CASFM 2018 Annual Conference

Watershed Planning Sessions:

**Session 1: Welcome to The River Mile**
Greg Murphy (Calibre Engineering), Chris Kroeger (Muller Engineering), Mike Galuzzi (Merrick & Company)

**Session 2: Planning for Recreation and Resilience on the Big Thompson River**
Chris Carlson, Andrew Earles, Kevin Gingery, Kevin Shanks, Brandon Parsons, Shannon Tillack, Julia Traylor, Ellie Garza, & Scott Schreiber (City of Loveland)

**Watershed Framework: To Manage Runoff and Create Low Maintenance Stream – Stroh Tributary Case Study**
Jacob James (Town of Parker), Barb Chongtoua (UDFCD), Jim Wulliman, Sara Johnson, Katy Shaneyfelt, & Sam Rogers (Muller Engineering Company), Andrew Earles & Brik Zivkovich (Wright Water Engineers)
Welcome to The River Mile

Greg Murphy, PE, ARCSA AP – Calibre Engineering
Chris Kroeger, PE – Muller Engineering
Mike Galuzzi, PE – Merrick & Company
Welcome to The River Mile
Welcome to The River Mile

RIVER PEDESTRIAN BRIDGES

- CHILDREN'S MUSEUM
- CRESCENT PARK
- SOUTH PLATTE RIVER
- LITTLE RIVER PATH
- LOT 10
- LOT 11
- LOT 12
- LOT 13
- LOT 14
- LOT 15
- LOT 16
- LOT 17
- LOT 18
- LOT 19
- LOT 20
- LOT 21
- LOT 22
- LOT 23
- LOT 24
- CENTENNIAL PARK
- PEPsi CENTER STATION
- PEPsi CENTER STADIUM
- AURARIA CAMPUS
- MILE HIGH STATION
- CHERRY CREEK
- SPEER BOULEVARD
- CONFLUENCE PARK
- MILE HIGH STADIUM
- AQUARIUM
- FISHBACK PARK

SOURCES:
- Calibre
- MULLER ENGINEERING COMPANY
- MERRICK
Welcome to The River Mile

RIVER EDGE IMPROVEMENTS
Welcome to The River Mile

CONTAMINATION CLEANUP
Welcome to The River Mile

7TH STREET BRIDGE

MILE HIGH STADIUM
CRESCE NT PARK
SOUTH PLATTE RIVER
LOT 19
LOT 17
LOT 11
LOT 13
LOT 9
LOT 6
LOT 4
LOT 2
LOT 1
CENTENNIAL PARK
CONFLUENCE PARK
PEPSI CENTER STADIUM
PEPSI CENTER STATION
MILE HIGH STATION
AURARIA CAMPUS

Calibre
MULLER ENGINEERING COMPANY
MERRICK
Welcome to The River Mile

EARTH FILL IMPORT

5 - 10 ft

10 - 15 ft

20 ft
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile

PHASE I PARKING RAMP
Welcome to The River Mile

KAYAK PARK UPGRADE
Welcome to The River Mile

RIVER DREDGING AND UPGRADE

[Map showing various landmarks and lots around the river.]
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile
Welcome to The River Mile

The story of this new urban district will be written around the rediscovery and revitalization of the South Platte. And the transformation of this stretch of the river into a mile-long social catalyst. The plan for this new urban district will unlock the waterfront as no other place in Denver does. Homes, restaurants, retail and entertainment offerings will open up to the river.

