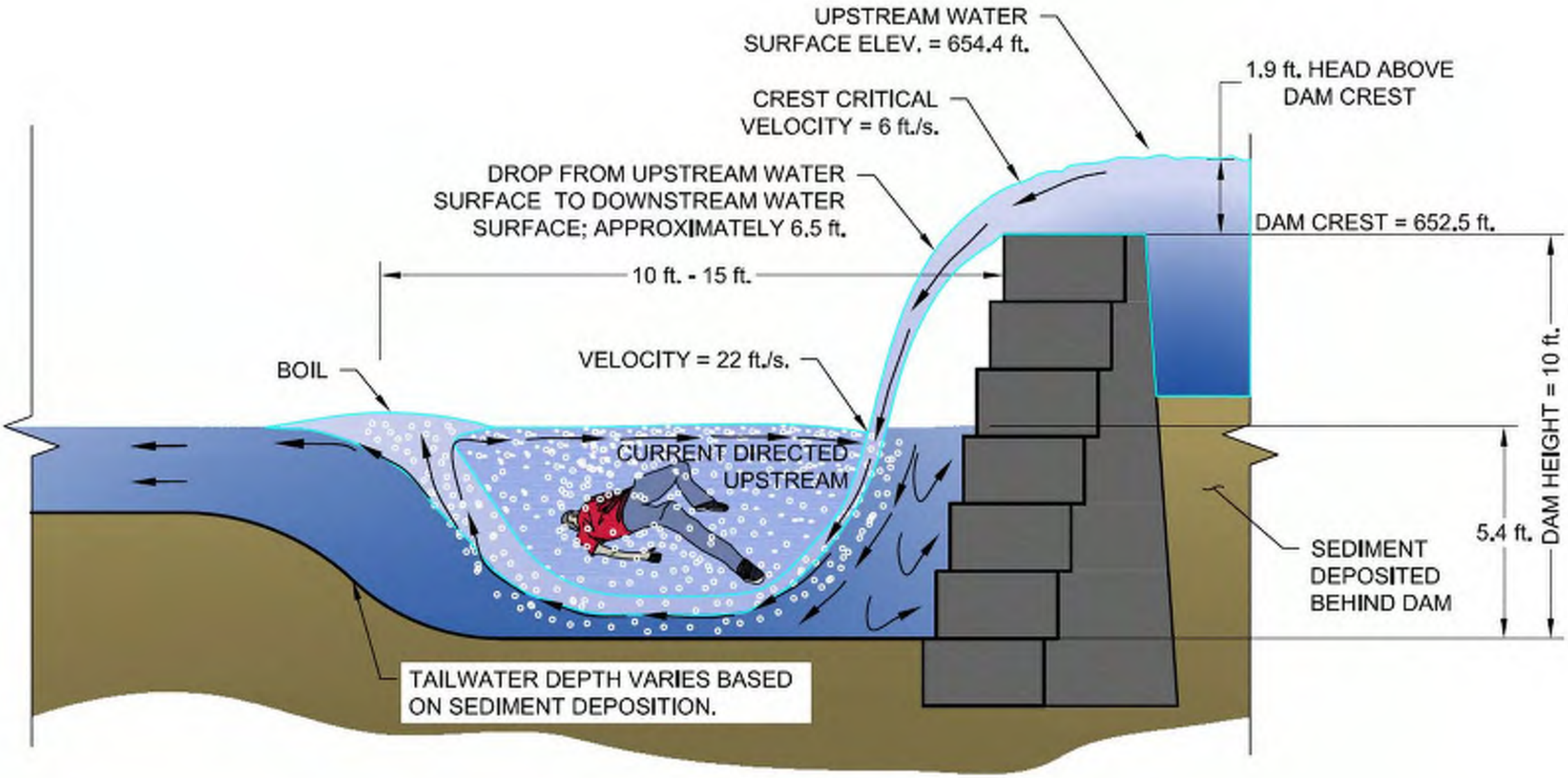
CASE III

- HIGH TAILWATER WITH SUBMERGED HYDRAULIC JUMP
- THE RESULTING "HYDRAULIC" WILL TRAP A PERSON IN THE REVERSE ROLLING CURRENT
- RESCUE BOATS WILL BE "SUCKED" TOWARDS FALLING JET
- DIVING TO THE BOTTOM MAY CAUSE THE PERSON TO BE CARRIED DOWNSTREAM



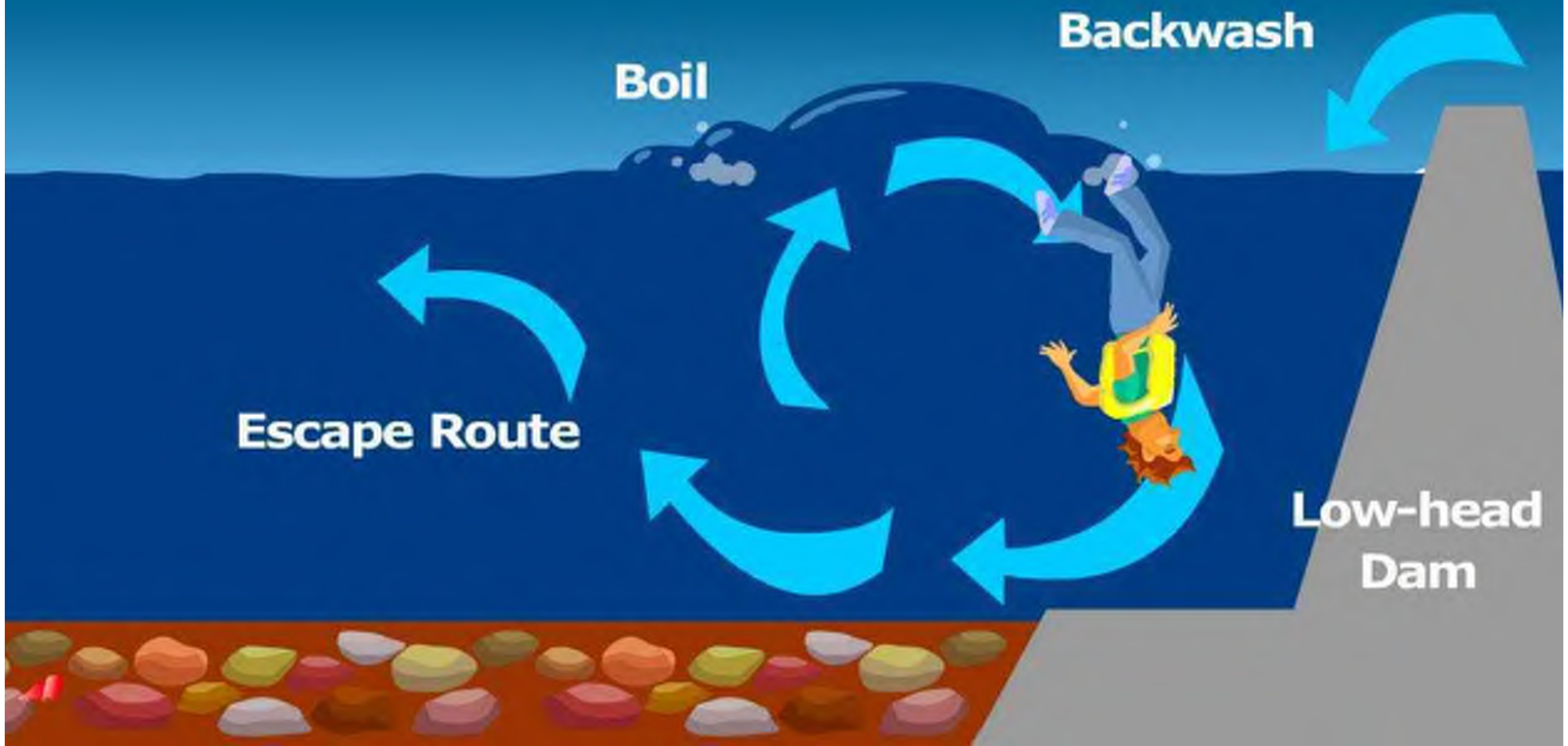
CASE IV

- VERY HIGH TAILWATER ASSOCIATED WITH HIGH FLOWS INUNDATES THE DROP STRUCTURE
- NO HYDRAULIC JUMP OCCURS
- NO UNUSUAL HAZARD TO PERSONS OR BOATS


UPSTREAM WATER
SURFACE ELEV. = 654.4 ft.
1.9 ft. HEAD ABOVE
DAM CREST
CREST CRITICAL
VELOCITY = 6 ft./s.
DROP FROM UPSTREAM WATER
SURFACE TO DOWNSTREAM WATER
SURFACE; APPROXIMATELY 6.5 ft.
DAM CREST = 652.5 ft.
10 ft. - 15 ft.
VELOCITY = 22 ft./s.
BOIL
CURRENT DIRECTED
UPSTREAM
5.4 ft.
DAM HEIGHT = 10 ft.
SEDIMENT
DEPOSITED
BEHIND DAM
TAILWATER DEPTH VARIES BASED
ON SEDIMENT DEPOSITION.

Dangers Posed by Low-Head Dams

The recirculating currents and turbulent waters below can swamp vessels and drown boaters.



Colorado Low Head Dam Safety Initiative

- Discussions at CO DNR began in January 2019
- Identified absence of defined responsibility/authority for regulation of Low Head Dams
- How to make positive change to this situation?
- Create Inventory – identify the extent of this issue across the state
- Steering Committee – Gather advisory group to discuss possible approaches

Colorado Low Head Dam Safety Initiative

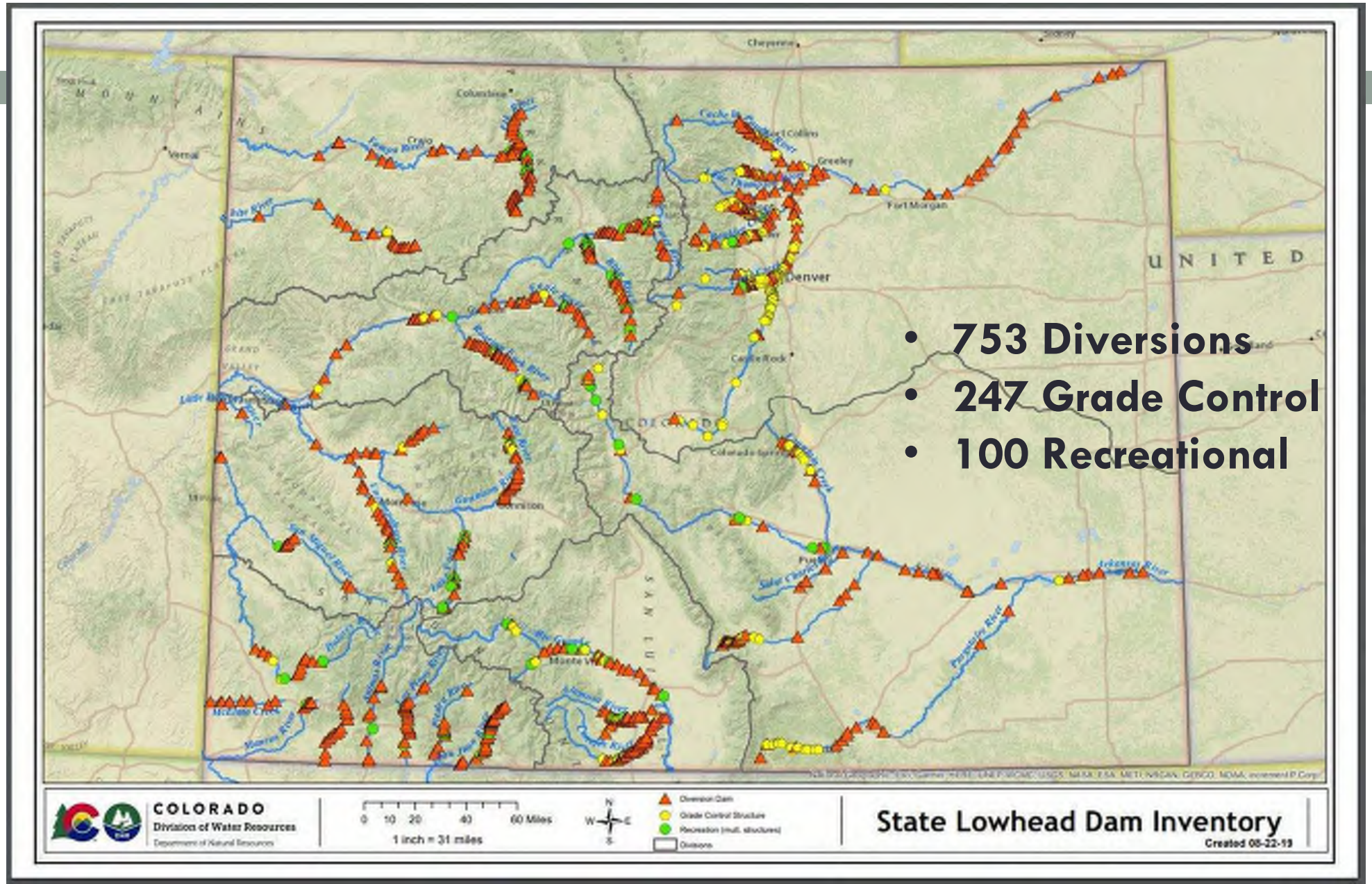
- Hired an intern to develop Low Head Dam Inventory
- LHD Steering Committee – Formed July 2019
- Strategic Partnerships established

Steering Committee

Colorado Department of Natural Resources, Assistant Director for Water- Amy Moyer
Colorado Department of Natural Resources, Assistant Director for CPW - Doug Vilsack
Colorado Division of Water Resources, Chief of Dam Safety - Bill McCormick
Colorado Parks & Wildlife, SE Region Assistant Regional Manager - Brad Henley
Colorado Water Conservation Board - Chief of Flood and Stream protection - Kevin Houck
Colorado Office of Outdoor Recreation Industry, Director - Nathan Fey
Colorado Division of Homeland Security and Emergency Management, State Hazard Mitigation Officer - Steven Boand
Mile High Flood District- Kevin Stewart
Wright Water Engineers- Andrew Earles
General public - Ruth Wright

Strategic Partnerships

Colorado Low Head Dam Inventory



- 753 Diversions
- 247 Grade Control
- 100 Recreational

Inventory Study Report

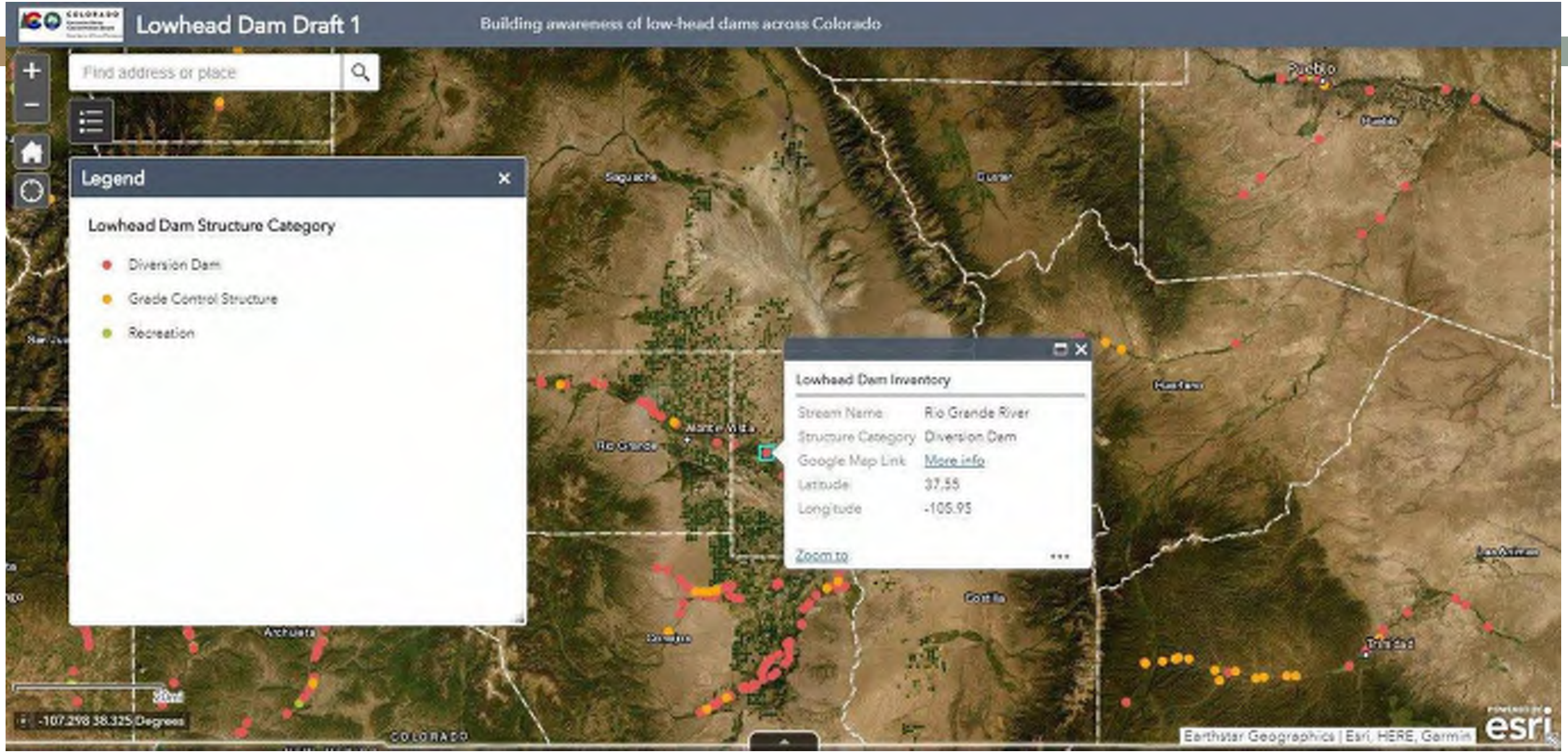
Colorado Low Head Dam Inventory Project 2019

Jackson Ditch Diversion Dam on the Cache La Poudre River, Ft Collins, Colorado
(Photo Courtesy of Wright Water Engineers)

By Sarah L. Zimmer
University of Colorado Denver
October, 2019

Table of Contents

Colorado Low Head Dam Inventory Website



Signage – Lower Platte and Beaver Diversion, Brush, CO

Signage – Lower Platte and Beaver Diversion, Brush, CO

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Signage – Lower Platte and Beaver Diversion, Brush, CO

Water Plan Grant Activities

- **Warn/Educate**
  - Website Development
  - PSA Partnerships/Case Studies
- **Control Exposure**
  - Signage
  - Incentivizing portage/explaining limited liability
- **Mitigate or Eliminate the Hazard**
  - Modify dams for multiple purposes
  - Remove dams for multiple reasons
- **Prepare for Emergency Response**
  - Educate and train first responders
  - Response planning

- $50K ($20k CWCB, $15k in-kind, $15k FEMA NDSP)

CO DNR Next Steps

- Execute CO Water Plan grant work plan; website, stakeholder outreach, signage, first responder training
- Establish where a Low Head Dam program lives within DNR
- Continue strategic partnerships with American Whitewater and DARCA to help disseminate inventory information
- Work with CDHSEM-Mitigation Section and apply for BRIC grants
- Work with CWCB to use their loan and grant programs to fund beneficial activities at Low Head dams

Conclusions and Next Steps

- Low head dam drownings can be prevented through combination of education, outreach, signage, physical dam modifications, and other practices.
- The hazards of low head dams are often latent and cannot be discerned by a typical recreational river user.
- The State of Colorado has been developing a program to improve safety at low head dams over the past year. Next steps for the State are to get inventory online, refine the database, conduct public outreach presentations and stakeholder meetings, and continue to install signs at dams with the potential to cause fatalities.
- If you have photographs or other information on low head dams in Colorado, please contact Bill, Andrew, or Karl, so that we can include your information in the database.

Questions & Answers

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Karl Kingery, P.E.
kkingery@wrightwater.com

Bill McCormick, P.E., P.G.
Colorado Division of Water Resources
bill.mccormick@state.co.us

THINKING DIFFERENTLY

UNIQUE STORMWATER CASE STUDIES

Calibre

WWE
WRIGHT WATER ENGINEERS, INC.

- 14 YEARS IN INDUSTRY
- SUPPORT PROBLEM SOLVING
- FAVORITE TRAVEL: TANABE, JAPAN

EMILY C. VILLINES, CPSM, MA

Calibre WWE

- 4 YEARS IN INDUSTRY
- DESIGN ENGINEER
- FAVORITE TRAVEL: TONGARIRO, NZ

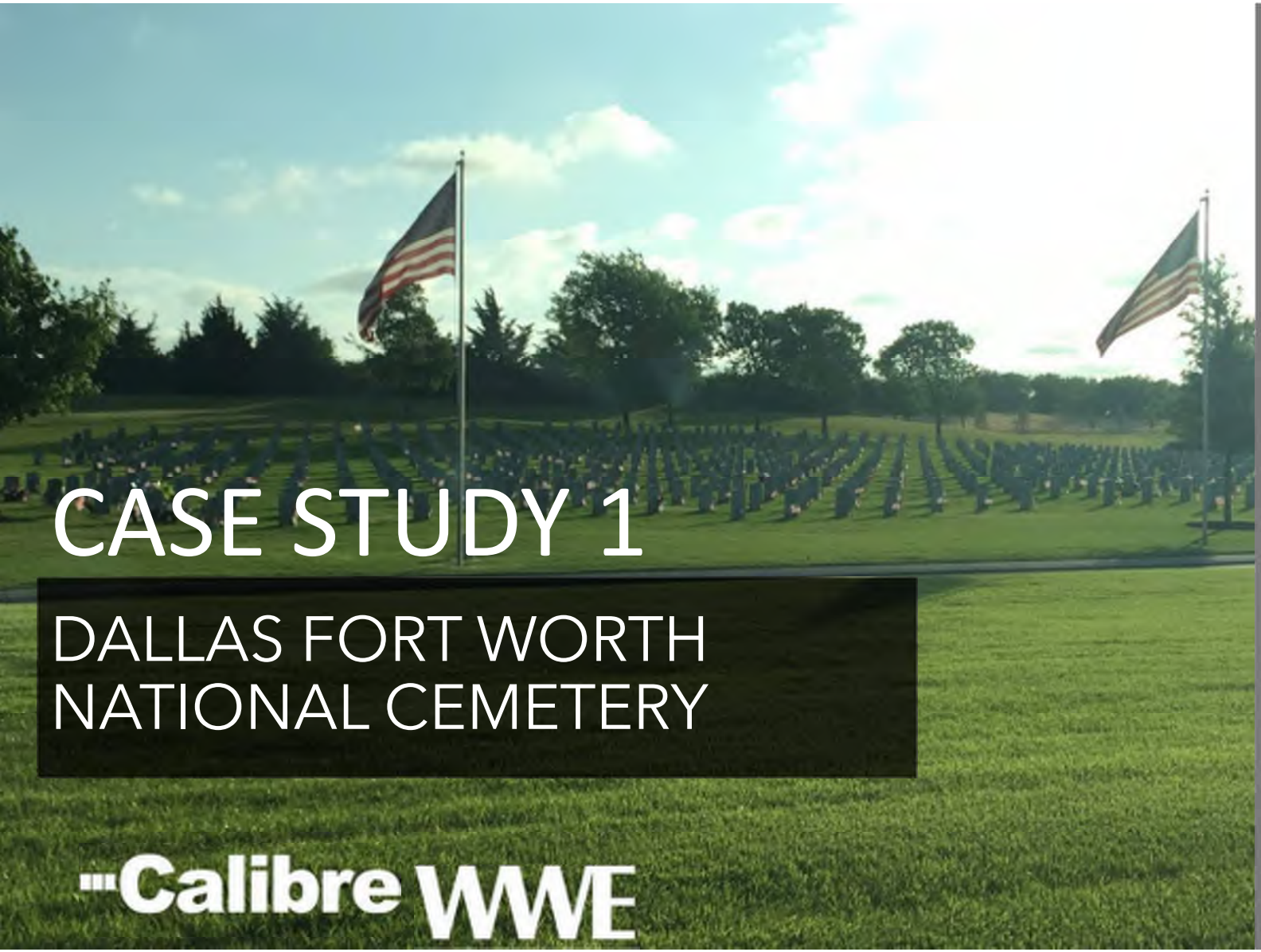
JESS N. KORDZIEL, EI, CFM

Calibre WWE

- 6 YEARS IN INDUSTRY
- WATER RESOURCES ENGINEER
- FAVORITE TRAVEL: CORN ISLANDS, NICARAGUA

MAGGIE LEWIS, PE

Calibre WWE



CASE STUDY 1

DALLAS FORT WORTH NATIONAL CEMETERY

Calibre WWE

WHAT IF THERE'S NO SEWER MAIN OR EXISTING STORM SEWER TO TIE INTO?

