



City & County of Denver

Green Infrastructure Program

Sarah Anderson

Green Infrastructure Program Manager
Public Works



Separated Storm System

13%
of Denver's 98,900+ acres
receive water quality
treatment
(2013, Matrix Report)

Over **1200** Total Outfalls

- 300+ Outfalls into Cherry Creek
- 300+ Outfalls into South Platte

Denver's Streams:
0/10 meet recreation standards
7/10 suitable for aquatic life

2016 Water Quality Report, Denver Dept. of Environmental Health



The PROBLEM

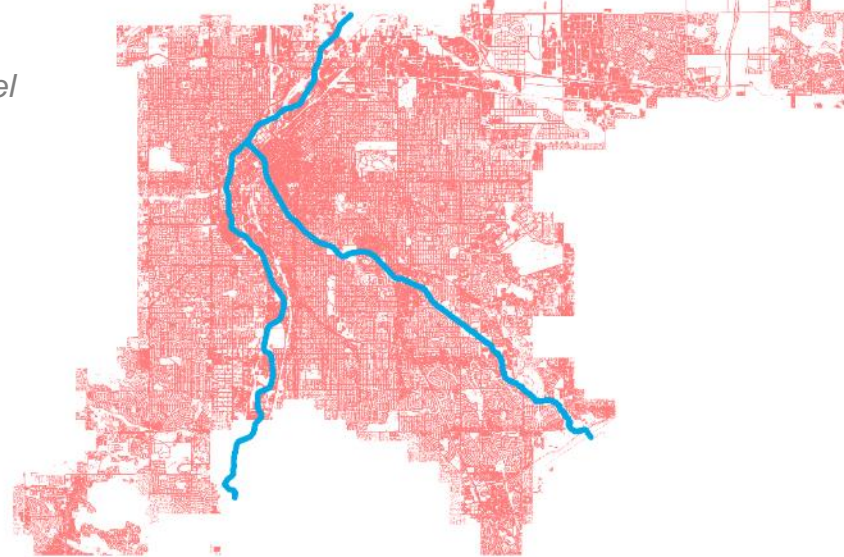
Growing Impervious Cover

49% of Denver* is currently covered in impervious surfaces

Source: DRCOG LiDAR Data

61-67% of Denver* is projected to have impervious cover by 2020 based on future land use

Source: CU Boulder Impervious Forecasting Model

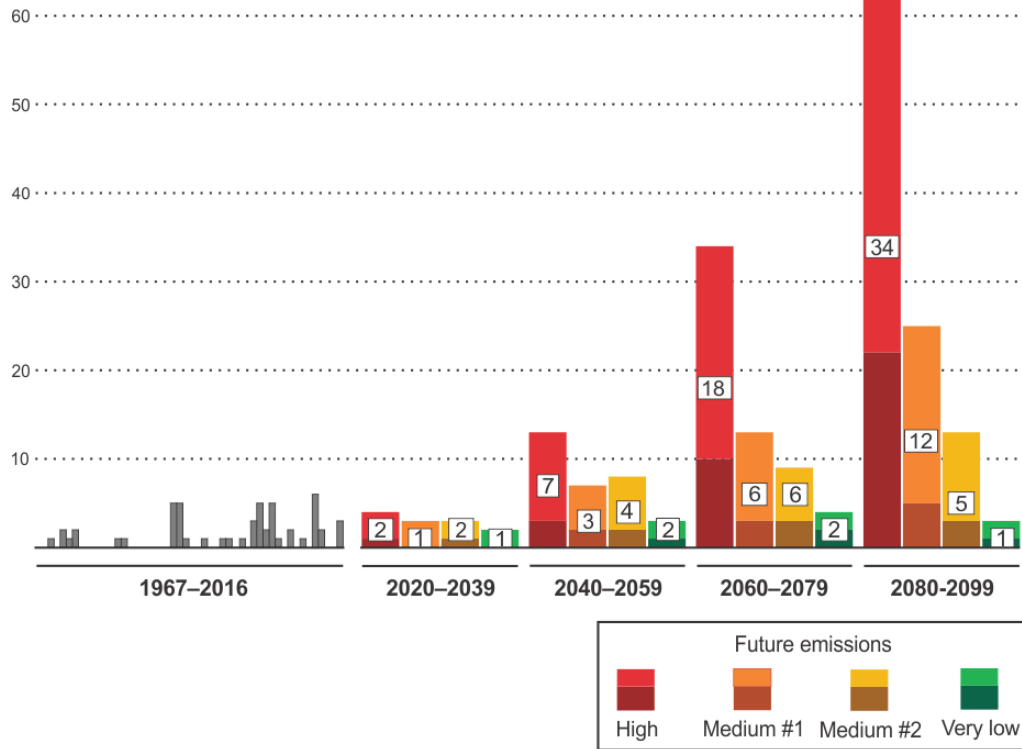


The **PROBLEM**

Climate Change in Denver

Temperature will increase

Days 100° or hotter in *typical years*, Denver metro area
Projected averages for 20-year periods

