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Final

Upper Granite Creek Watershed *E. coli* TMDL

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Open File Report 14-08

Acknowledgments

Special thanks go to Douglas McCarty, whose data analysis was invaluable to development of this TMDL. Thanks to Prescott Creeks Association for their collaboration and field assistance. Thanks also to various ADEQ staff for their field assistance and document review.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADEQ	Arizona Department of Environmental Quality
AgI	Agriculture-irrigation
AgL	Agriculture-livestock watering
A&Wc	Aquatic and Wildlife – cold water
ALEC	Arizona Laboratory for Emerging Contaminants
AZPDES	Arizona Pollution Discharge Elimination System
BMP	Best Management Practice
cfs	cubic feet per second
cfu	colony forming units
Colilert^{R}	Trademark of statistically based, EPA approved method for *E. coli* analysis
CGP	Construction General Permit
CWA	Clean Water Act
EC	Emerging contaminants
EPA	Environmental Protection Agency
FBC	Full Body Contact
FC	Fish Consumption
GI	Green Infrastructure
G-org	G-cfu/day = 1 billion cfu/day
HUC	Hydrologic Unit Code
Kolmogorov-Smirnov	Non-parametric Test for significant difference
LA	Load Allocation
MPN	Most Probable Number
mL	milliliter
MS4	Municipal Separate Storm Sewer System Permit
MSGP	Multi-sector General Permit
MST	Microbial Source Tracking
NPS	Nonpoint Source
PS	Point Source
p-value	Value set for statistical significance
PBC	Partial Body Contact
sq mi	square mile
SSM	Single Sample Maximum
Stv	standard deviation
SWMP	Storm Water Management Plan
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
UCL	upper confidence level
USGS	United States Geological Survey
YPIT	Yavapai-Prescott Indian Tribe
WIC	Watershed Improvement Council
WIP	Watershed Improvement Plan

WLA	Wasteload Allocation
WQS	Water Quality Standards

TOTAL MAXIMUM DAILY LOAD

Escherichia coli (E. coli)

Granite Creek Watershed - Headwaters to Watson Lake
Yavapai County, Arizona

Table ES-1. TMDL SUMMARY	
Waterbody Name/Segment Number	1) Granite Creek from Headwaters to Watson Lake HUC/Reach No. 15060202-059A (above the Yavapai-Prescott Indian Tribe); 15060202-059B (below tribal land) 2) Miller Creek from Headwaters to Granite Creek HUC/Reach No. 15060202-767 3) Butte Creek from Headwaters to Granite Creek HUC/Reach No. 15060202-768 4) Manzanita Creek from Headwaters to Granite Creek HUC/Reach No. 15060202-772
Pollutant of Concern	*E. coli*
Waterbody Designated Uses	Aquatic & Wildlife-cold, Full Body Contact, Fish Consumption, Agriculture-irrigation, Agriculture-livestock watering
Water Quality Target	Attainment of *E. coli* water quality standard of 235 cfu/100ml throughout watershed; Attainment of the corresponding load target at upper and lower USGS gauges on Granite Creek
TMDL Goal	Protection of public health and recreational uses

I. EXECUTIVE SUMMARY

Granite Creek is the major tributary to Watson Lake near the City of Prescott, Yavapai County, AZ. Granite Creek and Miller Creek were listed on Arizona's 303(d) list of water quality impaired waterbodies for *Escherichia coli (E. coli)* in 2010. Butte Creek and Manzanita Creek have been added in the 2012/14 303(d) list. The Upper Granite Creek Watershed (above Watson Lake) includes a portion of the Prescott National Forest and the City of Prescott, Private and State Trust Lands, Yavapai County Lands, Tribal Lands, and Military (Fort Whipple, now Veteran's Hospital) (Figure ES-1).

E. coli is an indicator of the possible presence of pathogenic organisms that may cause illness in those who come in contact with or ingest contaminated waters. The identified creeks have been assessed as exceeding the full body contact single sample maximum (SSM) standard of 235 cfu/100ml, showing more than one exceedance in any consecutive three-year period, per A.A.C. Title 18, Chapter 11, Section 106 D (2).

Sources of *E. coli* include humans, wildlife, and domestic animals. During storm events and winter snowmelt, significant contributions of *E. coli* are routed to the creeks, as stormwater collection is not separate from the natural hydrography in many places. Sanitary sewer overflows and septic seepage, cross connections, wildlife, and pets are all known sources of *E. coli* and expected contributors to impaired reaches.

E. coli levels are measured as a density-based unit, i.e. a number of bacteria colony forming units (cfu) per 100 milliliters (ml) of water. The density-based targets for this TMDL are based upon the applicable SSM water quality standard of 235 cfu/100ml.

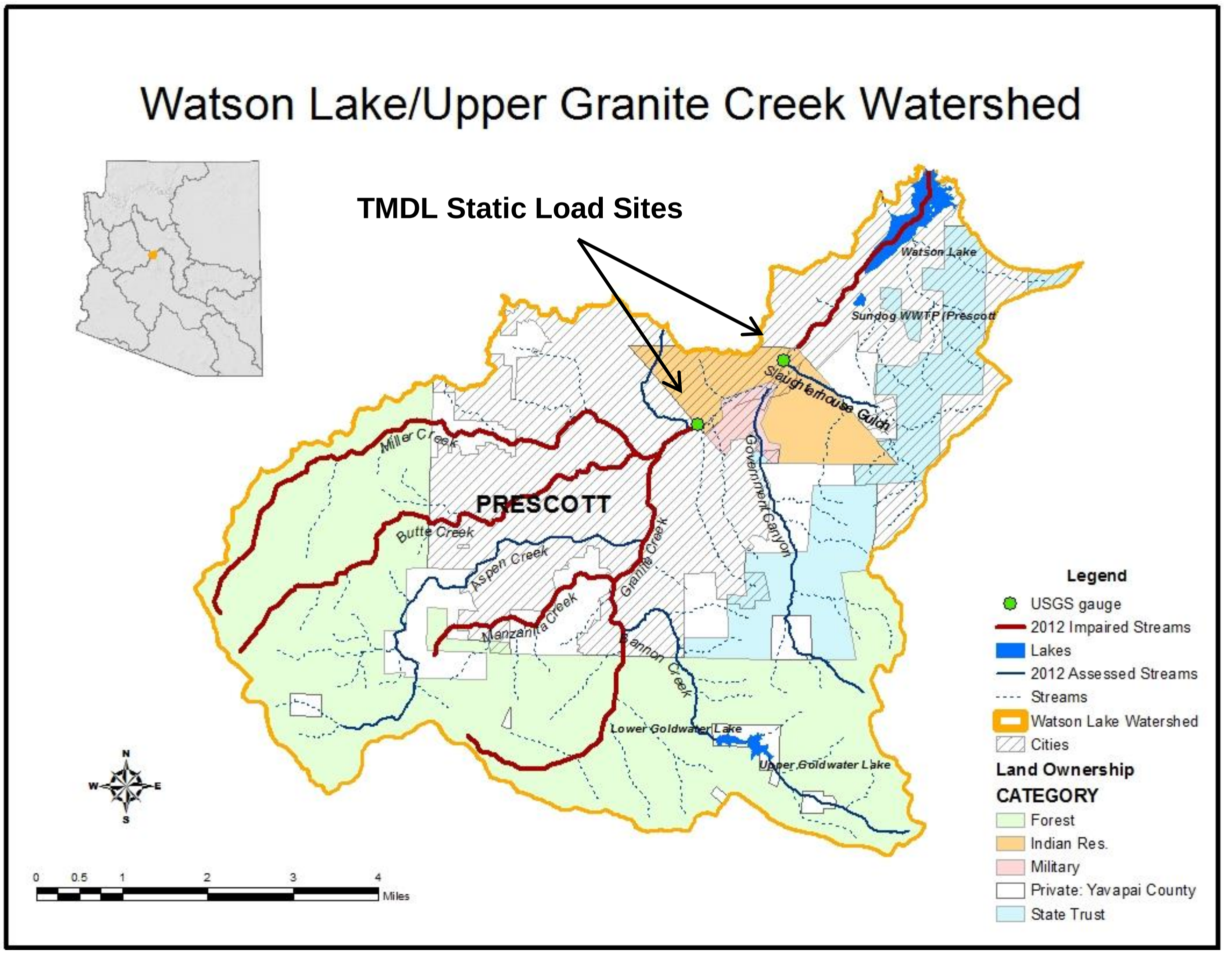

Figure ES-1. Watershed Location, Land Ownership, and Static TMDL Loading Sites

A small percentage of land (less than five percent) in the Watson Lake TMDL Watershed is owned by the Yavapai-Prescott Indian Tribe (YPIT). The location of YPIT land is depicted on Figure ES-1 as "Indian Reservation." The Arizona Department of Environmental Quality (ADEQ) must consider federal tribal trust responsibilities in the Watson Lake Watershed since TMDLs are subject to the approval of the U.S. Environmental Protection Agency (EPA). The United States has a trust responsibility to protect and maintain rights reserved by, or granted to, federally recognized Tribes and individual Indians, by treaties, statutes, and executive orders. The trust responsibility requires that federal agencies take all actions reasonably necessary to protect trust assets, including the fishery resources of the Indian tribes in the Watson Lake Watershed. ADEQ will assist EPA in fulfilling tribal trust responsibilities by adopting a TMDL that restores and maintains pollutant levels that are protective of fish and other beneficial uses related to the Yavapai-Prescott Indian Tribe to the degree that natural conditions allow.

