Redmond Paired Watershed Study

Stormwater Work Group

May 19, 2021

www.ecology.wa.gov/SAM

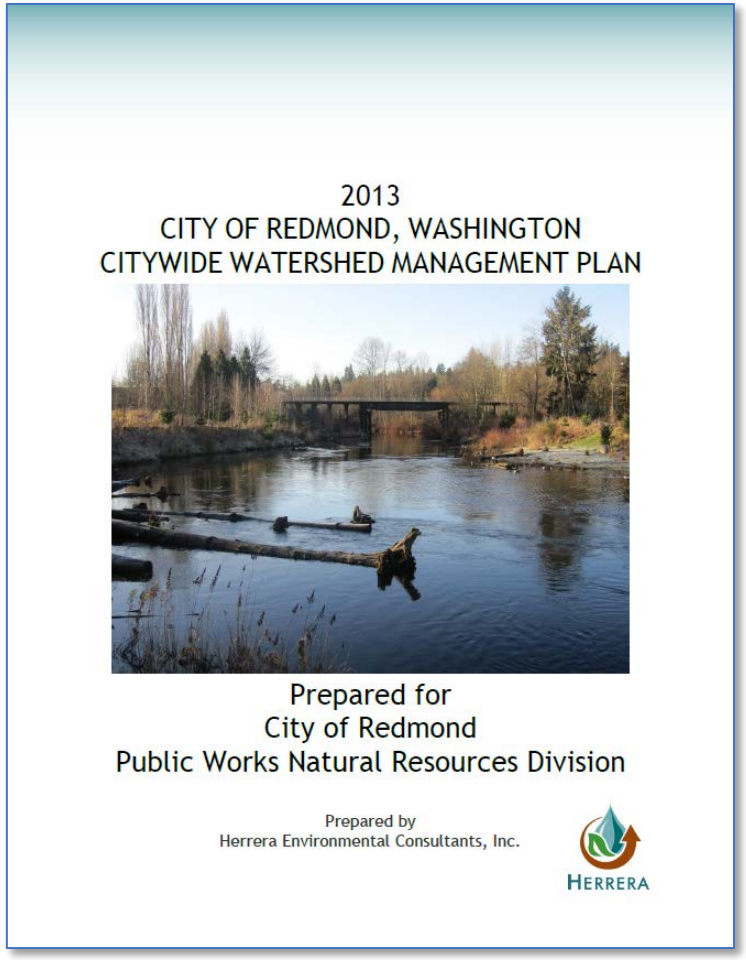
Background

Redmond Paired Watershed Study

Redmond Citywide Watershed Management Plan

Blueprint for rehabilitating Redmond's streams

- Best Available **Science**
- **Prioritize** Watersheds
- **Rehabilitate** Priority Watersheds by 2060
- **Evaluate** Effectiveness



Study Question

Redmond Paired Watershed Study

Are stormwater retrofits effective at rehabilitating receiving water conditions in small urbanized streams?

Study Question

Redmond Paired Watershed Study

- Shuster, W. and L. Rhea (2013). "Catchment-scale hydrologic implications of parcel-level stormwater management (Ohio USA)." Journal of Hydrology 485: 177-187.

- Selbig, W. R., et al. (2008). A comparison of runoff quantity and quality from two small basins undergoing implementation of conventional and low-impact-development (LID) strategies : Cross Plains, Wisconsin, water years 1999-2005. Reston, Virginia, U.S. Geological Survey.

- Roy, A. H., et al. (2014). "How Much Is Enough? Minimal Responses of Water Quality and Stream Biota to Partial Retrofit Stormwater Management in a Suburban Neighborhood." Plos One 9(1).

- Pitt, R., et al. (2013). Performance Results from Small- and Large-Scale System Monitoring and Modeling of Intensive Applications of Green Infrastructure In Kansas City. 2013 International Low Impact Development Symposium, Saint Paul, Minnesota.

- Bedan, E. S. and J. C. Clausen (2009). "Stormwater Runoff Quality and Quantity From Traditional and Low Impact Development Watersheds(1)." Journal of the American Water Resources Association 45(4): 998-1008.

Project Team

Redmond Paired Watershed Study

- Program Development and Oversight
- Funding
- Stakeholder Coordination
- Contract Administration