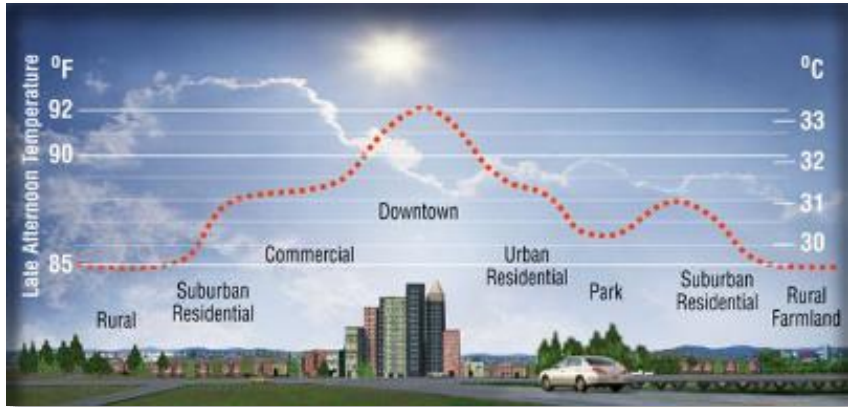


Sources:
Rocky Mountain Climate Organization, (<http://www.rockymountainclimate.org/extremes/denver.htm>)
Denver Climate Adaptation Plan (<https://www.denvergov.org/content/denvergov/en/environmental-health/environmental-quality/climate.html>)

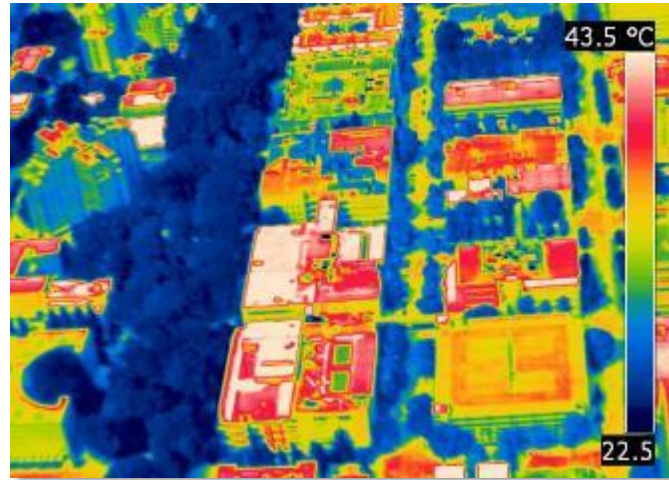
Changes:

- **Observed:** Daily minimums increasing more than daily maximums
- **Mid-century Projections:**
 - More than a month's worth of days >95° F
 - Fewer extreme cold months, more extreme warm months
 - Temperature regimes in the Front Range will look like current regime at Colorado/Kansas border
- **Late-Century Projections:** more than a month's worth of days >100° F

Climate Change in Denver: **Temperature**



Vegetation Stress



Lower stream flows



Urban heat island (3rd Worst in U.S.)

Climate Gap & Equity

Low income people more significantly impacted by climate change

- More heat-absorbing environments (more dark roads and buildings, fewer trees and vegetation) = higher UHI effect
- Lack access to coping mechanisms: AC and transportation

The PROBLEM

Climate Change in Denver: Precipitation

Precipitation *variability* will increase

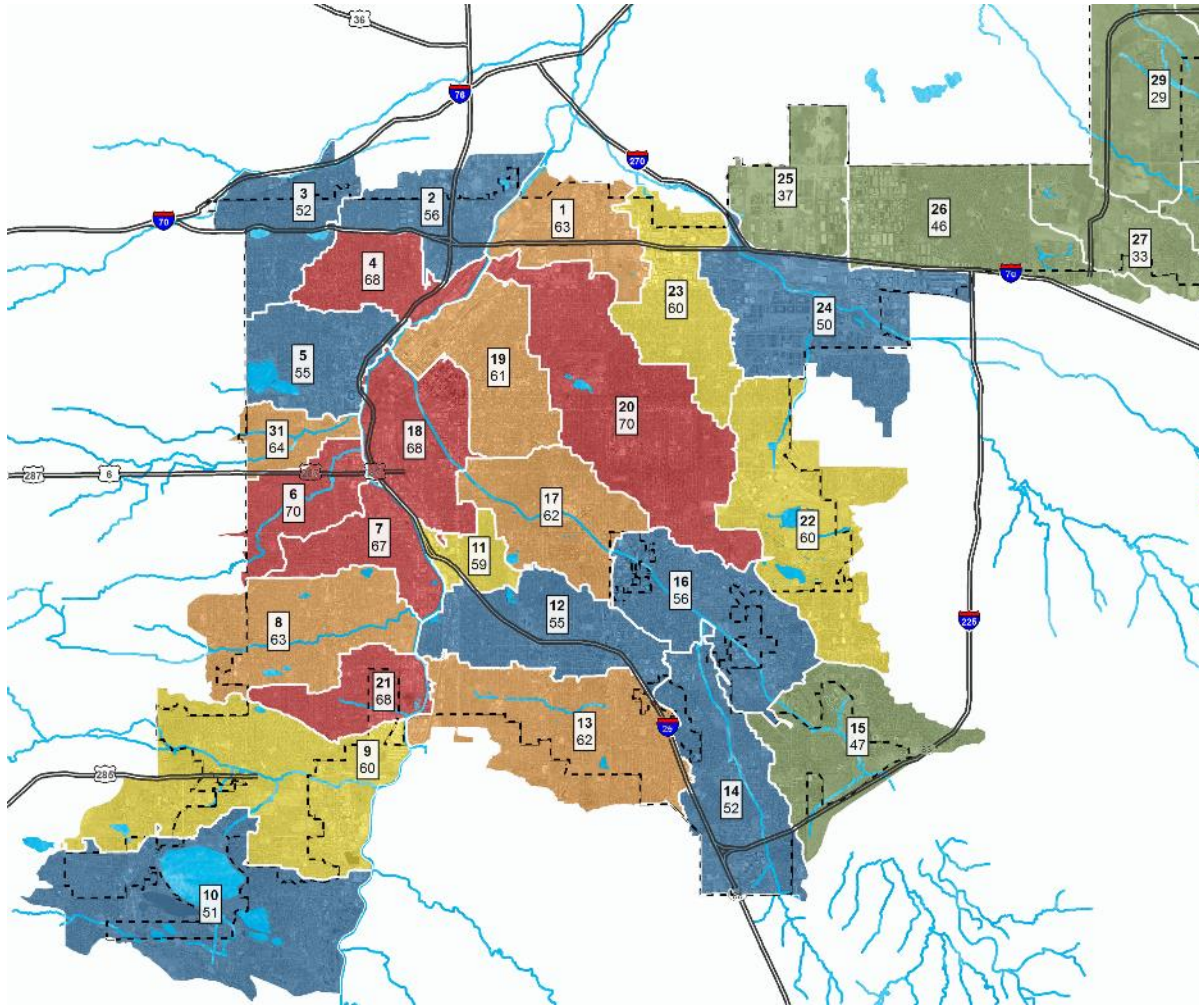
Changes:

- Increasing variability = increasing uncertainty
 - Wetter-than-normal years
 - Drought years expected to increase in frequency and severity
- More precipitation falling as rain instead of snow
- Peak runoff has already shifted 1-4 weeks earlier over last 30 years, will shift 1-3 weeks earlier by mid-century





- Improve water quality
- Reduce flood risks
- Improve air quality
- Reduce Urban Heat Island effect
- Climate resiliency
- Absorb local carbon emissions
- Improve public health outcomes
 - Increase physical activity
 - Improve mental wellbeing
 - Reduce stress
 - Lower traffic speeds and reduce injury crashes
- Improve property values



Objectives

- 1. Data Driven:** Prioritize basins with greatest WQ needs based on data
- 2. Strategic Prioritization:** Identify large & site-scale GI projects by using “Scorecard” criteria
- 3. Proactive:** Address wet and dry weather discharges
- 4. Meet Multiple City Goals:** Work with other city agencies to maximize collaboration opportunities & ‘OPM’

Primary Category	
Existing TMDL	Is drainage basin directly to the SPR & existing TMDL (126 cfu/ml)
303(d) listed waterbody	Does drainage basin contain a water body listed on the 303(d) list (impaired waterway)
Wet weather pollutant loading Dry weather pollutant loading	Average annual pollutant load per land use for wet weather Average annual dry weather pollutant load per area
Disconnected Impervious Area	Density of storm drain network (higher indicates greater need for WQ)
Redevelopment Potential	Per Blueprint (new development over 1 acre requires WQ)
Impervious Area within the ROW	Amount of ROW divided by total basin area (streets largest contributor of pollutants)
Existing Treatment	Amount of treatment expected by existing WQ facilities

Secondary Category	
Park Density	Ratio of park per 10,000 persons
Economics	% of persons in low to moderate income level (HUD defined)
Green-ness	Ratio of total tree canopy coverage divided by basin area
Heat Island Effect	Measure of heat energy absorbed by urban materials
Transportation Pollutant Index	Total vehicle miles traveled



- **Approach; Goals and Objectives; Partners; Planning**
- **Denver Urban Watersheds and Water Quality**
 - **Watershed and WQ Basins; Land Use and Impervious Surfaces; Climate and Hydrology; Benefits of Green Infrastructure; Equity**
- **Baseline Conditions and Impairments to Denver’s Urban Waterways**
 - **E.Coli; Total Suspended Solids; Nutrients**
- **Project Prioritization Process | Scorecard**
- **Basin Conditions and Project Opportunities**
 - **Priority Basins, City Property**
- **Special Projects**
- **Monitoring and Maintenance**

[central platte valley opportunities]