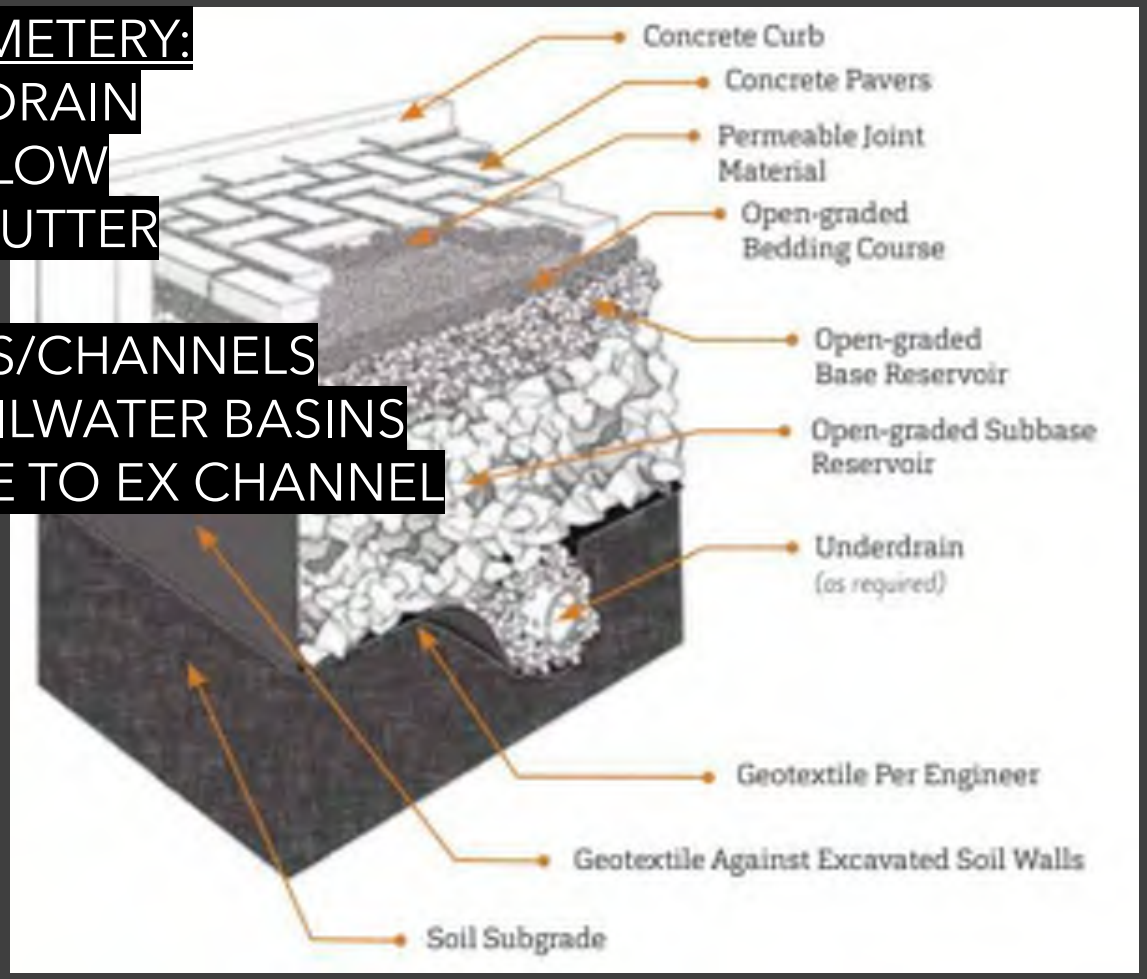

OUTFALL INTO A NATRUAL CHANNEL
AFTER WATER QUALITY ENHANCEMENT!
Calibre WWE

THE USUSAL DRAINAGE PLAN IS A THREE STEP PROCESS:

1. RUNOFF/SHEETFLOW
2. CHANNEL FLOW/CURB GUTTER
3. PIPE TO DETENTION

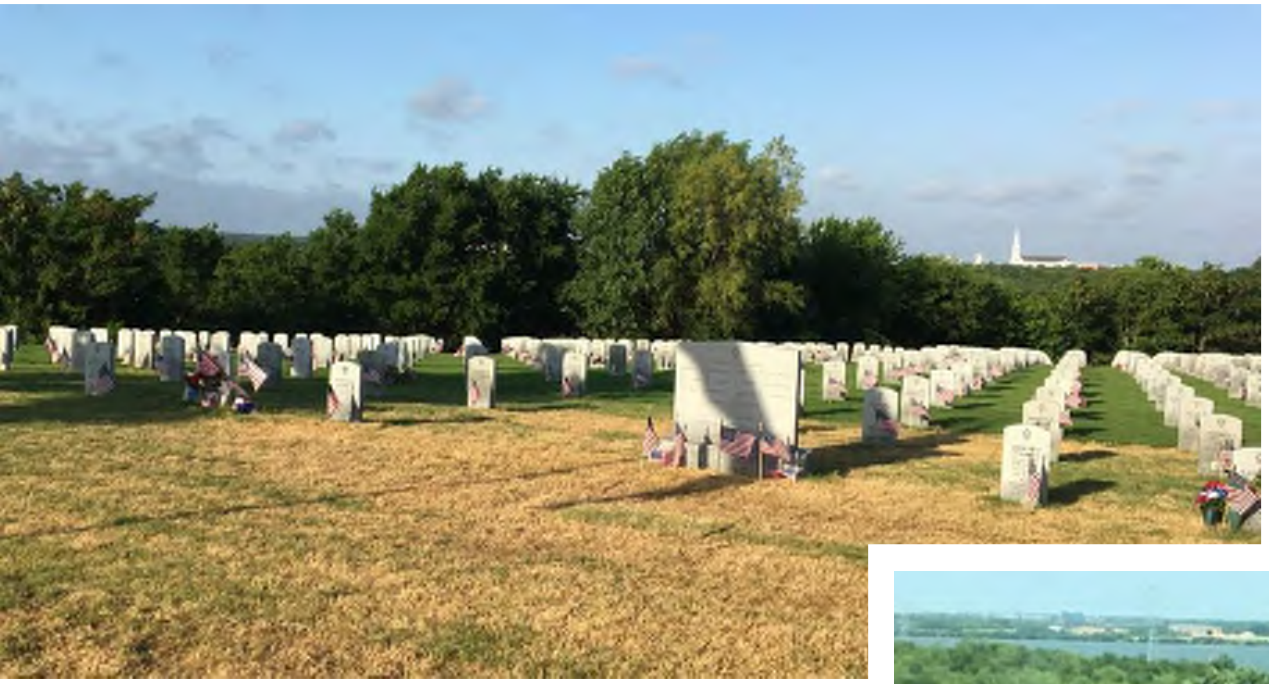
FOR A CEMETERY:

1. UNDERDRAIN
2. SHEETFLOW
3. CURB/GUTTER
4. INLETS
5. DITCHES/CHANNELS
6. LOW TAILWATER BASINS
7. RELEASE TO EX CHANNEL



Calibre WWE

Calibre WWE

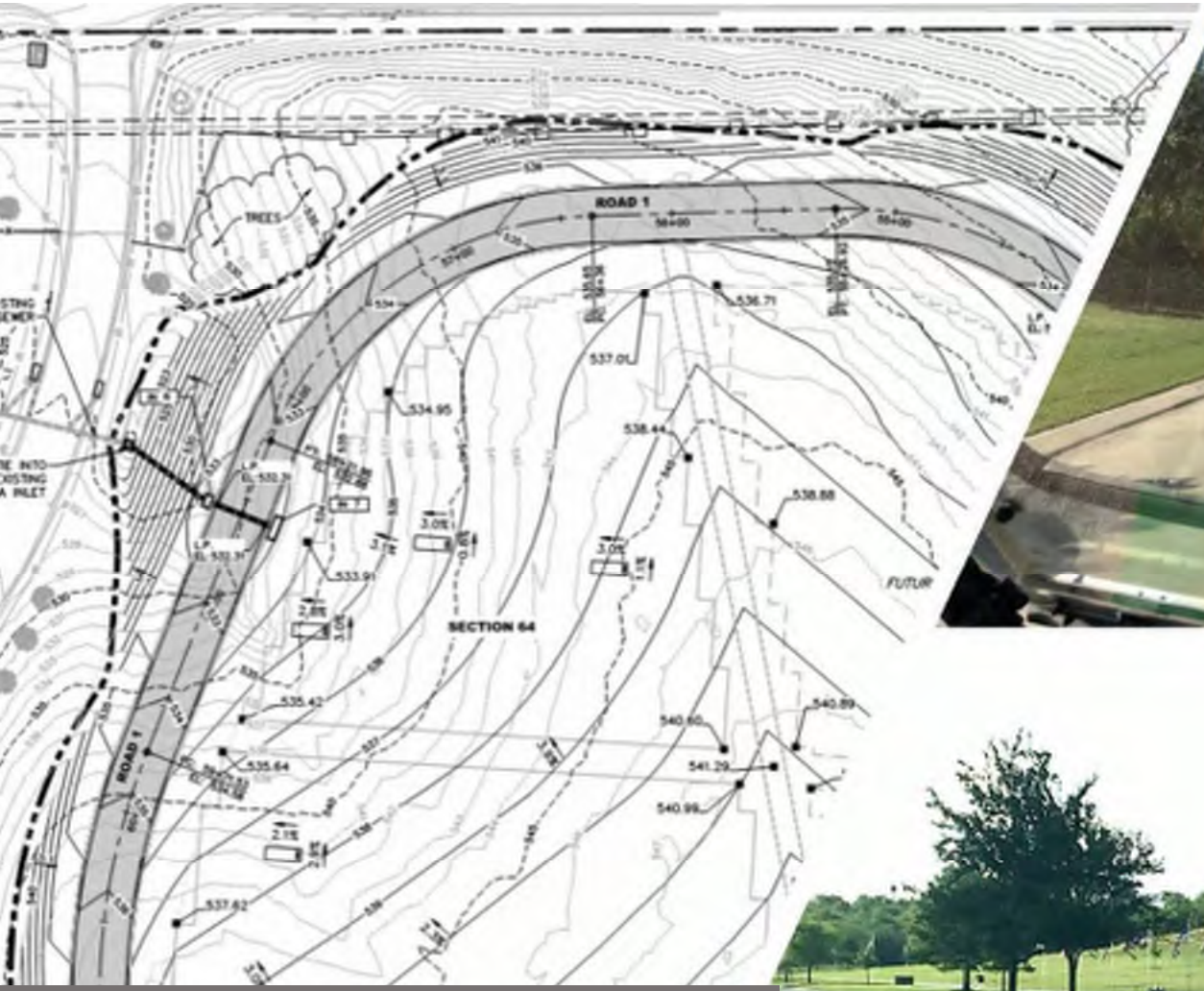


GRADE IS SET

Calibre WWE

SMART DITCHES

UNIQUE ROADS



Calibre WWE

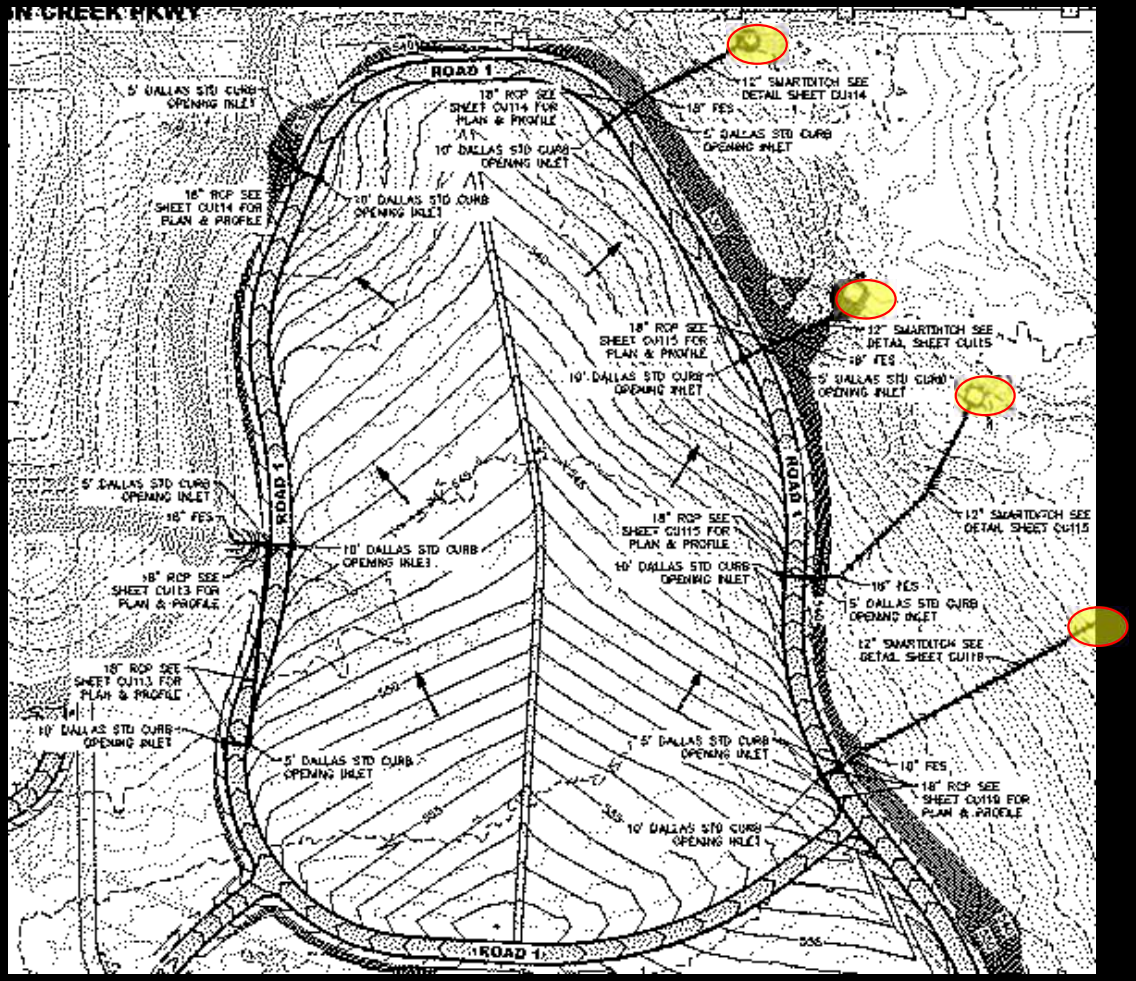

ONCE THE WATER HAS
RUN OFF, WHAT'S IN IT?
Calibre WWE


FOR CEMETERIES? ALL THAT…
AND MORE.
Calibre WWE

SEE THAT DETENTION POND?

Calibre WWE

CEMETERY DOES NOT WANT TO SEE THAT POND.



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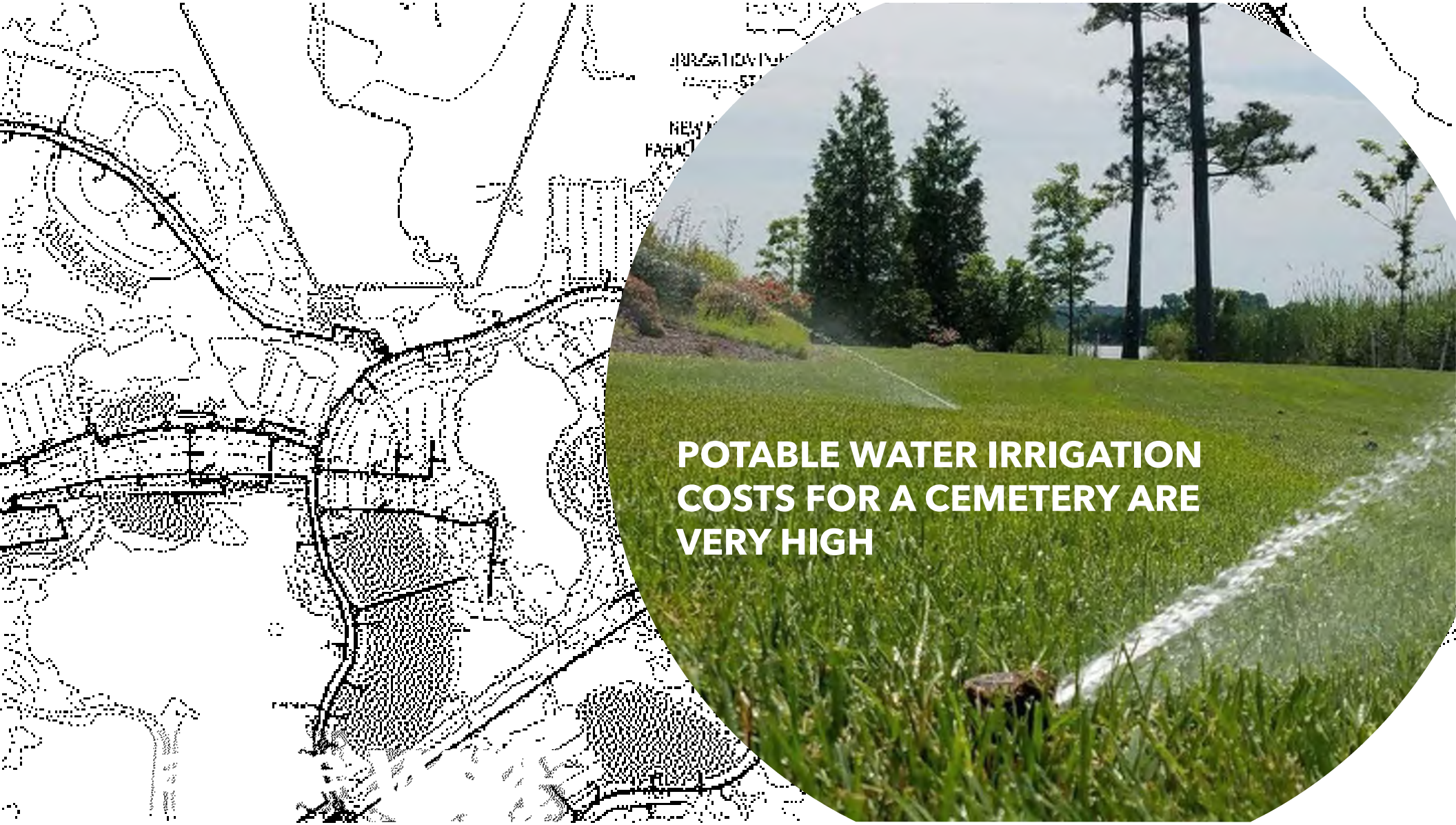
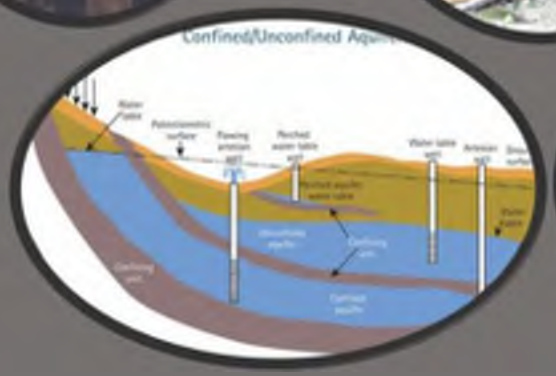
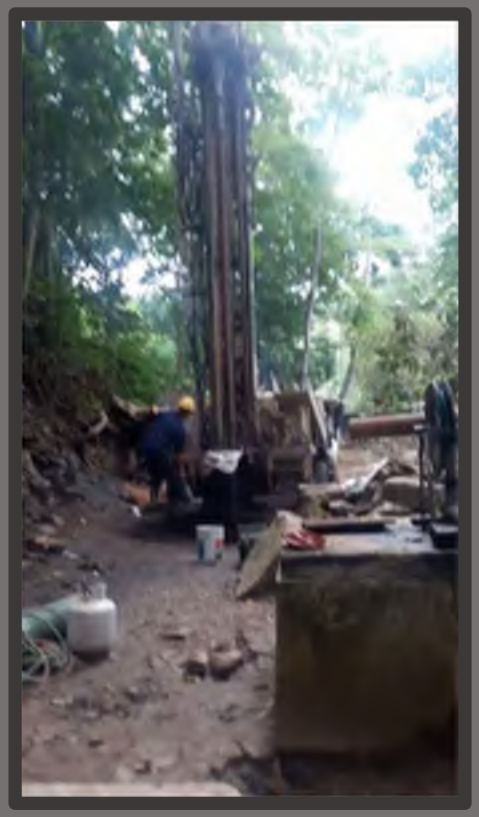


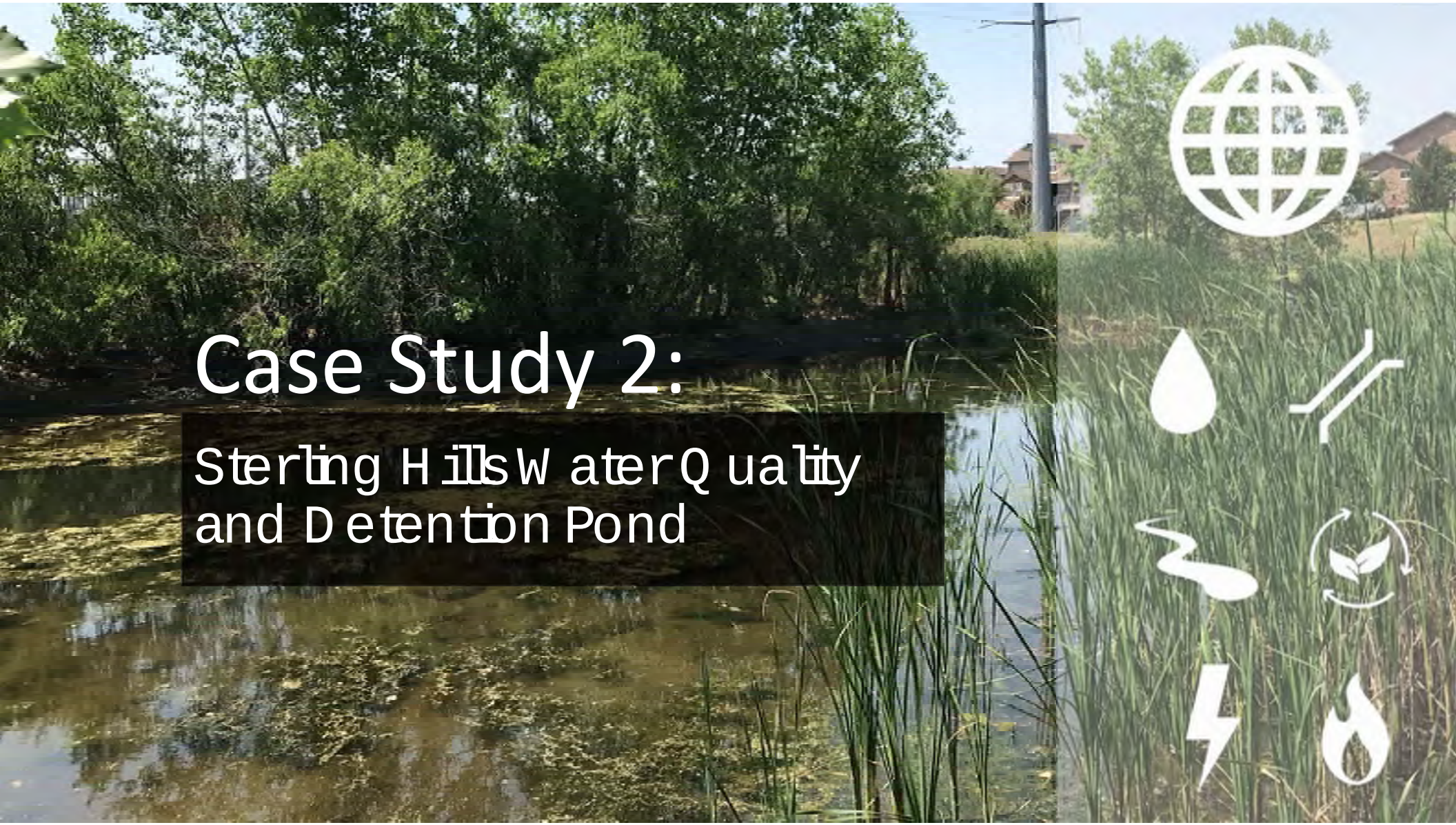
POTABLE WATER IRRIGATION COSTS FOR A CEMETERY ARE VERY HIGH

WHY NOT USE WHAT'S ALREADY THERE?





Calibre WWE



Case Study 2:

Sterling Hills Water Quality and Detention Pond

There are hundreds of water quality ponds in Colorado that have been designed using historical design standards

Many of these ponds do not include design features which are now required by many municipalities and MHFD.

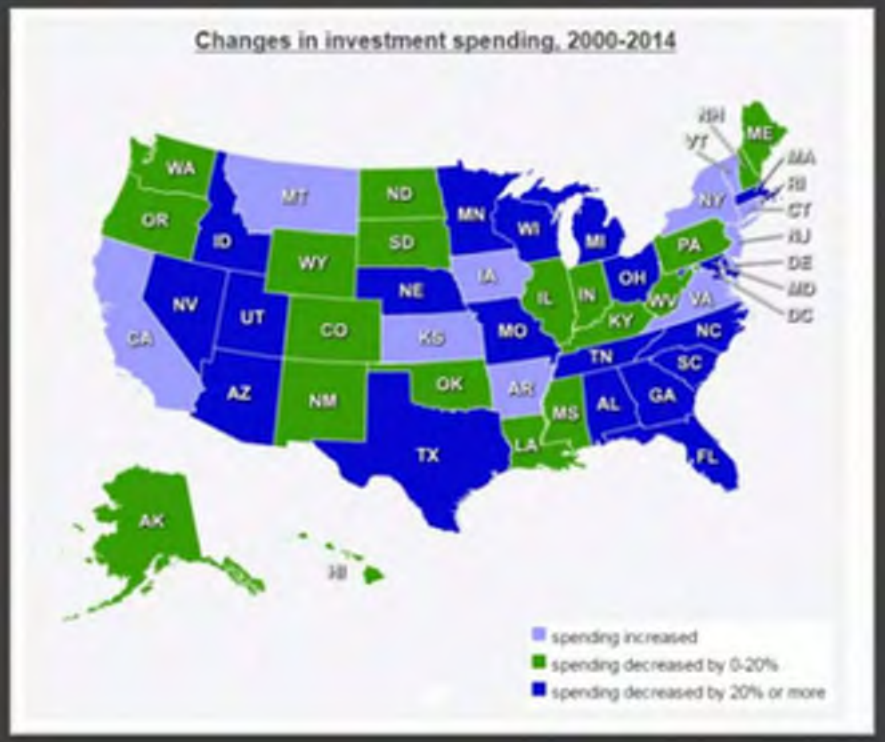
Often homeowners and business associations are required to perform maintenance of ponds due to MS4 permits and local stormwater ordinances.

Working closely with the City of Aurora and the Sterling Hills West Metro District was key to this project's success!

Maintenance and restoration of relic ponds is necessary to ensure functionality and to comply with stormwater and water rights legislation.