It will be one of the City’s great places –

rivermiledenver.com
Welcome to The River Mile

Resources:

- UDFCD VOL. 3
- City and County of Denver ultra-urban green infrastructure guidelines
- City of Philadelphia green streets design manual
- District-scale green infrastructure scenarios for the Zidell development site, City of Portland
Welcome to The River Mile

Denver Green Roof Initiative

• Green (includes offsite financial contribution)
• Green + Energy
• Energy
• Certification

Calibre  
Muller Engineering Company  
Merrick
Welcome to The River Mile

Green Roofs
Welcome to The River Mile

Beautiful as much as functional
Welcome to The River Mile

Social, quality of life, and economic opportunities
Welcome to The River Mile - image from urban study by United Network Studio
Welcome to The River Mile

- image from urban study by United Network Studio
Welcome to The River Mile

Back of curb to building face

- Avoid overly dominant components
- Maximize pedestrian space and usability
Welcome to The River Mile

Underground Treatment
Welcome to The River Mile

Underground Treatment

- Better multi-function use of Right of way
- Better for tree health
- Low maintenance
- Promotes infiltration
- Better runoff reduction
Welcome to The River Mile

Structural Support Systems
Welcome to The River Mile

Roof drainage conveyance
Welcome to The River Mile

Surface treatment options
Welcome to The River Mile

Surface drains to convey stormwater below ground
Welcome to The River Mile

Tree Grates
Welcome to The River Mile

Purposeful, artistic, compatible with mobility goals
Welcome to The River Mile

Are we avoiding planter beds? NO
Welcome to The River Mile

Works here. How about here?
Welcome to The River Mile

Provide room for the “Needs”
Welcome to The River Mile

Can’t forget about the “Wants”
Welcome to The River Mile

Streets
Welcome to The River Mile

Curbless?
Welcome to The River Mile

Inlet Options
Welcome to The River Mile

Inlet Options
Welcome to The River Mile

Plazas
Welcome to The River Mile

Plazas

- Sunken water quality treatment
Welcome to The River Mile

2-D FLOODPLAIN MODEL
Welcome to The River Mile

OPTION 1 - CULVERT
Welcome to The River Mile

OPTION 2 - LEVEES
Welcome to The River Mile

OPTION 3 – MODIFY RIVER
Welcome to The River Mile

DENVER URBAN WATERWAYS RESTORATION STUDY
Welcome to The River Mile

TYPICAL SECTION
Welcome to The River Mile

Riparian/Wetland Habitat

Aquatic Habitat/Fish

Trails/Paths

MULTIPLE USES
Welcome to The River Mile

River Access

Leisure

Boating

Multiple Uses
Welcome to The River Mile

Flood Control

Swimming/Play

Multiple Uses
Welcome to The River Mile

River Surfing

RIVER RUN PARK, Englewood, Co.
Welcome to The River Mile

River Surfing

RIVER RUN PARK, Englewood, Co.
Welcome to The River Mile

CONFLUENCE PARK WHITEWATER COURSE, Denver
Welcome to The River Mile

Areas of deposition

SEDIMENT TRANSPORT
Welcome to The River Mile
Questions

Greg Murphy, PE, ARCSA AP - Calibre Engineering
Chris Kroeger, PE - Muller Engineering
Mike Galuzzi, PE - Merrick & Company
Planning for Recreation and Resilience on the Big Thompson River

Chris Carlson, P.E., Andrew Earles, Ph.D., P.E., Kevin Gingery, P.E., Kevin Shanks, RLA, Brandon Parsons, Shannon Tillack, P.E., Julia Traylor, Ellie Garza & Scott Schreiber, P.E.

Colorado Association of Stormwater & Floodplain Managers (CASFM) Annual Conference
September 2018, Snowmass Village, Colorado
Overview of Presentation

• Need for Master Plan
• Unique Aspects of Project Approach
• Key Aspects of Master Plan
• Implementation
Need for Big Thompson River Corridor Master Plan
Master Plan Objectives

- Capture a long term vision for the river corridor
- Recommend projects that mitigate flood hazards, restore the river’s ecology, and meet multiple objectives
- Improve resiliency in the corridor
- Restore natural river & floodplain functions
- Recommend how the City can better capitalize on its river – recreation, trails, tourism, redevelopment, etc.
- Improve opportunities for public interaction
- Recommend how to manage & maintain the river corridor
Science Based, Community Driven