BMP OPPORTUNITIES

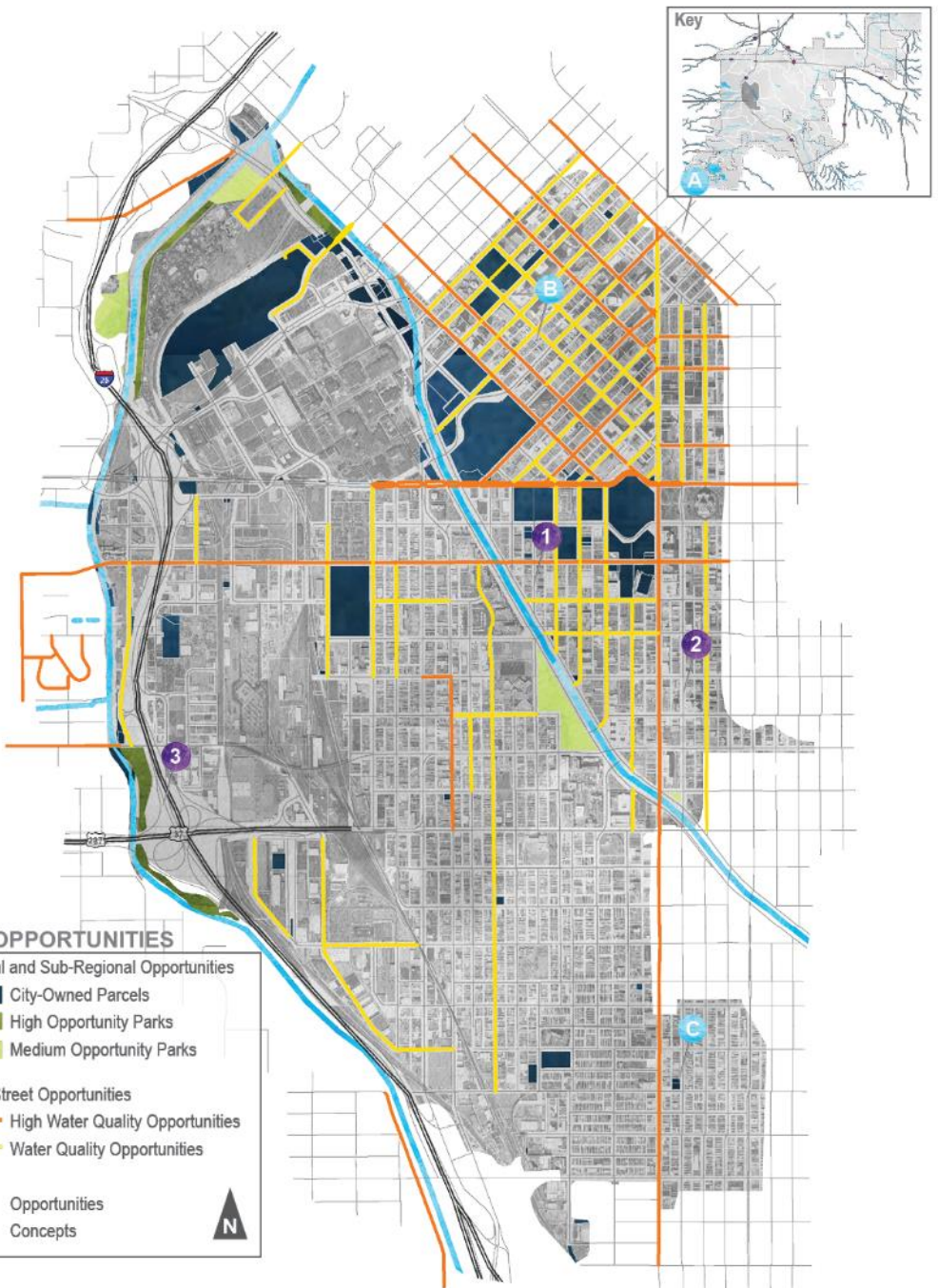
Regional and Sub-Regional Opportunities

- City-Owned Parcels
- High Opportunity Parks
- Medium Opportunity Parks

Green Street Opportunities

- High Water Quality Opportunities
- Water Quality Opportunities

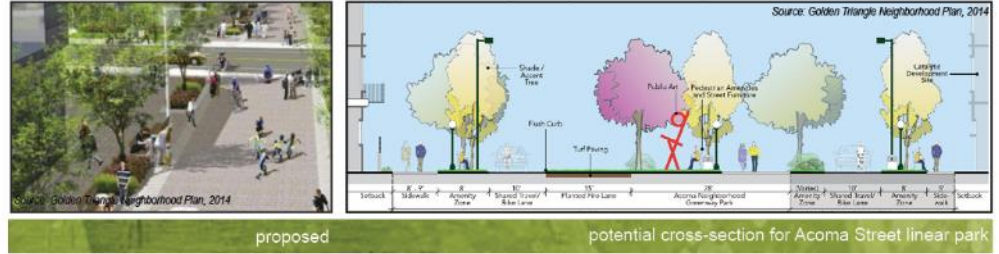
- Opportunities
- Concepts



1 Speer Boulevard Proposed: Rain Gardens in Median



2 Acoma Street Proposed: Urban Neighborhood Greenway (Golden Triangle Neighborhood Plan)



3 Frog Hollow Proposed: Extended Detention Basin



green streets

9.74 miles | high priority green street opportunities
16.98 miles | green street opportunities

The process to identify site-scale opportunities (Section 4.4) resulted in a network of green street opportunities in each basin. Streets projects were considered high priority if potential partner opportunities exist and/or the project would offer significant water quality benefits. While streets represent one of the largest sources of urban stormwater pollution, they also represent one of the best opportunities for the installation of green infrastructure. Practices suitable for use within the right-of-way are illustrated in Denver's Ultra-Urban Green Infrastructure Guidelines: <https://www.denvergov.org/content/denvergov/en/wastewater-management/stormwater-quality/ultra-urban-green-infrastructure.html>.

park opportunities

- High Potential Park Opportunities:**
- Frog Hollow Park
 - Platte River Park
 - Speer Boulevard Park
 - Milstein Park
- Medium Potential Park Opportunities:**
- Centennial Park
 - Gates Crescent Park
 - Sunken Gardens Park

New water quality facilities in parks will be considered if they do not impact or limit park use or function. All park related projects will require further study, approval by the Department of Parks and Recreation (DPR), and a public involvement process. The designer must work with Denver Parks Planning during all phases to ensure compliance with DPR standards and specifications.