(photo cred: ASCE)

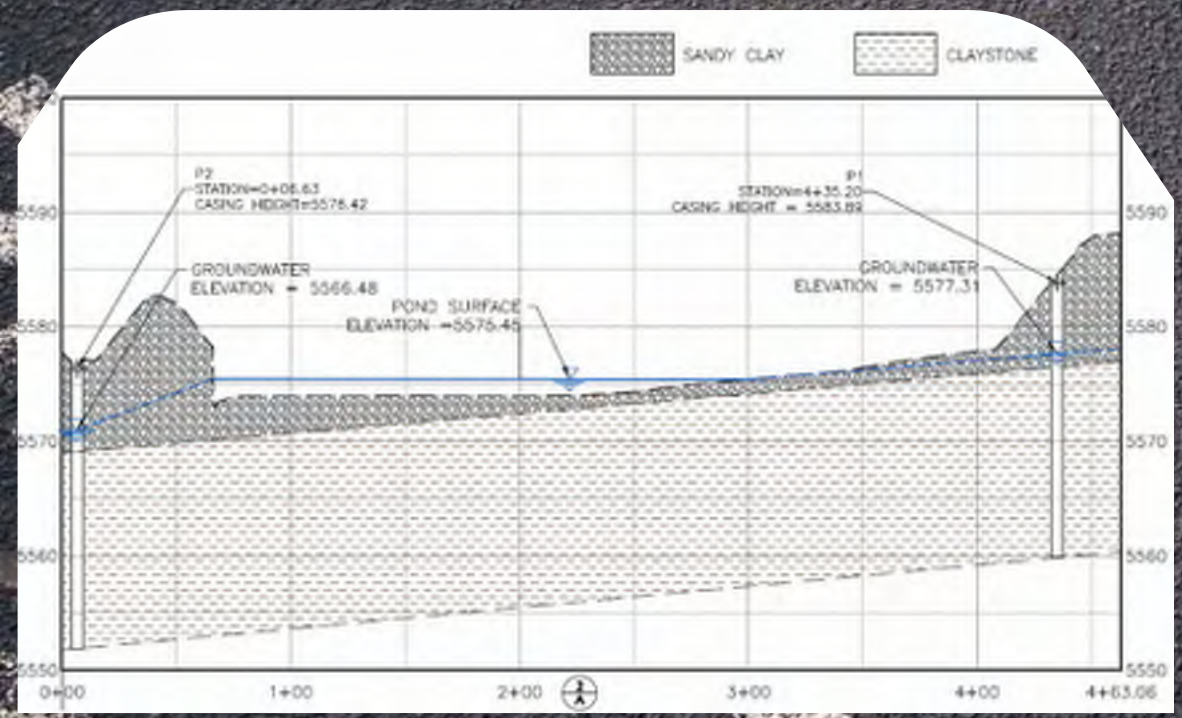
(photo cred: Brookings Institute)

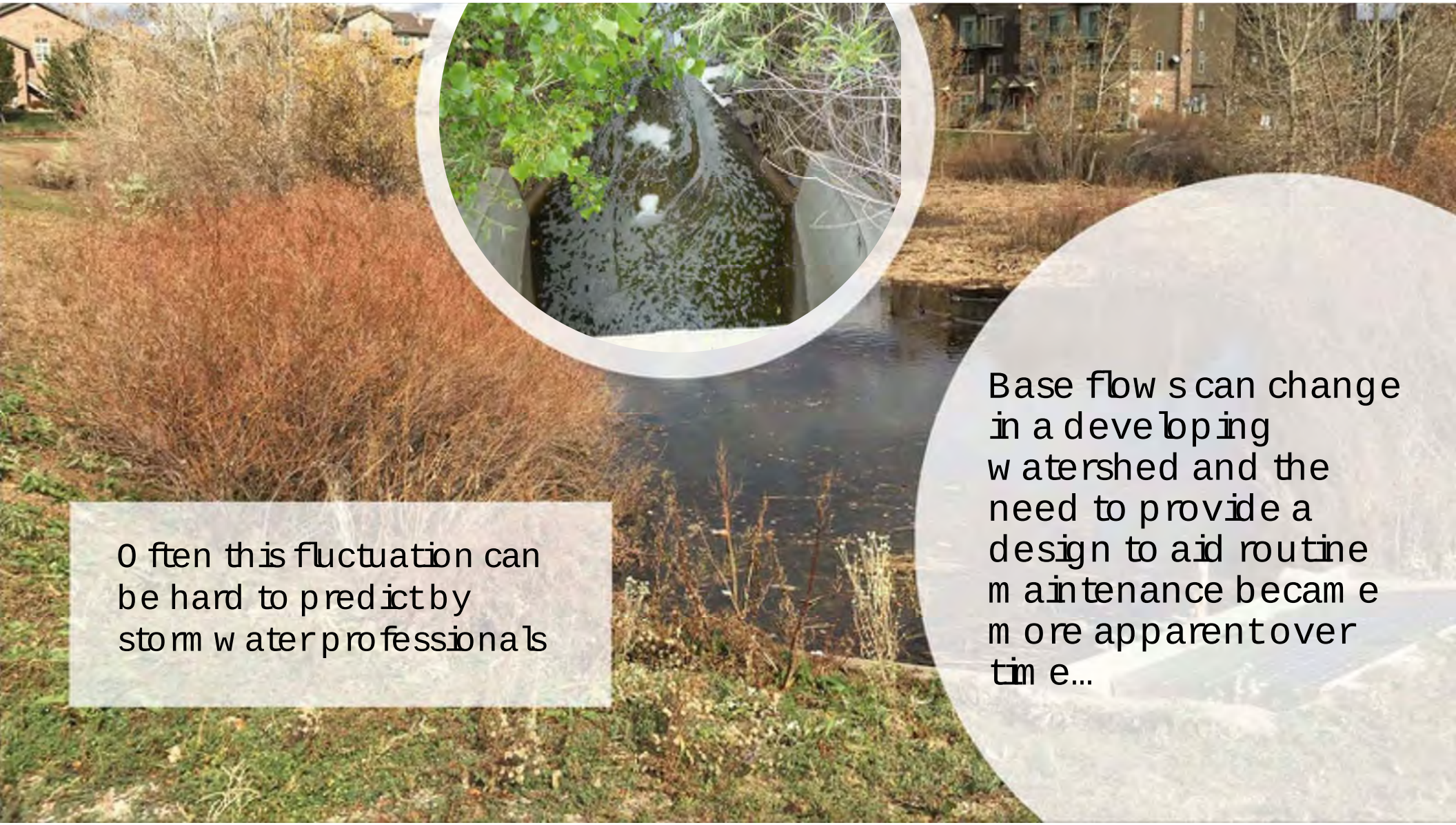


Spending money on infrastructure is not nationally trending ... let alone investing in existing facilities.

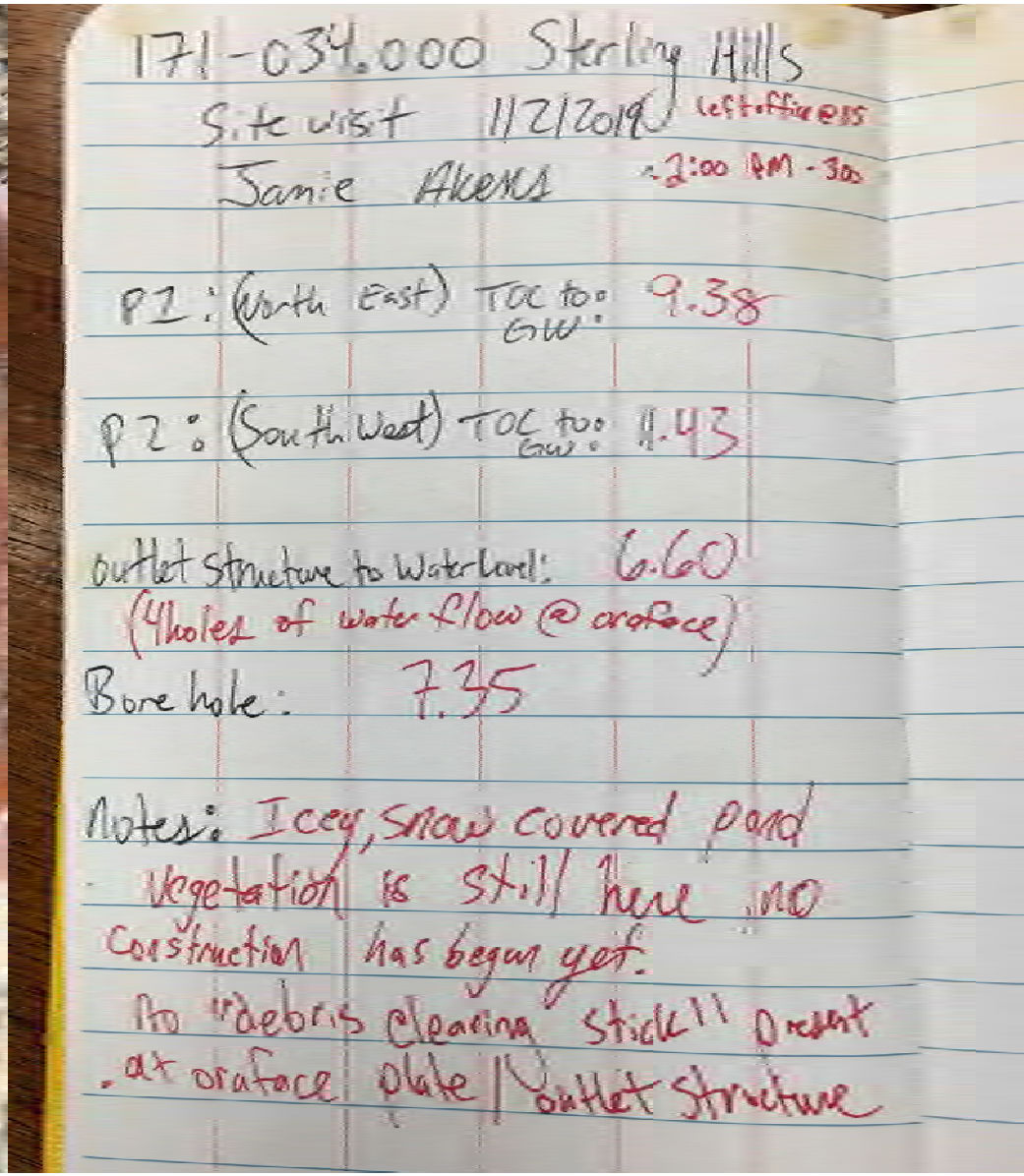
A retrofit to an existing facility to aid in maintenance can **save money** in the long run

Retrofit Challenge: Restrictive claystone layer below pond resulted in a near constant base flow




Often this fluctuation can be hard to predict by storm water professionals
Base flows can change in a developing watershed and the need to provide a design to aid routine maintenance became more apparent over time…

Troubleshooting: WWE staff conducted groundwater monitoring on site for several months to assess this fluctuation.



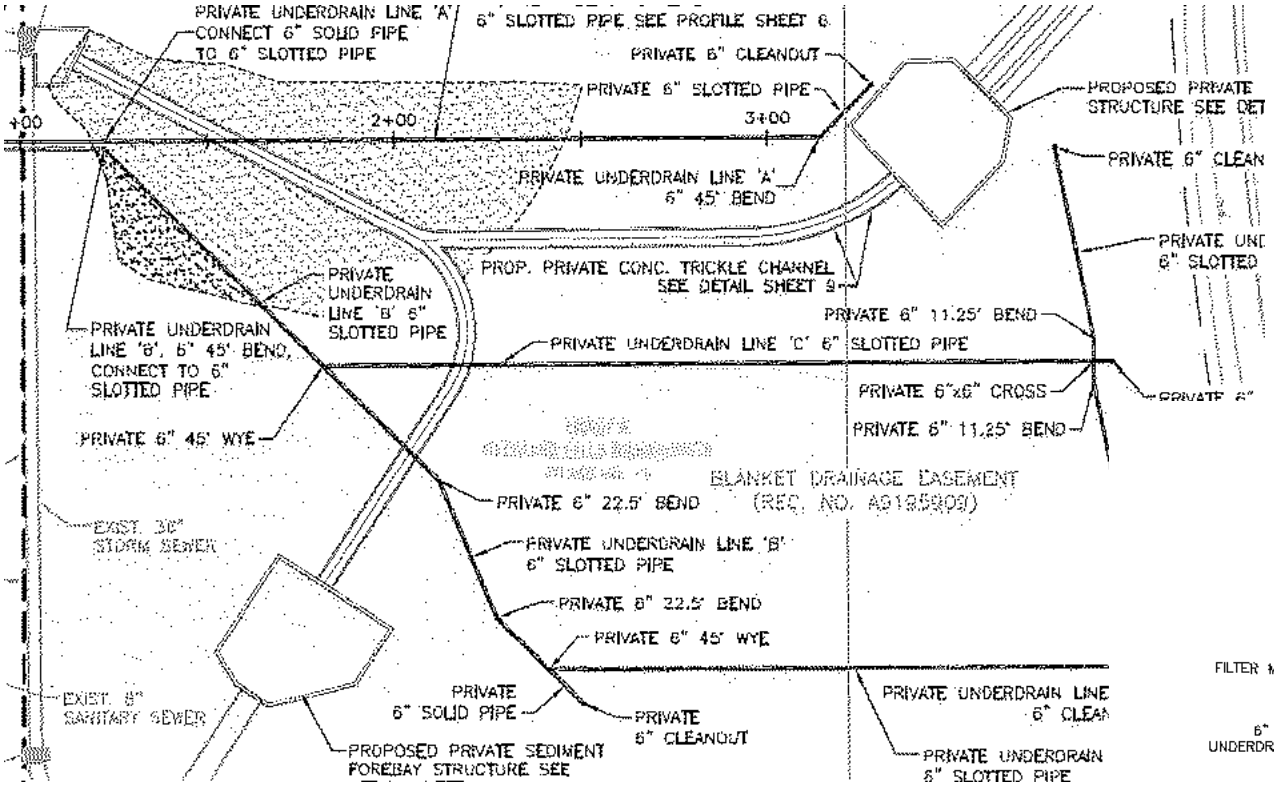
171-034.000 Sterling Hills
Site visit 11/2/2019 left office @15
Janie Akers ~2:00 PM - 3:00

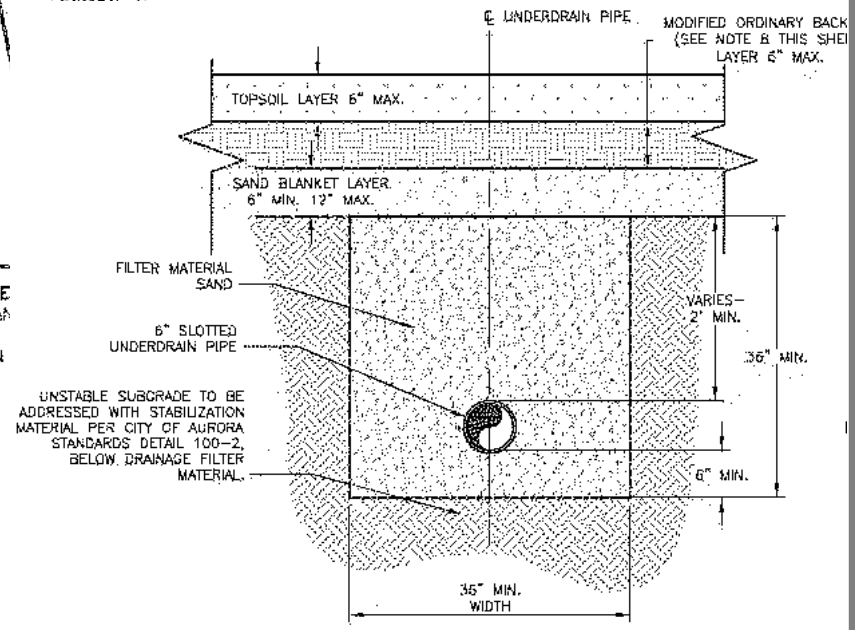
P1: (North East) TOC to GW: 9.38

P2: (South West) TOC to GW: 11.43

outlet structure to Water level: 6.60
(4 holes of water flow @ orifice)
Bore hole: 7.35

Notes: Icey, snow covered pond
vegetation is still here, no
construction has begun yet.
No "debris cleaning stick" present
at orifice plate / outlet structure

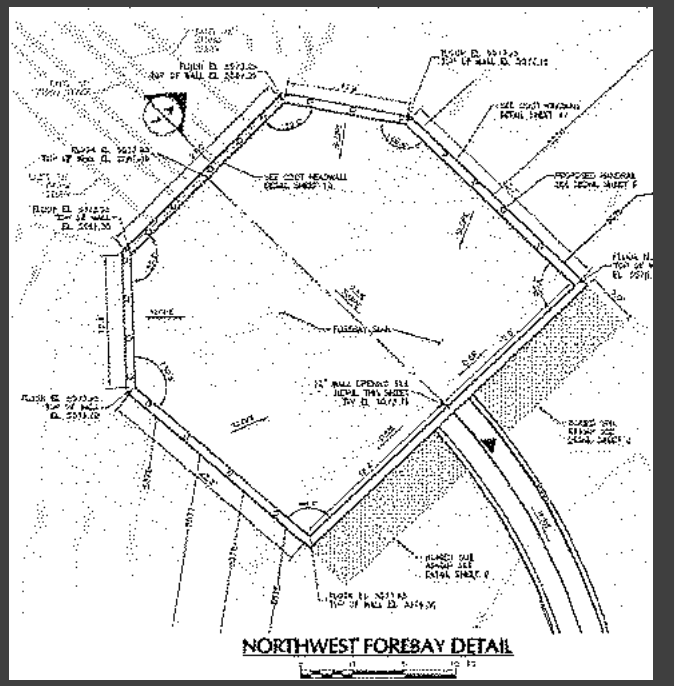


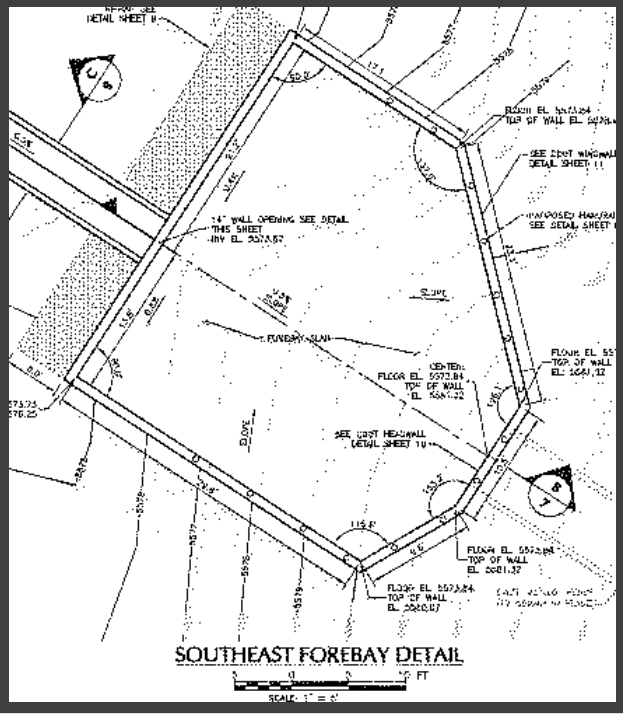


1
12
UNDERDRAIN SECTION AT BLANKET DRAIN
(PRIVATE)
N.T.S.

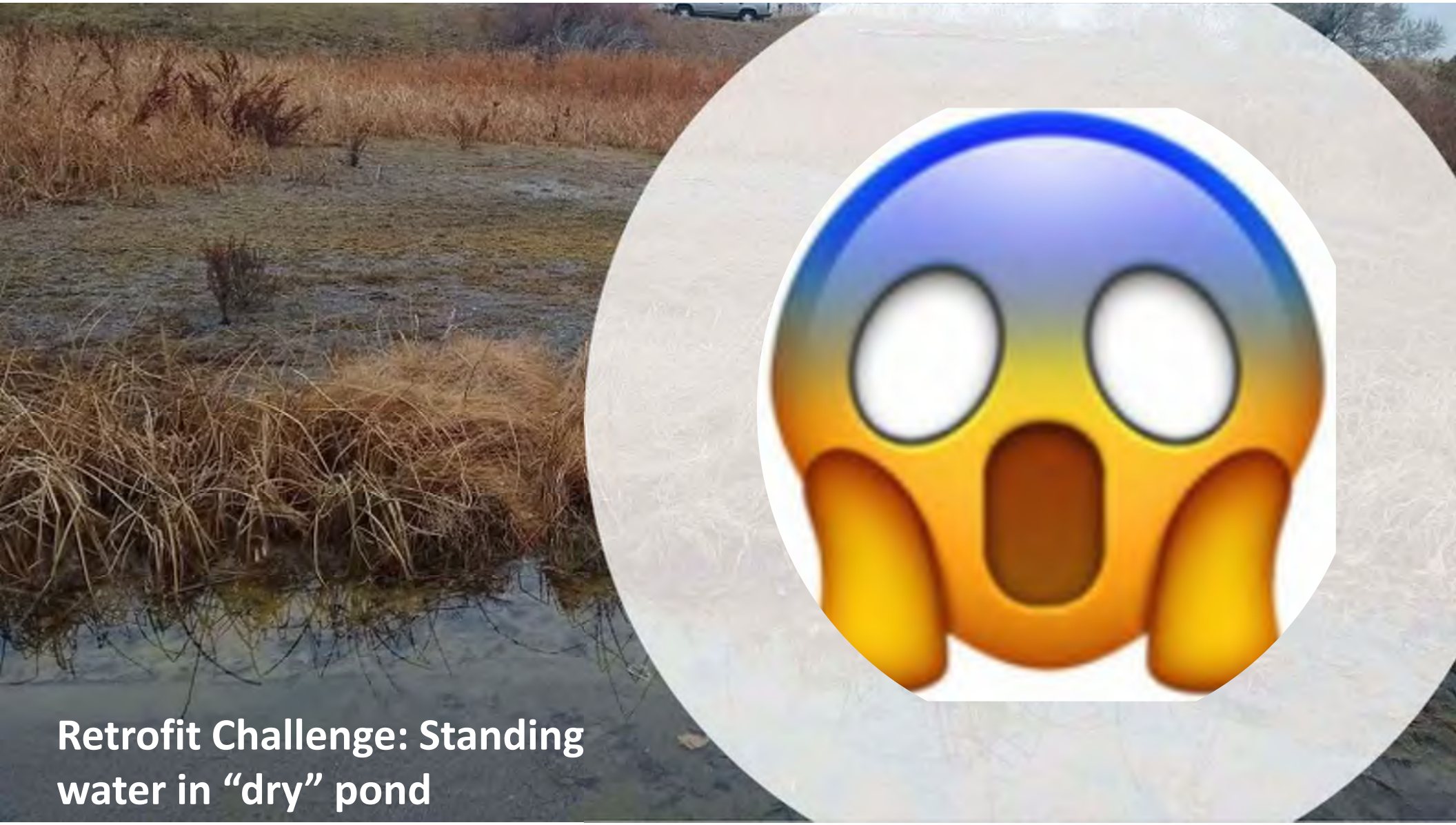
Solution: Underdrain and sand blanket layer

RETROFIT CHALLENGE

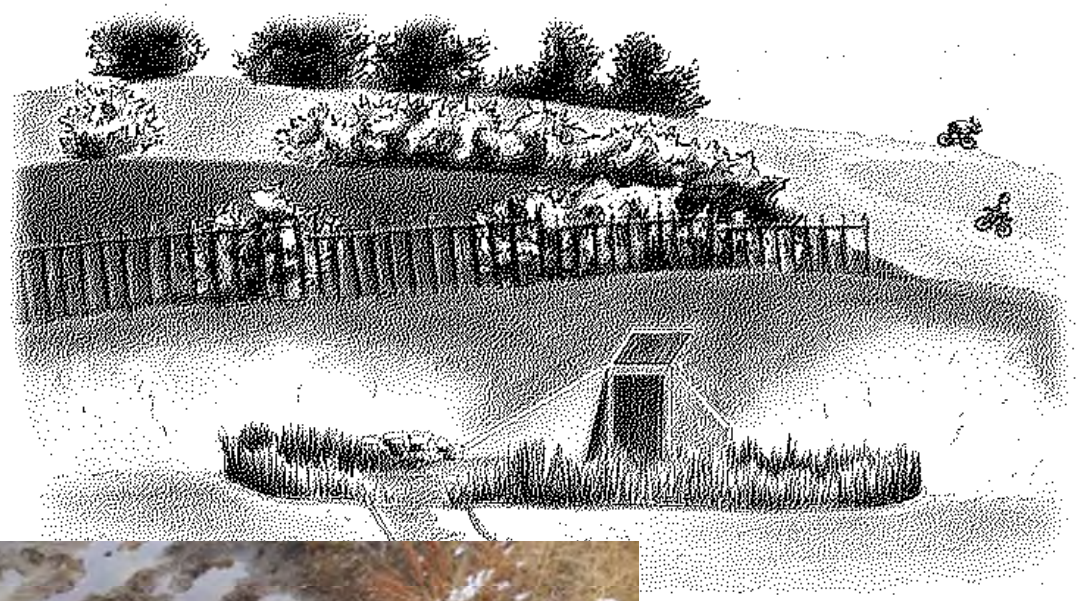


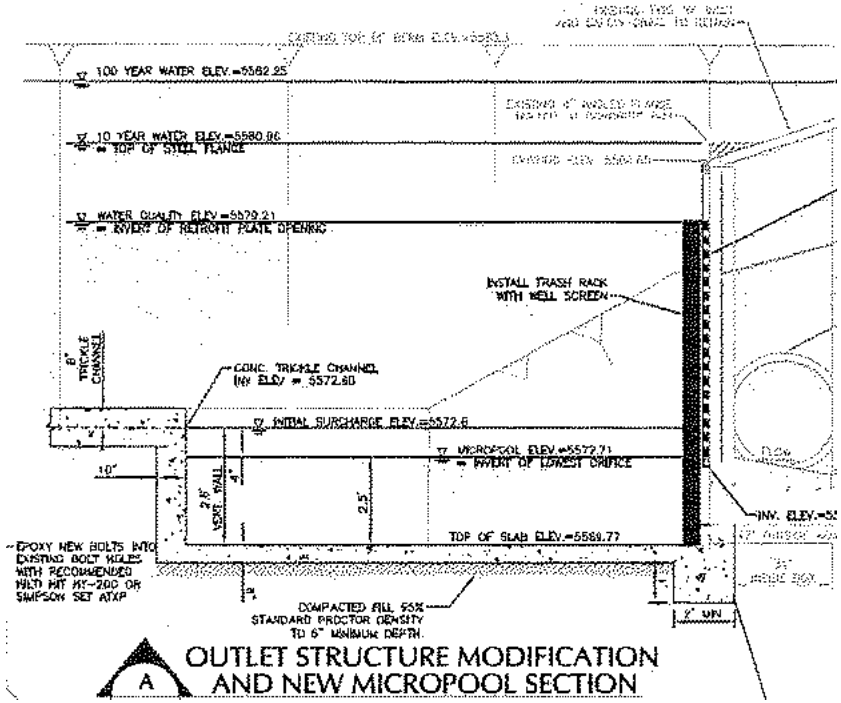


Solution: Retrofit design included sediment forebays at all piped inflows to pond