In determination of TMDL loads, ADEQ utilized flow duration equations from two U.S. Geological Service (USGS) gauges on Granite Creek and GIS modeling analysis of relative source contributions by sub-watershed (ADEQ, 2014). Section VI of this report shows that non-stormflow events are meeting the SSM criteria. Therefore, the TMDL load reduction and allocations are set for stormflow events at the two USGS gauges (Figure ES-1). Reductions are based on the target load (90th percentile in G-cfu/day) calculated as the product of SSM (235 cfu/100 ml), 0.75 upper confidence level (UCL) median storm flow, and a conversion factor (Table ES-2). Wasteload allocations assigned to permittees will be concentration-based, the concentration target is 235 cfu/100 ml at each point of discharge.

Table ES-2. Aggregated Loads and Allocations (G-cfu/day)[1]

TMDL Static Load Sites	Target Flow (cfs)	TMDL Target Load	Existing Load	Percent Reduction	Natural Background	Total Allocation	LA 50%	WLA 50%	Concentration Target (cfu/100 ml)
Lower USGS Gauge #09503000	53	304.52	4,200.30	92.8	18.98	295.54	144.77	144.77	**235**
Upper USGS Gauge #09502960	18.3	105.15	2,070.57	94.9	18.98	86.17	43.085	43.085	**235**

[1]G-cfu/day = 1 billion cfu/day = E. coli concentration (#cfu/100ml) * cfs (discharge) * conversion factor of 0.02446

II. INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) requires states to periodically submit to the EPA a list of water bodies that are water quality impaired. Water quality impaired streams and lakes are those that, for one or more assigned designated use(s), the applicable water quality standard is not fully achieved. This list of water bodies is referred to as the “303(d) List.”

In Arizona, the agency responsible for developing the 303(d) List is ADEQ. The list is approved by EPA Region 9, which has the ultimate authority to accept, reject, or add to the list.
This TMDL was assigned a high priority by ADEQ due to the documented non-attainment of a human health based water quality standard. Completion of this TMDL is consistent with the priority assigned by ADEQ.

Granite Creek, Miller Creek, Butte Creek, and Manzanita Creek are located in Yavapai County, within the Upper Granite Creek Watershed of the Verde River Watershed. Approximately 12.2 stream miles of Granite Creek are impaired for *E. coli*, draining an approximately 40 square mile watershed that includes a large portion of the City of Prescott. When the other three creeks are included, the total impaired stream miles are 29.7.

III. WATER QUALITY STANDARDS

Water Quality Standards (WQS) are derived to protect water body designated uses. Table 1 lists the designated uses for Granite Creek and its tributaries. Not all of the named tributaries are listed in Appendix B of the Surface Water Quality Standards (WQS). However, through the “tributary rule” (R18-11-105), all tributaries to a listed water above 5000 feet all carry three designated uses: Aquatic and Wildlife-cold (A&W-c), Full Body Contact (FBC), and Fish Consumption (FC). Granite Creek also carries Agriculture-irrigation (Ag-I) and Agriculture-livestock watering Ag-L) uses.

Table 1. Designated Uses

Stream Name	Designated Uses
Granite Creek	A&W-c, FBC, FC, Ag-I, Ag-L
Miller Creek	A&W-c, FBC, FC
Butte Creek	A&W-c, FBC, FC
Aspen Creek	A&W-c, FBC, FC
Manzanita Creek	A&W-c, FBC, FC
Schoolhouse Wash	A&W-c, FBC, FC
Banning Creek	A&W-c, FBC, FC
North Fork Granite Creek	A&W-c, FBC, FC
Government Wash	A&W-c, FBC, FC
Slaughterhouse Gulch	A&W-c, FBC, FC
Various unnamed washes	A&W-c, FBC, FC

EPA published the current national water quality criteria for bacteria in surface water in 1986 (EPA, 1986). The criteria are based upon "currently accepted illness rates," which are "an estimated eight illnesses per 1,000 swimmers at fresh water beaches." That rate of illness was calculated using the fecal coliform indicator group at the maximum geometric mean of 200 cfu/100 ml of water. In the 1986 criteria document, EPA made a transition from fecal coliform to *E. coli* at the same illness rate, which is a maximum geometric mean of 126 cfu/100 ml of water.

Arizona's *E. coli* standard is used as an indicator of bacterial contamination and is designed to protect human health in the case of recreational use of waters with some possibility of small ingestion rates. Arizona's approved water quality standard for *E. coli* reads:

> *The following water quality standards for Escherichia coli (E. coli) are expressed in colony forming units per 100 milliliters (cfu/100 ml) or as a Most Probable Number (MPN):*

E. coli	***FBC***	***PBC***
Geometric mean (minimum of 4 samples in 30 days)	*126*	*126*
Single Sample Maximum	*235*	*575*

These standards apply to all Arizona water bodies, except those on tribal land. Granite Creek is considered intermittent, which is a subset of the perennial category for application of surface water standards; hence, it carries the Full Body Contact (FBC) designated use with a SSM of 235 cfu/100 ml. This numeric concentration value remains unchanged in the establishment of loading targets for the Granite Creek watershed. Recreational use along Granite Creek and its tributaries includes walking, hiking, biking, wading and camping. There is a golf course located between two of the tributaries and several parks. There are also several camps in the upper Granite Creek watershed.

IV. PROBLEM IDENTIFICATION

Monitoring for *E. coli* is included in the protocol of the ambient surface water monitoring program at ADEQ (March, 2009). Initial samples were collected from 2002-2004, but the 305(b) assessment was inconclusive. In 2007, when the Watson Lake Nutrient TMDL was initiated, ADEQ began intensive monitoring of Granite Creek and its tributaries, including *E. coli*, for source assessment. Additionally, the Prescott Creeks Preservation Association (Prescott Creeks), a 501(c)(3) nonprofit organization with the mission "to achieve healthy watersheds and clean waters in central Arizona for the benefit of people and wildlife through protection, restoration, education and advocacy," received a Clean Water Act (CWA) Section 319 (nonpoint source) grant to conduct sampling in the upper watershed. Data collected by ADEQ and Prescott Creeks resulted in the determination that *E. coli* was indeed a water quality issue.

V. SOURCE DETERMINATION

V-1 Sample Design

In concert with Prescott Creeks, ADEQ chose sample locations considering the following criteria:

- Near the top and bottom of major tributaries (background and sub-watershed contributions)
- Land use/ownership changes
- Residential and urban population density
- Impervious surface
- Golf courses
- Properties with domestic animals or agriculture in close proximity to creeks
- Public parks and trails (trash, diapers, domestic animal waste)
- Areas on septic vs areas within the sewer collection system
- Proximity to the creeks of leach fields and sewer pipes and manholes
- A select subset of sites for microbial source tracking (MST) and emergent contaminant (EC) sampling
- Hydrological characterization: summer monsoon runoff events, winter storm flow events, rain on snow events, and recharge from spring snowmelt.

Figure 1 shows sample site locations and highlights the stream reaches found to be impaired by *E. coli* as of the 2012 Water Quality Assessment.