Site-scale GI Practices suitable for urban environment/ROW

2 years till adoption

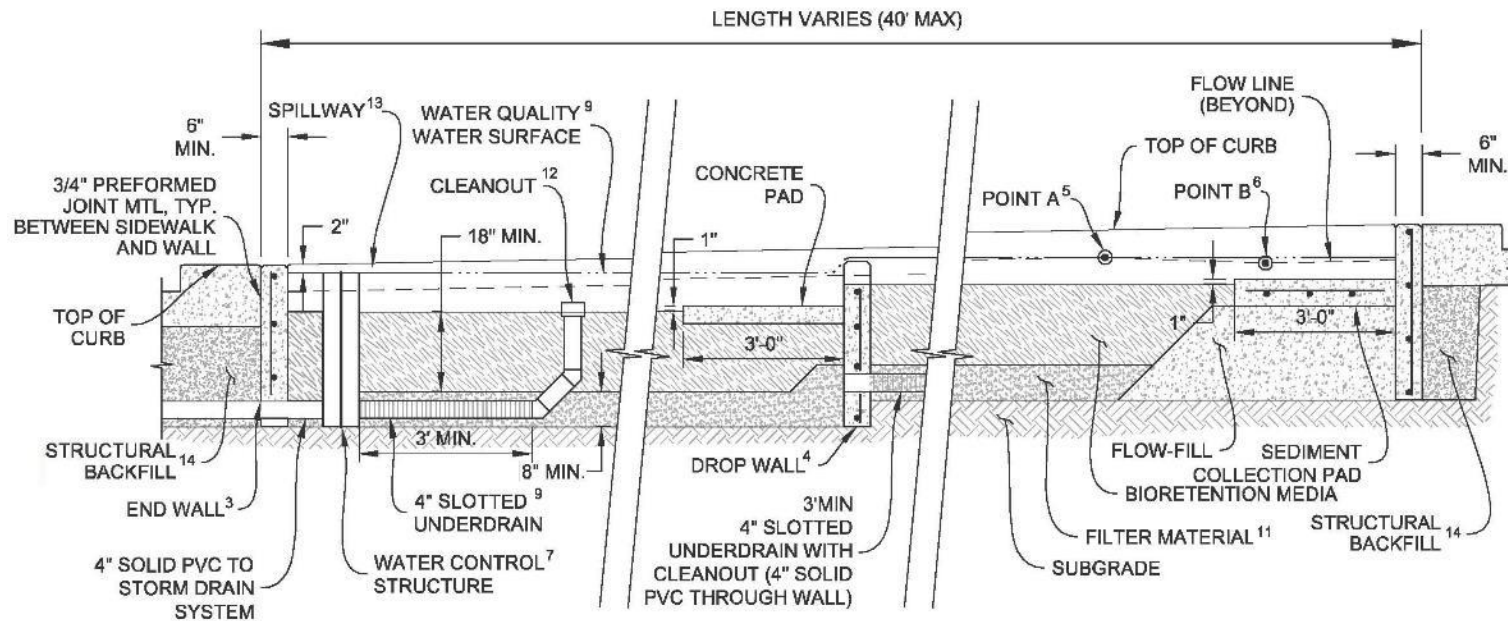
**20 staff from Public Works alone,
Denver Parks & Recreation, CPD, NDCC, Development
Services, & DDPHE**

Environmental Protection Agency

Urban Drainage & Flood Control District

Right Consultant Team

Biggest concerns: safety, costs & maintenance



¹ SUPERSCRIPIT NUMBERS REFER TO DESIGN NOTES PRECEDING THESE DETAILS

GREEN GUTTER SECTION 
 (LONGITUDINAL SLOPE OF 2% SHOWN WITH 40' PLANTER LENGTH)
 SCALE: 1"=3'

Detailed 6 new BMPs including:

Description & Design Recommendations

Sizing

Pedestrian Considerations & Geometry

Materials

Plant Lists | 3 Matrixes

Utilities

Maintenance Responsibilities

Checklists for plan review, inspection and maintenance



2014



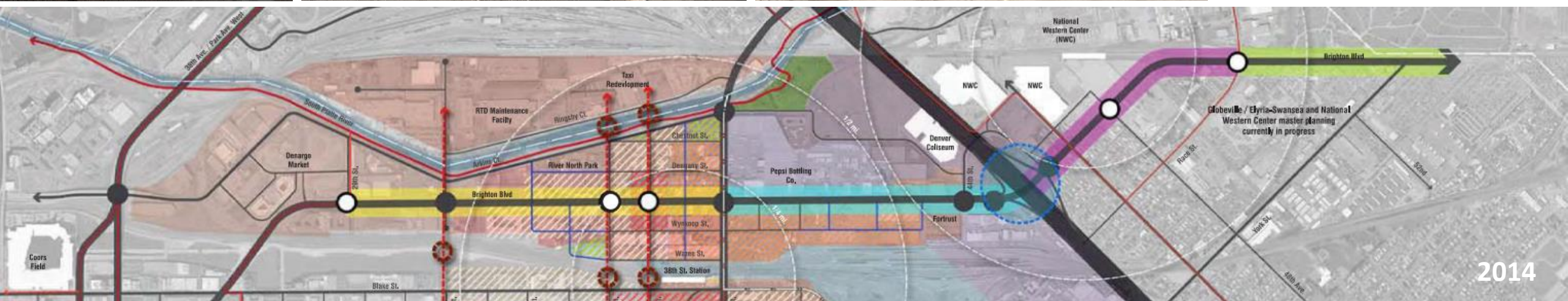
2017



November 2018

Public/Private Partnerships

- General Improvement District
- Business Improvement District
- IGA w/ Public Works



2014

Brighton Blvd.



Project Partners:

- Green Infrastructure Group
- Transportation & Mobility





Project Partners:

- Denver Parks & Recreation
- Public Works Green Infrastructure
- Public Works Wastewater
- Denver Department of Public Health and Environment

Asbury & Tejon (La Lomita) Park



Project Partners:

- Public Works Wastewater
- Public Works Green Infrastructure Group
- Denver Parks & Recreation