Retrofit Challenge: Standing water in “dry” pond

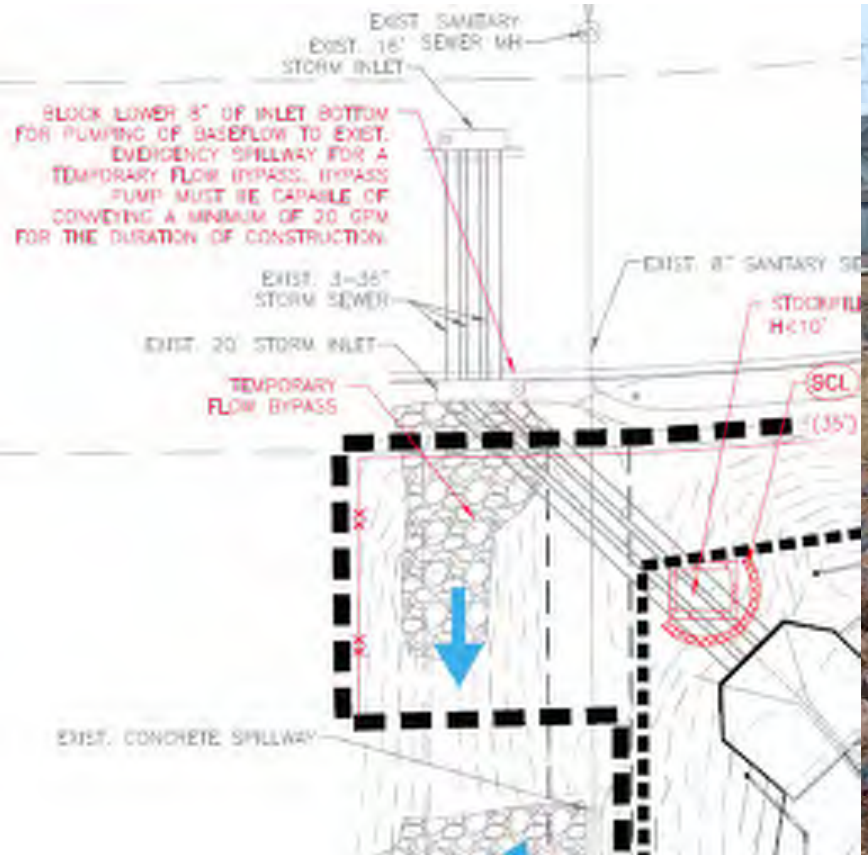


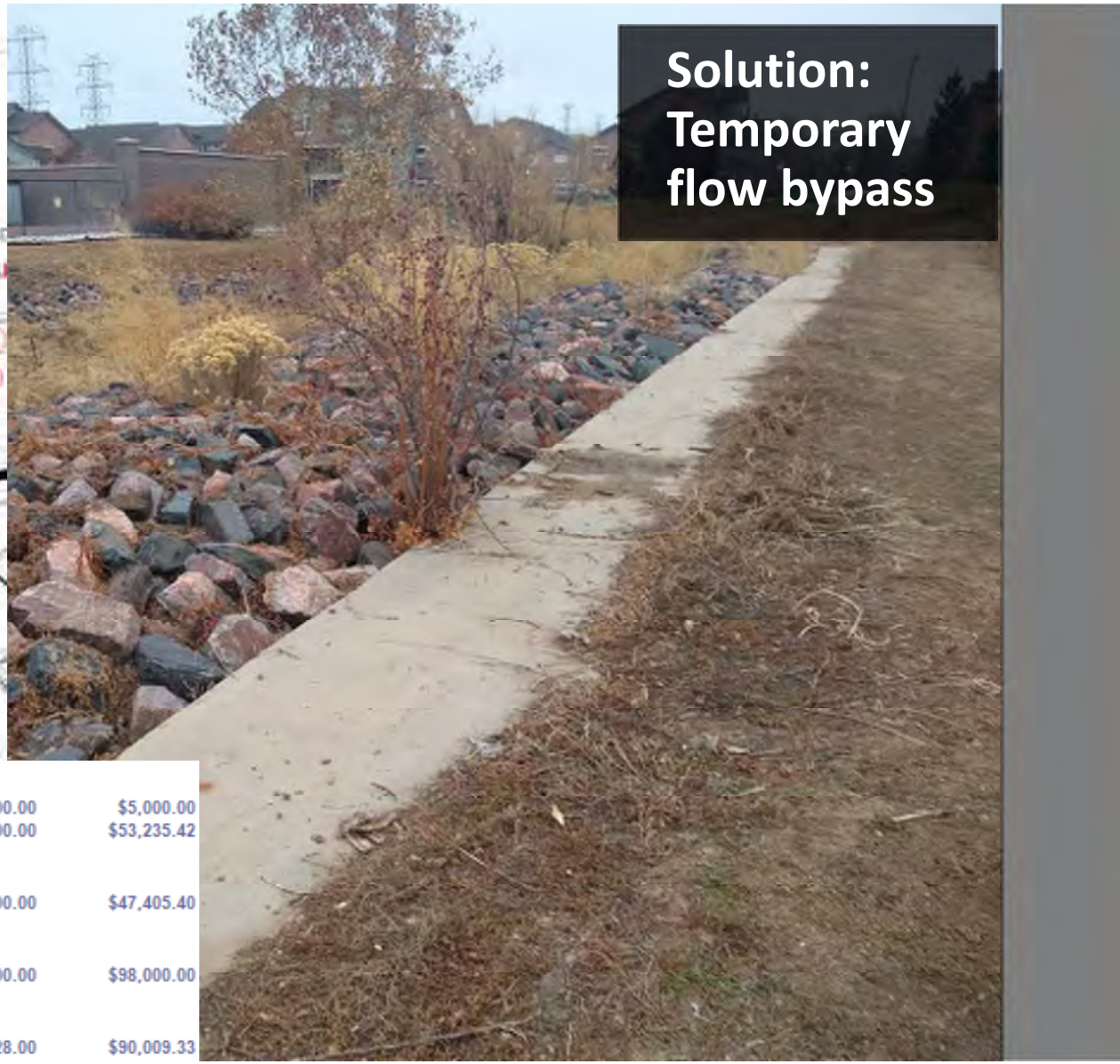


Solution: Design of micropool and initial surcharge volume for outlet structure

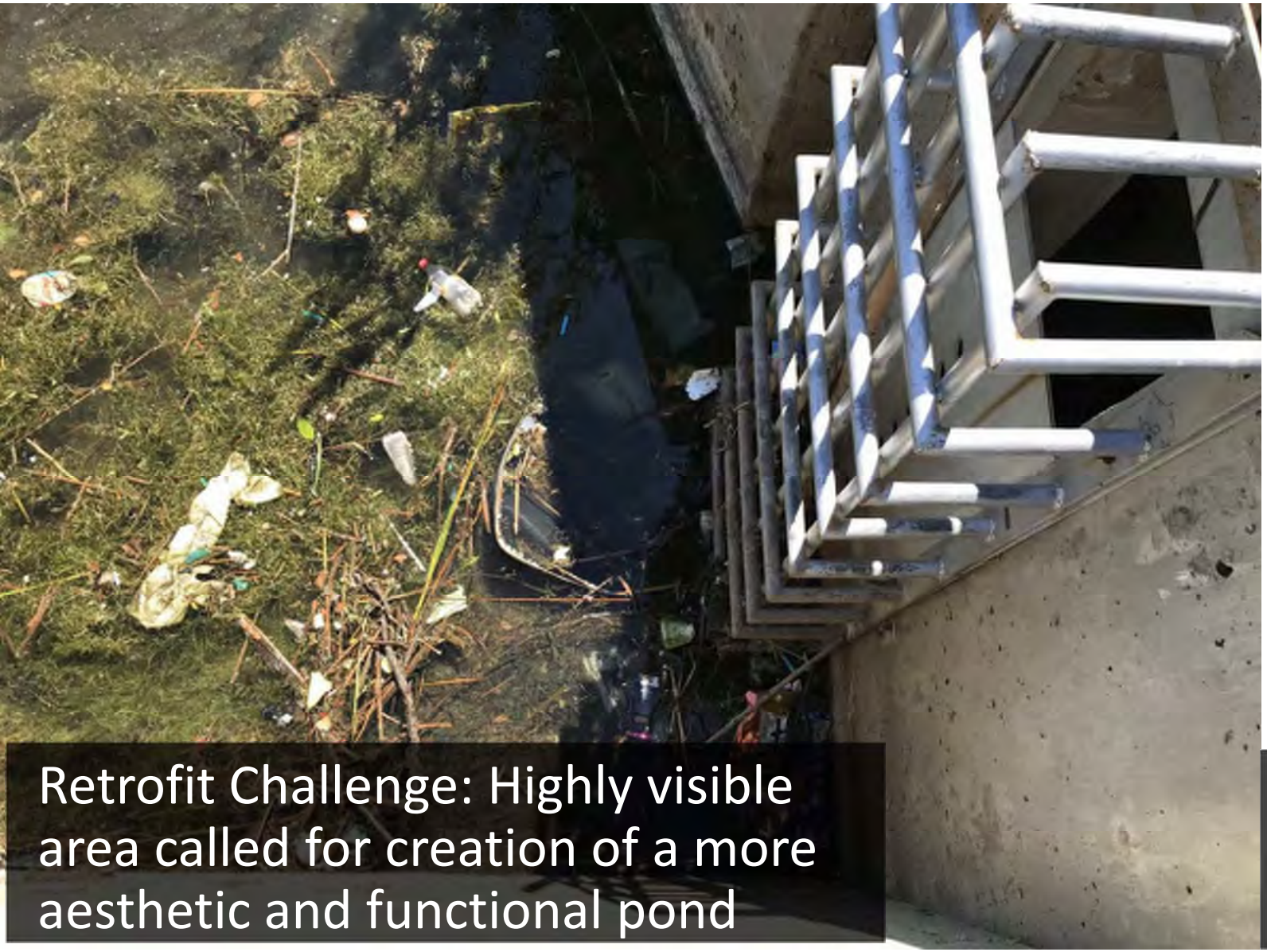
Sediment and Erosion Control in bottom of pond

RETROFIT CHALLENGE





⊟ Water Control				
	EA	$5,000.00	$5,000.00	$5,000.00
	LS	$0.00	$562,000.00	$53,235.42
⊟ Water Control and Dewatering				
	LS	$25,000.00	$75,000.00	$47,405.40
⊟ Water Control and Dewatering Operations				
	LS	$98,000.00	$98,000.00	$98,000.00
⊟ Water Control/Dewatering				
	LS	$13,000.00	$160,028.00	$90,009.33



Retrofit Challenge: Highly visible area called for creation of a more aesthetic and functional pond

“One person’s trash is another pond’s purpose”

Solution: Landscaping services requested by engineers

QUESTIONS?

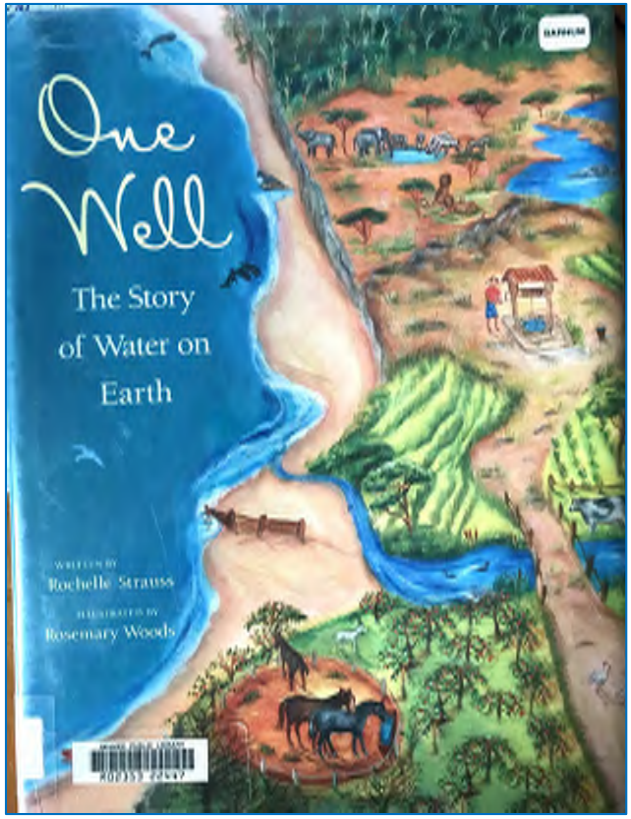
Trash Vault Squads:

Introducing infrastructure to K-12 students

Donny Roush, City & County of Denver
Troy Carmann, ICON Engineering

Who doesn’t want this?

Engineer-ese vs. Educate-ese

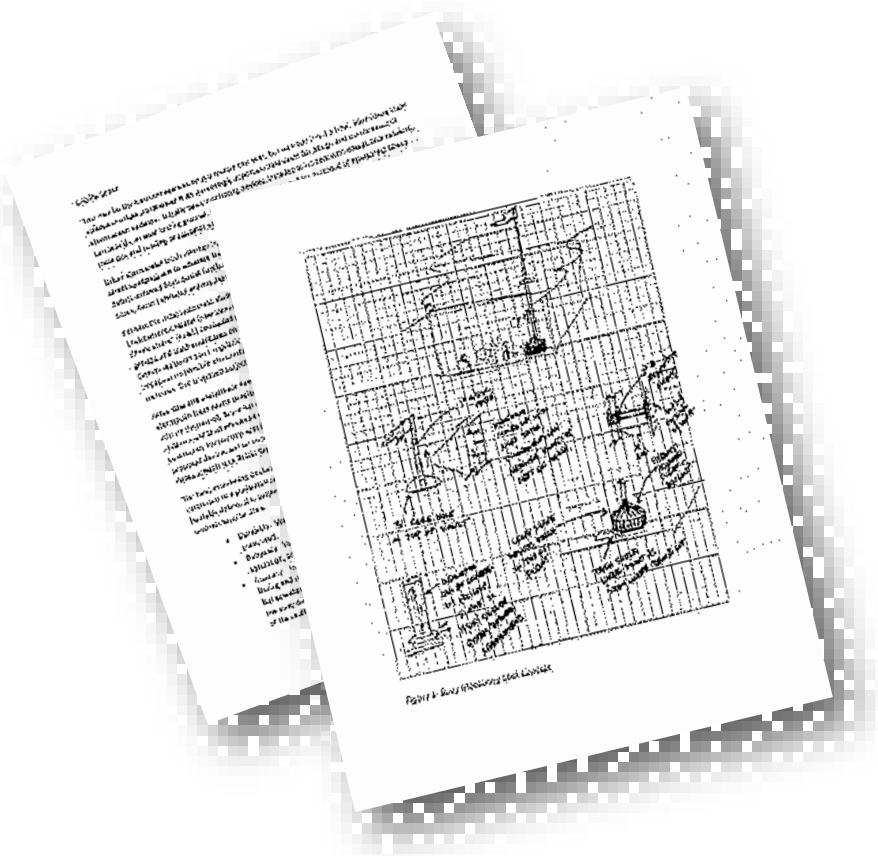


- Be bilingual (or find a translator)
- Know your young people
- Learning environments = chaotic
- …so, try a learning target
- Connect to a bigger picture
- Consider “One Water”

Denver's Stormwater Education & Outreach

Denver's Stormwater Education & Outreach

Thanks



This project supported by the 2019 CASFM Research Grant.

Trash vaults at DPS schools

Bruce Randolph 6-12

- 765 students
- District-run, traditional
- Clayton neighborhood
- Adjacent to 39th Ave. Greenway

Joe Shoemaker ECE-5

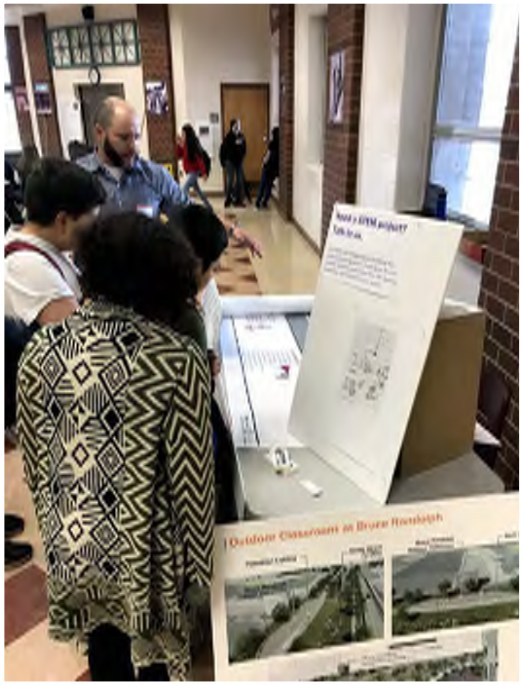
- 471 students
- District-run, innovation
- Hampden Heights neighborhood
- Adjacent to Cherry Creek

Trash vaults at DPS schools

SHOEMAKER

BRUCE RANDOLPH

@ Bruce



What we did:

- Student & teacher recruitment
- Walking tour
- Trash measuring demo
- Virtual field work to river

What we planned:

- Field work to river
- Peer-to-peer presentation
- Visit existing outdoor classrooms
- Build & install trash measuring device

With:

- Vanessa Alvear, 6th Grade Science Teacher
- Alanna, Karlo, D'Quarius, Daniel, Angel, Yahir

@ Shoe

What we did:

- Walking tour
- Interpreting drawings
- Review & revision of design
- Trash measuring demo
- Volume calculations of vault

What we planned:

- Peer-to-peer presentation
- Monitoring of trash measuring device
- Support of “Water around the World” learning expedition

With:

- Ryan Pleune, Adventure/FitnessTeacher
- Calin, Callum, Beckett, Heidi, Yandel, Oriane

...about those ed translators

- Environmental education as a field
- Professional certification
- North American Association for Environmental Education
- Colorado Alliance for Environmental Education

naaee
North American Association for Environmental Education

caee

Trash Vault Squads:

Introducing infrastructure to K-12 students

Co-Creating a Regional Vision for People + Nature

Taking a watershed approach

Dana Coelho, Alliance Director
Metro Denver Nature Alliance

September 29, 2020
Colorado Association of Stormwater and Floodplain Managers

Align nature-based efforts to ensure more equitable access to nature and to promote healthy people, communities, and natural places.

MetroDNA

METRO DENVER NATURE ALLIANCE

Connecting Communities. Championing Nature.

www.metrodna.org

In support of our mission & vision, Metro DNA performs three mutually reinforcing roles.

Our work is rooted in both conservation + equity.

NWOOD TITUTE learn | change

ROCKY MOUNTAIN WILD

THE ALLIANCE CENTER

BOYS & GIRLS CLUBS METRO DENVER

DENVER PARK TRUST

AFCHA EL LABORATORIO

WILD

Colorado Environmental Film Festival

DENVER ZOO

ARAPAHOE COUNTY COLORADO'S FIRST

SOUTHWEST DENVER COALITION

DENVER BOTANIC GARDENS

Learning for Kids

The Nature Conservancy

CAEE Colorado Alliance For Environmental Education

UNIVERSITY of DENVER

DENVER PARKS & RECREATION

GOCO GREAT OUTDOORS COLORADO

Butterfly PAVILION

DENVER AUDUBON

THE TRUST FOR PUBLIC LAND

Colorado Public Health Parks and Recreation Collaborative

VOLUNTEERS FOR OUTDOOR COLORADO

MileHighConnects

Wild Within Reach

Biohabitats SOUTHERN ROCKY MOUNTAIN BIOREGION

DENVER PUBLIC WORKS

HIGH LINE CANAL CONSERVANCY

Barr Lake & Milton Reservoir Watershed Association

DENVER MOUNTAIN PARKS FOUNDATION

drcog DENVER REGIONAL COUNCIL OF GOVERNMENTS

SOUTH SUBURBAN PARKS & RECREATION

SAND CREEK REGIONAL GREENWAY

WESTMINSTER COLORADO

Climate Courage
Heart of the West Counseling
Jo Burns Consulting

The Park People

Bluff Lake Nature Center

walk2connect co-op

Denver CU IN THE CITY

GOWILD northeast metro coalition

Xcel Energy FOUNDATION

NATIONAL PARKS CONSERVATION ASSOCIATION

Collaborative Projects

Metro DNA-led

- **Nature Narratives:** crafting and elevating a shared story and partner voices
- **Safe Summer Kick Off on Get Outdoors Day:** building community health, wealth, and safety through connections to the natural world; partnership with SouthWest Denver Coalition, Denver Parks & Recreation, and National Park Service
- **Regional Vision:** Defining shared social-ecological goals and strategies to achieve those goals; partnership with The Nature Conservancy and Biohabitats

Partner-led

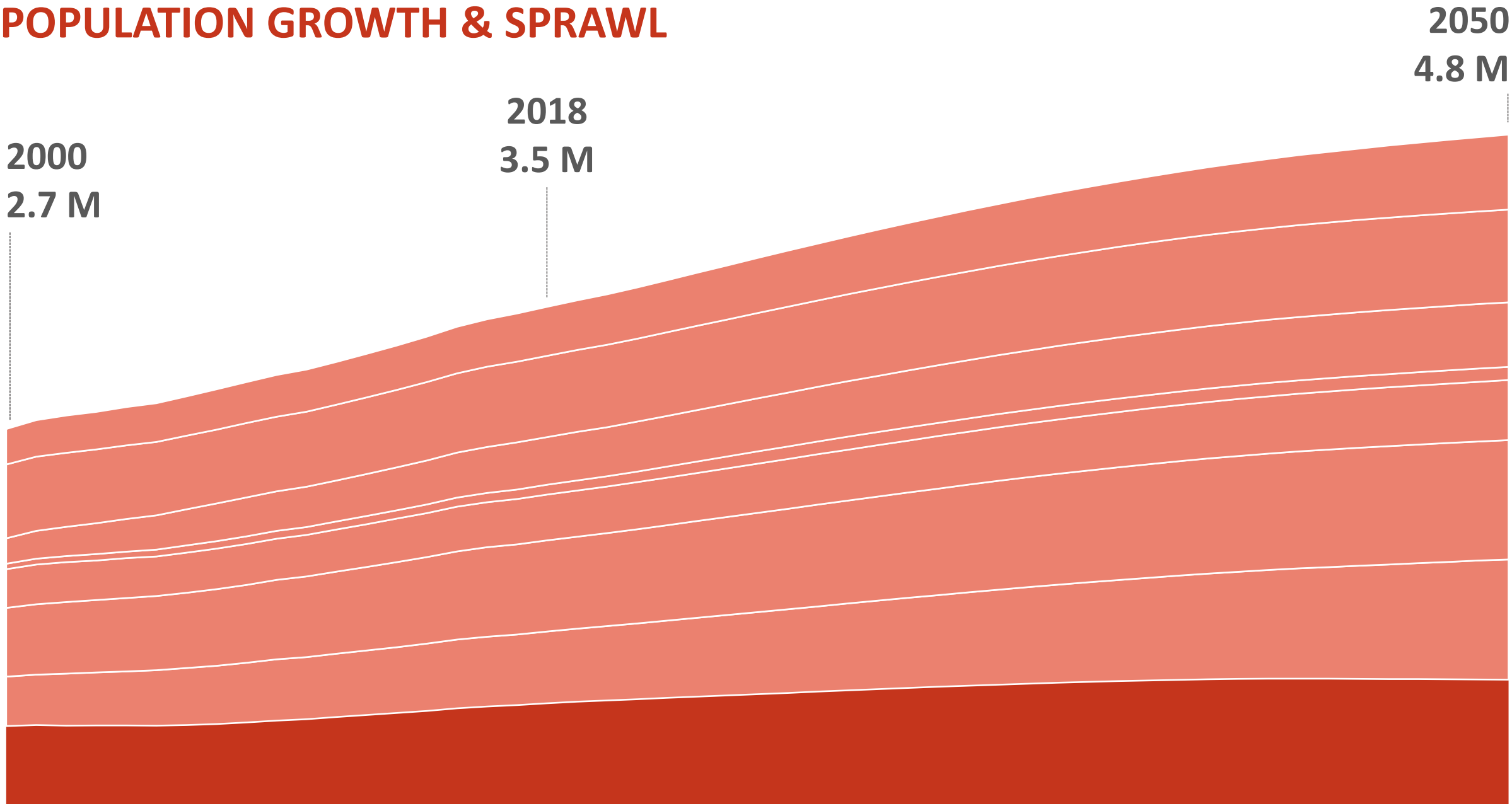
- **City Nature Challenge:** documenting observations of wild plants and animals; Wild Foundation, CO DNR, and TNC
- **Summit for Action:** two-day workshop on solutions-based recommendations for Justice, Equity, Diversity, Accessibility and Inclusion; Ecoinclusive
- **Rx for PRONTOS:** a dialog prescription programs for parks, recreation, outdoors, nature, trails, and open space across the state; Colorado Public Health and Parks & Rec Collaborative, CDPHE, and NPS
- **Stewardship Mapping and Assessment Project (STEW-MAP):** understanding our environmental stewardship “landscape” – who does what, where, and how are we all connected organizationally;Denver Urban Field Station

CONVERGENCE:

Water/Climate + Habitat Loss + Environmental Justice

Biohabitats

POPULATION GROWTH & SPRAWL



GREEN NETWORK BENEFITS

PROTECT ECOLOGICAL RESOURCES

- Water cleaning and storage
- Wildlife habitat

PROVIDE BEAUTIFICATION

- Passive recreation
- Gathering/ socializing

CREATE REINVESTMENT & GROWTH POTENTIAL

- Economic development

PROVIDE EQUITY & EMPOWERMENT

- Environmental education
- Transportation alternatives

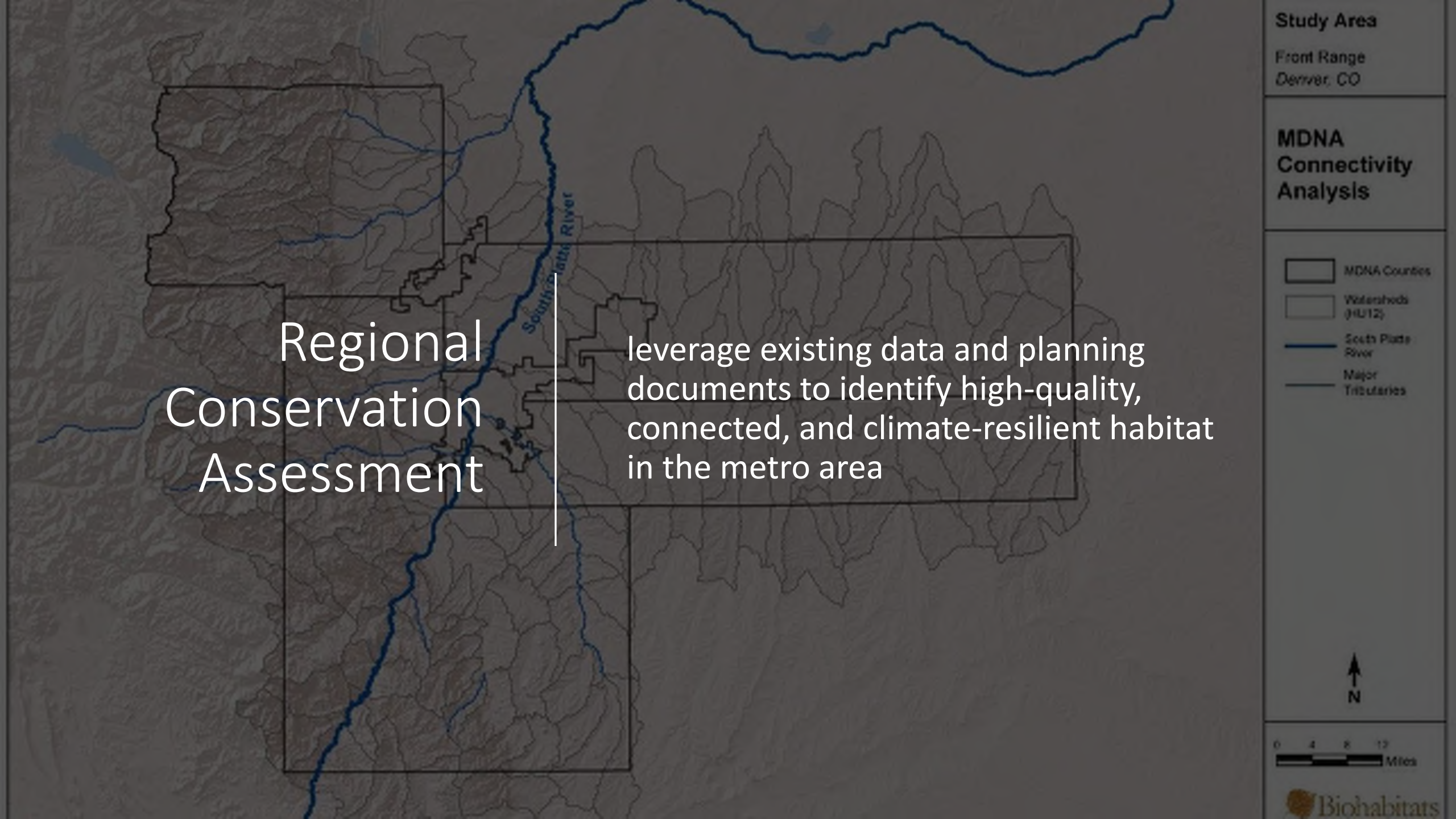
IMPROVE HEALTH & QUALITY OF LIFE

- Cooling and shade
- Active recreation
- Food production

Biohabitats

Jonathan Jarvis, Designing climate resilience for people and nature at the landscape scale,
https://escholarship.org/uc/item/2mq6v6tn

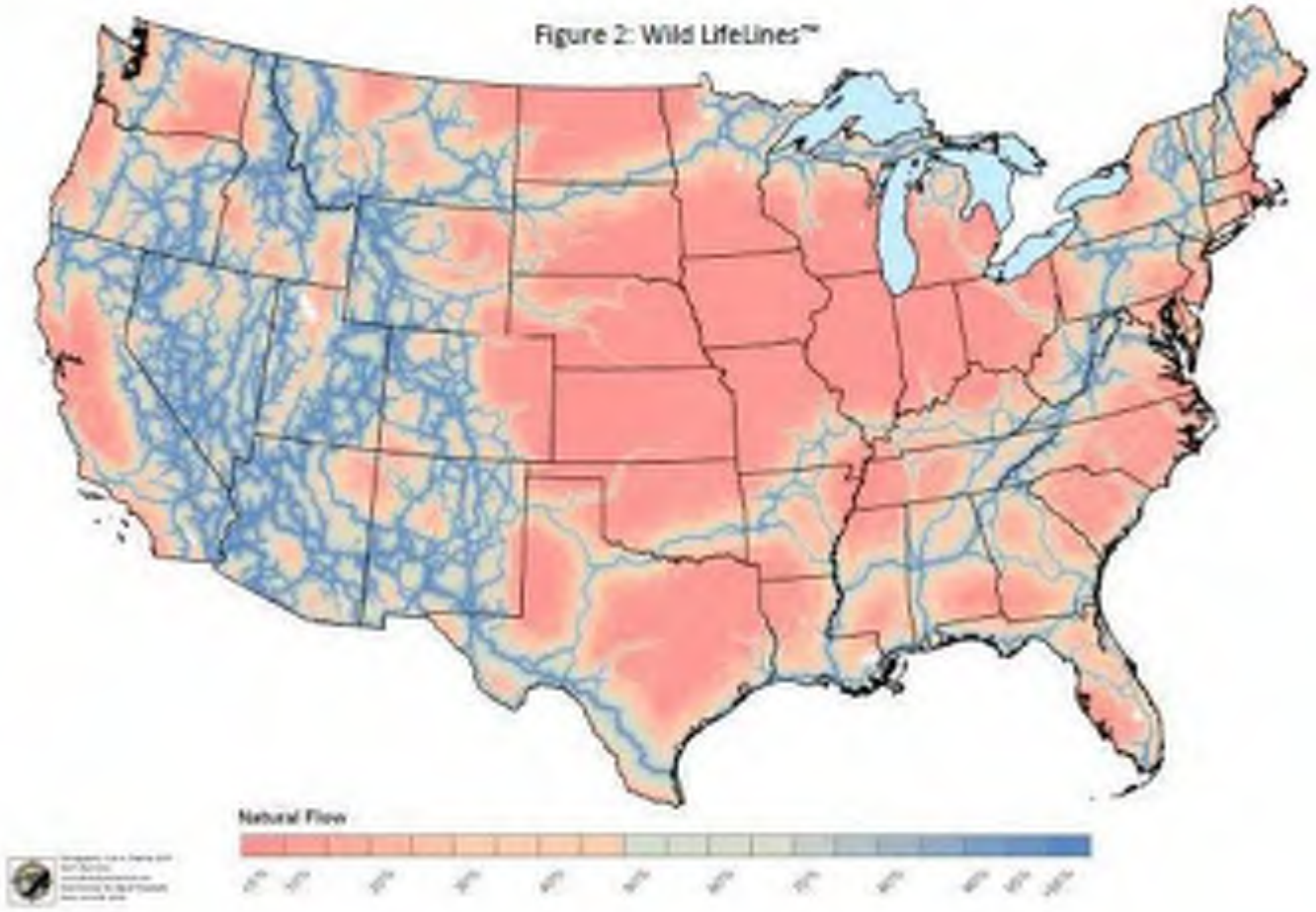
"We have confidence that [a] unified vision of conservation will result in significant progress over the long term. **The coming together of nature conservation, historical preservation, ecosystem services, environmental justice and civil rights, sustainability, public health, and science communities is overdue, but when fully accomplished will reap significant reward.** As these interests increasingly practice the skills of collaboration, and gain experience in working closely together in more common cause, they will find their collective 'voice' to be powerful, influential, and effective."