- Reach “Fact Sheets”
- Baseline resiliency score cards
- Field investigations
- Gap analysis
- Engineering & planning
  - Hydrology & hydraulics
  - Fish
  - Vegetation
  - Wildlife
  - Water quality
  - Irrigation diversions
  - Parks & recreation

- Trails
- Natural areas
- Bridges and roads
- Utilities
- Buildings
- Private property & infrastructure
Vision for the Corridor

- A resilient, connected corridor
- Improve flood conveyance / reduce hazards
- Preserve ecological functions
- Urban fishery – improve fishing & access
- Continue open lands acquisition
- Improve river access & water-based recreation
- Regional corridor trail + trail connections
- Open land for wildlife & wildlife viewing
Vision for the Corridor

- Improve water quality
- Downtown access – trail/corridor connection
- Corridor access for future developments
- Redevelopment opportunities on Lincoln Avenue/Hwy. 287
- Comprehensive maintenance and management program
- Growing community involvement – waterway clean-ups, education, nature walks, community events
Open Lands & Natural Areas
Natural Areas

- Wildlife corridor - seating & wildlife viewing areas
- Weed and invasive species control; plant shrubs
- Cattail reduction/diversify wetland species
- River bank erosion protection
- Aquatic restoration & habitat – fishery enhancement
- Protect old gravel pit overtopping
- Water quality
Trails and Recreation

- Water recreation – tubing, fishing, swim/play
- Designated river access points & tubing route
- More trails – including soft surface trails and connections to neighborhoods
- Natural vs. manicured landscaping & appearance
- Trailhead improvements
- Natural play areas
- Bike skills/riding park
Transportation

- Currently 10 roadway crossings of the Big Thompson River within the study boundary
- Current crossing capacity (protection level) 5-50 year event
- Focus on Wilson, Lincoln, Railroad, and the future Boyd Lake Ave.
- Significant issues also at Hwy. 402/St. Louis, Taft & 1st
### Resilience Assessment Table

<table>
<thead>
<tr>
<th>Resilience Assessment Category</th>
<th>Reach 29: Morey - Ross</th>
<th>Reach 30: Rossum - Namaqua</th>
<th>Reach 31: Namaqua - Wilson</th>
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### Resilience Assessment Score Table

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Unique Aspects of Project Approach
Balance of Planning & Engineering
Public Outreach

- Farmers Markets
- Summer Concerts
- Summer Festivals
- 2-day Workshop
- Project Website
- Open City Hall
Recreation
Stakeholders & Partners

Multiple concurrent, ongoing projects

- City of Loveland
  - Public Works
  - Parks & Recreation
  - Water & Power
  - Community & Strategic Planning
- Larimer County
- Big Thompson Watershed Coalition
- Big Thompson Water Quality Forum
- Colorado Department of Local Affairs
Key Aspects of Master Plan

- Flood Hazard Reduction
- Gravel Pit Hazard Reduction
- Geomorphology
- Aquatic Habitat
- City Utilities
- Water Quality
- Natural Areas
- Parks, Recreation, Trails and Land Use
- Community Involvement Opportunities
Resilience

res·il·i·ence /rəˈzilyəns/
noun

1. An ability to recover from or adjust easily to misfortune or change.
Floodplain Preservation
Balance of Recreational Access & Wildlife

Morey Wildlife Reserve – Passive Recreation and a Refuge for Wildlife
Balance of Recreational Access & Wildlife

Fairgrounds Park – Active Recreation and River Access
Connecting the River & Community
## Implementation

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<th>Reach</th>
<th>Flood Hazard Reduction</th>
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Top 5 Priorities

1. Maintenance of River Corridor
2. River Coordinator
3. US 287 - Lincoln Avenue Conveyance Improvements
4. Wilson Avenue – Elevation of Approaches
5. Mariano Exchange Ditch Water Quality Evaluation
Maintenance

- Bank Erosion
- Concrete Debris
- Sediment Accumulation
- Tree Removal
- Woody Debris
- Transient Settlements
Maintenance
Maintenance Types
Restorative Maintenance: $1,280,000