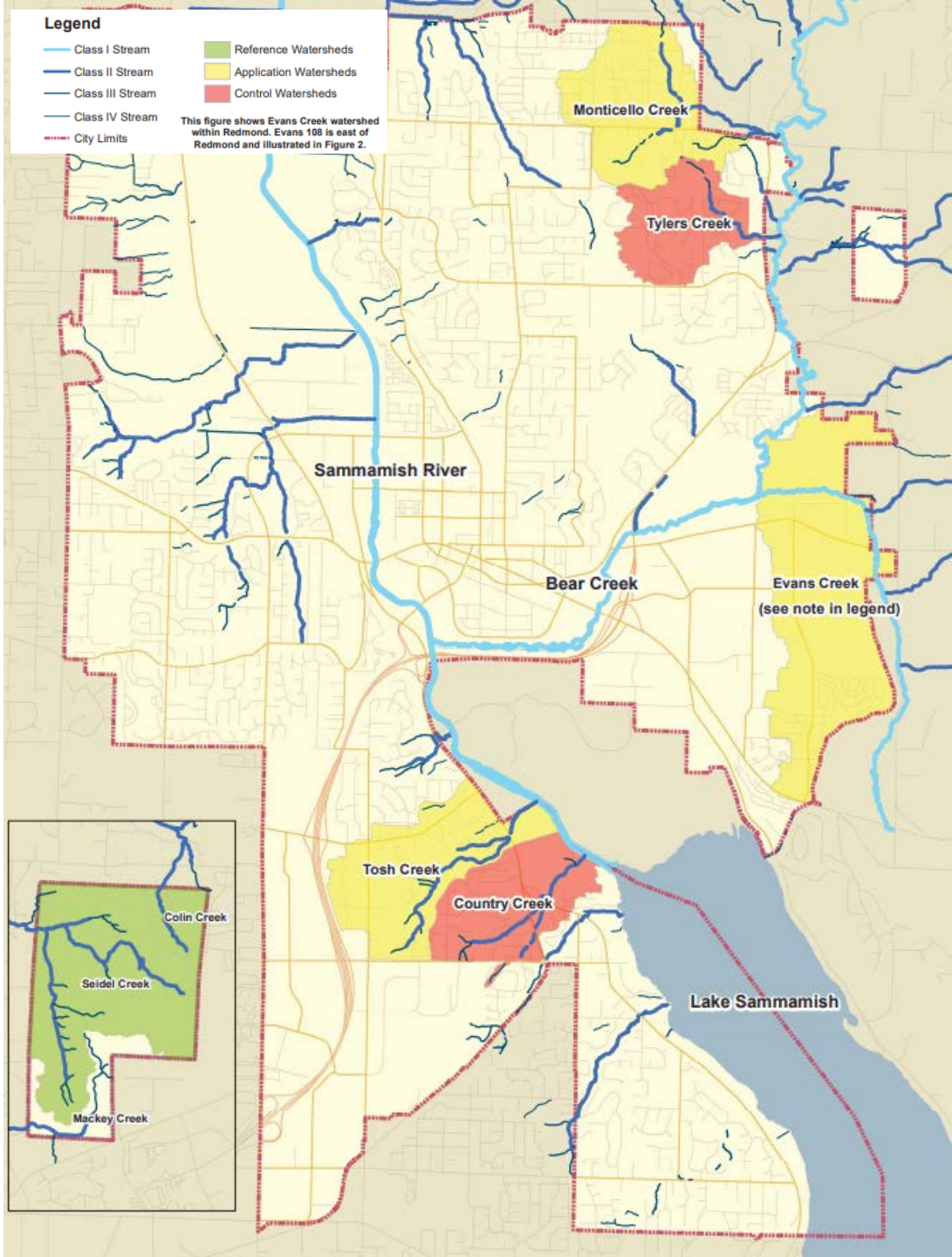
- Sponsor Jurisdiction
- Project Management

- Experimental Design
- Field Data Collection
- Quality Assurance / Quality Control
- Data Management and Analysis
- Reporting

Experimental Design

Redmond Paired Watershed Study

- Three “Application” watersheds
  - Moderately impacted by urbanization
  - Prioritized for rehabilitation efforts
- Two “Reference” watersheds
  - Relatively pristine
  - Not subject to rehabilitation efforts
- Two “Control” watersheds
  - Heavily impacted by urbanization
  - Not subject to rehabilitation efforts



Experimental Design

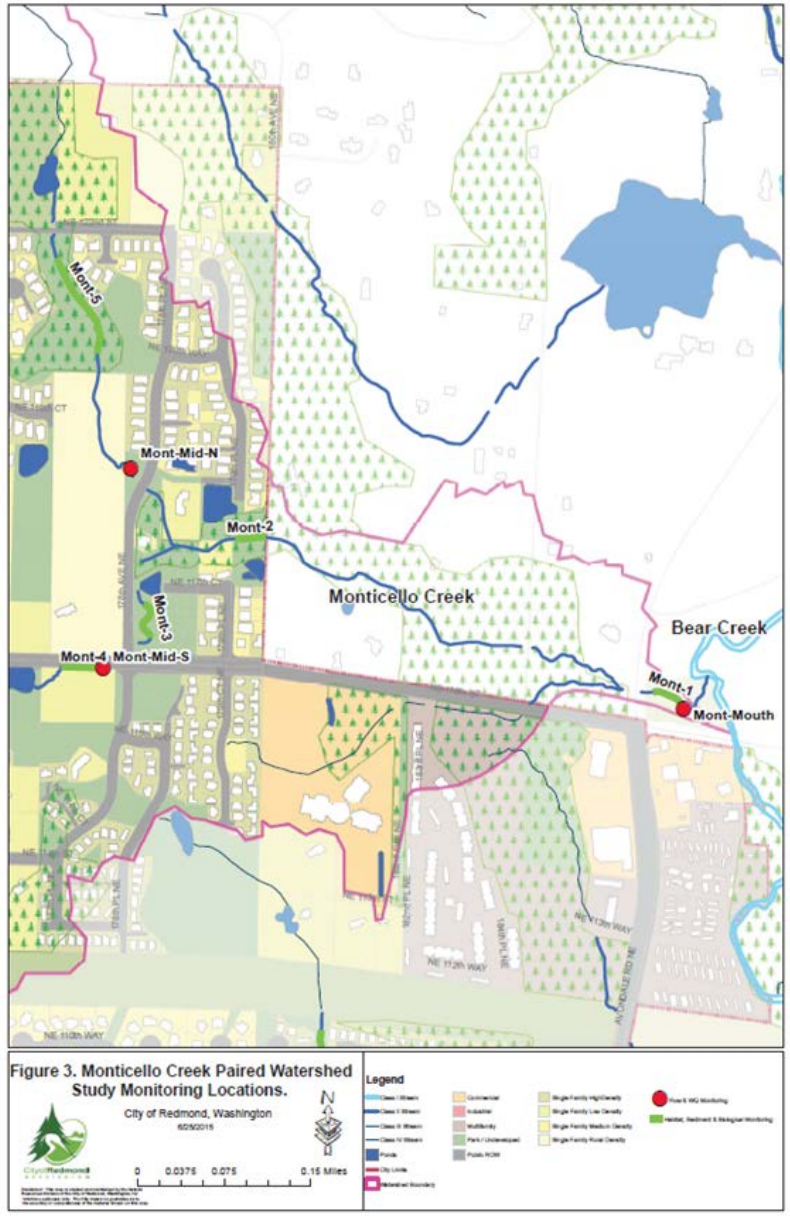
Redmond Paired Watershed Study

Watershed Type	Watershed Name	WQ & Flow Sites (#)	Physical Habitat Sites (#)	Dominant Land Use/Cover	Watershed Areas (acres)	Watershed Area in Redmond (acres)
Reference	Colin	1	1	Forest	1,990	90
Reference	Seidel	2	3	Forest	1,188	615
Application	Monticello	3	5	Residential/Commercial	345	264
Application	Tosh	2	4	Residential/Commercial	299	276
Application	Evans	2	2	Residential	397	NA
Control	Tyler's	2	2	Residential/Commercial	168	167
Control	Country	2	2	Residential/Commercial	212	212