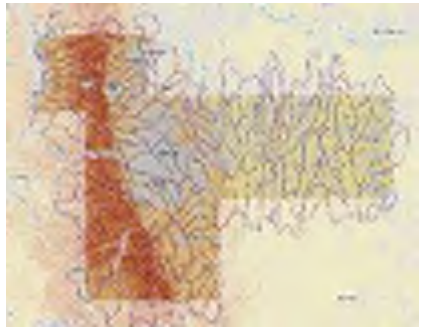
Regional Conservation Assessment

leverage existing data and planning documents to identify high-quality, connected, and climate-resilient habitat in the metro area

POTENTIAL & EXISTING CONNECTIVITY/VULNERABILITY



CPW



Biohabitats

Biohabitats

http://landscapeconservation.org/catalyst-fund/2019-catalyst-fund-grant-awards

SPARCC

We all do better when everyone thrives.

Atlanta

Chicago

Denver

Los Angeles

Memphis

San Francisco Bay Area

http://www.sparcchub.org/communities

COLORADO RIVER GREENWAY SOURCEBOOK

Prepared for the City of San Luis Rio Colorado, Sonora, Mexico as part of the River Sisters Initiative

https://www.afcanatura.org/river-sisters

PRECEDENTS

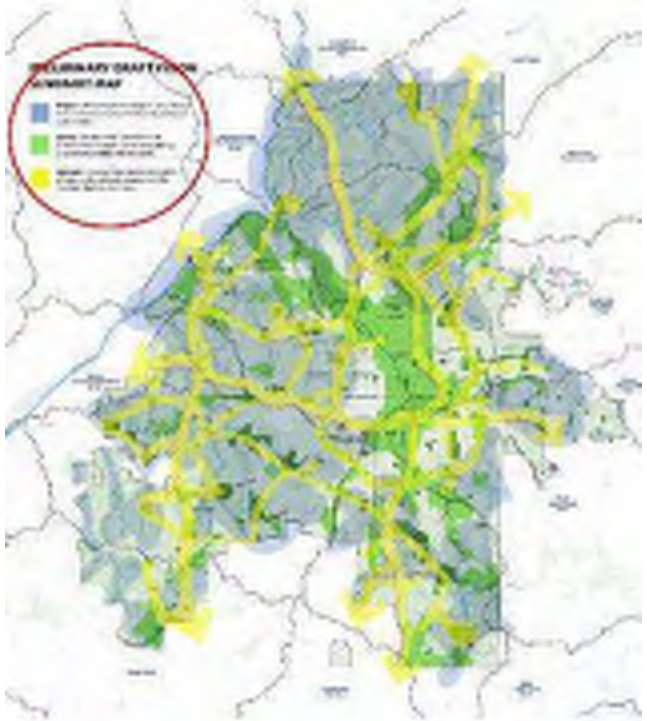
Regional water/ecological data + Social-ecological

Inspire deeper understanding of stewardship and dynamics of water

Address human & environmental challenges

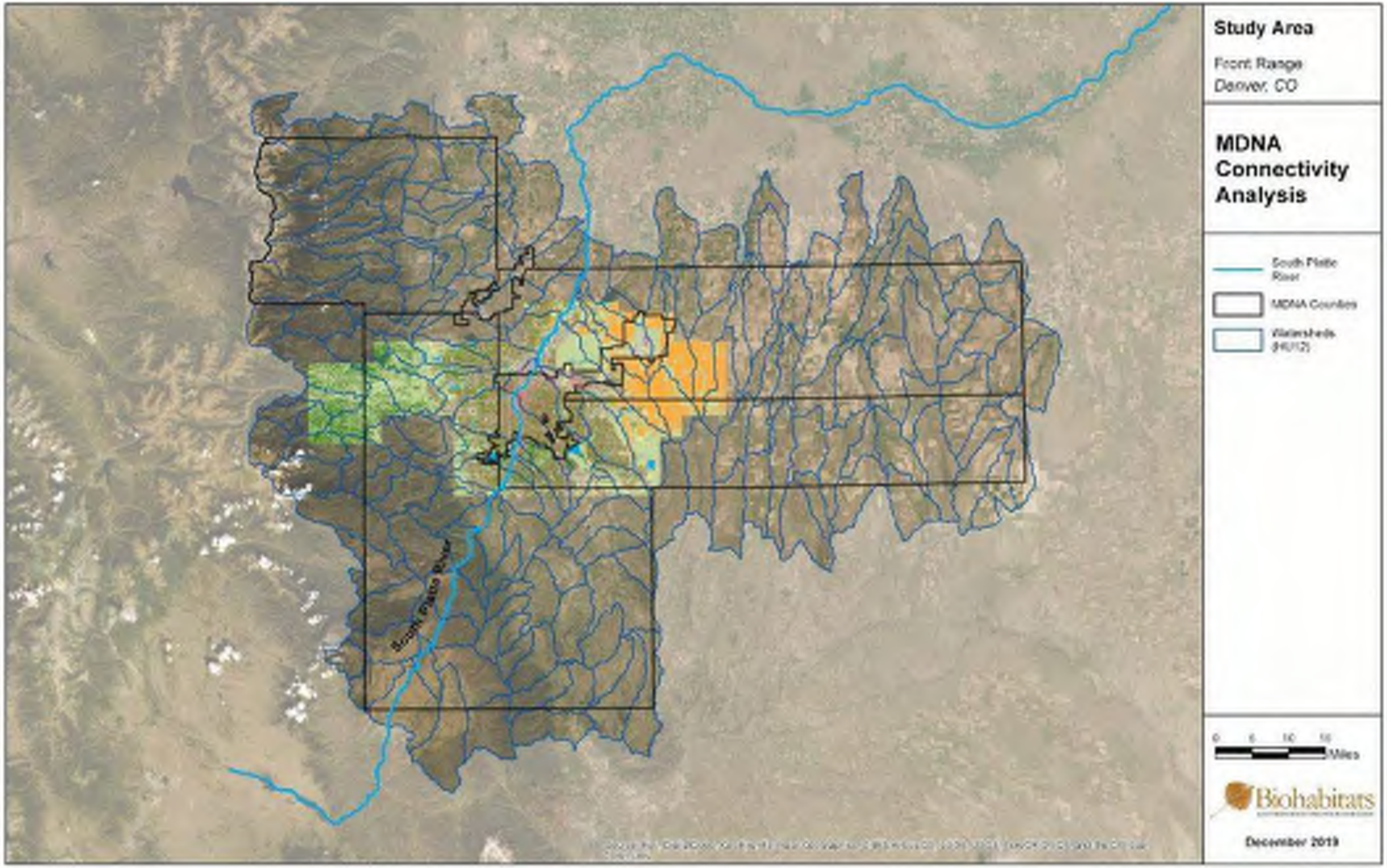
Bring people together in shared vision and provide hope

Inspire investments & build momentum

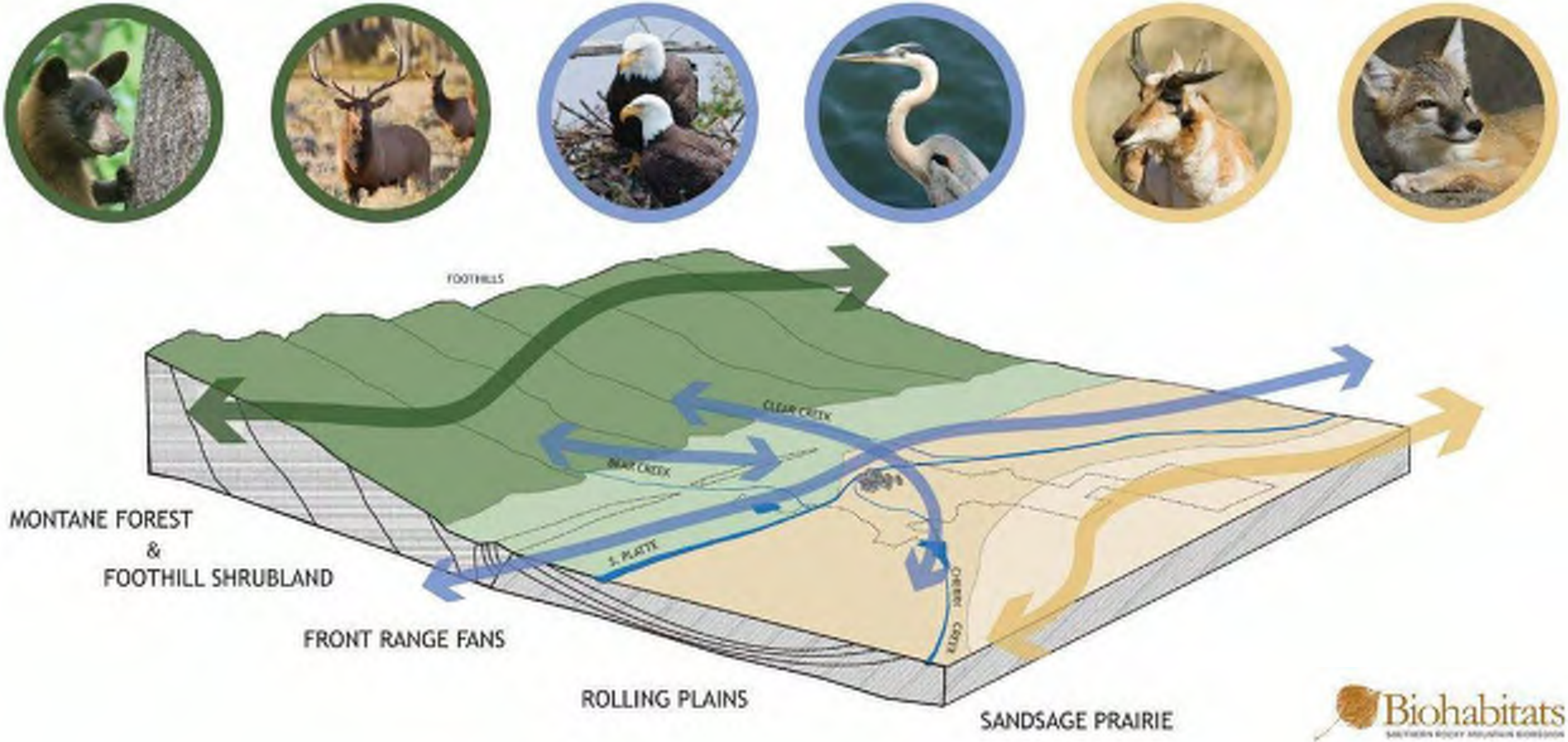


GREEN INFRASTRUCTURE PLAYBOOK

Biohabitats
SOUTHERN ROCKY MOUNTAIN REGION

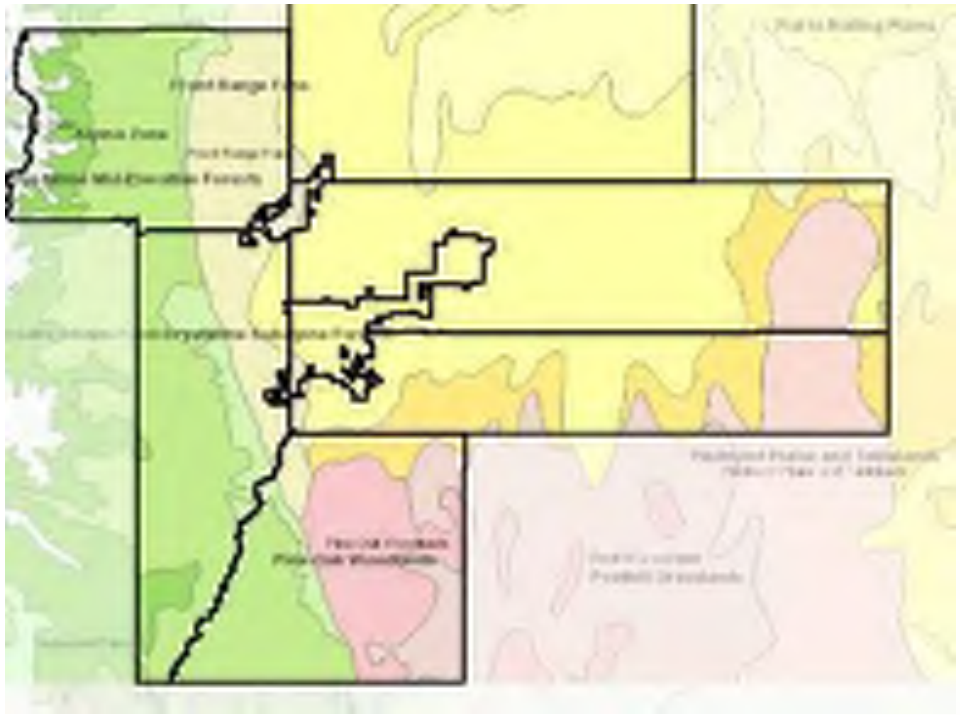

Study Area
Front Range
Denver, CO
MDNA Connectivity Analysis
South Platte River
MDNA Counties
Watersheds (HUC12)
0 5 10 15
Miles
Biohabitats
December 2019

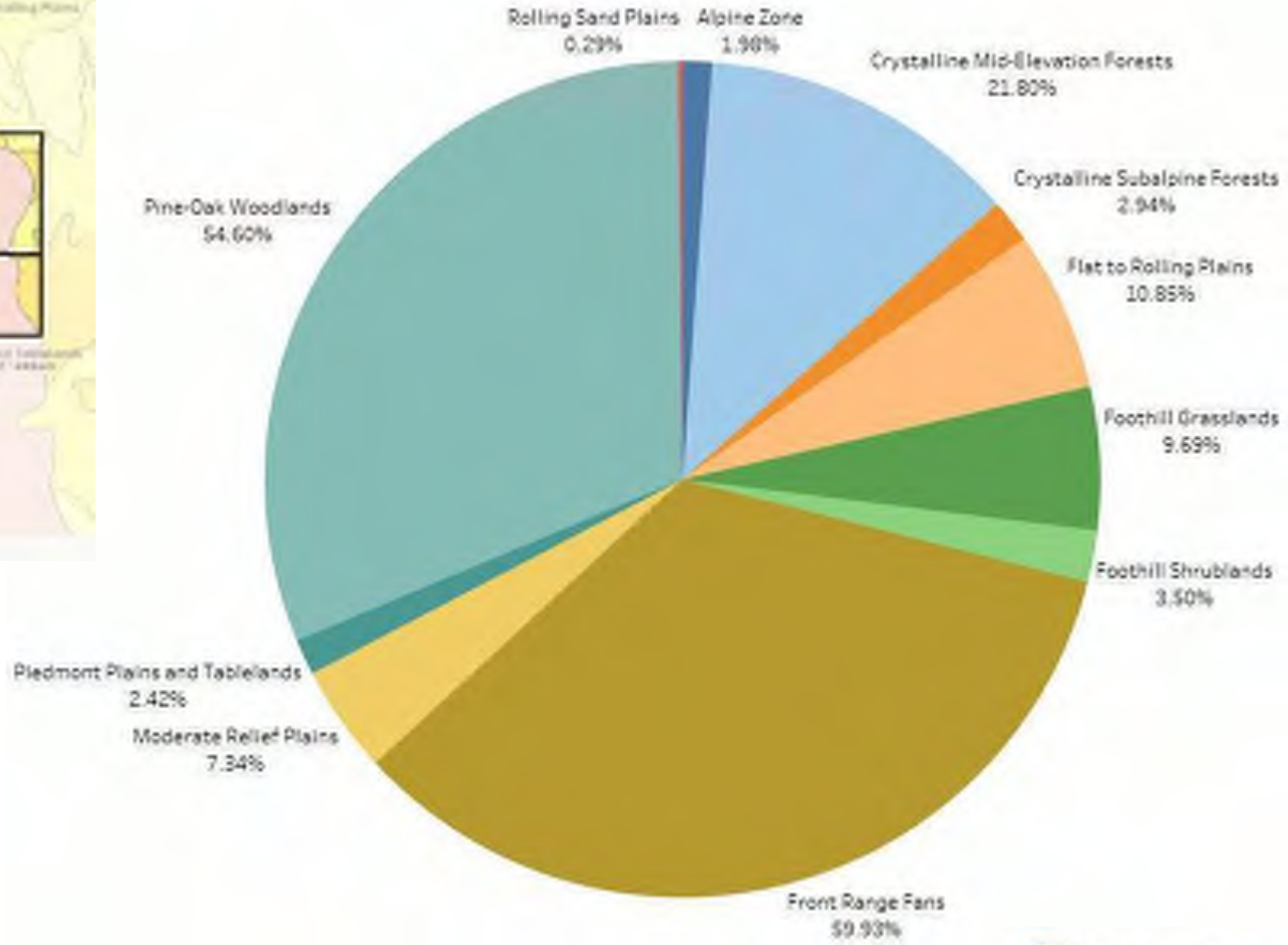
Regional planning framework & ecoregions



Biohabitats

METRO DNA ECO REGIONS





1	Alpine Zone
2	Crystalline Mid-Elevation Forests
3	Crystalline Subalpine Forests
4	Flat to Rolling Plains
5	Foothill Grasslands
6	Foothill Shrublands
7	Front Range Fans
8	Moderate Relief Plains
9	Piedmont Plains and Tablelands
10	Pine-Oak Woodlands
11	Rolling Sand Plains

Biohabitats

MDNA ecoregions & potential conservation targets

all data in acres except where noted as %

ROLE OF MDNA ECOREGIONS IN STATEWIDE CONSERVATION PLANNING

Ecoregions in Denver Metro Area	Acres in CO	Acres in US	% of ecoregion type in CO	CO proportion of 1/2 earth target ?	Existing (2018) Protected Areas	CO ecoregional target GAP
Alpine Zone	2,368,625	5,510,834	43%	1,184,313	2,249,737	(1,065,424)
Crystalline Mid-Elevation Forests	2,850,523	4,984,183	57%	1,425,262	1,733,802	(308,541)
Crystalline Subalpine Forests	3,050,267	3,914,655	78%	1,525,134	2,678,385	(1,153,252)
Flat to Rolling Plains	8,455,697	20,767,327	41%	4,227,849	458,557	3,769,291
Foothill Grasslands	1,155,168	1,155,168	100%	577,584	86,422	491,162
Foothill Shrublands	2,986,015	7,259,594	41%	1,493,008	1,239,154	253,853
Front Range Fans	500,215	500,215	100%	250,108	122,166	127,941
Moderate Relief Plains	3,969,131	8,075,630	49%	1,984,566	534,383	1,450,182
Piedmont Plains and Tablelands	8,546,418	8,546,418	100%	4,273,209	1,483,492	2,789,717
Pine-Oak Woodlands	371,522	371,522	100%	185,761	17,848	167,913
Rolling Sand Plains	2,956,328	6,778,348	44%	1,478,164	316,183	1,161,981
	37,209,909			18,604,955	10,920,129	7,684,825
Other ecoregions in state	28,790,091					
Total acres in state (all types)	66,000,000					

Red indicates ecoregions only found in Colorado

Biohabitats

MDNA Counties with ecoregions found only in Colorado

Pine-Oak Woodlands				
	CO Ecoregion Gap target=		167,913	acres
	County total acres	Protected in acres	Remaining u acres	% target avail
Adams			0	0
Arapahoe			0	0
Broomfield			0	0
Denver			0	0
Jefferson			0	0
Douglas	202,761	10,795	191,966	114%
Boulder			0	0

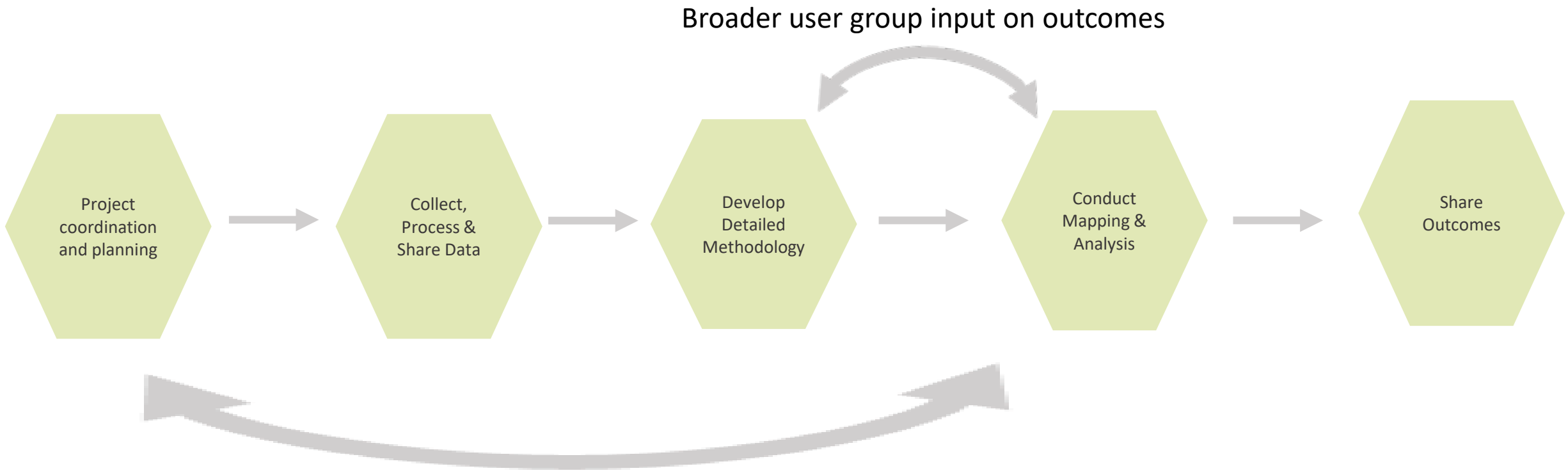
Front Range Fans				
	CO Ecoregion Gap target=		127,941	acres
	County total acres	Protected in cc acres	Remaining u acres	% target avail
Adams			-	0%
Arapahoe	6,015	1,005	5,010	4%
Broomfield	14,299	2,189	12,110	9%
Denver	8,046	1,361	6,686	5%
Jefferson	92,977	33,068	59,909	47%
Douglas	18,830	6,955	11,875	9%
Boulder	159,326	51,989	107,337	84%

Foothill Grasslands				
	CO Ecoregion Gap target=		491,162	acres
	County total acres	Protected in acres	Remaining u acres	% target avail
Adams			0	
Arapahoe	20,245	5,787	14,457	3%
Broomfield			0	0%
Denver			0	0%
Jefferson			0	0%
Douglas	91,759	7,517	84,242	17%
Boulder			0	0%

Piedmont Plains and Tablelands				
	CO Ecoregion Gap target=		2,789,717	acres
	County total acres	Protected in cc acres	Remaining u acres	% target avail
Adams	102,346	6,208	96,137	3%
Arapahoe	104,364	6,711	97,654	4%
Broomfield			-	0%
Denver			-	0%
Jefferson			-	0%
Douglas			-	0%
Boulder			-	0%

Biohabitats

Project Timeline + Process



Conservation by Design Step: "Identify Challenges"
Core Team – Prep of baseline materials

Spatial Analysis & Modeling of Habitat Connectivity

Within the Greater Denver Metro Region

Chris Rehak | April 25, 2020

Introduction

Conservation and restoration have become planning priorities in urban-wildlife interface areas across the country due to increased habitat fragmentation resulting from urban sprawl and increasing populations. This fragmentation habitat connectivity can result in negative impacts for ecological function and health for natural communities. Habitat connectivity analysis is a method to improve understanding of these connections and wildlife movement patterns across the landscape and is important in helping to develop strategic approaches.