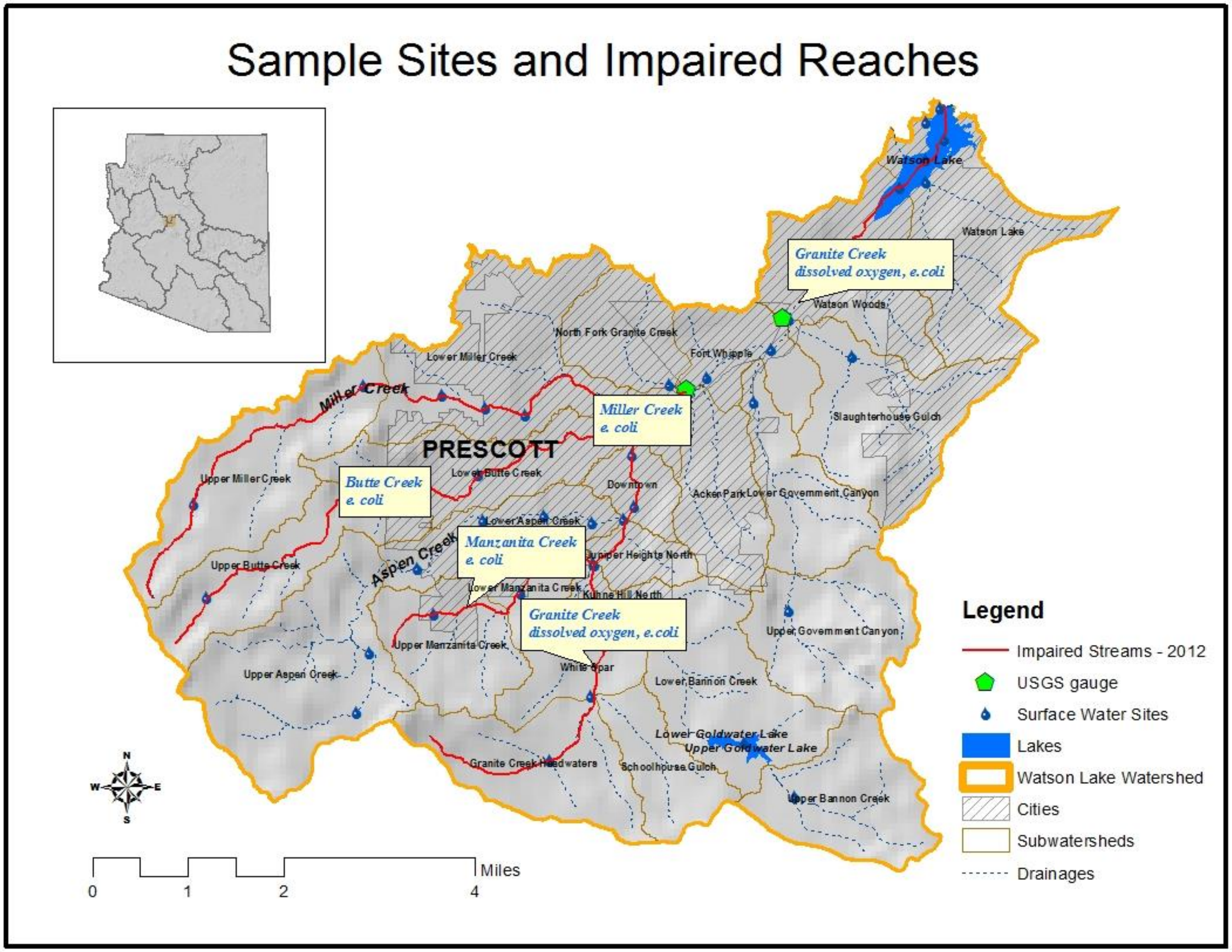

Figure 1. Location of Sample Sites and Streams Impaired for *E. coli* TMDL

V-2 Summary of Results

Spatially and temporally, elevated *E. coli* levels appear to be foremost a non-point source problem arising from a combination of sources, although there have been occasions where broken pipes and manholes have spilled raw sewage. Teasing out and quantifying *E.coli* sources has proven very difficult. Results indicate widespread pollution distributed across the developed sub-watersheds with statistically higher values in some areas. Further source determination will be needed to identify specific relative contributions and what mitigation or Best Management Practices (BMPs) will prove most effective in improving water quality. However, there are several general conclusions to draw from data collected so far (see Appendix A for results by location):

- 'Background' samples from Prescott National Forest lands at the top of the watershed did not produce *E. coli* levels above the WQS.
- Levels increase downstream: from forest, to low density development, to high density development.
- In general, the larger *E. coli* loads were associated with high intensity storms and winter rain on snow events that resulted in overland flow and increased turbidity.
- The highest *E. coli* concentrations were captured during monsoon events, but these events produce very flashing flows and lower loads delivered downstream.
- Declining discharge conditions from snowmelt and recharge showed generally lower concentrations.
- MST and EC sample results suggested a correlation with areas of septic use.
- Parks and trails are a nexus for recreational activity and vulnerable to waste disposal issues, particularly domestic animal waste. Appendix B shows a lists parks and trails taken from the City of Prescott website. These would be logical places to focus BMPs.

In 2010, ADEQ funded the development of a Watershed Improvement Plan (WIP). The document contains a thorough review of these potential non-point sources (WIP, 2012). A brief summary of WIP findings provides insight into potential nonpoint sources, although none could be directly quantified:

- There are approximately 5000 customers of the City's water service (combination of City and County parcels) that are not connected to the sewer system and rely on septic systems for wastewater disposal.
- As a rough estimate, there are 166 residential parcels likely to have one or more septic systems that are within the 100-year floodplain; a reasonable estimate for septic discharges is a total load of 19 lbs/yr of nitrate and 0.4 lbs/yr of orthophosphate.
- There are 55 acres of golf courses that receive treated effluent at Grade B+, which does not have a nitrogen management requirement.
- Gray water reuse occurs in the watershed, requiring a Type 1 Reclaimed Water General Permit (for less than 400 gallons per day); some nutrients and pathogens may be present.
- Five acres are zoned for horses or boarding stables; the only known grazing within the project area is on Yavapai-Prescott Indian Tribe property and on private and State Trust Lands off of Prescott Lakes Parkway.
- Numerous residences of the upper watershed keep animals on their property: a few hundred horses, no more than a few dozen cattle, chickens, ducks, geese, turkeys, sheep, goats, and pigs.
- Wildlife present include mountain lion, bobcat, mule deer, squirrels, wild turkeys and other avian species, skunks, raccoons, and javalina.
- Pet waste from domestic dogs and cats or boarding facilities; there are no designated dog parks within the Watson Lake drainage.

- Runoff from wildfires; The Indian Fire of 2002 burned a total of 1300 acres including the upper reaches of several tributaries and Upper Granite Creek. Areas of wildfire and controlled burning within the wildland-urban interface likely contribute nitrate and phosphorus to creeks during storm events.
- Impervious cover within the Watson watershed is 5,310 acres or 18.6 %, which increases the volume and velocity of runoff; EPA (2009) rates a subwatershed with between 10 – 25 % impervious cover as “degraded”; impervious cover in all but the headwater subwatersheds are well above 10% - in some cases over 50% - indicating serious degradation in most of the Watson Lake watershed. Annual phosphorus, nitrogen, chemical oxygen demand, and metal loads increase in direct proportion with increasing impervious area.
- In all, Prescott has 400 miles of streets and storm sewers (conveyances other than wastewater).
- The Microbial Source Tracking data collected through the Watershed Improvement Planning project found bacteria from bovine sources during a January 2010 storm so it is likely the cattle may be contributing nutrients to Granite Creek under storm conditions.
- High recreation within the watershed is considered a source of *E. coli* but not nutrients.

VI. TMDL TARGET DEVELOPMENT

Loading data from the Granite Creek basin as a whole was statistically tested for fit with a two-parameter lognormal distribution and found to be generally consistent with the distribution at a p value of 0.05. Three data points out of 187 comprised outliers at the tails of the distribution. However, since the water quality standard presupposes a lognormal distribution for *E. coli* concentrations as outlined in Table 1 and Appendix C of the Granite Creek Modeling Report (ADEQ, 2013), the distribution is taken as a given when determining target loads for the project.

To complete the load target calculation, the 75th upper confidence level (UCL) median flow from the dataset is multiplied by the target concentration and a conversion factor of 0.02445 to yield target bacterial loads in units of Giga-organisms per day (G-orgs/day). The conversion factor of 0.02445 serves to convert the product of *E. coli* densities and flows into daily loads and is derived as follows:

$$1 \text{ cfu/100ml} \times 1000\text{ml/1L} \times 28.3\text{L/1 ft}^3 \times 86{,}400 \text{ sec/1 day} \times 1 \text{ G-org/}1\text{x}10^9 \text{ cfu} = 0.02445 \text{ G-org/day}$$

The 0.75 UCL median flow value was chosen due to uncertainties in the median value associated with limited sampling events to evaluate at most sites. It also allows for an implicit margin of safety in the target load value that is reasonable when assessed in comparison with other *E. coli* TMDLs.

VI-1 Baseflow-Stormflow Analysis

Analysis was conducted on the entire dataset for the lowest three sites on the Granite Creek main-stem. These three sites were used as controls to assess the attainment status of each flow class for the entire project watershed. The lowest site of the project area, VRGRA027.35 (located in the Watson Woods subwatershed near Sundog Road), was associated with the USGS gauge 09503000 (Granite Creek near Prescott, Ariz.). The other two sites, VRGRA029.64 and VRGRA029.97 (located in the Fort Whipple subwatershed just above the Yavapai Indian Reservation) were associated with USGS Gauge 09502960 (Granite Creek at Prescott, Ariz.).

Both USGS gauge locations were analyzed with cumulative loading and discharge data from the project sampling dates by flow class. The 90th percentile *E. coli* values were compared to target values for each class. Results are summarized in Table 1 (ADEQ, 2013). Target loads presented for each category in Table 2 are the product of the concentration target and the 0.75 UCL category median flow with the conversion factor applied.

Inspection of these results indicates clearly that impairment is due to the influence of stormflow and consequently, the critical conditions necessary to address for the improvement of bacteriological water quality on Granite Creek are stormflow conditions. Subsequent analysis focused exclusively on stormflow conditions.

Table 2. Baseflow/Stormflow Cumulative Assessment

90th percentile load Cumulative Watershed Assessment Loads in G-orgs/day	**Fort Whipple**	**Watson Woods**
Base/Stable flow		
Number of Samples:	3	7
Existing 90th P-tile Load:	**9.46**	**65.60**
0.75 UCL Category Median Flow:	3.8# cfs	26 cfs
Target Concentration:	235 cfu/100 ml	235 cfu/100 ml
Target Load:	21.70	149.39
Percent Reduction:	**Meets***	**Meets**
Stormflow		
Number of Samples:	11	16
Existing 90th P-tile Load:	**2,070.57**	**4,200.30**
0.75 UCL Category Median Flow:	18.3 cfs	53 cfs
Target Concentration:	235 cfu/100 ml	235 cfu/100 ml
Target Load:	105.15	304.52
Percent Reduction:	**94.9%**	**92.8%**

* - Category and location assessed as provisionally meeting load target. Minimum set size of four necessary for unqualified assessment.
\# - Median flow used due to minimal flow samples for establishment of 0.75 UCL flow.