Basin Level Strategies

Preserve existing green space

Reduce impervious surfaces

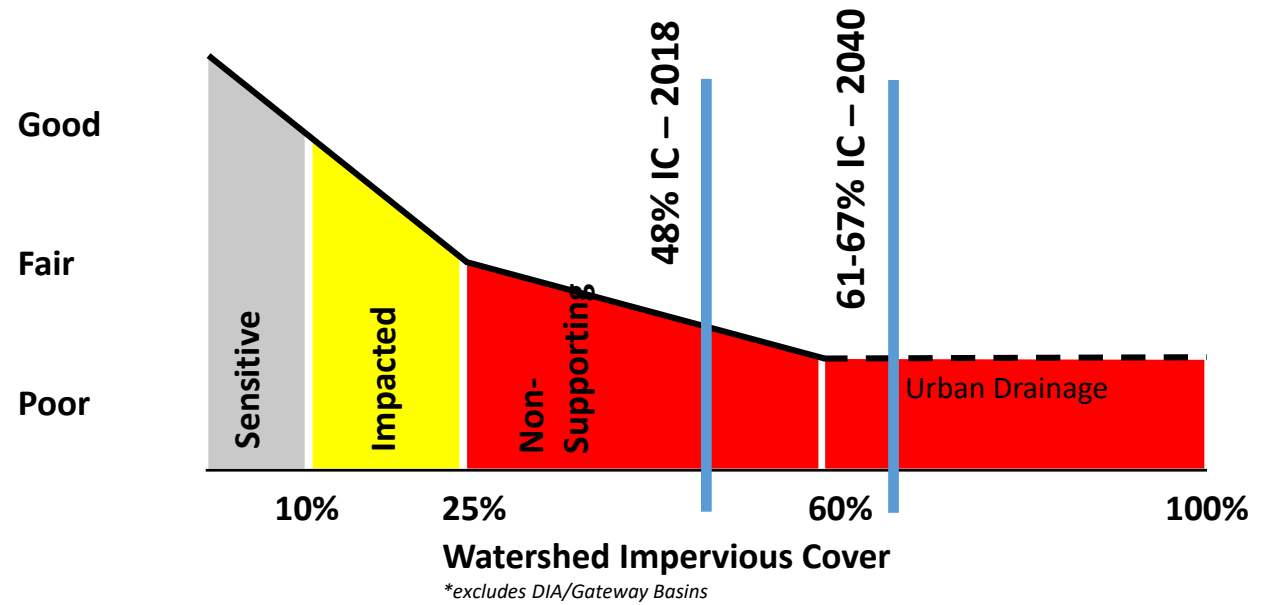
Initial Goal: NET ZERO

Long Term: Reduce Impervious Cover to improve watershed health

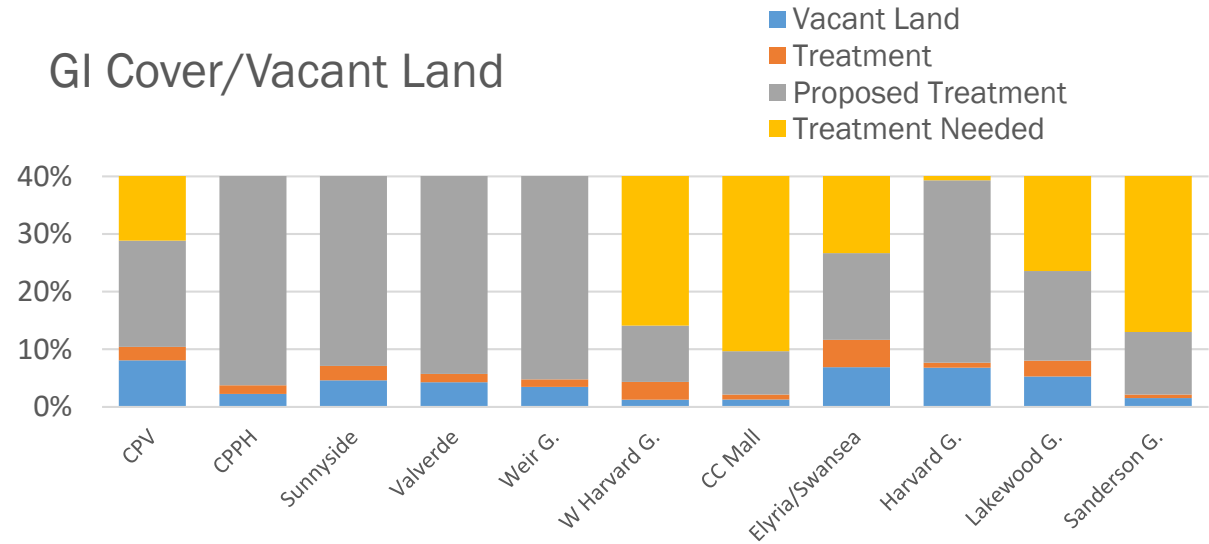
Treat stormwater runoff

40% Coverage of GI Practices before in-stream improvements can be *effective*

ACOE Urban Waterways:
\$500 million primarily in-stream improvements



GI Cover/Vacant Land



Next Steps: PRT

Impervious Cover Forecasting Model: Permit Thresholds



- **Impervious Cover**

- Increase to 61-67% by 2040



- **Treatment**

- 25% will be untreated under current policy

5,177 acres or **8 square miles**

of new, untreated impervious area (eqv: Montclair Basin)

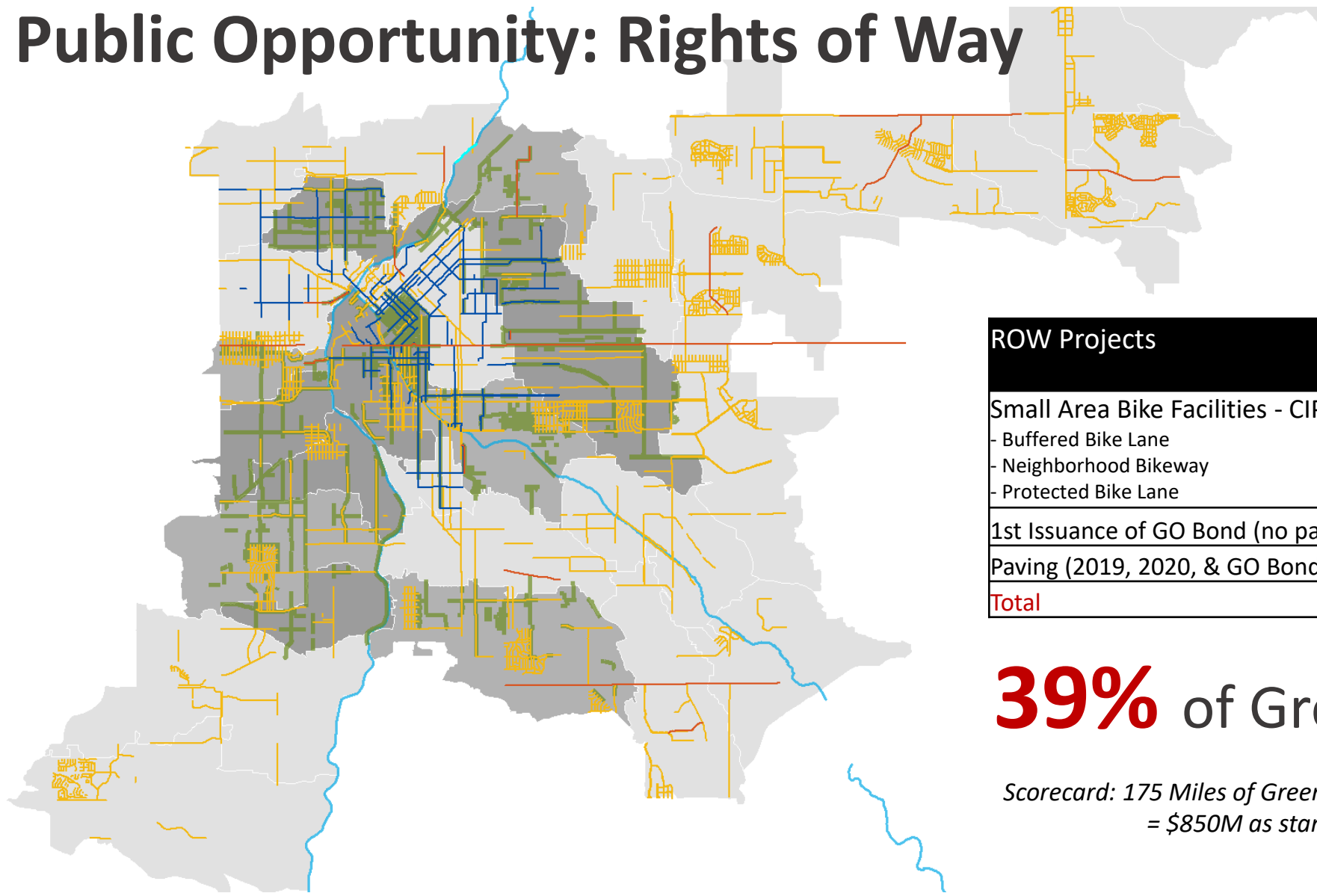
Need to:

Change permit thresholds to match development patterns-

Small Sites Initiative

Next Steps: Policies to support PRT

Public Opportunity: Rights of Way



LEGEND

- Small Area Bike Projects
- GO Bond Projects
- Paving Projects
- Green Streets
- South Platte River/Cherry Creek

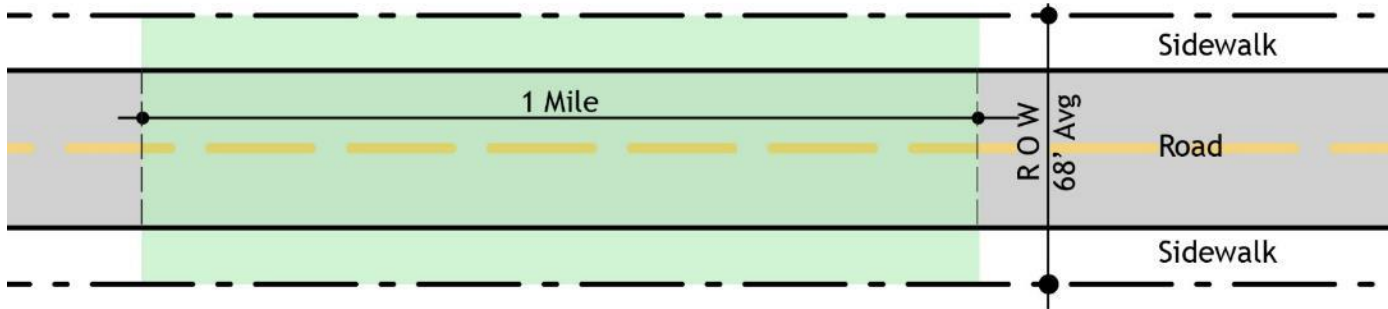
ROW Projects	Total		On Green Streets	
	Miles		Miles	%
Small Area Bike Facilities - CIP funded	68.90		29.6	43%
- Buffered Bike Lane				
- Neighborhood Bikeway				
- Protected Bike Lane				
1st Issuance of GO Bond (no paving)	32.60		8.9	27%
Paving (2019, 2020, & GO Bond)	446.00		43.9	10%
Total			82.4	

39% of Green Streets

*Scorecard: 175 Miles of Green Streets & Green Alleys
= \$850M as stand-alone projects*

Next Steps: Policies to support PRT

Provide an equivalent level of Water Quality Capture Volume (WQCV) treatment for a road way one mile in length.



How It's Calculated:

1 Mile of Road (5280') x Right-of-way Width (68') = 359,040 sf
 $359,040 \text{ sf} \div 43560 \text{ sf} = 8.24 \text{ acres per 1 Mile of Road}$

For every 8.24 acres of impervious area treated, one Green Mile of Green Streets has been achieved.

Goal: 25 Miles of Green Streets in 5 years

25 Miles x 8.24 acres = 206.06 Acres

Simplify to 8 acres = 1 Green Mile, 25 Miles = 200 Acres

Current Projects:

25 Mile Goal	200.00	25.00
	Treated Acres	GM Equivalent Miles
Built Projects 2018		
Brighton Blvd	13.10	1.64
Carla Madison Rec Center	0.46	0.06
21st & Broadway	3.50	0.44
Cherry Creek Drive South	0.10	0.01
Future Projects		
Federal Blvd	12.10	1.51
Lowell & Evans	1.60	0.20
Marion Street	1.28	0.16
39th Ave Open Channel Streets	6.00	0.75
Totals	38.14	4.77
	Percent Complete	19.07%

Next Steps: 25 Green Miles in 5 Years

‘STREETZY’ Guide includes:

**Greater design GL’s for a variety of streets based on typologies & land uses
(align with Blueprint)**

Support 25 mile Goal & One Build

**Include updates to UUGIG
(lessons learned)**

**Technical assistance for engineers, LA’s
(CAD drawings, specs, BID items, etc.)**



Next Steps: Design Guidelines

Use Infrastructure Planning Support (IPSS)

- Analyze projected climate impacts through 2100 on multiple sectors
- Project how vulnerable and sensitive the infrastructure is to climate change
- Potential resulting damages & costs
- Analysis of adaptation options that can offset the vulnerability
- Potential risks associated with adaptation strategy as well as planning for specific climate scenarios



Next Steps: Vulnerability Analysis

Brian Wethington

Green Infrastructure Group Project Manager

brian.wethington@denvergov.org

Sarah Anderson

Green Infrastructure Group Program Manager

sarah.anderson@denvergov.org

For More Information, please visit:

<http://www.denvergov.org/greeninfrastructure>

Thank You!