Purpose

Determine the optimal habitat connectivity patterns within the Greater Denver Metro area for the Mule Deer, which rely heavily on a variety of habitats and riparian areas. It is a good representation of a umbrella species within the study area. The goal is to identify primary connectivity corridors and from this output, identify pinchpoints or areas of impedance and restoration areas that contain the highest potential for improving connectivity.

A Deer Migration You Have to See to Believe | National Ge...

Researchers have only recently found the longest large mammal migration in the continental United States: Mule deer migrate 150 miles...

https://www.youtube.com/

https://www.roadtube.com/

Programs Used for Analysis

ArcGIS Pro

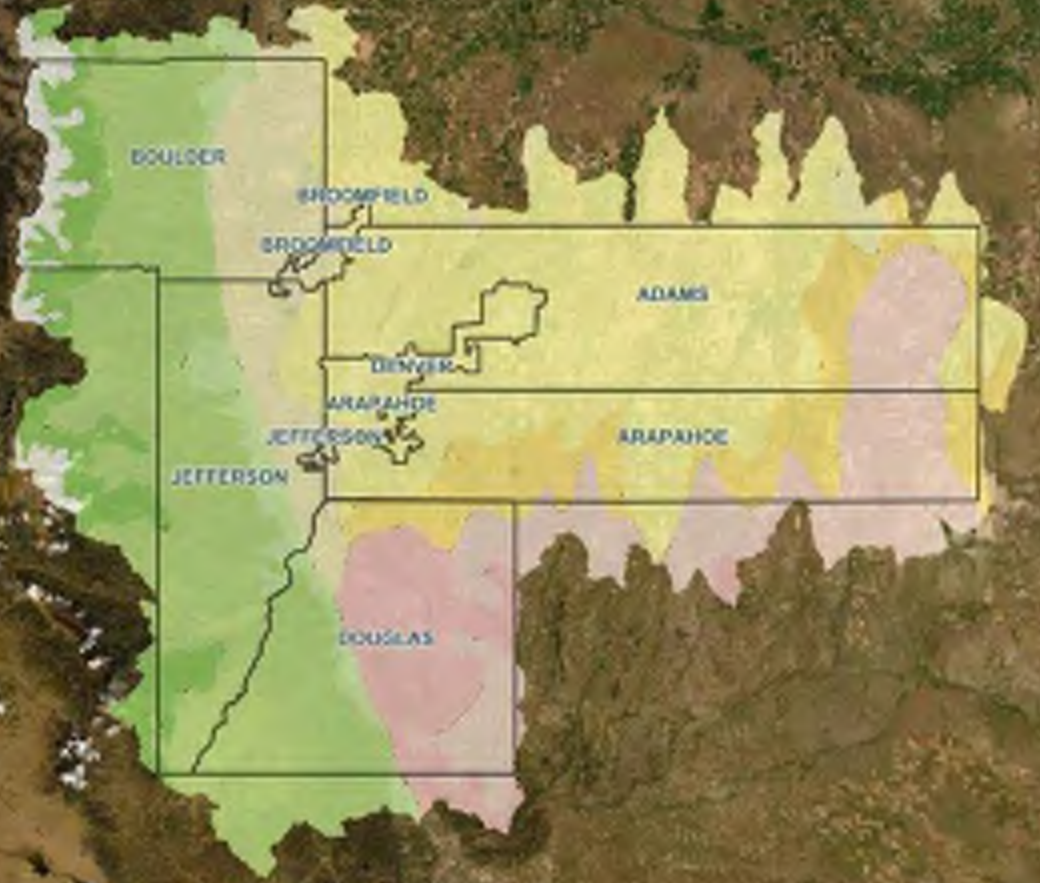
Circuitscape

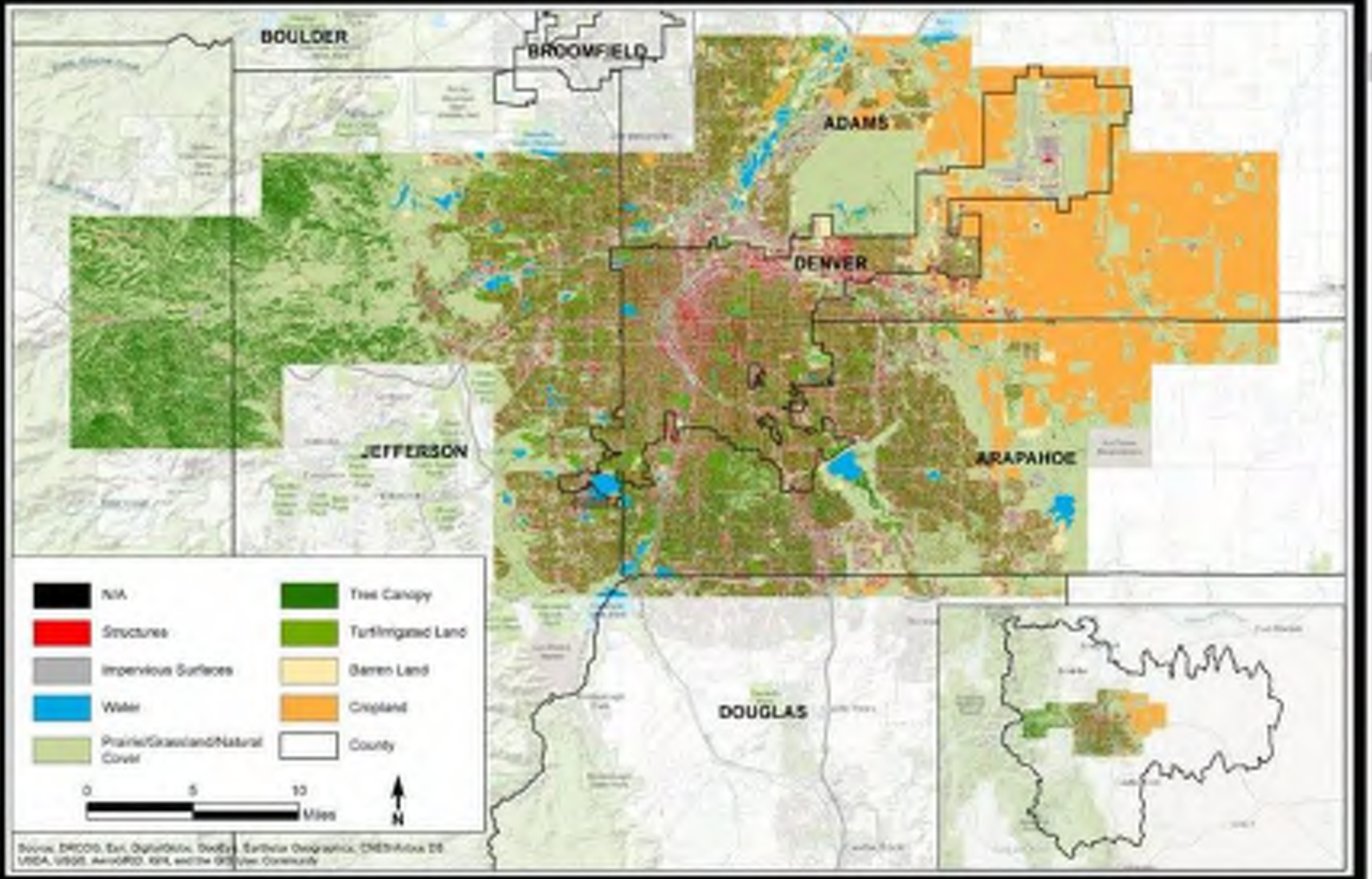
Study Area

- Metro Denver Nature Alliance
- 7 Counties
- Intersected with USGS HUC12 Watersheds
- 6,148 square miles

EPA Level IV Ecoregions (West to East)

- Alpine
- Crystalline Sub-alpine Forests
- Crystalline Mid-Elevation Forests
- Foothill Shrublands
- Front Range Fans
- Moderate Relief Plains
- Pine-Oak Woodlands
- Flat to Rolling Plains
- Piedmont Plains and Tablelands
- Foothill Grasslands
- Rolling Sand Plains





Existing Land Cover Data

- Source: Denver Regional Council of Governments (DRCOG)1-meter pilot land cover study
- Used as a template for land cover classification in remaining study area.

Colorado Parks and Wildlife Wildlife Mapping

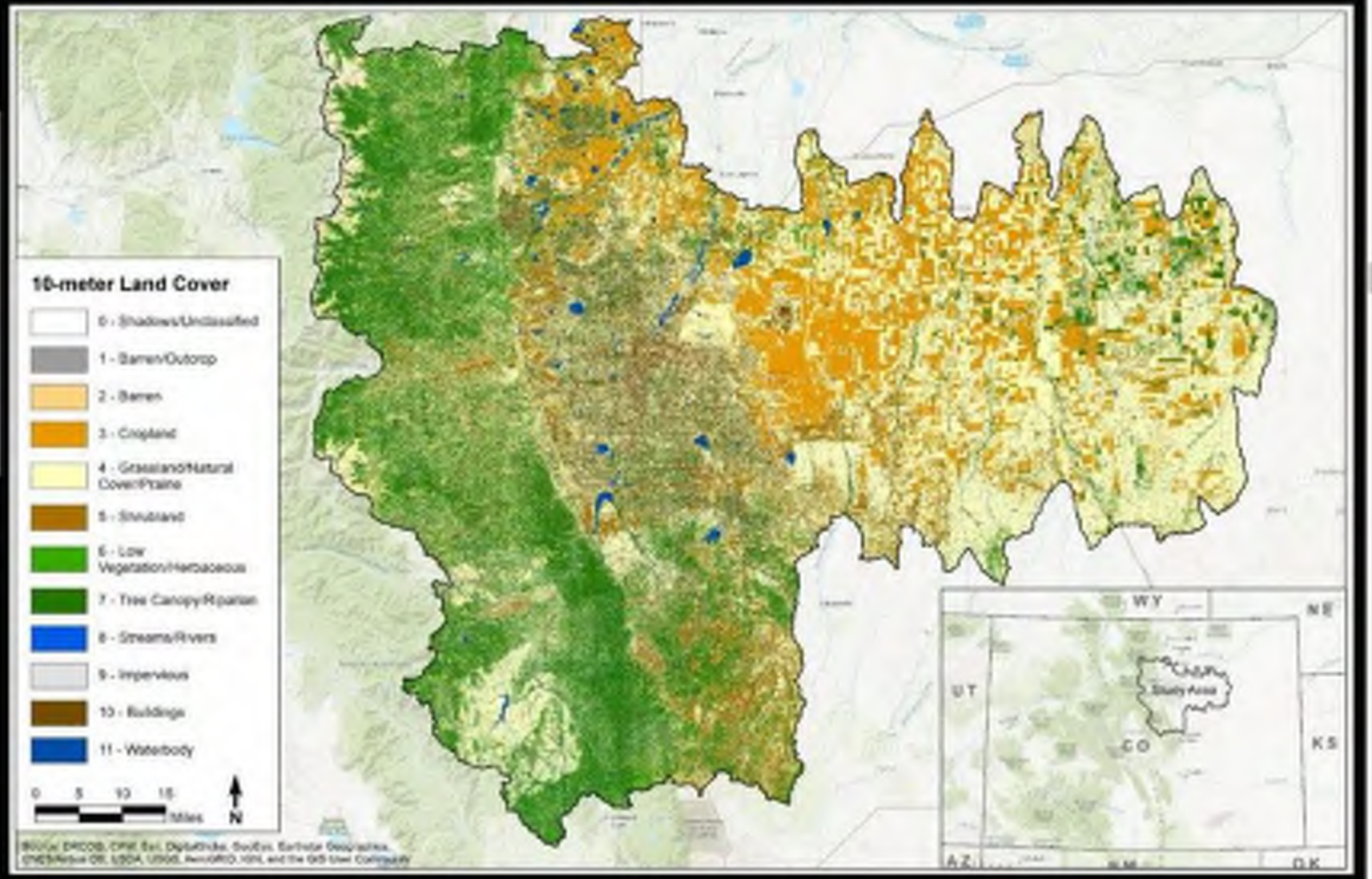
- Mule Deer Concentration Area (dark)
- Mule Deer Resident Population (light)
- Assists in defining core habitat cores in prairies and grasslands of Eastern Plains.
- Land cover classification tends to struggle differentiating cover types in semi arid regions.

Land Cover Classification

- 2017 USDA NAIP Imagery (1-meter)4-band imagery (NIR) allows for vegetation extraction.
- 636 individual images, Mosaicked into a single image.
- Imagery clipped into 15 quadrants for manageable land cover classification

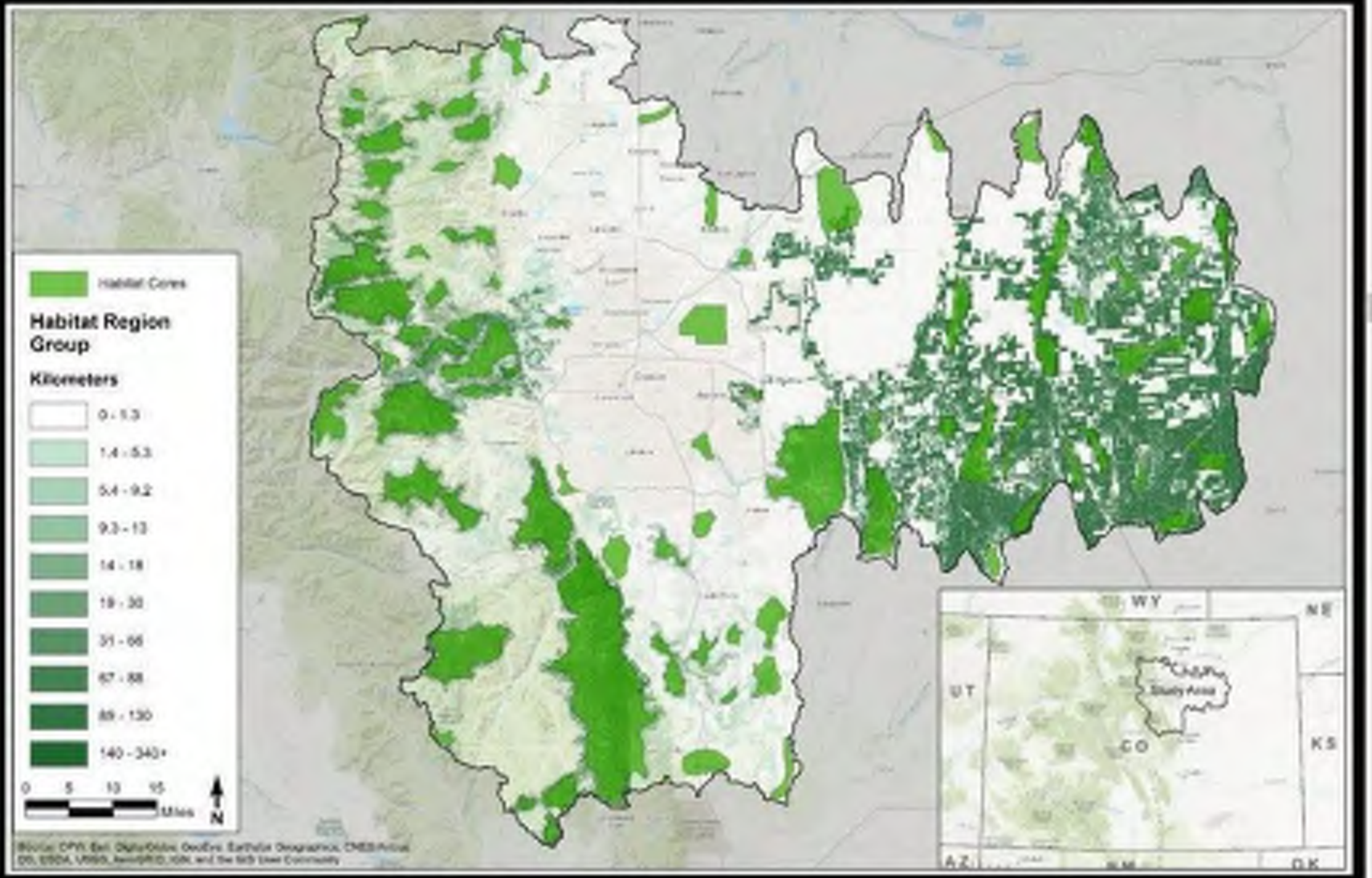
Final Land Cover Classification

- 11 classes (excluding shadows)
- All classified segments mosaicked into a single raster and clipped to study area boundary.
- Resampled to 10-meter resolution for processing and analysis of habitat cores.



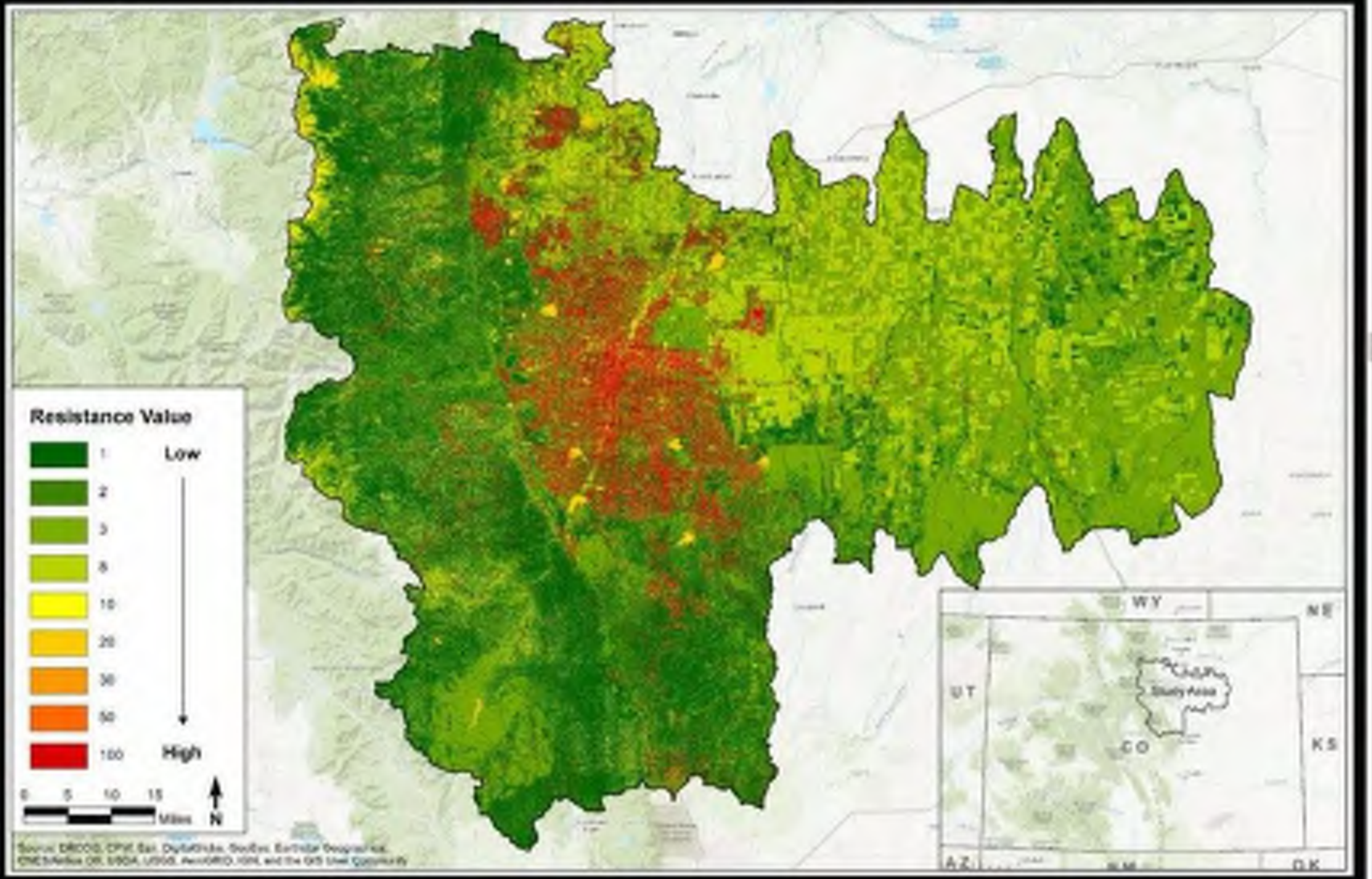
Habitat Core Analysis

- Utilized land cover classes of tree canopy, grassland, prairie, herbaceous and shrublands.
- Region Group geoprocessing tool creates outputs that identify contiguous/connected regions and assigns a unique ID.
- Zonal Geometry geoprocessing tool calculates the area of these unique rasters.
- Manual digitization of "Habitat Core" polygons are created around core areas.
- CPW Mule Deer habitat information was utilized in plains to determine specific habitat core areas.



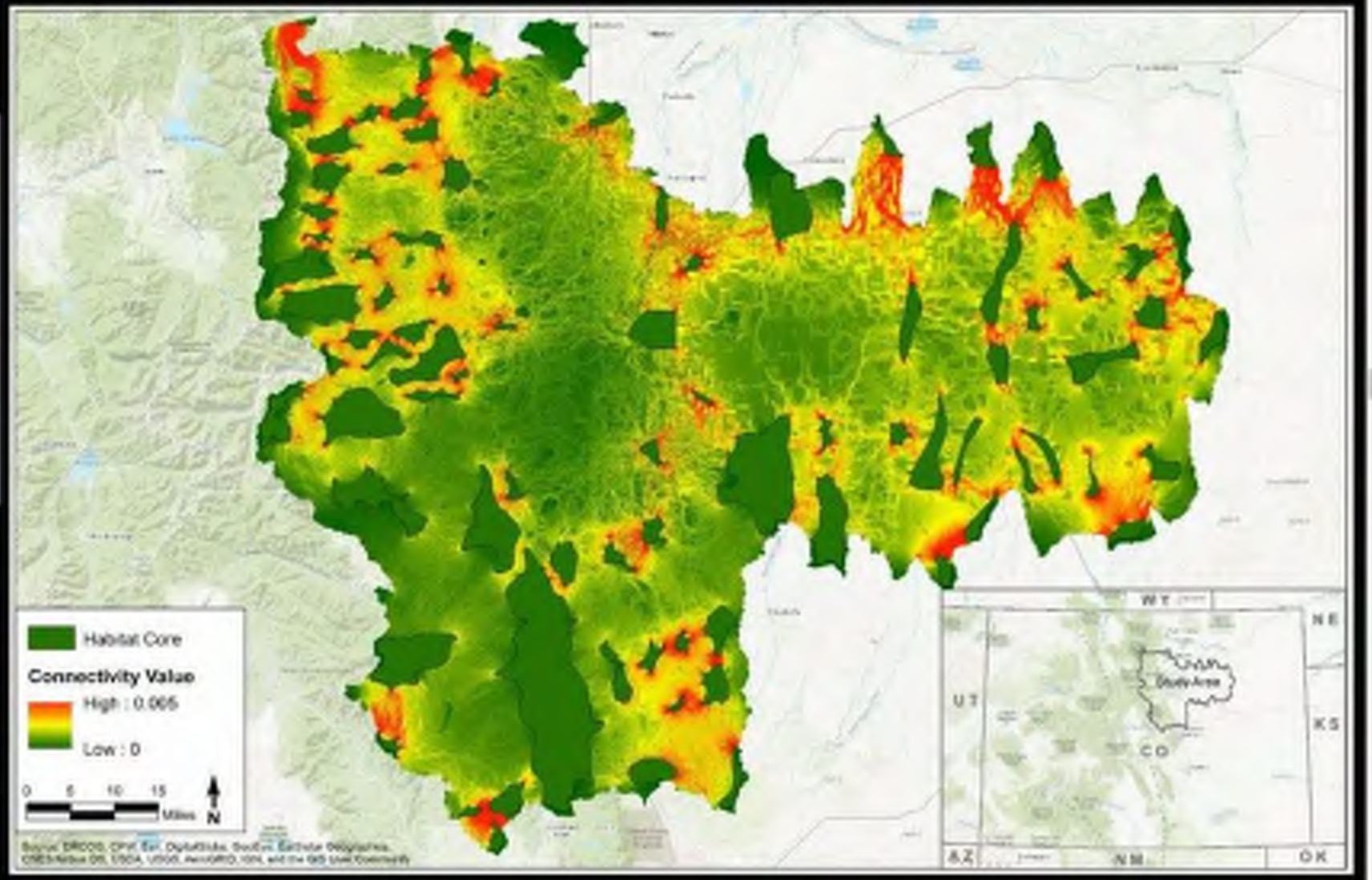
Landscape Resistance

- Determines impedance to movement across the landscape
- Impervious surfaces such as buildings, roads, rock outcrops are 30-100
- Waterbodies are 20
- Croplands are 8
- Shrubland, Vegetation, Grassland/Prairie are 1-3



Circuitscape Current Map

- Represents connectivity and ease of movement across the landscape.
- Lower values = low resistance to movement
- Higher values = high resistance to movement
- Can begin to visualize currents and patterns across the study area.