- Bank Erosion: $180,000
- Sediment Accumulation: $340,000
- Woody Debris/Trash: $590,000
- Concrete Debris: $150,000
- Hazardous Tree: $20,000
Questions
Watershed Framework: To Manage Runoff and Create Low Maintenance Stream – Stroh Tributary Case Study

by: Jacob James, P.E., CFM
Town of Parker, Colorado

Barbara Chongtoua, P.E.
Urban Drainage & Flood Control District

Jim Wulliman, P.E., Sara Johnson, P.E., CFM, Katy Shaneyfelt, E.I., and
Sam Rogers, P.E., CFM
Muller Engineering Company

Andrew Earles, Ph.D. P.E. and Brik Zivkovich, E.I.
Wright Water Engineers, Inc.
Overview

- The Development Process - Seeking a Win-Win Approach
- Reducing Runoff and Laying Out the Land
- Costs of Development
- Modeling
- Lessons Learned and Technical Conclusions
Process of Development

Stormwater Master Plan
Annexation Agreements/Pre-Development Agreements
Subdivision/Site Layout
Sketch Plan
Preliminary Plan
Final Plat
Construction
Process of Development

Prior to development

- **Major Drainage Master Planning**
  - Based on assumptions of how watershed will develop
  - Future developed flows guide anticipated stabilization needs
  - Cannot be progressed beyond concept level due to unknowns

- Stormwater Master Plan
- Annexation Agreements/Pre-Development Agreements
- Subdivision/Site Layout
- Sketch Plan
- Preliminary Plan
- Final Plat
- Construction
Process of Development

Preparation for development

- **Annexation Agreements/Pre-Development Agreements**
  - Identifies development obligations to build infrastructure
  - Based on Master Plans and preliminary engineering reports
  - Timing of improvements
  - Constructed by developer or fee in lieu

Diagram:
- Stormwater Master Plan
- Annexation Agreements/Pre-Development Agreements
- Subdivision/Site Layout
- Sketch Plan
- Preliminary Plan
- Final Plat
- Construction
Active development stage

- **Subdivision/Site Planning**
  - Sketch 30%
  - Developers submit concept design documents
  - Obligations within annexation/pre-development agreements coordinated with early design documents

- Stormwater Master Plan
- Annexation Agreements/Pre-Development Agreements
- Subdivision/Site Layout
  - Sketch Plan
  - Preliminary Plan
  - Final Plat
- Construction
**Process of Development**

**Active development stage**

- **Subdivision/Site Planning**
  - Preliminary 70%
  - Developers submit preliminary design documents

**Diagram:***

- Stormwater Master Plan
- Annexation Agreements/Pre-Development Agreements
- Subdivision/Site Layout
- Sketch Plan
- Preliminary Plan
- Final Plat
- Construction
Process of Development

Active development stage

- **Subdivision/Site Planning**
  - Final Plat
    - Final design documents
    - Cost estimates are finalized for securities and/or fee in lieu obligations
    - Development agreements are finalized codifying obligations and triggers

- Stormwater Master Plan
- Annexation Agreements/Pre-Development Agreements
- Subdivision/Site Layout
- Sketch Plan
- Preliminary Plan
- Final Plat
- Construction
Process of Development

Active development stage

- **Construction**
  - Inspection of public infrastructure during construction through final acceptance and transfer to municipality

- **Stormwater Master Plan**
- **Annexation Agreements/Pre-Development Agreements**
- **Subdivision/Site Layout**
- **Sketch Plan**
- **Preliminary Plan**
- **Final Plat**
- **Construction**
Challenges & Constraints

- Development obligations are determined well before understanding the true impact of development.
- Stormwater master plans need to be updated and interpreted.
- Development design can occur with limited communication; opportunities and critical information may be missed.
- Submittal reviews may produce lengthy comments and design revisions.
Seeking a Win-Win