Experimental Design

Redmond Paired Watershed Study

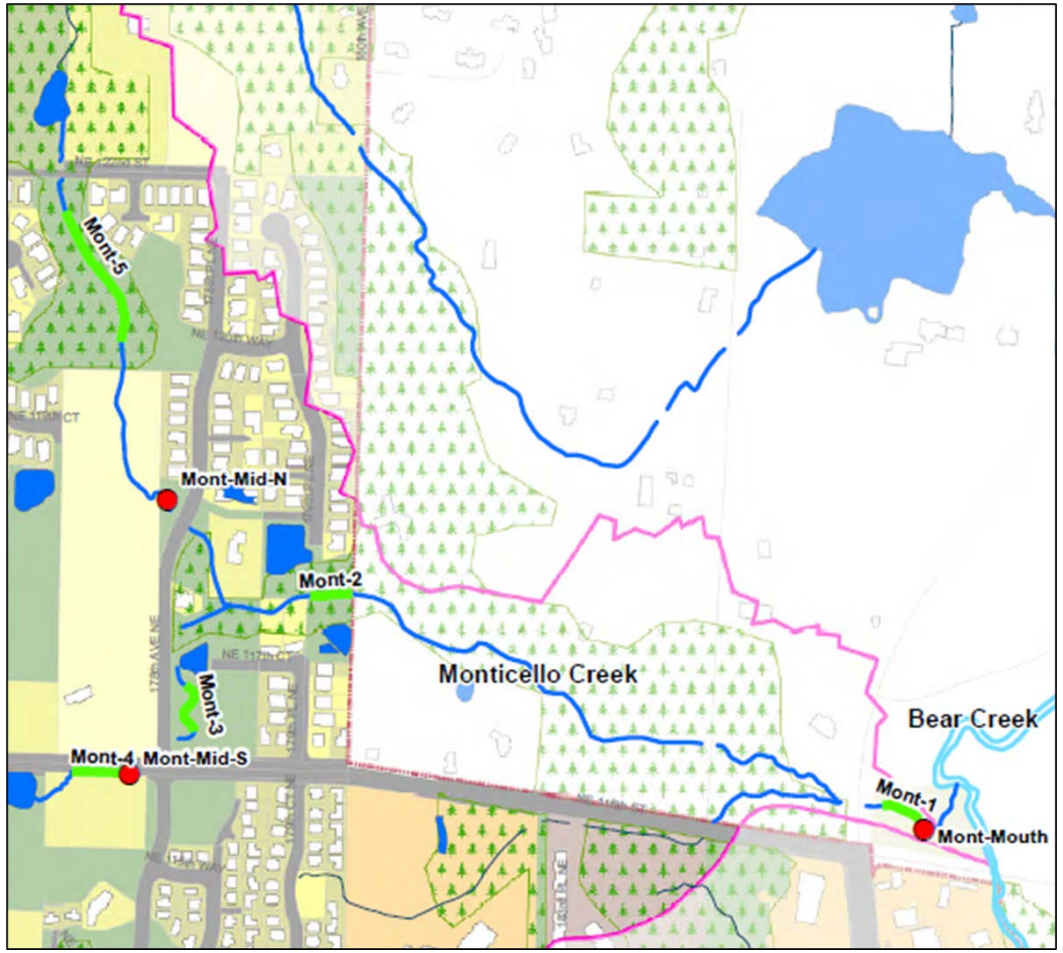
- Hydrologic monitoring
  - Continuous
- Water quality monitoring
  - 12 storm flow events annually
  - 4 base flow events annually
  - Continuous in-situ
- Habitat quality monitoring
  - Annually
- Sediment quality monitoring
  - Annually
- Biological monitoring
  - Annually