VI-2 Margin of Safety (MOS)

An implicit margin of safety is built into the analysis by requiring a greater percentage of samples to meet the concentration target than the origins of the *E. coli* standard presume. This is warranted for two reasons: many samples collected in the course of the project exceeded the upper limit of quantification when analyzed (loading is known to be higher than the upper limit of quantification, but the magnitude of the exceedance was not established at the time of sample analysis), and the exceedance rate applied is broadly consistent with how ADEQ evaluates *E. coli* and other parameters for human health and agricultural designated uses in water quality assessments (ADEQ, 2013). The 90th percentile value was selected in recognition of the fact that single sample maximums are not intended to be construed as values never to be exceeded (EPA, 2006), but rather represent an implied percentile or confidence level of a frequency distribution. Adopting the 90th percentile value for attainment evaluations adds an implicit margin of safety over the 75th percentile level the single sample maximum value was originally drawn from and obviates the need to include an additional explicit margin of safety. Critical benchmarks for comparison between EPA criteria and ADEQ's TMDL development can be found in the Granite Creek *E. coli* Modeling Report (ADEQ, 2013).

VI-3 Natural Background

Natural background was evaluated for stormflow conditions using nine samples collected in headwater subwatersheds of upper Miller, upper Granite Creek, and upper Aspen Creek. Event concentrations were converted to daily loads using the discharge measured at sampling time. The loads were then ranked, and the 90th percentile load value from the set was selected as the representative stormflow loading for natural background, corresponding with the 90th percentile target evaluation threshold for general stormwater loading. Since there were relatively few data points under stormflow conditions (9), the 90th percentile value corresponded to the largest measured load in the set, which was calculated as 18.98 G-cfu/day. This load consisted of a concentration of 50.4 cfu/100 ml and a flow value of 15.4 cfs, a rain on snow event. In a ranked analysis, there is no confidence level per se, but collection of additional stormflow data would increase the 'confidence' in background loading. Details of background analysis can be found in the Granite Creek Modeling Report (2013).

VI-4 Linkage Analysis

The linkage analysis is the means by which current water quality conditions are tied to existing physical conditions and processes in the watershed. It provides insight and direction for prioritization of problem areas. For this project, it is evident upon inspection that stormwater loading from within the Prescott city limits is greatly exacerbating the total *E. coli* loading of Granite Creek and is thus contributing disproportionately to the impairment of the creek. A map showing Prescott area anthropogenic impact index assignments is displayed in Figure 2. The map exhibits the degree of development present in the Prescott metro area roughly correlating to the percent imperviousness measures for each subwatershed used in the analysis.

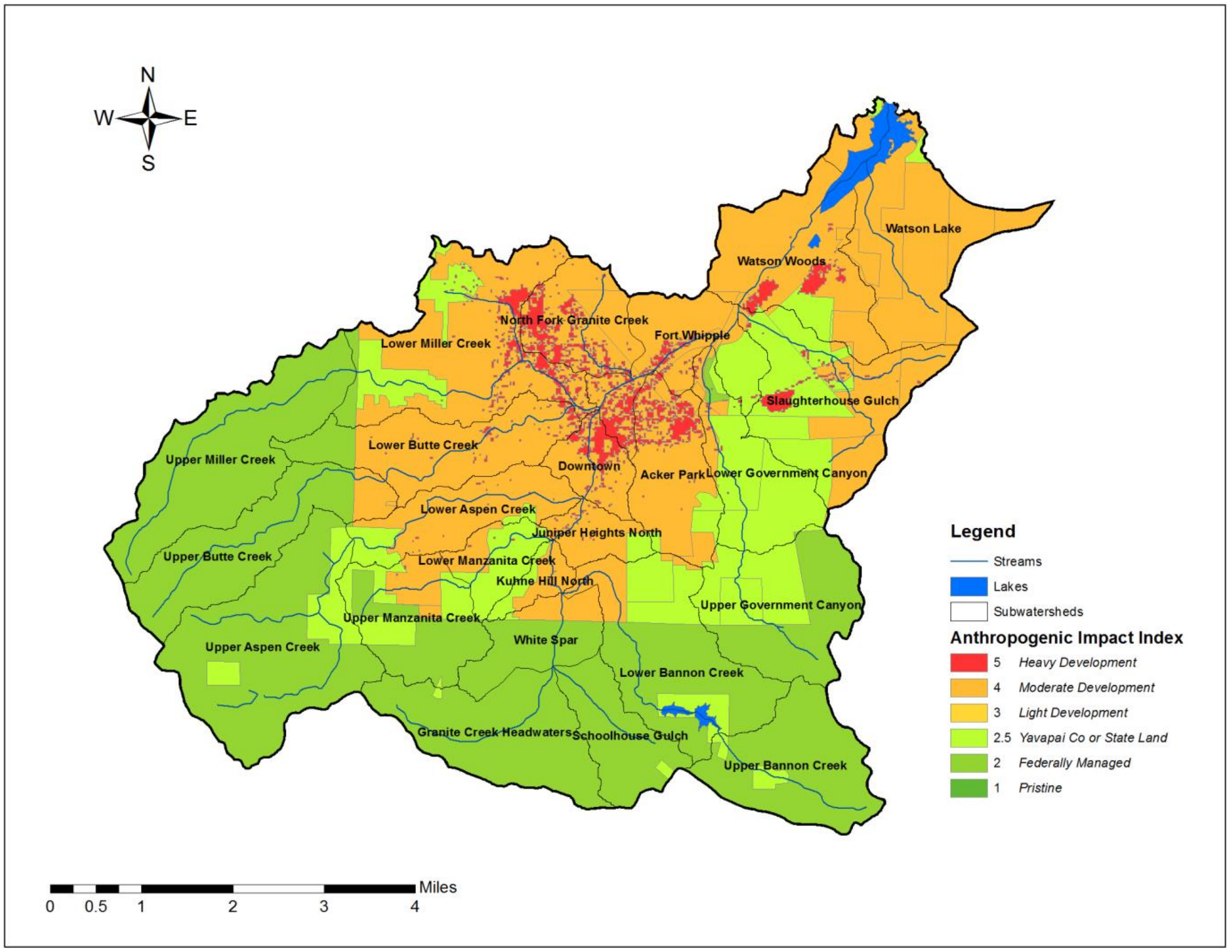

Figure 2. Prescott and Granite Creek Basin Anthropogenic Impact Indices

ADEQ tested the hypothesis that the physical cause of impairment is associated with urbanization and development with higher percentage of impervious surfaces, along with inadequate stormflow control measures. A simple nominal categorizing of subwatersheds/sites by development status (developed or rural) was applied based on the predominant influence on water quality at each of the sampling sites in the watershed (ADEQ, 2013). Percent impervious area for each subwatershed, was a significant attribute, though not the predominant one in the assignment of land use class for each subwatershed. However, influence at the individual sampling sites overrode subwatershed impervious characteristics in a few cases where characterization differed, as in a rain on snow event that was spatially variable. Figure 3 exhibits the nonparametric distribution boxplots for stormwater samples by land use class. A Kolmogorov-Smirnov two-sample comparison was run on the medians of each set. Results indicated with high confidence (p=0.004) that the medians were significantly different.

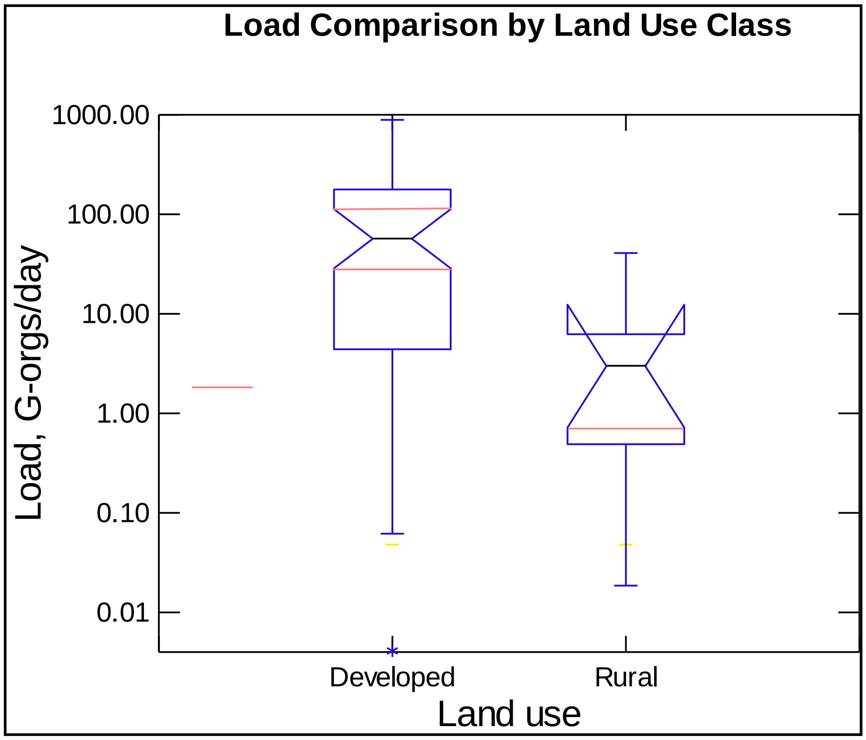

Figure 3. Loading by Land Use Class

These results are similar to the analysis performed for the WIP; one third of the sites were urban (developed) and showed a 33 percent greater exceedance rate than rural (residential) sites (WIP; Appendix A).