- Dynamic, concurrent stormwater planning
  - Stormwater design is incorporated throughout process
  - Efforts are collaborative
  - Feedback loop is continuous, reducing rework
  - Stormwater informs layout
  - Uses open spaces to reduce runoff and soften streams
  - Infrastructure costs are reduced
  - Long-term maintenance costs are reduced
  - Provides value to community

Diagram:
- Stormwater Master Plan
  - Annexation Agreements/Pre-Development Agreements
  - Subdivision/Site Layout
    - Sketch Plan
    - Preliminary Plan
    - Final Plat
  - Construction
Seeking a Win-Win

- Dynamic, concurrent stormwater planning
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  - Infrastructure costs are reduced
  - Long-term maintenance costs are reduced
  - Provides value to community
Reducing Runoff, Softening Streams

- Soil
  - Loamy texture
  - Organic
  - Low salts

Diagram showing different layers of soil:
- O (humus or organic)
- A (topsoil)
- E (eluviated horizon)
- B (subsoil)
- C (parent material)
- R (bedrock)
Reducing Runoff, Softening Streams

- Air
  - Avoid over-compaction
  - Rip, scarify, disc
  - Encourage root pathways

![Image showing plant root development with varying compaction levels: no compaction, moderate compaction, heavy compaction.]

Only you can prevent bad porosity!
Reducing Runoff, Softening Streams

- Vegetation
  - Establish dense turf-forming grass for surface roughness
  - Consider native, deep rooted vegetation for pathways into soil
Reducing Runoff, Softening Streams

- Ecology
  - A cup of topsoil contains:
    - 200 billion bacteria
    - 20 million bacteria species
    - 60 miles of fungi
    - 20 million protozoa
    - 100,000 nematodes
    - 50,000 arthropods
  - …and an earthworm
Water

- Distribute runoff over vegetated open spaces
- Water sustains the life of the soil and vegetation

Runoff is reduced via

- Interception
- Infiltration
- Evapotranspiration
- Deep percolation
Reducing Runoff, Softening Streams

Symbiosis between soil, air, vegetation, ecology, and water:

1. Saves water in the land to support life
2. Saves water courses
3. Saves water quality
4. Saves water supply
Reducing Runoff, Softening Streams

SAVE Water in landscape areas

Conventional Curb and Gutter w/ Inlet

Runoff Reduction Slotted Curb

Directly Connected Impervious Area (DCIA)
Separate Pervious Area (SPA)

Unconnected Impervious Area (UIA)
Receiving Pervious Area (RPA)
Laying Out the Land

SAVE Water in the stream network
Laying Out the Land

Urban Development

Truncated and Impacted Stream Network

Traditional Urban Scale (A Scale)
100 to 130 ac

Downstream Regional Detention

Traditional approach
Laying Out the Land

Clustered Urban Development

Preserved Stream Network

Distributed Detention

Neighborhood Scale
(B Scale)
10 to 40 ac

Recommended approach
Laying Out the Land

Curb outfalls rather than inlets and laterals
Laying Out the Land

Grass swales rather than storm sewers
Distributed detention rather than downstream detention
Laying Out the Land

Soft streams rather than structural
Costs of Development
Oak Gulch Watershed
Oak Gulch Planning Timeline

OSP (2003) $18,715,963

OSP Addendum (2015) $22,176,659

Updated Analysis Checks → Drops (2016) $32,604,342

Additional Analysis for West Stroh Tributary (2018)
Lot Layout

Traditional

Low Maintenance Stream Distributed Detention
Stormwater Layout

Traditional

Low Maintenance Stream
Distributed Detention
Stormwater Layout

Traditional

Low Maintenance Stream
(Distributed Detention)
West Stroh Hydraulic Profile – 100-yr Event