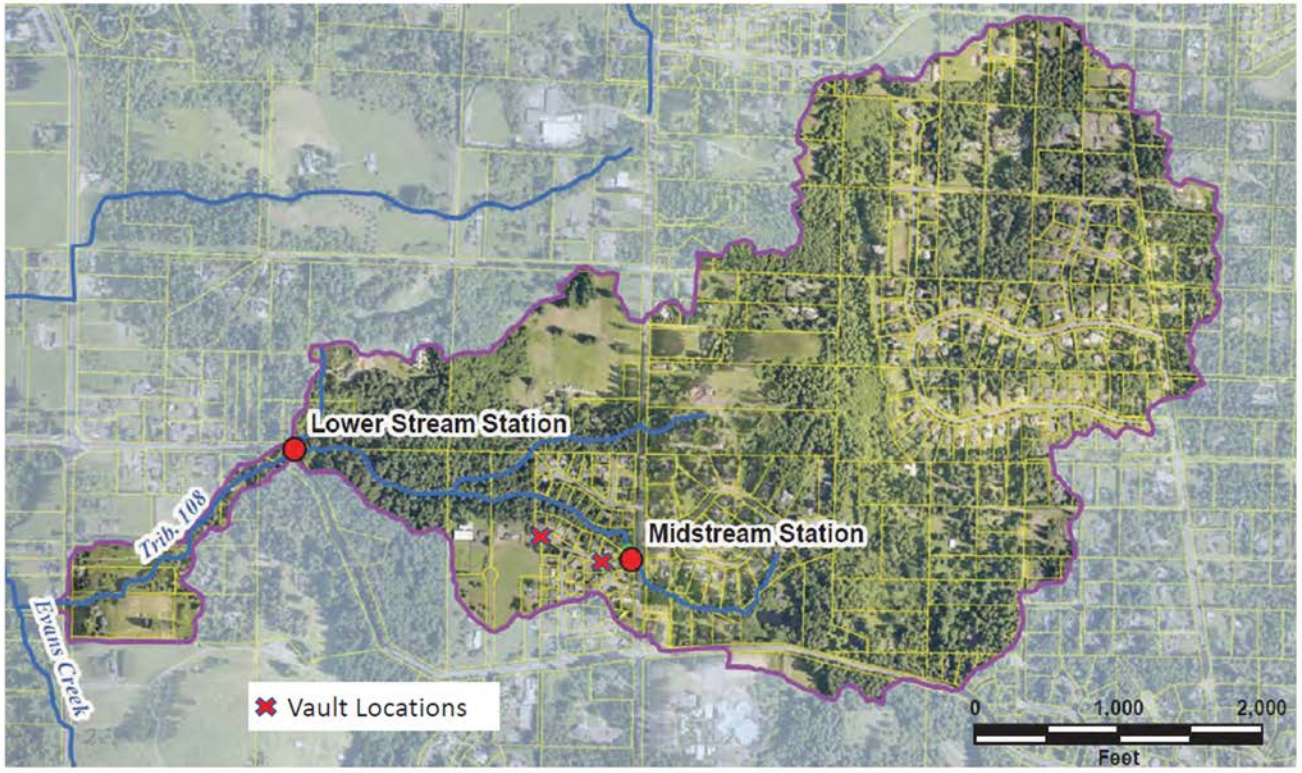
Rehabilitation Efforts

Redmond Paired Watershed Study

Monticello Creek Watershed



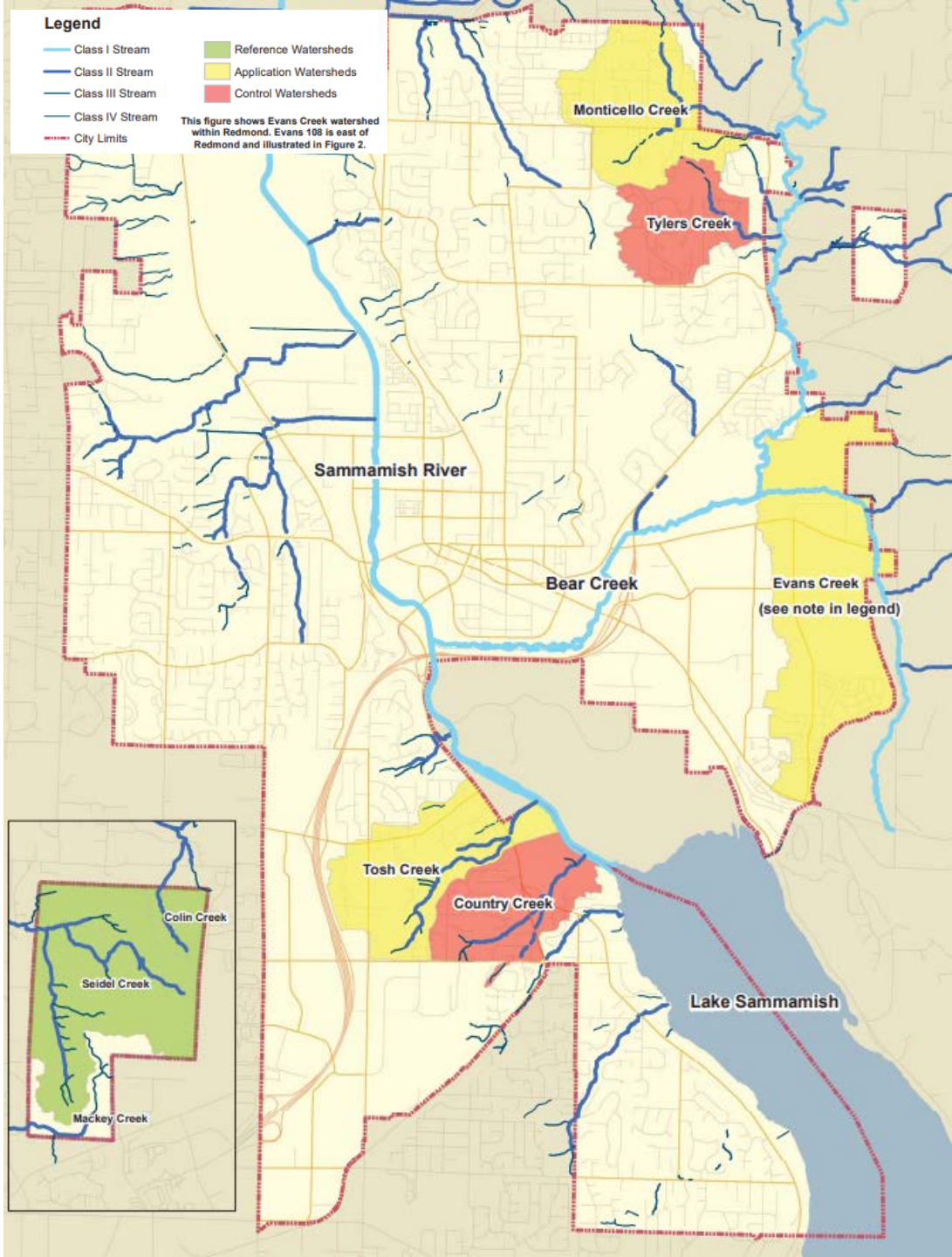
Evans Creek Tributary 108 Watershed



Trend Analysis Report WY2016 - WY2019

Redmond Paired Watershed Study

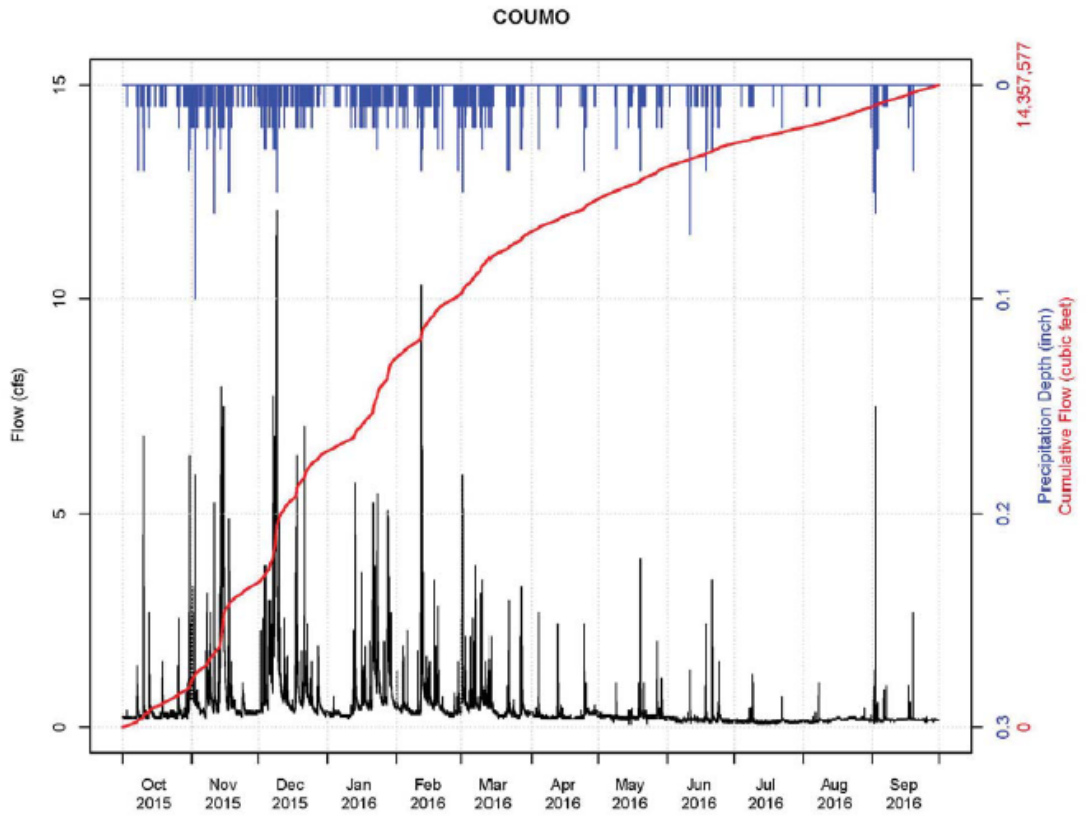
- Pattern of Interest
  - Receiving water conditions are **improving** in the **Application watersheds**
  - Conditions are remaining **static or deteriorating** in **Control and Reference watersheds**



Hydrologic Monitoring

Redmond Paired Watershed Study

- Correlation Analyses for Hydrologic Indicators Versus Time
- Correlation Analyses of Rainfall Runoff Response Versus Time
- Comparison of Rainfall Runoff Response Before and After Vault Construction in the Evans Creek Watershed



Hydrologic Monitoring

Redmond Paired Watershed Study

- **Correlation Analyses of Rainfall Runoff Response Versus Time**

Table 5. Seasonal Kendall's Tau Correlation Coefficients for Rainfall Runoff Response (flow volume and maximum flow rate) Versus Time (WY2016 through WY2019).