After land use categorization, each subwatershed was attributed with the cumulative area upstream in square miles draining to it, including the square mileage of the selected subwatershed itself. Event loads were then normalized by square mile contributions. Stormflow loads by square mile were averaged for each cumulative subwatershed (Table 3). Bolded red load figures are loads and associated locations that require the highest priority in beginning to address stormflow loading problems.

These watersheds share the characteristics of having enough data to be reasonably confident of the average loading value with a magnitude of the value that is cause for concern compared to overall developed subwatershed geomean. All highlighted average values in Table 3 exceeded the geomean of subwatershed averages and had sufficient data for confident evaluation.

Table 3. Stormflow and Non-storm Loading per sq. mi., G-orgs/day

Subwatershed Characteristics			Avg. of Load per Square Mile	
Rural/Urban	Subwatershed	Percent Impervious	Nonstorm	Stormflow
Rural	Upper Granite	5	0.01	2.80
	Upper Miller	3	0.06	1.23
	Upper Aspen	4	0.01	0.73
	White Spar	19	0.01	--
	Upper Butte	2	0.0001	--
Developed	Watson Woods	15	1.14	**237.14**
	Slaughterhouse Gulch	21	0.34	**157.79**
	Acker Park	65	--	**141.28**
	Lower Miller	43	0.76	**82.78**
	Fort Whipple	29	0.20	**70.98**
	Lower Manzanita	54	0.59	**59.76**
	North Fork Granite	70	1.17	**55.77**
	Lower Butte	58	0.25	**37.88**
	Upper Manzanita	18	0.33	14.64
	Upper Government*	3	1.65	12.01
	Lower Aspen	68	0.24	11.48
	Lower Government	22	--	11.10
	Lower Bannon*	11	0.07	10.99
	Downtown	83	0.09	10.28
	Kuhne Hill North	42	--	0.91
	White Spar	19	0.0001	0.21

Figure 4 displays a map of the basin graphically depicting the results in Table 3. At the time of initial data analysis (spring 2013), no data had been collected from the Acker Park subwatershed and samples from Lower Government Canyon and Slaughterhouse were few. Subsequent data from July, August, September and November of 2013 as well as August of 2014, confirm that significant *E. coli* loading is occurring from Acker Park. The August results for both drainages in this subwatershed were > 2,419.6 cfu/100 ml, which is the upper limit of the Colilert^{R} *E. coli* method. A 1:10 dilution was performed on the November samples, showing a result of 1,046 cfu/100 ml at the bottom of the western drainage, and a result of 11,199 cfu/100 ml at the bottom of the eastern drainage. These latter events corroborate and further refine the earlier analysis. (See Appendix A of this report for *E. coli* exceedances broken out by site, month, and year) It is highly recommended that further data collection and analysis include the use of dilutions to better quantify source contributions.

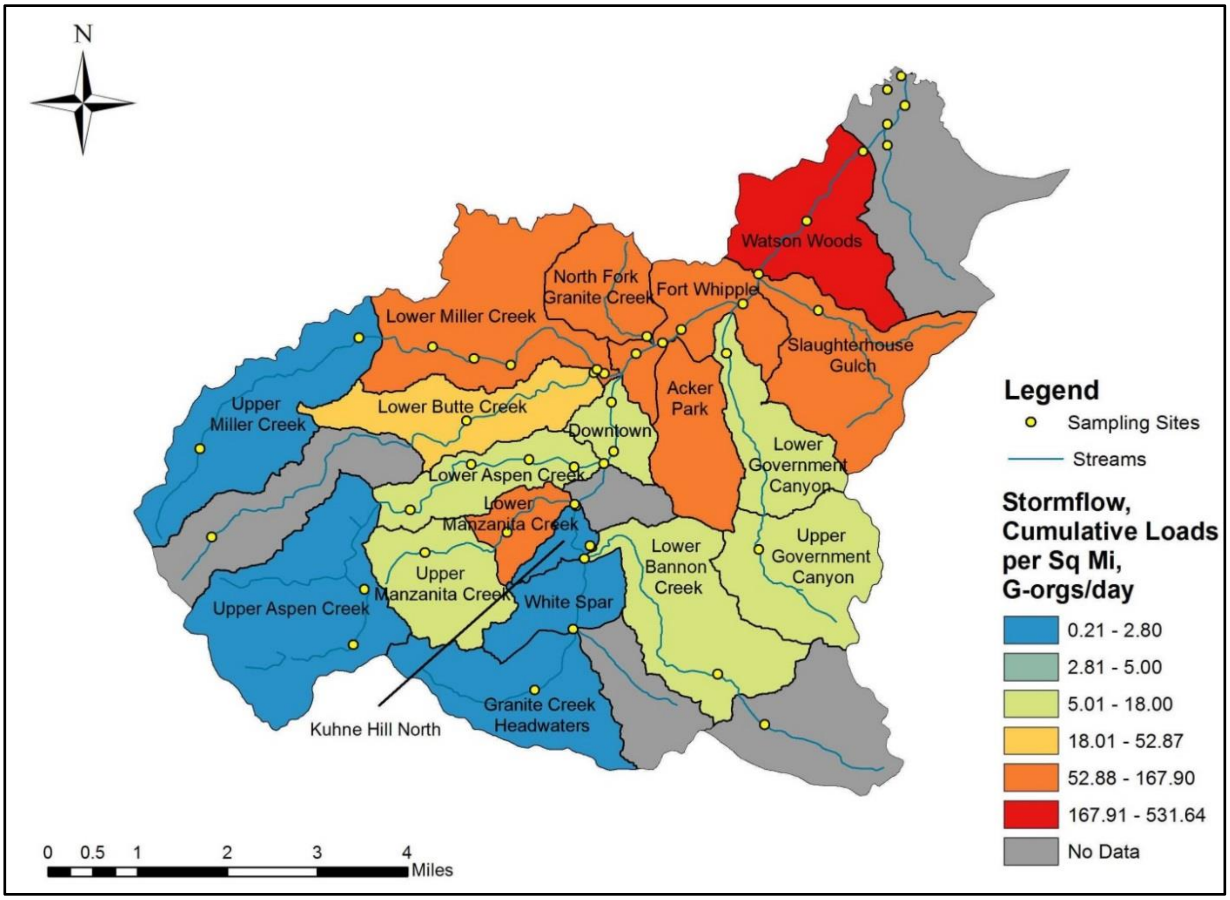

Figure 4. Granite Creek Basin Cumulative Loads per Square Mile (Data Analysis Report)

VII. PERCENT REDUCTIONS

The Modeling Report (2014) summarizes load targets, load allocations, natural background allocations, and necessary percent reductions for standards attainment for each of the nested subwatersheds in the basin under stormwater conditions. Subwatersheds represented in Appendix D of that report were analyzed using cumulative flows and loads, which include all discharge and loading from subwatersheds upstream of the itemized subwatershed. Data resolution was insufficient to statistically break out each subwatershed individually. Therefore, the TMDL will apply aggregated load targets only at the two gauge locations in order to benchmark future improvements. Subwatershed analysis should be viewed within the context of guiding prioritization of reductions and further source characterization. Future field sampling should initially be targeted towards robustly quantifying cumulative subwatershed contributions in stormwater conditions near each subwatershed's pour point. Further sampling for source identification within each subwatershed may be necessary once the first objective is achieved.

Figure 5 displays a "heat" map showing cumulative percent reductions by subwatershed for those subwatersheds with sufficient data. The map relates existing loading to target values for attaining water quality standards set forth in the Granite Creek Modeling Report (ADEQ, 2014). Figure 4 and Figure 5 offer slightly different perspectives on the same problem, thus complementing one another in their presentations.

Since *E. coli* concentrations and loads can typically range over several orders of magnitude, higher values tend to get compressed at the upper end of the scale for percent reductions: a one order-of-magnitude reduction corresponds to a 90% reduction, while a two order-of-magnitude reduction corresponds to a 99% reduction. Reductions of less than one order-of-magnitude occupy the entire range from 1% to 90%. The scale for percent reductions in Figure 5 was manually determined to discriminate more finely near the top end of the possible range for reductions. Subwatersheds requiring no reductions are shown in green. Subwatersheds requiring more than a one order-of-magnitude reduction are shown in red. Data serving as the basis for Figure 5 can be found in Appendix A of the Granite Creek Modeling Report, 2014.