Proposed:
No Detention

Existing

Proposed:
Distributed Detention
West Stroh Tributary Cost

Watershed Framework Stroh Ranch Service Plan Cost Comparison

<table>
<thead>
<tr>
<th>Service</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stream Restoration</td>
<td></td>
</tr>
<tr>
<td>Traditional Approach</td>
<td>$9,888,227</td>
</tr>
<tr>
<td>Low Maintenance Stream Approach</td>
<td>$5,778,192</td>
</tr>
</tbody>
</table>
Modeling
Scenario 1: A-Scale
Scenario 2: B-Scale
Scenario 3: C-Scale
Cover-type Distribution

Surface Type Distribution

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DCIA</td>
<td>SPA</td>
<td>UIA</td>
</tr>
</tbody>
</table>

Area (acres)

0 10 20 30 40 50 60 70 80

Legend:
- DCIA
- SPA
- UIA
- RPA
West Stroh Gulch Watershed

2-year Hydrograph

FLOW (cfs)

Undeveloped Condition (Historic)

TIME (h:mm)
West Stroh Gulch Watershed
2-year Hydrograph

- Undeveloped Condition (Historic)
- Developed Condition - Scenario 1

FLOW (cfs)

TIME (h:mm)

0:00 0:30 1:00 1:30 2:00 2:30 3:00
West Stroh Gulch Watershed

2-year Hydrograph

- Undeveloped Condition (Historic)
- Developed Condition - Scenario 1
- Developed Condition - Scenario 2

FLOW (cfs)

TIME (h:mm)
West Stroh Gulch Watershed
2-year Hydrograph

- Undeveloped Condition (Historic)
- Developed Condition - Scenario 1
- Developed Condition - Scenario 2
- Developed Condition - Scenario 3

FLOW (cfs)

TIME (h:mm)

0:00 0:30 1:00 1:30 2:00 2:30 3:00
West Stroh Gulch Watershed
2-year Hydrograph

- Undeveloped Condition (Historic)
- Developed Condition - Scenario 1
- Developed Condition - Scenario 2
- Developed Condition - Scenario 3
- Developed Condition - Scenario 3 with Distributed Detention
Continuous Simulation

- Water budget analysis
- Rainfall time series
- Evapotranspiration & groundwater
- Accounting for irrigation
- Why do continuous simulation?
Conceptual Hydrologic Model

- Disconnected Impervious Area (No ET)
  - Receiving Pervious Area
  - Separate Pervious Area
  - Surface runoff (DCIA)

- Directly Connected Impervious Area (No ET)

- Site Level BMP WQCV/EURV

- Distributed FSD

- Evaporation & Evapotranspiration

- Infiltration

- Surface runoff (RPA)

- Seepage from channel

- Permeable Conveyances

- Shallow groundwater interflow & baseflow

- Surface flow

- Shallow groundwater

- Percolation to Deep Groundwater
SWMM Hydrographs – Traditional versus Green
Technical Conclusions

- Traditional modeling practices for stormwater master planning are at a scale that fails to capture many watershed processes that affect infiltration.

- Often, the tributary network upstream of a regional detention facility is sacrificed for development.

- Using a distributed approach protects or recreates the functions of the lower order tributary network.

- Benefits reduce the peak rates and volumes of runoff for design events and help shift the water budget back toward a more natural condition.

- For the study area, the low-maintenance stream approach with distributed FSD results in infrastructure savings of approximately 20%, while providing a more aesthetic and environmentally sensitive approach to managing stormwater runoff.
Lessons Learned

- Early communication of expectations, minimize later costs and frustrations
- Understand which type of developer/landowner you are working with
- Development regulations vary between municipalities
- Incentives based on runoff reduction need to be clearly defined
- Requires close coordination with Planning Department, Developer, H&H modeler
- This pilot needs to culminate in documentation that is easy to understand and follow
Acknowledgements

- EWRI Task Committee - Implementing a Watershed Approach to Manage Stormwater as a Resource for Urban Stream Systems

- Project Collaborators – Harris Kocher Smith, Norris Design, Matrix Design Group, Redland Consulting, DTJ Design, and Stantec
Questions & Answers

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