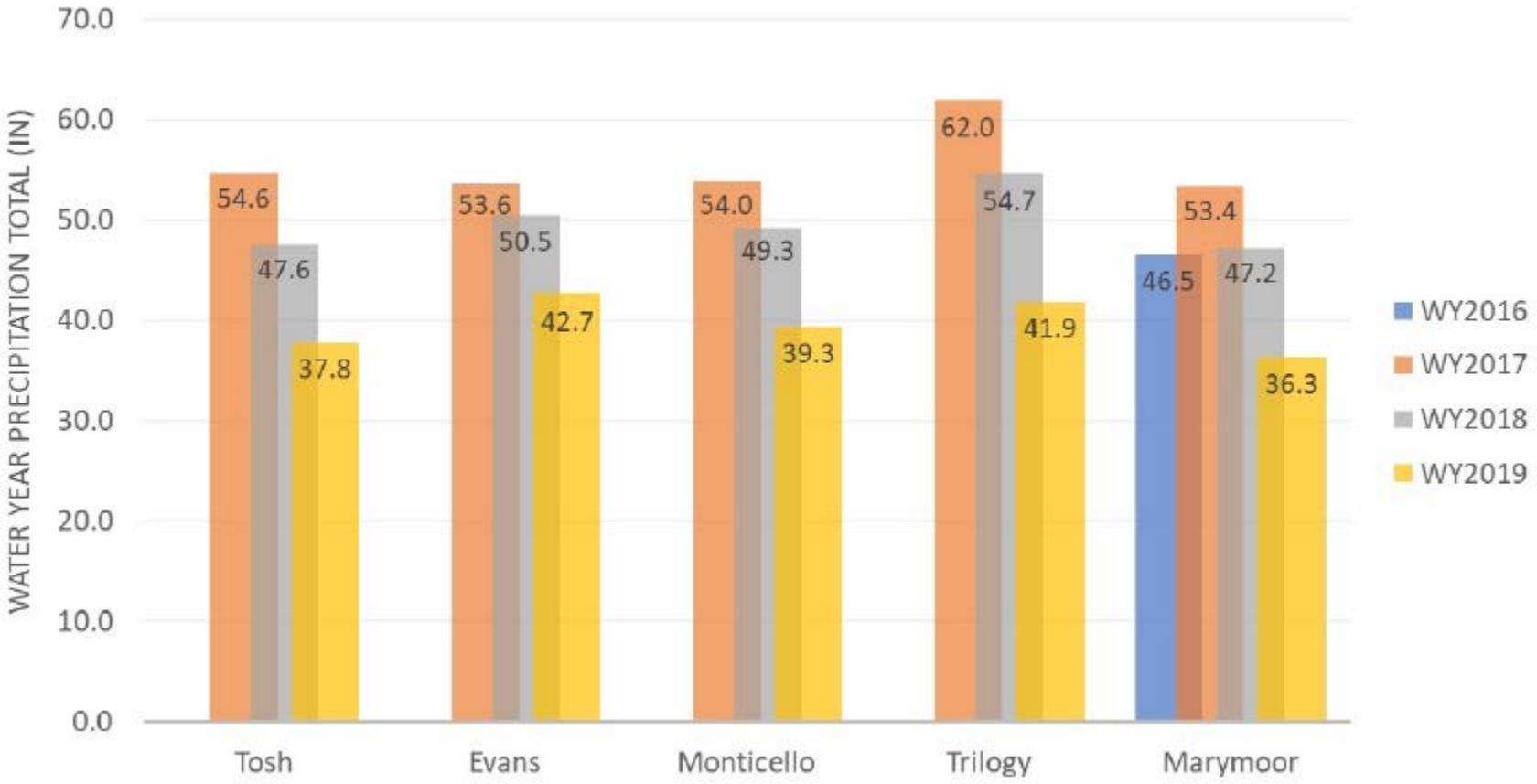
Station	Flow Volume vs. Precipitation Depth		Maximum Flow Rate vs. Precipitation Depth	
	Coefficient	p-value	Coefficient	p-value
EVALSS	-0.034	0.245	-0.114	**<0.001**
EVAMS	-0.072	**0.013**	-0.089	**0.002**
MONM	-0.130	**<0.001**	-0.138	**<0.001**
MONMN	-0.125	**<0.001**	-0.132	**<0.001**
MONMS	-0.205	**<0.001**	-0.182	**<0.001**
TOSMO	-0.009	0.760	-0.056	0.060
TOSMI	-0.141	**<0.001**	-0.200	**<0.001**
COLM	-0.023	0.451	-0.056	0.066
SEIMN	-0.124	**<0.001**	-0.138	**<0.001**
SEIMS	-0.090	**0.002**	-0.101	**<0.001**
COUMO	-0.243	**<0.001**	-0.144	**<0.001**
COUMI	-0.041	0.169	-0.106	**<0.001**
TYLMO	-0.153	**<0.001**	-0.126	**<0.001**
TYLMI	0.055	0.068	0.065	**0.031**

Values in bold indicate significant decreasing trend ($\alpha = 0.05$)

Hydrologic Monitoring

Redmond Paired Watershed Study

- **Correlation Analyses of Rainfall Runoff Response Versus Time**



Hydrologic Monitoring

Redmond Paired Watershed Study

- **Comparison of Rainfall Runoff Response Before and After Vault Construction in the Evans Creek Watershed**

Mann-Whitney Test Comparing Rainfall Runoff Response (maximum flow rate) Before and After Vaults Became Operational (October 31, 2017).					
	Natural Log (Maximum Flow Rate (cfs)) vs. Natural Log (Precipitation Depth (in))				
Station	Chi-squared value	p-value	Median - Before	Median - After	Trend
EVALSS	0.524	0.235	-0.010	-0.035	-
EVAMS	2.244	1.000	-0.027	-0.024	+
MONM	0.235	0.314	0.046	0.045	-
MONMN	0.074	0.393	0.072	0.060	-
MONMS	0.052	1.000	-0.005	0.031	+
TOSMO	2.005	0.078	0.014	-0.025	-
TOSMI	8.669	**0.002**	0.064	-0.099	-
COLM	11.631	1.000	0.058	0.309	+
SEIMN	2.992	1.000	0.022	0.083	+
SEIMS	6.011	1.000	-0.075	0.052	+
COUMO	1.066	0.151	0.029	-0.063	-
COUMI	6.593	1.000	-0.019	0.134	+
TYLMO	1.821	0.089	0.043	-0.036	-
TYLMI	9.081	1.000	-0.082	0.231	+

Hydrologic Monitoring

Redmond Paired Watershed Study

- Comparison of Rainfall Runoff Response Before and After Vault Construction in the Evans Creek Watershed
  - **No clear pattern related to rehabilitation efforts**
    - Possible confounding influence from interannual hydrologic trend?
    - Design defect that reduces vault performance relative to design expectations?
    - **Vaults are not treating enough of the watershed area** to have a detectable impact on flows at monitoring station?
      - 1.18 acres treated
      - 397 acres watershed

Water Quality Monitoring

Redmond Paired Watershed Study

- Data Screening
- Correlation Analyses for Water Quality Indicators Versus Time
- Correlation Analyses of Mass Loading Estimates Versus Time
- Correlation Analyses of Continuous Temperature and Conductivity Data Versus Time
- Comparison of Water Quality Indicators Before and After Street Sweeping in the Monticello Creek Watershed