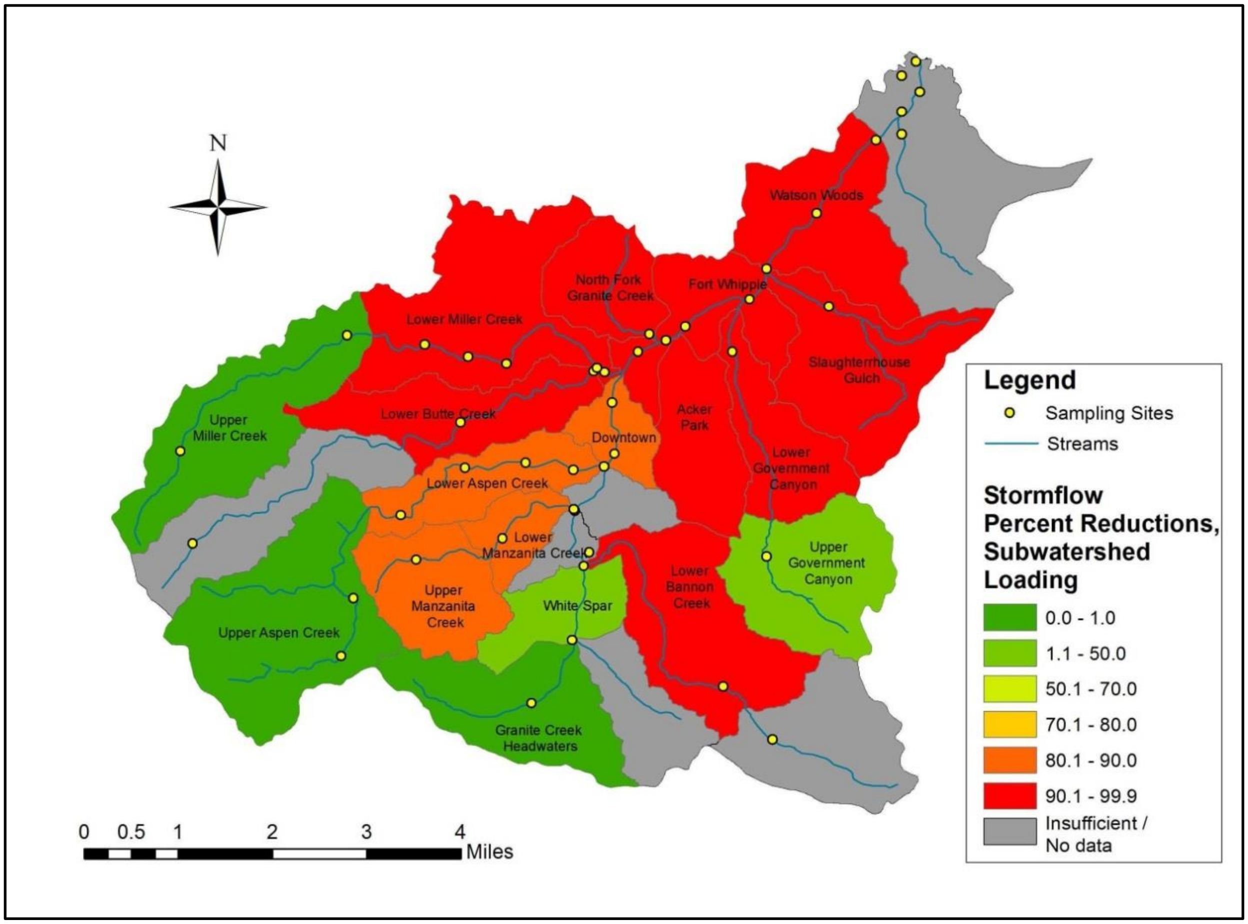

Figure 5. Cumulative Percent Reductions by Subwatershed

VIII. TMDL to ACHIEVE SSM *E. coli* WQS of 235 cfu/100 ml

VIII-1. TMDL Calculation Method and Determination of Load Reduction

TMDLs identify the amount of pollutant that can be assimilated by the waterbody and still meet water quality standards. In order to calculate *E. coli* mass load in Giga-organisms per day (G-orgs/day) from discharge in cubic feet per second (cfs), a conversion factor is required. The conversion factor of 0.02445 serves to convert the product of *E. coli* densities and flows into daily loads and is derived as follows:

$$1 \text{ cfu}/100\text{ml} \times 1000\text{ml}/1\text{L} \times 28.3\text{L}/1 \text{ ft}^3 \times 86{,}400 \text{ sec}/1 \text{ day} \times 1 \text{ G-org}/1\text{x}10^9 \text{ cfu}$$

The mass balance calculations for this TMDL are based on flow and load duration curves generated at the two USGS gauges above Watson Lake. The TMDL or loading capacity and the resulting load reductions necessary to meet the TMDL is determined using the TMDL equation:

$$\text{TMDL} = \sum \text{WLA} + \sum \text{LA} + \text{MOS}$$

Where WLA is waste load allocation (point sources), LA is load allocation (nonpoint sources and natural background), and MOS is a margin of safety. Loading capacity, existing loads, and reductions needed for water quality standard attainment are calculated for Granite Creek as mass loads in G-orgs/day to the creek and concentration targets in cfu/100 ml for permitted and non-permitted sources.

Load Reductions (LR) will be needed, as the existing load is larger than the LA calculated using the TMDL equation. The LR can be calculated by:

$$\text{LR} = \text{Existing load} - (\text{LA} + \text{Natural background} + \text{MOS})$$

The percent reduction needed is calculated by using:

$$\% \text{ Reduction} = (\text{LR}/\text{Existing Load}) * 100$$

VIII-2. Margin of Safety (MOS)

The MOS is intended to account for uncertainties and random variations associated with data collection, lab analysis, equipment and method precision and accuracy limitations, modeling, and random error associated with flow measurements. The MOS for this TMDL is implicit rather than explicit. The 0.75 UCL median flow value was chosen due to uncertainties in the median value associated with limited sampling events to evaluate at most sites. In addition, adopting the 90th percentile value for attainment evaluations adds an implicit margin of safety over the 75th percentile level the single sample maximum value was originally drawn from and obviates the need to include an additional explicit margin of safety. These two applications allow for an implicit margin of safety in the target load value that is reasonable when assessed in comparison with other *E. coli* TMDLs.

VIII-3. Natural Background (NB)

The determination of natural background was made from ranking loads from samples collected in headwater subwatersheds of upper Miller, upper Granite Creek, and Upper Aspen Creek. The 90th percentile load value was selected as representative stormflow loading, corresponding to 18.98 G-cfu/day, or 50.4 cfu/100 ml at a flow of 15.4 cfs.

VIII-4. Concentration-based TMDL and Associated Loads at the USGS Gauges

This TMDL contains both a concentration-based target of 235 cfu/100 ml to be met at all locations in the watershed, and an aggregated load-based target set at both USGS gauges (Table 4). In practical application, meeting the concentration-based target will achieve the load-based target, and vice-versa. Choice of the 75th percentile upper confidence limit of median flow allows for an implicit margin of safety; these values are 18.3 cfs for the upper gauge and 53 cfs for the lower gauge (Granite Creek Modeling Report, 2014).

Table 4. Aggregated Loads and Allocations (G-cfu/day[1])

TMDL Static Load Sites	Target Flow (cfs)	TMDL Target Load	Existing Load	Percent Reduction	Natural Background	Total Allocation	LA 50%	WLA 50%	Concentration Target (cfu/100 ml)
Lower USGS Gauge #09503000	53	304.5	4,200.3	92.8	18.9	295.5	144.7	144.7	**235**
Upper USGS Gauge #09502960	18.3	105.2	2,070.6	94.9	18.9	86.2	43.1	43.1	**235**

[1]G-cfu/day = 1 billion cfu/day = E. coli concentration (#cfu/100ml) * cfs (discharge) * conversion factor of 0.02446

VIII-5. Translation of Aggregate Loads into Allocations by Land Manager

Table 5 breaks the total allocation down by land manager and the percent of the watershed under each jurisdiction. Each allocation is identified as either a load allocation (LA) for nonpoint source, or wasteload allocation (WLA) for point source.

Nonpoint sources are diffuse sources not regulated under a surface water discharge permit. Load allocations (LA) for nonpoint source entities have been included in Table 5 for completeness and to show that the total *E. coli* allocation is essentially split 50-50 between nonpoint sources and point sources, based on jurisdictional area within the Watson Lake watershed. The urbanized area accounts for 14 percent of the watershed but approximately 50 percent of the TN and TP load (Tetra Tech, 2012). Mass based load targets for *E. coli* are similarly divided 50-50 for point source and nonpoint source inputs based on watershed area.

Table 5. Load Allocations and Wasteload Allocations by Land Manager (G-cfu/day)

Land Manager	Square Miles[1]	Percent of Watershed	LA at #0902960	WLA at #0902960	LA at #09503000	WLA at #09503000	Concentration Target (cfu/100 ml)
Unallocated LA (10% of LA) TBA			4.3		14.5		
Prescott Forest	18.1	40	34.3		115.3		
State Lands	2.2	5.0	4.3		14.4		
Military (VA)	0.08	0.2	0.17		0.58		
Subtotal Nonpoint Source	20.4	45.2					
All Nonpoint Source							**235**
Unallocated WLA (10% of WLA) ADOT MS4, MSGP, CGP, Other TBD				4.3		14.5	
City of Prescott MS4	17.6	39.0		30.8		103.7	
Yavapai County MS4	4.5	10.0		7.9		26.6	
Subtotal Point Source	22.0	49.0					
All Point Source							**235**
Total Nonpoint + Point Source		94.2[2]					

[1]as cited in WIP; [2]does not include tribal land

VIII-6 WLA Applied to Permits

Wasteload allocations are assigned to entities with individual or general Arizona Discharge Pollution Elimination System (AZPDES) stormwater permits. Collectively, the permitted point sources, Municipal Stormwater (MS4) permits, Multi-sector General permits (MSGP), and Construction General permits (CGP) are assigned a concentration based WLA equal to 235 cfu/100 ml. This WLA is applied, as a water quality based effluent limit (WQBEL), to all existing and future AZPDES (individual and general) permittees within the Upper Granite Creek watershed.