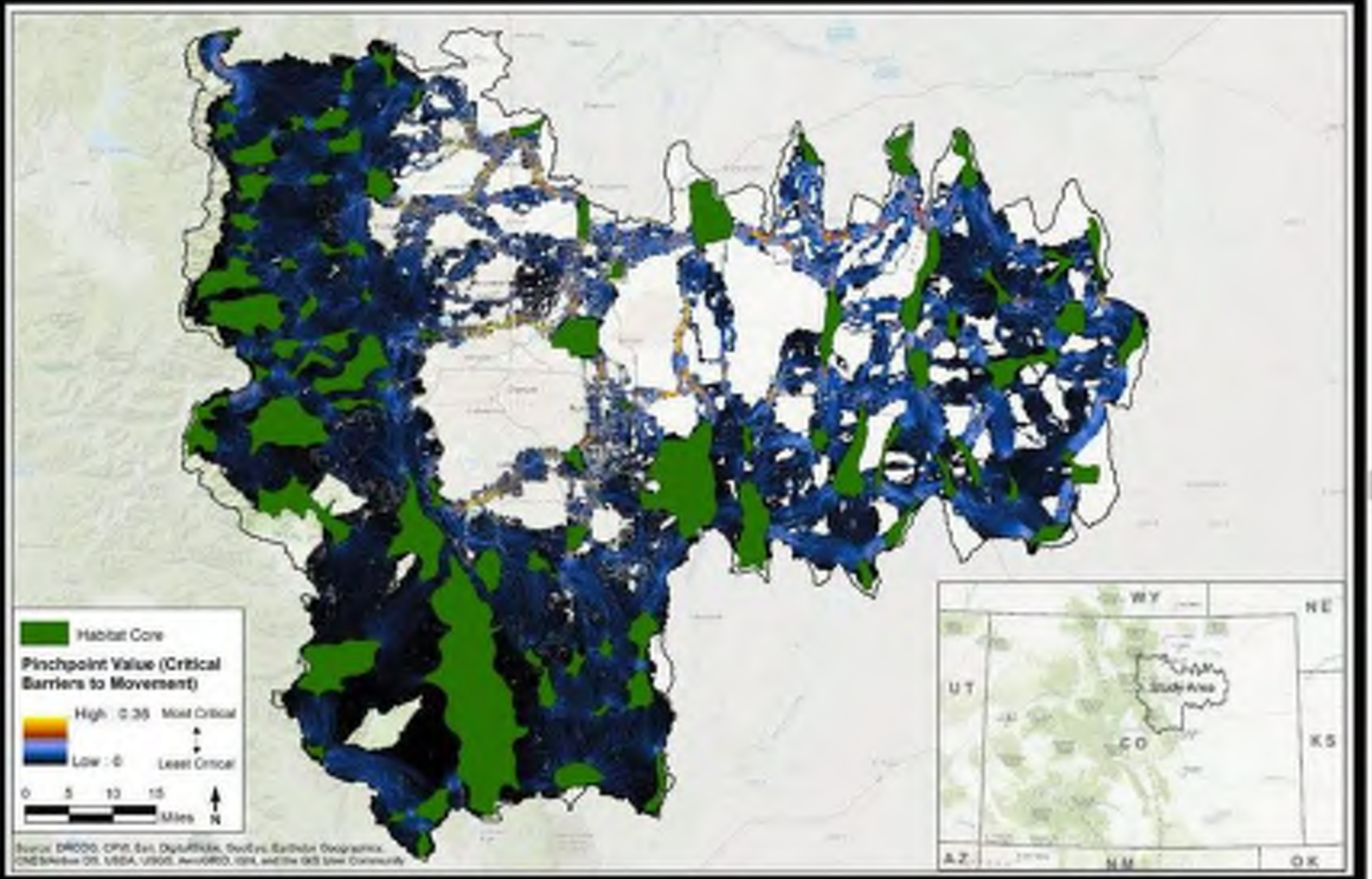


Least Cost Path Analysis

- Shortest and most efficient path from one habitat core to another
- Theoretically represents the most cost efficient route given the input information
- This would be the most optimal path for a Mule Deer to take to get from one habitat core to another
- Often follows riparian areas and waterways

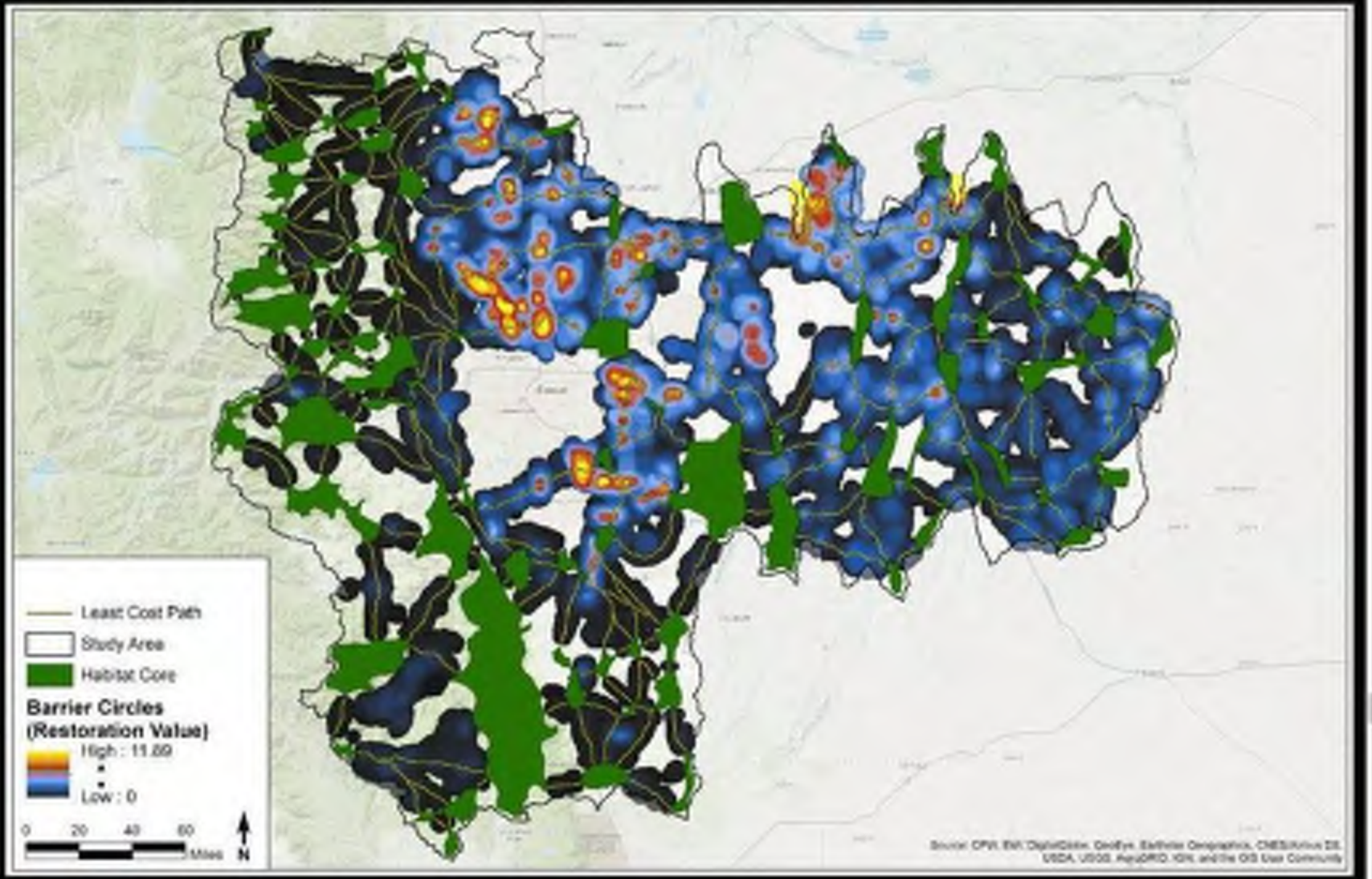
Pinchpoint Analysis

- Hybrid approach using least cost pathways and circuit theory to identify most efficient movement pathways.
- Helps to identify critical pinchpoints within these pathways that often occur at wildlife-urban interface.



Barrier Analysis (Approximated Restoration Value)

- Detects important barriers that affect the quality and/or location of corridors.
- Restoration practices in these areas will theoretically have the most positive impact for improving habitat connectivity.
- Concentrated along least cost path corridors and wildland-urban interface.
- East/Southeast Denver and North Denver are biggest hot spots.



Project Timeline + Process

Collect, Process, & Share Data

- Complete classification of 2016 1m land cover data and conduct accuracy assessment
- Obtain and review other relevant spatial data
- Get updates on parallel studies (CDOT, CPW) at different scale

Develop & Confirm Methodology

- High Quality and Resilient Habitat Assessment
  - Habitat framework
  - Focal species
  - Metrics and weighting
- Connectivity Analysis
  - Focal habitats/guilds/species
  - Habitat cores
  - Resistance/barrier values
- Check in and review meetings (monthly)

Conduct Mapping & Analysis

- Execute High Quality and Resilient Habitat Assessment
- Review with Advisory group
- Incorporate minor refinement (if necessary)
- Execute Connectivity Analysis for one species/movement guild
- Review with Advisory group
- Repeat for additional species/movement guilds

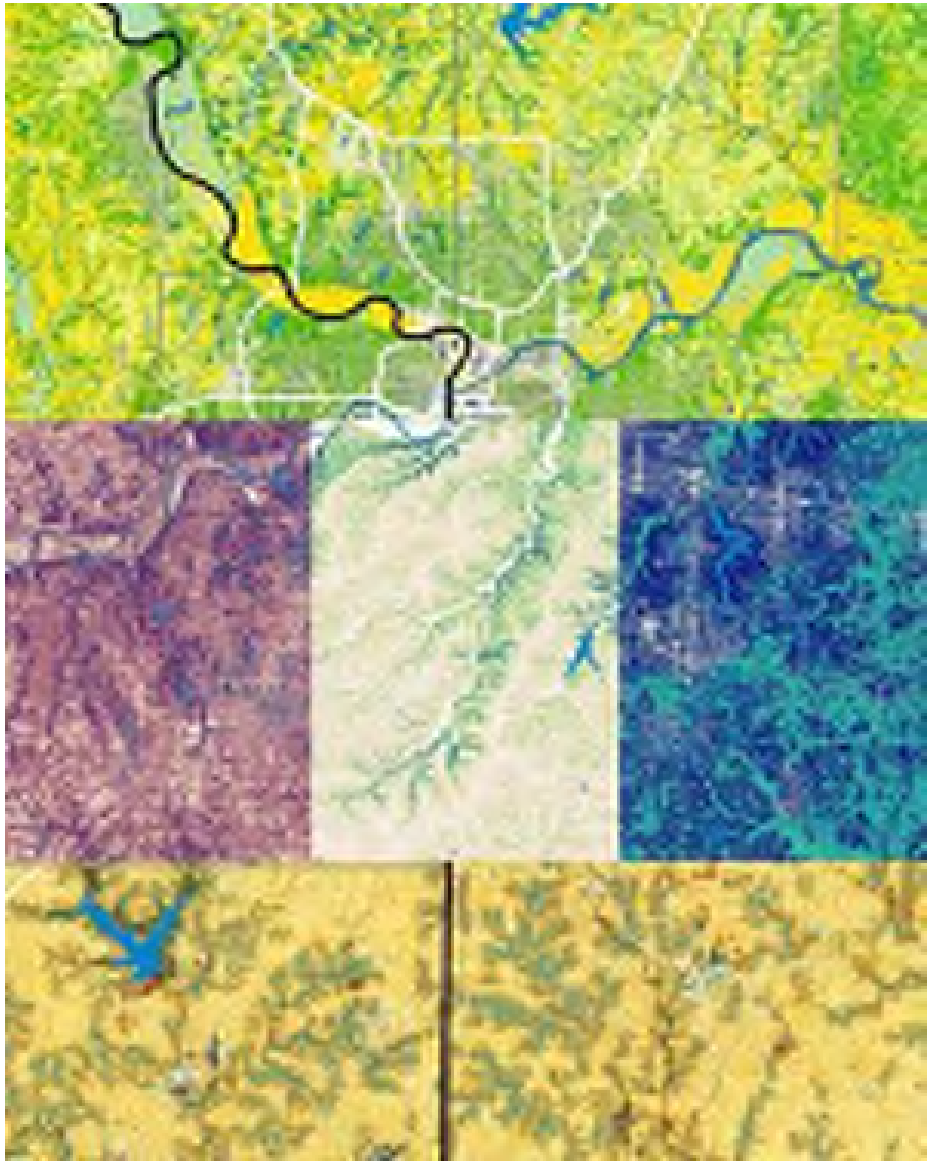
Project team + collaborators

- **Core Team:** TNC, Biohabitats, and Metro DNA; meet weekly to coordinate all aspects of the project.
- **Leadership Council:** decision makers from land and water management agencies committed to project implementation, meets 2-3 times per year.
- **Technical Advisory Team:** technical experts from a range of institutions who will directly shape the analysis and project outcomes, meets once every other month.

https://cmp-openstandards.org/about-os/os-what/

Project deliverables

- **Regional Conservation Strategy:** portfolio of targets, metrics, and priority lands and waters to guide collaborative actions.
- **Biodiversity Atlas for decision-makers:** publicly-available geo-database used to prioritize protection, restoration, and enhancement activities.
- **A diverse, engaged, and invested** Leadership Council, Technical Advisory Team, and partner network.



https://www.marc.org/Environment/Natural-Resources/Natural-Resources-Inventory/Natural-Resource-Inventory.html

Desired outcomes

- Influencing how decision makers prioritize lands and waters to protect, connect, restore, and enhance;
- Ensuring all people can have equitable access to nature and build community well-being;
- Supporting wildlife in the face of a changing climate;
- Creating a base of ecological knowledge to inform future policy, planning, and funding actions;
- Deepening collaboration between key organizations in the region; and
- Improving planning and decision-making through the development of shared goals, priorities, and metrics.

GOAL SCENARIO:

Our job is to filter for decision-makers!

NATURAL HABITAT & CONNECTIVITY

Regional Conservation Assessment

- Close Coordination with Land Managers & Decision Makers
- Science-Driven Assessment & Map of Priority Areas to Protect, Restore, and Enhance
- Key Focal & Indicator Wildlife Species

SOCIAL VULNERABILITY & ACCESS TO NATURE

- Socioeconomic Status
- Household Composition & Disability
- Minority Status & Linguistic Isolation
- Housing & Transportation
- 10-Minute Walk to a Park

REGIONAL VISION FOR PEOPLE + NATURE

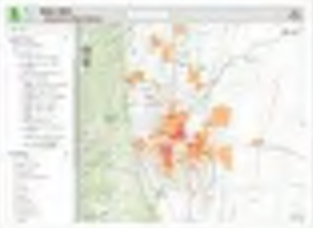
- **Provide decision-makers with information and strategies to efficiently incorporate conservation needs into policies.**
- **Combined, dynamic, and applicable vision for nature, natural infrastructure, access, and land use for the Metro Denver region**

Regional Outcomes

- Improved Water & Air Quality
- Species Preservation & Restoration
- Equitable Access to Recreation & Nature
- Stable / Decreased Greenhouse Gas Emissions
- Decreased Mitigation & Restoration Costs
- Shrinking Inequality Gap

Metro Denver Nature Alliance (MetroDNA)

MetroDNA Mapping Portal:



Project Story Map:

Downloadable PDF Maps:

Overview:

Metro Denver Nature Alliance (MetroDNA) is an emerging alliance of organizations with a compelling vision: ***Within one generation, the Metro Denver area will be a thriving place for both people and nature.***

The Metro Denver Nature Alliance will provide the critically needed regional awareness, vision, and coordination to help our entire community become a thriving place for both people and the rest of the natural world. Primary aims include: 1) working collaboratively to understanding existing needs and assets of local community organizations; 2) leveraging those assets to improve the health of people and nature; and 3) deepening people's connection to the natural world, especially children from under resourced communities. Recognizing that there are many organizations already working directly with residents and communities, the unique function of MetroDNA will be to serve the organizations as our direct stakeholders who in turn represent their constituents in the community.

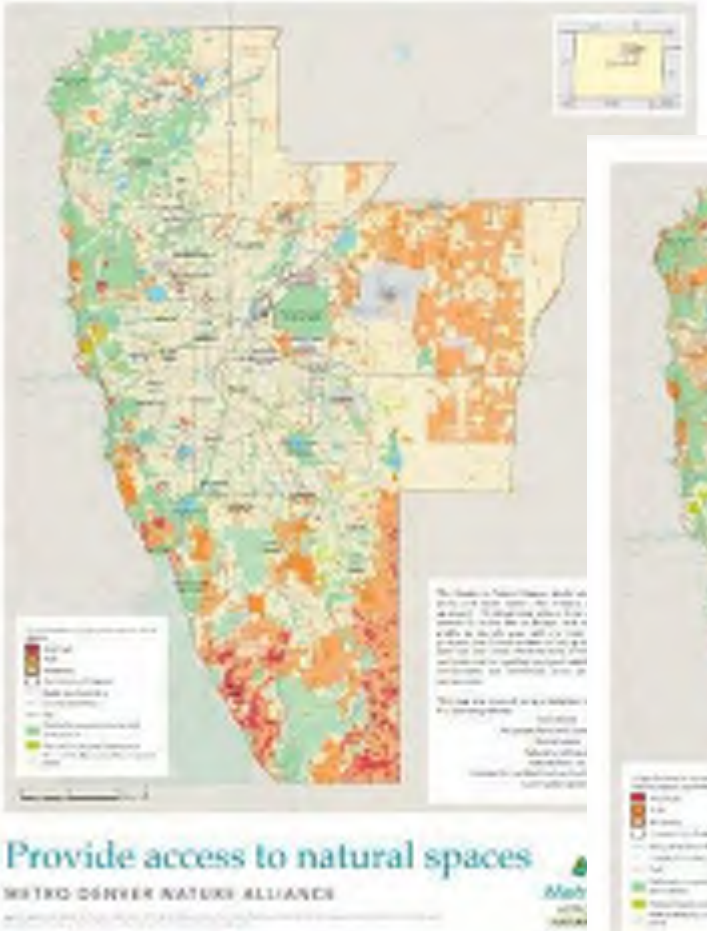
Organizations involved in the executive committee include The Nature Conservancy, The Trust for Public Land, Denver Museum of Nature & Science, Denver Zoo, Denver Botanic Gardens, University of Denver Rocky Mountain Land Use Institute, the Boys & Girls Club of Metro Denver, LiveWell Colorado, National Wildlife Federation, Groundwork Denver, Volunteers for Outdoor Colorado, and the Alliance for a Sustainable Colorado.

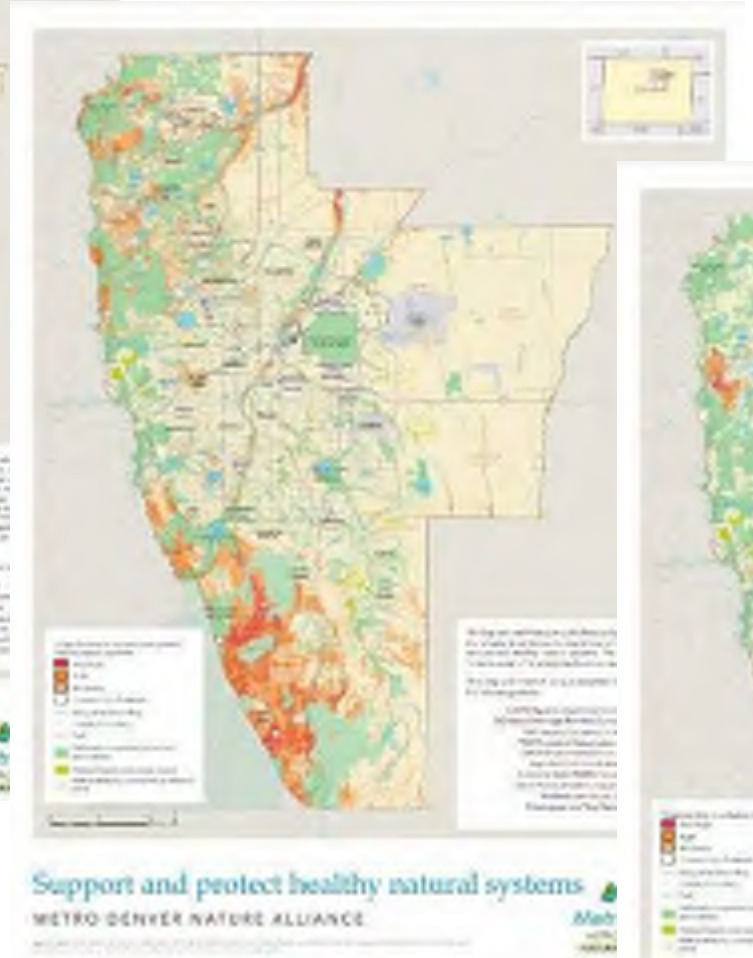
Help Documents:

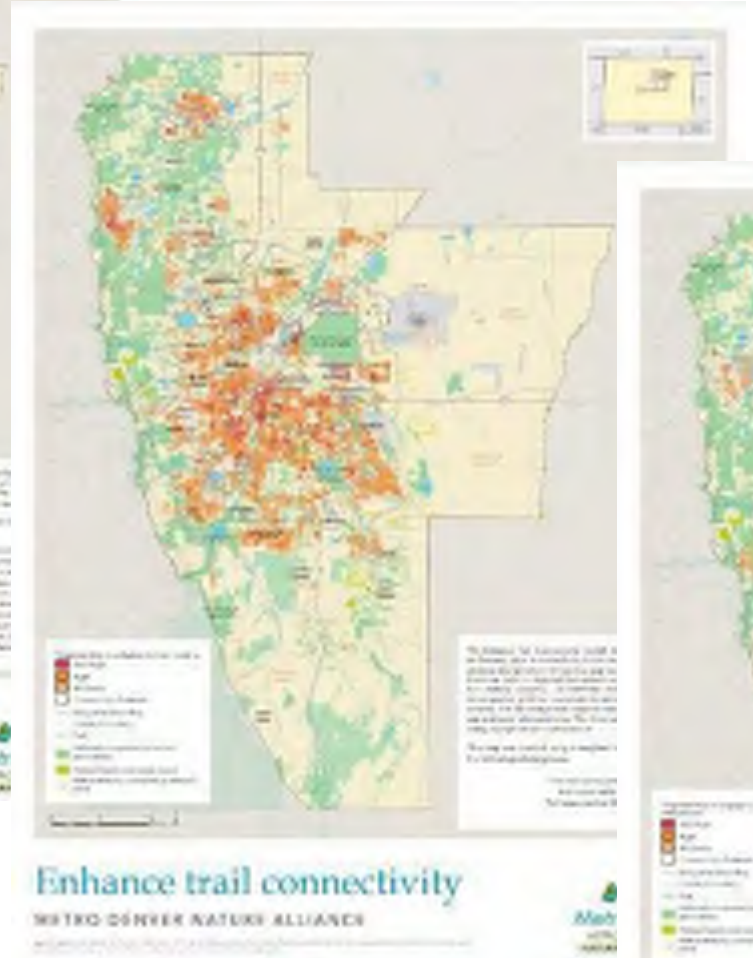
Description of data layers:

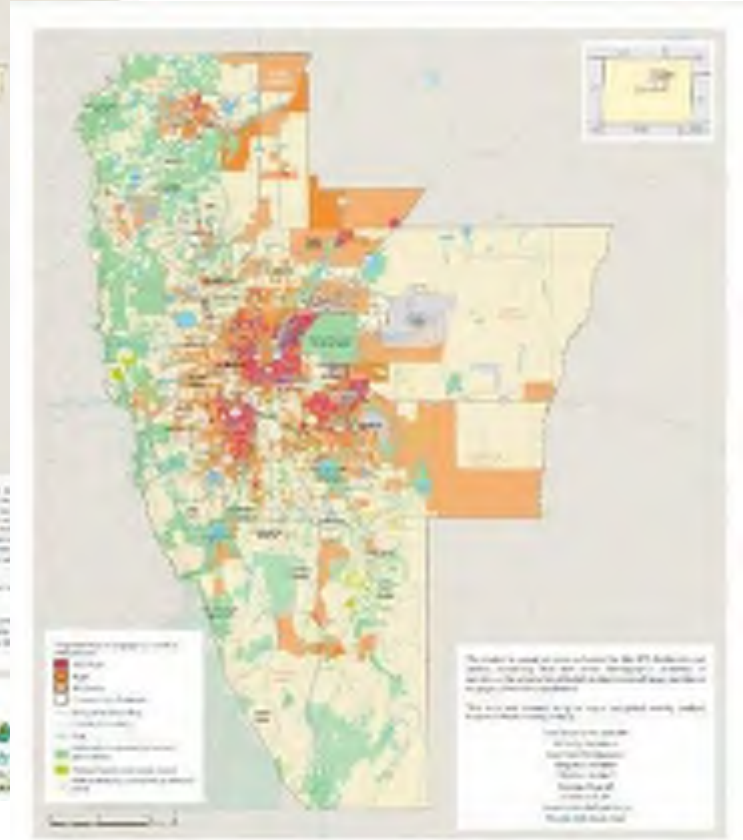
Web Portal Users Guide:

www.metrodna.org/projects/trust-for-public-land-mapping-project/









https://web.tplgis.org/denver_mdna/

STEW-MAP

The Denver Stewardship Mapping and Assessment Project (STEW-MAP)

Across the country, people are planting trees, organizing community gardens, monitoring local ecosystems, and cleaning up nearby parks or natural areas. Those who do this work may not think of what they do as "stewardship", however, they are indeed stewards of their local environments. Care of shared natural resources in urban areas increasingly relies on the work of environmental stewardship groups and coalitions. At the same time, land managers and other decision makers often do not understand the roles and contributions of civic stewards. Stewards themselves may also not be aware of others doing similar work in their area.

Why do we need STEW-MAP?

At present, no natural resource agency or organization is collecting or distributing comprehensive civic stewardship data at the local level. The Denver Stewardship Mapping and Assessment Project (STEW-MAP) will fill this gap by surveying formal and informal stewardship groups across seven Colorado counties. Based on methodology developed by the New York City Urban Field Station, the Denver STEW-MAP will paint a picture of the region's environmental stewardship "landscape", documenting where the many private and public sector organizations work, how they are connected, and from where they source information and tools.

STEW-MAP will enable government and civic groups alike to enhance the capacity of the stewards of our communities. This tool can support civic participation, increase neighborhoods' social cohesion, and support requests for funding and programming. Better understanding of civic environmental stewardship in urban areas will lead to less duplication of effort and better coordinated land and resource management. By collecting, analyzing, and sharing this information, the USDA Forest Service will be able to meet its obligation to provide timely civic stewardship information to local land managers and policy makers.

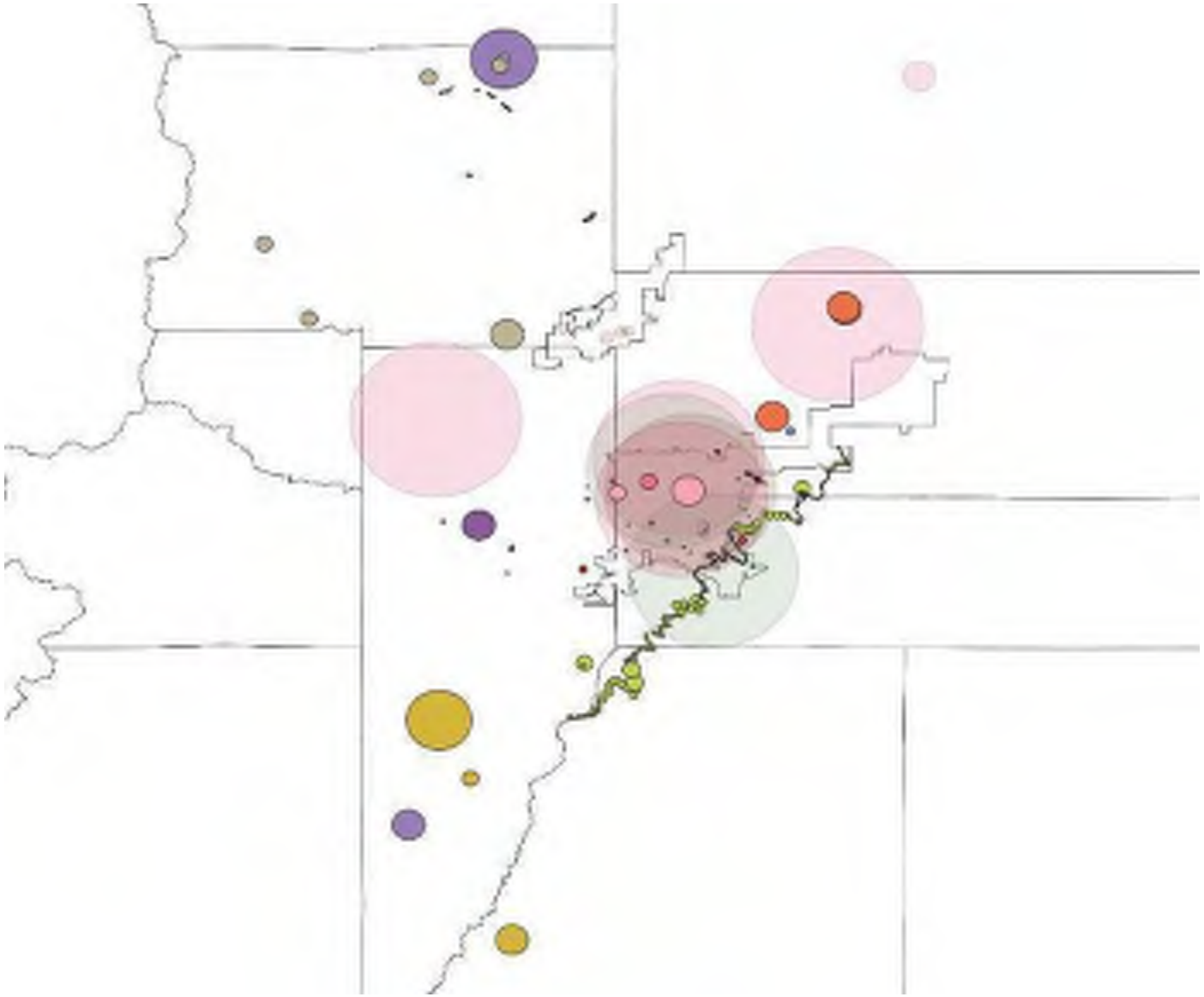
Methodology

The Denver Stewardship Mapping and Assessment Project (STEW-MAP) seeks to answer the question: What are the social and spatial (geographic) interactions among groups that conserve, manage, monitor, advocate for, and educate the public about their local environments? Methods include an organizational-level survey with subsequent maps and social network datasets created from survey responses. In this way, the project adds a social layer of

www.fs.usda.gov/rmrs/dufs-stew-map

Where does stewardship happen?