Water Quality Monitoring

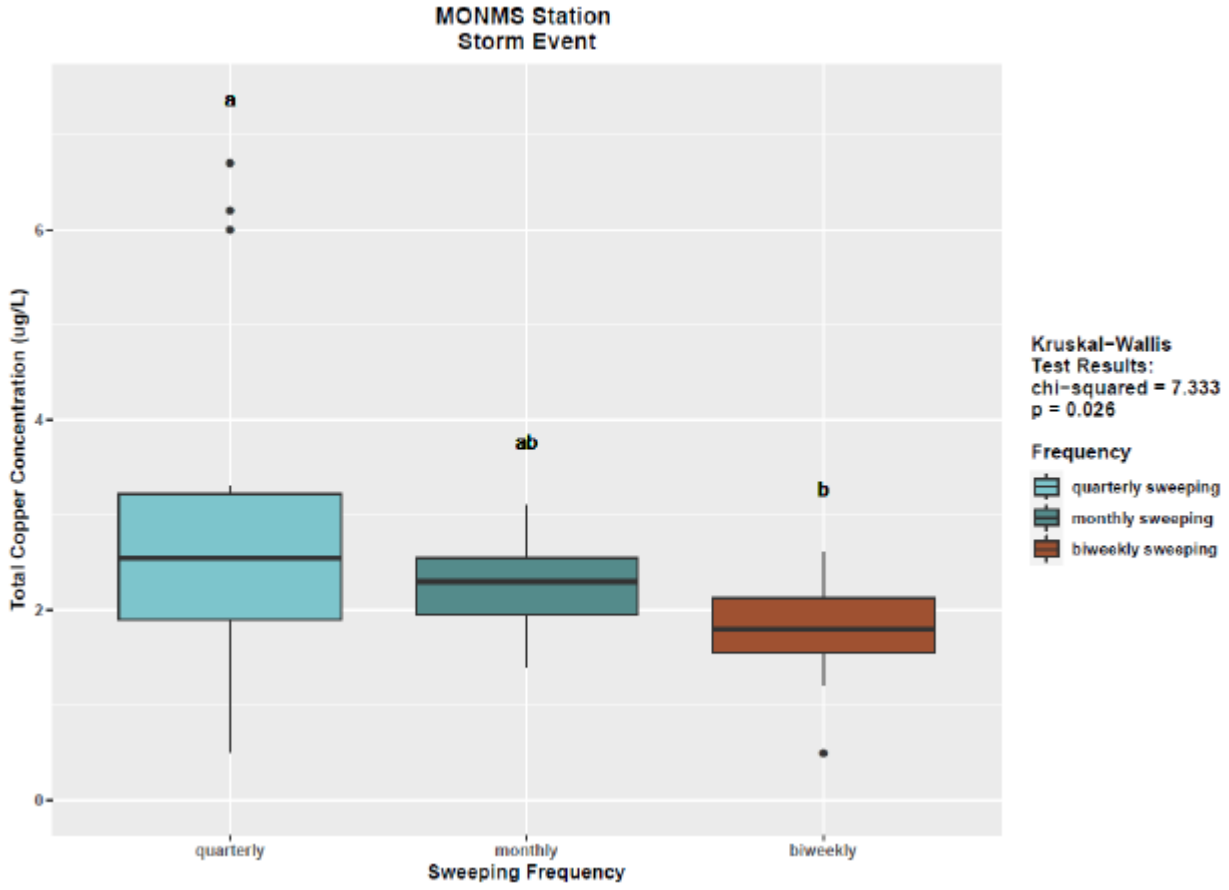
Redmond Paired Watershed Study

- Comparison of Water Quality Indicators Before and After Street Sweeping in the Monticello Creek Watershed
  - Statistically significant **reductions in copper and TSS** confirmed through **multiple analyses** (correlation, load reduction, before and after)
  - Results consistent with SPU street sweeping study
    - Significant reduction in particulate copper and course sediment (>250 microns)
    - Sampling conducted at edge of pavement

Water Quality Monitoring

Redmond Paired Watershed Study

- Comparison of Water Quality Indicators Before and After Street Sweeping in the Monticello Creek Watershed



Trend Analysis Report – WY2016 through WY2019

Redmond Paired Watershed Study

- Conclusions

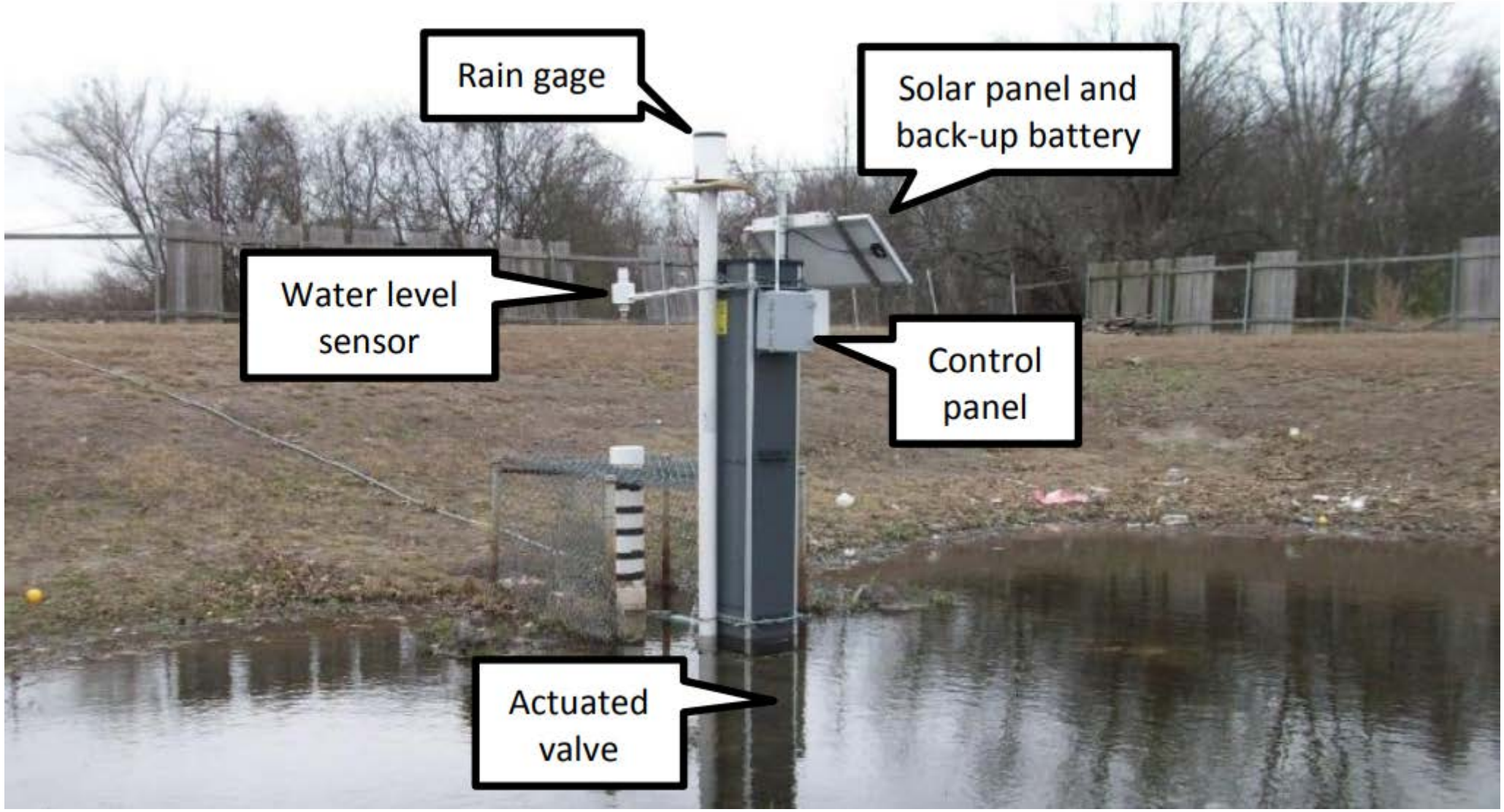
  - An **interannual hydrologic trend** was detected in the rainfall runoff response across most stations.