The WLA applies to discharges that occur in response to precipitation events and is applicable for each separate discharge that may issue from the permitted entity or site. The exception is for MS4 permits where the WLA is expressed as a system-wide requirement. Permittees can demonstrate compliance with the WLA by either direct sampling of outfall discharges or demonstrate that best management practices quantitatively reduce the discharge of pollutants to a level that meets the WQBEL. If single grab samples exceed the WLA, permittees should evaluate the effectiveness of BMPs, modify or implement new BMPs, or provide additional measures to improve water quality.

ADEQ recognizes certain sectors of activities and facilities covered under the general permits may not be reasonably expected to add *E. coli* loading, however monitoring determination is under the purview of the Stormwater Unit and will be determined on a site by site basis.

Beyond the general guidelines presented in the following paragraph regarding points of compliance for WLAs (discharge locations to waters of the State carrying the FBC designated use), the ADEQ Stormwater Unit shall establish more specific locations when necessary on a case-by-case basis where dischargers under all general or individual permits (MS4, MSGP, CGP) issued by ADEQ are expected to meet their WLAs. The ADEQ Stormwater Unit shall also determine whether *E. coli* loading to tributaries or the main-stem of Granite Creek from all future general permittees has reasonable potential to occur in their permit reviews. If there is such reasonable potential, new permittees will be subject to the appropriate concentration-based WLA in this TMDL; if there is no reasonable potential, new permittees will not be issued an E. coli WLA.

The point of compliance for WLAs for all discharges from MS4, MSGP, CGP, or individual AZPDES permit operations shall be the point of discharge to a reach carrying a FBC designated use. All entities subject to individual and general AZPDES permit requirements will be considered to be operating consistent with the provisions of this TMDL if they adhere to the terms of their discharge permits as expressed for *E. coli* concentration.

The Arizona Department of Transportation (ADOT) has an individual Municipal Stormwater (MS4) permit. ADOT is not a generator but a conveyance system and their permit is statewide. General permits that have been issued within the watershed include the City of Prescott MS4, Yavapai County MS4, and several MSGPs and CGPs. MS4 and MSGP facilities covered under AZPDES individual permits are detailed in Table 6 and shown in Figure 6. CGPs are numerous and relatively short-lived, so they are not listed.

Table 6. MS4 and MSGP Permits in the Granite Creek Watershed

FID No.	Permit No.	Issue Date	Permit Type	Permittee Name
Citywide	AZMS4-2002-30	2002	General MS4	City of Prescott: Storm Water
Unincorp	AZMS4-2002-40	2002	General MS4	Yavapai County: Storm Water
Corridors	AZS000018	2008	Individual Statewide MS4	AZ Dept. of Transportation: Storm Water
6	AZMSG-60156	5/27/11	General MSGP	Fann Contracting Inc.: Trucking
7	AZMSG-60592	7/19/11	General MSGP	Lamb RV Storage: Transit
3	AZMSG-68954	3/29/12	General MSGP	City of Prescott: Sundog Treatment Works
4	AZMSG-68974	3/29/12	General MSGP	City of Prescott: Transfer Station & Service

Note: #2 in Figure 7 has been consolidated into the Prescott MS4; #9 has been terminated

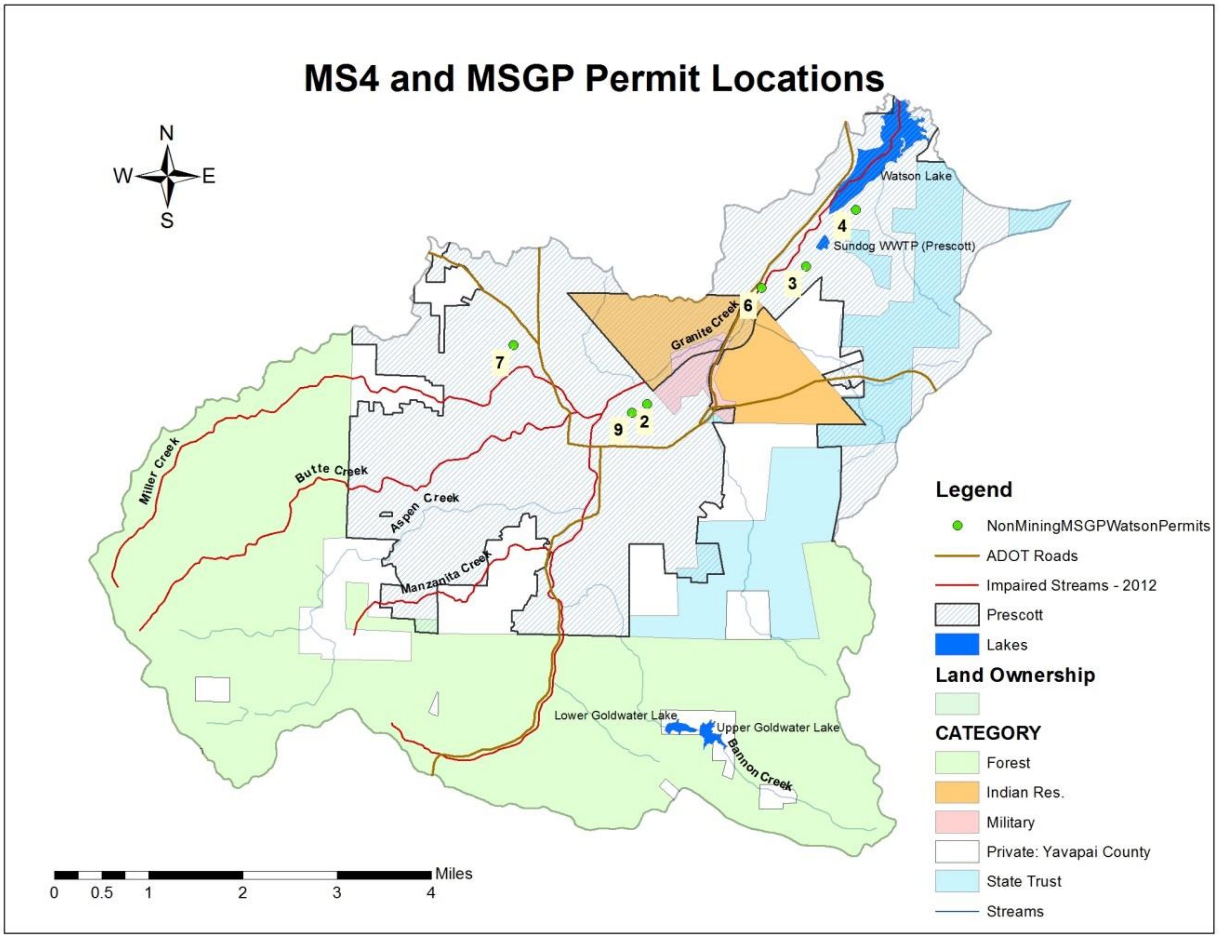

Figure 6. Location of MS4 and MSGP Permits

IX. TMDL IMPLEMENTATION

Because *E. coli* is a watershed-wide problem, ADEQ recommends collaboration between point source and nonpoint source entities so that progress in meeting the TMDL can be tracked and quantified. The best vehicle for this collaboration would be the Watershed Improvement Council (WIC).

IX–1. Recommendations from the Watershed Improvement Plan (WIP), excerpted from Prescott Creeks et al, 2012

Watershed investigations as part of the WIP are comprised of volunteer water quality monitoring, a watershed field survey, watershed residents' survey, and riparian buffer assessment. Water quality monitoring was conducted between 2009 and 2012 for physical parameters including pH, dissolved oxygen, and temperature; chemical parameters like Total Nitrogen, Total Phosphorus, Total Kjeldahl Nitrogen (TKN), and ammonia; and biological parameters including *E. coli* and *Bacteroides* for MST. Monitoring also included testing for pharmaceuticals with the Arizona Lab for Emerging Contaminants (ALEC). Both the ALEC monitoring and MST testing revealed strong anthropogenic influences on lower Manzanita Creek, lower Butte Creek, North Fork of Granite Creek, and lower Miller Creek.

In a 2010 watershed field survey, Creek Crew volunteers systematically walked 16.5 miles of stream to document sources and causes of excess nutrients and *E. coli.* Of the sources/causes documented, the majority of them were related to stormwater drainage, followed by structural and activity impacts to the riparian buffer. Miller, Butte, Granite, and Aspen Creeks had the most observations per mile of creek surveyed. This data points towards urban pollutants carried in stormwater, exacerbated by a lack of adequate riparian buffers along the urban creek reaches.
A 2010 rapid vegetation assessment and physical survey of the Upper Granite Creek Watershed was undertaken to assess the current functionality of the watershed channels in terms of their ability to filter pollutants from runoff. Results indicate that riparian impacts are scattered across the watershed and are not isolated to a specific land use. Urban reaches of Miller, Butte, and Granite Creeks had the lowest riparian scores, signifying that these reaches had little to no vegetation, other disturbances, and/or limited width due to human activities or structures.