24 mapped areas



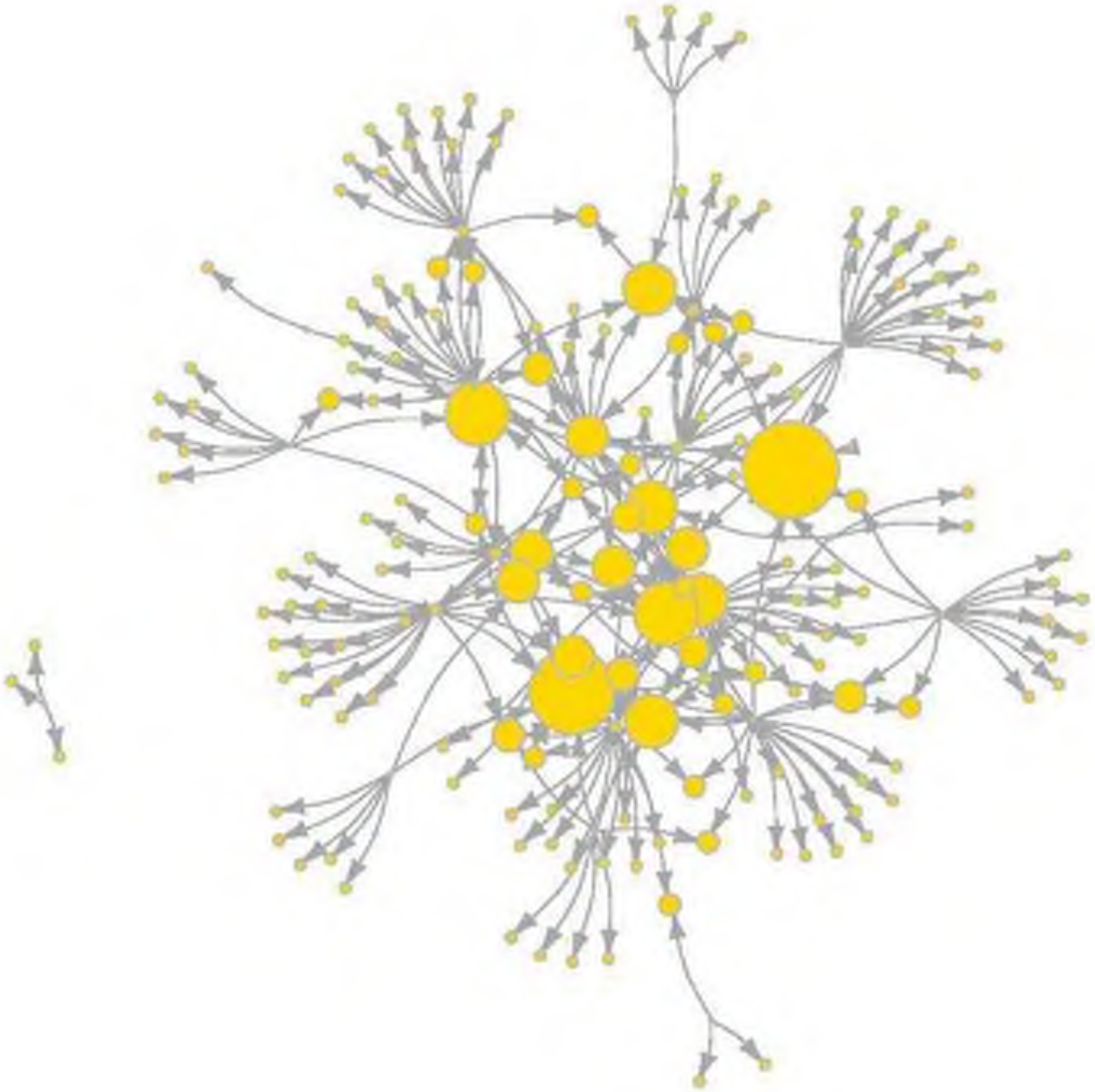
Network Visual

24 respondents named at least one group for a total of 183 different named groups.

Average number of connections: 9.17 groups

Top 4 named organizations:

City and County of Denver	**9**
US Forest Service	**8**
Colorado Parks & Wildlife	**6**
Metro DNA	**6**



Living infrastructure

A strategically planned and **managed**

network of working landscapes, natural lands and waterways at multiple scales that

conserve ecosystem functions, **restore** ecosystem processes and **regenerate** healthy, robust and **resilient** communities.

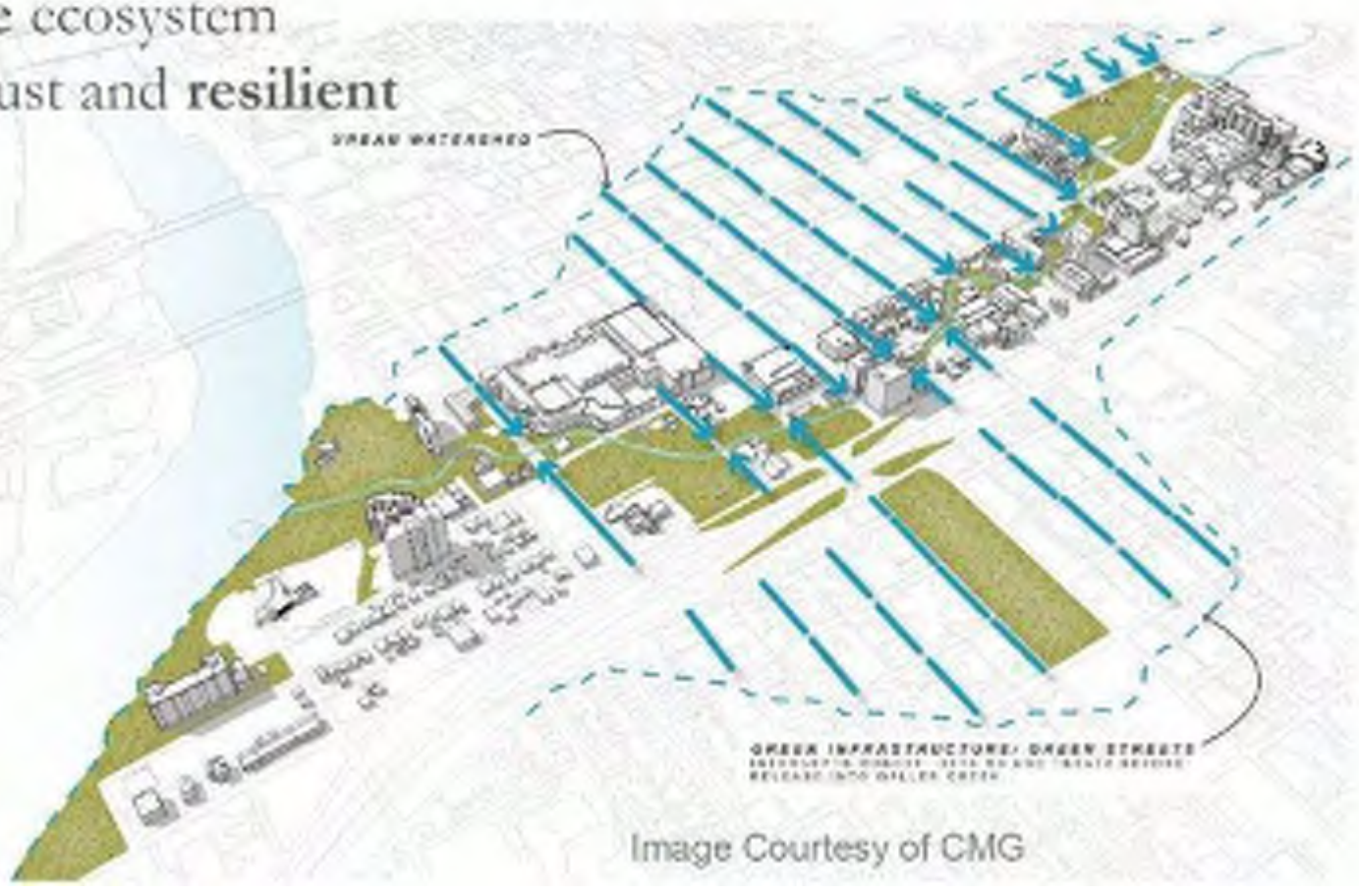


Image Courtesy of CMG

Biohabitats
SOUTHERN ROCKY MOUNTAIN DIVISION

PARTNER BENEFITS

network connections, mission alignment and context within a shared vision, increased capacity, expanded reach, and leveraged resources

COMMON OUTCOMES

more equitable access to nature, healthier people and places

MetroDNA

METRO DENVER NATURE ALLIANCE

Learn more + engage!
www.metrodna.org/projects/regional-vision

Become a partner!
www.metrodna.org/join

Dana Coelho, Alliance Director
dana@metrodna.org | 303-883-9405

Covid-19: The Unplanned Risk in Risk MAP

By: Marta Blanco Castano and Thuy Patton
Colorado Water Conservation Board (CWCB)

CASFM Virtual Conference
September 29, 2020 @ 3:30pm

COLORADO
Colorado Water
Conservation Board
Department of Natural Resources

Agenda

- Background on CWCB
- 2020 – The 'Jumani' Year
- Program Messaging
- Engagement Trends
- Outreach Prior to Covid
  - Website and Resources Tour
- Outreach during Covid and Moving Forward
- Takeaways and Lessons Learned
- Wrap Up – Q/A

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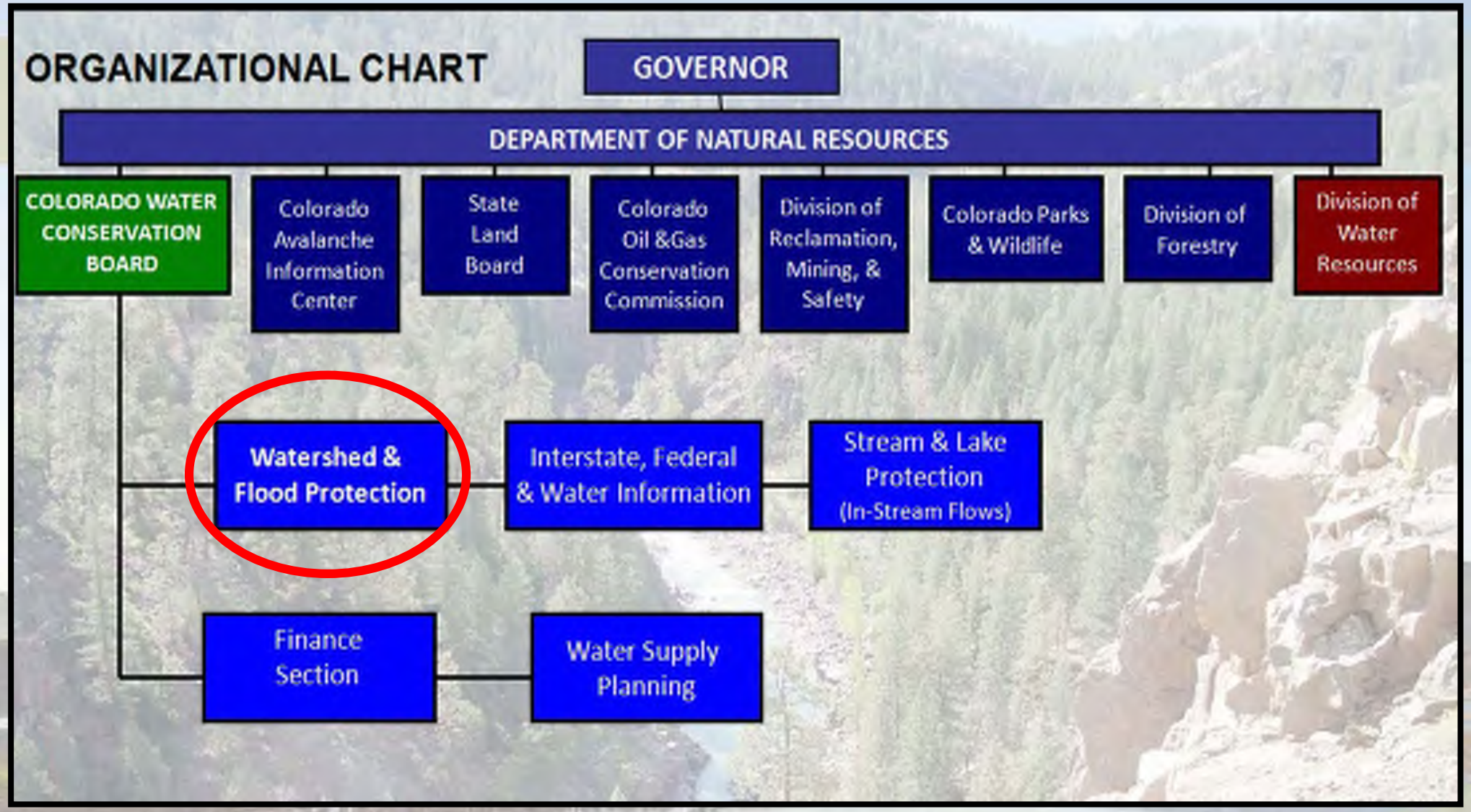
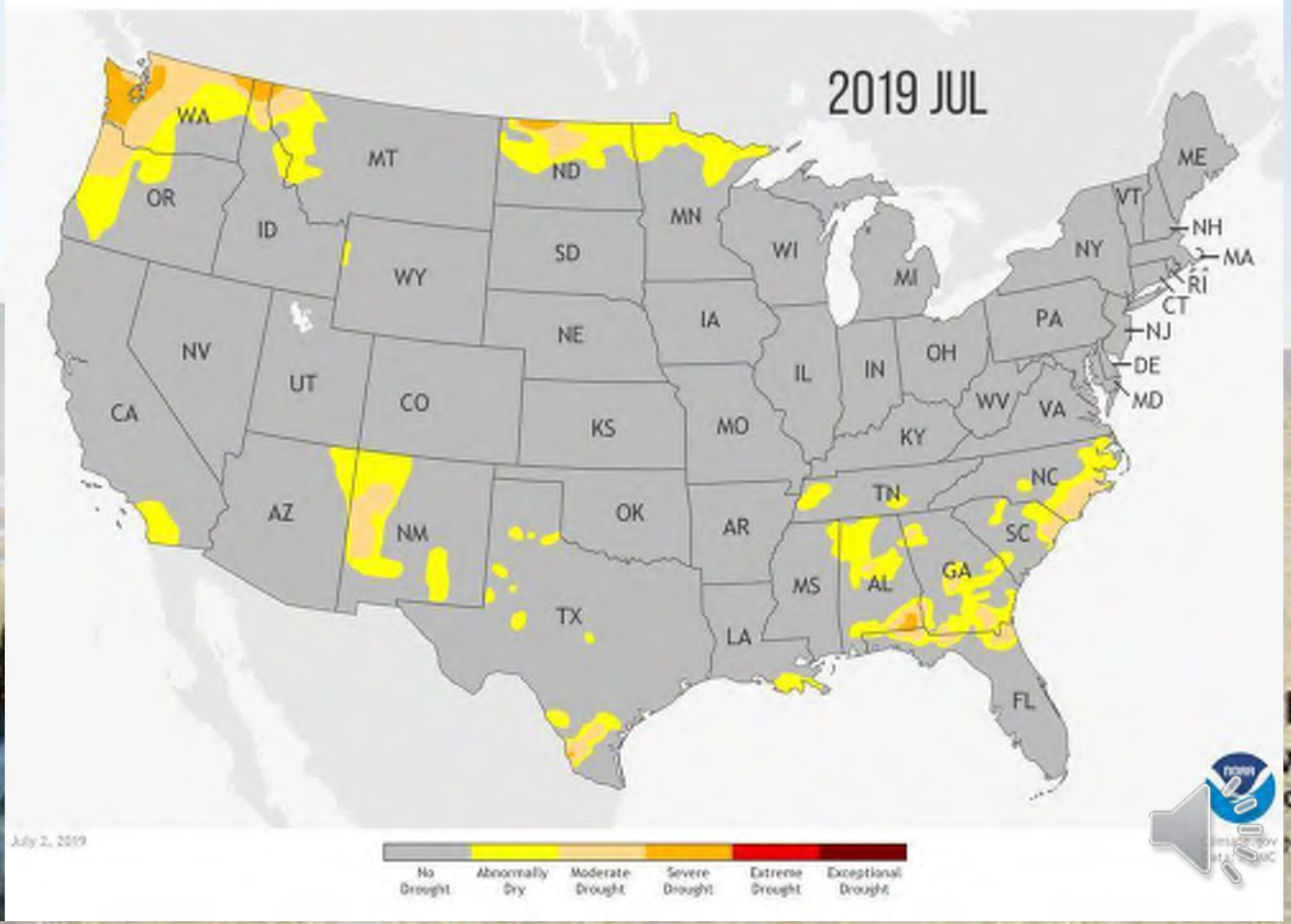


CWCB is a Cooperating Technical Partner (**CTP**) with FEMA since 2002

"To Conserve, Develop, Protect and Manage Colorado's Water for Present and Future Generations"

2020 – The 'Jumanji' Year

- Spring snowmelt began at the height of Covid lockdowns
  - CWCB on potential flood alert (remember 1997 and other late spring/early summer floods!)



- Severe drought

- Wildfires

Program Messaging

"What's the goal again??"

Crafting the Message

- Care about what you know, and showing that you care
  - Doing a little research on the stakeholder or community beforehand (roles, sensitive history, ongoing issues, prevalent hazards, etc.)
  - Why are we here and what's in it for you?
  - Be a good listener → understand their concerns and how they will be addressed
  - "We are in this together" – **Partnership** messaging
- Individualized messaging/outreach for each community as follow up
- Ask about preferred communication avenues

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Engagement Trends over Time

- **Map Mod** - Outreach offered only at beginning and near end of project.
- **Risk MAP** – focusing more on outreach and communication.
- Additional milestone meetings added → Flood Risk Review, Resilience, community focused kickoffs
- Training needed for more effective communication → engineers vs. community members

Engagement Trends Cont.

Colorado Patterns:

- Rural environment versus more urban
- Technical challenges/limitations:
  - GIS capabilities/software issues
  - Lack of local resources
  - Transitioning to 2D modeling
- Turnover/FPA has multiple roles and limited time

BUT:

- Audiences are more engaged post 2013 floods
- More review involvement from local communities and their contractors

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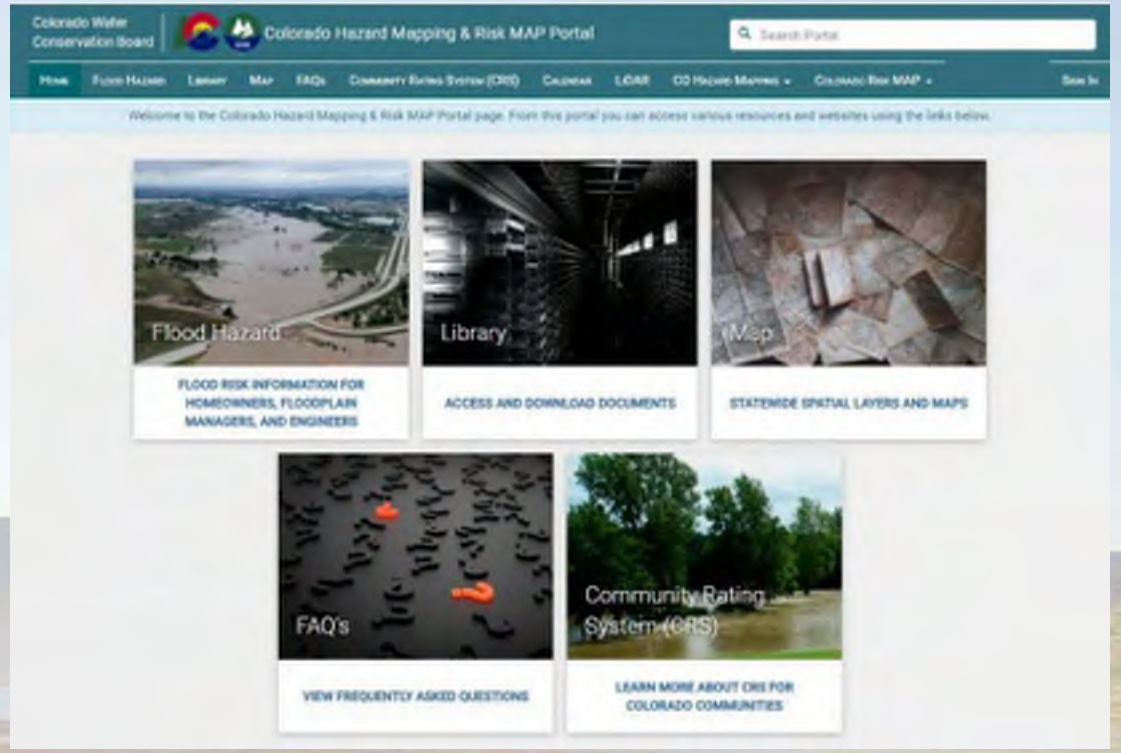
Outreach Prior to Covid

- **Online Portal** for Mapping Projects – www.coloradohazardmapping.com
- Quarterly **Newsletter** Distribution
- Memorandum of Understanding (**MOU**) / Memorandum of Agreement (**MOA**)
  - Project outline/summary
  - Expectations from all partners
  - Local community responsibilities
  - High level schedule/milestones
  - Acknowledgement from community
- **Training Needs** – Developing video tutorials:
  - How to's and Overview of Mapping Process (for FAQs and newer FPAs)
  - 2D technical group
- Updated central **database of community contacts**
- **Questionnaires** – to obtain local input and feedback



Home | Flood Hazard | Library | Map | FAQs | Community Rating System (CRS) | Master Calendar | LiDAR Request | CO Hazard Mapping | Colorado Risk MAP | Sign In

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

HOMEOWNER

ENTER YOUR ADDRESS BELOW AND VIEW TAILORED DATA AND INFORMATION ABOUT FLOOD HAZARDS BASED ON YOUR LOCATION

Generate Report

COUNTY FLOOD INFORMATION

Adams	Alamosa	Arapahoe	Archuleta	Baca	Bent	Boulder	Broomfield	Chaffee	Cheyenne	Clear Creek	Conejos	Costilla
Crowley	Custer	Delta	Denver	Dolores	Douglas	Eagle	El Paso	Elbert	Fremont	Garfield	Gilpin	Grand
Gunnison	Hinsdale	Huerfano	Jackson	Jefferson	Kiowa	Kit Carson	La Plata	Lake	Larimer	Las Animas	Lincoln	Logan
Mesa	Mineral	Moffat	Montezuma	Montrose	Morgan	Otero	Ouray	Park	Phillips	Pitkin	Prowers	Pueblo
Rio Blanco	Rio Grande	Routt	Saguache	San Juan	San Miguel	Sedgwick	Summit	Teller	Washington	Weld	Yuma	

GENERAL INFORMATION

VIEW GENERAL INFORMATION ABOUT FLOOD HAZARDS INCLUDING TERMS, HOW STUDIES ARE CONDUCTED, ETC.

CHAMP

VIEW INFORMATION AND STATUS ABOUT THE CHAMP PROJECT

General Information

Training Videos

The Colorado Water Conservation Board (CWCB) is starting an initiative to create training videos. This training series is typically meant to inform local stakeholders on the importance of flood risk and how to utilize the results of study information being created by CWCB.

ANNOUNCEMENT

THIS FIRST VIDEO SERVES AS AN ANNOUNCEMENT FOR THIS INITIATIVE AND DISCUSSES THE IMPORTANCE

VIEWING FLOODPLAINS FOR HOME ADDRESS

TUTORIAL FOR USING THE COLORADO HAZARD MAPPING WEBPAGE TO VIEW FLOODPLAIN AND STUDY INFORMATION. SHOWS HOW TO VIEW EFFECTIVE AND NEW (UPCOMING) FLOODPLAINS AND RISK ASSESSMENT

Outreach During Covid and Moving Forward

- Early onset emails to communities with important program information and to obtain local operation status
- Immediate shift to Virtual Platforms
  - Hybrid meetings when available (some virtual, some in person)
  - Working with local community platforms when requested
  - Pre recorded tutorials and resources provided ahead of meetings
  - Various video meeting and digital collaboration platforms available
- More frequent touch points (emails/calls/surveys)
- Increase use of website as a resource in addition to:
  - New trainings and videos
  - Increased database of resources

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Takeaways/Lessons Learned

- Track responses and check in frequently
- Take the lead but keep local concerns in mind
- Keep messaging succinct and consistent – information overload is not effective!
- Recognize the uniqueness of each community:
  - Rural communities are more likely to request in person meetings
  - Must be able to accommodate local needs
- Maintain normal processes as much as possible
  - Most seek normalcy and the ability to continue operating/serving constituents

Takeaways/Lessons Learned Cont.

- This too shall pass:
  - Even with Covid's new standards, flood and other hazard risks still exist and our program must evolve to adapt and meet needs of local communities
- Take note of what worked well and what didn't – share experiences and resources to empower decision-making and effective partnerships
- Follow up with local communities more than usual – we are unsure of longer term impacts still

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THANK YOU! Questions?

Marta Blanco Castano, GISP

Flood Mapping Program Assistant - Colorado Water Conservation Board (CWCB)

marta.blancocastano@state.co.us or 303-866-3441 x3225

Thuy Patton, CFM

Previous Flood Mapping Program Manager - Colorado Water Conservation Board (CWCB)

(In the twilight zone – now at FEMA Region 8)

http://coloradohazardmapping.com/ and https://cwcb.colorado.gov/

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