  - The two detention vaults constructed in the Evans Creek watershed appeared to provide no measurable benefit. The likely explanation is they are **not treating enough watershed area**.

  - A consistent and significant **decrease in TSS and total copper** concentrations was observed in the Monticello Creek watershed that could indicate the progressive increase in **street sweeping frequency** is benefiting water quality.

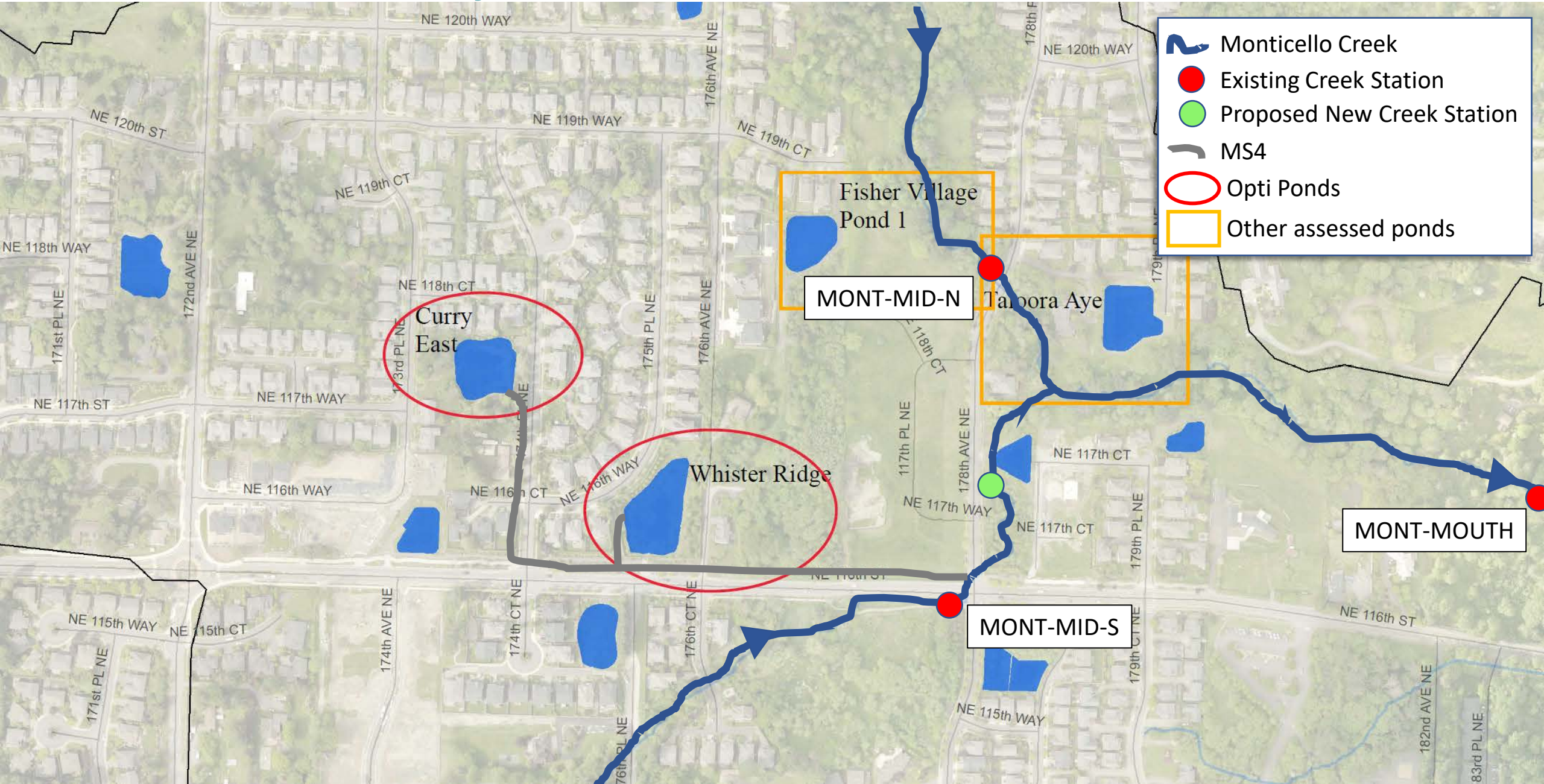
Next Steps

Redmond Paired Watershed Study



Next Steps

Redmond Paired Watershed Study



SAM
Stormwater Action Monitoring

SAM
Stormwater Action Monitoring

www.ecology.wa.gov/SAM