A Watershed Residents' Survey was mailed to approximately 40,000 households between December 15, 2009 and March 15, 2010. The survey was designed to gather information about watershed residents' knowledge of watershed and water quality issues, perceptions of water quality, attitudes and values about protection and restoration of local water ways, and environmental behaviors. Nearly 1,500 survey responses were received. Survey results demonstrate that there is general public support for protecting and restoring our waterways, yet there are large gaps in public knowledge about watersheds and sources of pollutants.

Through these data collection activities, potential sources of pollution were identified as: aging and degraded municipal sewer infrastructure; failing or ill-maintained septic systems; water reuse; horses, cattle, and other livestock; and pets. Background sources such as wildlife and forest fires also contribute to nutrient loading. The lower subwatershed areas are highly urbanized. Therefore, the types of potential bacteria and nutrient sources are greater than in the mostly undeveloped upper subwatersheds. The urbanized creek segments have been channelized and separated from their natural floodplains, increasing the risk of flooding to nearby properties. The majority of natural riparian vegetation has been replaced by walls or other structures and cannot adequately perform biological filtration functions. Stormwater drainage from roads and neighborhoods is directed into the nearest waterway untreated. The data indicate that the primary factors leading to water quality impairments in the project area are increased runoff volumes due to impervious surfaces, and a lack of stormwater detention and infiltration/filtration.

Green infrastructure (GI) is the primary recommendation for addressing stormwater and associated pollutants in the watershed. GI is a broad term for features that rely on natural processes such as soil, water, and plants to provide ecosystem services such as clean air, clean water, and temperature regulation. GI encompasses existing forests and green spaces as well as constructed bio-retention features such as rain gardens, wetlands, and filter strips. Many of these practices were originally developed in temperate climates but are gaining popularity in municipalities in the arid Southwest as a way to manage urban stormwater at a lower cost than the traditional "grey" infrastructure (pipes and culverts) while providing other economic, social, and environmental benefits (EPA, 2009). The Watershed Improvement Council (WIC) recommends that GI be integrated with traditional grey infrastructure to the maximum extent possible within the watershed to *1) keep pollutants out of the creeks, and 2) effectively reduce stormwater quantity, lessening the possibility of promoting conditions that would lead to inflow and infiltration (I & I) problems in the sanitary sewer collection system* (italics added by ADEQ for clarification).

Because a watershed-aware citizenry is key to improving surface water quality, the (WIC) also recommends a variety of education and outreach activities to engage the community and raise awareness to targeting different audiences and community groups. Public workshops, mailings, educational articles, and expanding the existing creek signage and storm drain marker programs are recommended.

As part of a comprehensive strategy, the WIP also includes BMP recommendations for golf course turf management, manure management, green waste, forest protection and restoration, and invasive vegetation management. Specifically, the WIP identifies four priority BMP projects which are described in detail in Appendix H of that document and listed below:

- Bioretention and Sediment Basins at Prescott Rodeo Grounds*
- Whipple Street Bioretention Basins*
- Green Infrastructure Demonstration at Prescott Community/Adult Center*
- Green Industrial Site Practices at the APS Construction Yard

* projects since funded through the Non-point Source (CWA Section 319) Grant Program

To ensure continued investments in watershed health, the WIC recommends that continuous, local funding sources be investigated. In addition to federal, state, and private grant programs, an example of such funding is a "watershed protection fee" levied on municipal utility customers. The Watershed Residents Survey of 2010 found that the majority of respondents supported a fee to address local water quality and watershed issues in addition to supporting protection and restoration efforts within the watershed. The fee would be a property-based charge calculated, for example, on the amount of impervious area on a property. In return, the fee would provide an incentive to reduce impervious cover, disconnect downspouts, and install rainwater harvesting features.

ADEQ is updating the WIP in 2015 with the Watson Lake and Granite Creek TMDL results and has focused additional sampling within the Miller Creek subwatershed in areas determined to be the best candidates for source control and BMP implementation. The WIC has identified the need to prioritize parks and trails, as they are a nexus for recreational activity and vulnerable to waste disposal issues, particularly domestic animal waste. Appendix B lists parks and trails from the City of Prescott web site.

IX–2. WIP as Vehicle for TMDL Implementation

There are several objectives in reconvening the WIC and updating the WIP. ADEQ will use this forum to coordinate outreach and education efforts and stakeholder involvement in source identification, monitoring efforts, BMP identification, and project implementation and tracking. ADEQ acknowledges that plans will be considered working documents, subject to refinements or adjustments as needed. It will be important to update the WIP on a regular basis so that source characterization and TMDL implementation are timely noted. Table 7 identifies key milestones for implementation of the TMDL.

Table 7. Milestones for TMDL Completion and Implementation

Milestone	ADEQ Program/Entity Responsible	Target Date
Reconvene WIC	Watershed Protection Unit	February 2015
Monitoring to identify BMP projects in Miller Creek subwatershed	Watershed Protection Unit	February-July 2015
Effectiveness monitoring of established BMPs	Watershed Protection Unit	July 2015 – Sept 2016
Incorporate TMDL findings in updated WIP	Watershed Protection Unit	September 2015
Incorporate WIC goals and objectives in WIP	Watershed Protection Unit	December 2015
Initial Miller BMP/project load reductions	Watershed Protection Unit	February 2016
319 Cycle 18 BMP/project load reductions	Watershed Protection Unit	June 2016
Internal review of draft WIP update	Watershed Protection Unit	July 2016
Finalize updated WIP	Watershed Protection Unit	August 2016
Public Review of updated WIP	Stakeholders	Aug-Sept 2016
Implement Cycle 18 project(s)	Watershed stakeholders	July 2016-June 2018
Review and approve stormwater monitoring plans (City and County)	Watershed Protection Unit	See Appendix C (MS4 timeline)
Review of stormwater monitoring data	Stormwater Unit and Watershed Protection Unit	Annually
Submit Granite Creek DO Delist Report to EPA	Watershed Protection Unit	August 2016
Implementation of additional projects/BMPs	Applicants/Grantees/Other	Ongoing TBD
Determine project/BMP load reductions	Watershed Protection Unit	Ongoing TBD
Effectiveness monitoring of established BMPs	Watershed Protection Unit	Ongoing TBD
Update data analysis	Watershed Protection Unit	2020

X. PUBLIC INVOLVEMENT

Public involvement has included collaboration with Prescott Creeks Association for sampling and BMP implementation. A formal public meeting was held at the City of Prescott Council Chambers on December 11, 2014 from 3:30 p.m. to 5:30 p.m. Public notice of the meeting and availability of the draft documents was made via a posting in a newspaper of general circulation, *The Prescott Daily Courier*; via email notifications, direct communication with stakeholders and webpage postings.

The draft TMDL report was made available for a 30-day public comment period beginning on December 11, 2014 and ending on January 29, 2015 to allow extra time considering the holidays. Responses to questions and comments received during the 30-day public comment period are being addressed in a 45-day public notice posted in the *Arizona Administrative Register*, September 21, 2015 to November 5, 2015.

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APPENDIX A

Single Sample Maximum *E. coli* Exeedances (nutrient results at or above SSM included)

Mo	Yr	Site Name	*(> 3.0) TN (mg/L)	*(> 1.0) TP (mg/L)	*(> 235) *E. coli* (cfu/100ml)	Dilution
Nov	2013	Granite at Watson Woods			3873	1-10
	2013	Slaughterhouse abv Granite			2851	1-10
	2013	Government abv Granite			1046	1-10
	2013	Acker at Whitlow St.			11,199	1-10
	2013	Acker at EZ St.			1046	1-10
	2013	Granite at Granite Park			4106	1-10
	2013	North Fork Granite at 6th St.			1664	1-10
	2013	North Fork Granite at Sun St.			3076	1-10
	2013	Miller abv Butte			2613	1-10
	2013	Butte abv Miller			959	1-10
	2013	Granite at Leroux St.			2143	1-10
	2013	Granite at Granite St.			1670	1-10
	2013	Banning abv Granite			789	1-10
	2013	Aspen at Park Rd.			241	1-10
	2013	Granite at Leroux St.			882	1-10
	2013	Granite at Granite St.			307	1-10
	2013	Butte abv Miller			727	1-10
	2013	Miller abv Butte			708	1-10
	2013	North Fork Granite at 6th St.			259	1-10
Dec	2007	Granite at Ponderosa Rd	10.7			
	2008	Manzanita at White Spar Rd	2.96			
	2008	Granite at Leroux Rd			238.2	
	2008	Manzanita at White Spar Rd			396.8	
	2008	Granite above Manzanita			488.4	
	2008	Butte at Lincoln Rd			325.5	
	2008	Miller at Lincoln Rd			478.6	
	2008	Willow at Pleasant Valley Rd			365.4	
	2008	Granite at Watson Woods			1,299.7	
	2009	Manzanita at White Spar Rd	2.9			
	2009	Granite above Banning			1,299.7	
	2009	Manzanita at White Spar Rd			>2,419.6	
	2009	Aspen at Park Rd			>2,419.6	
	2009	Butte at Lincoln Rd			2,419.6	
	2009	Miller at Lincoln Rd			>2,419.6	
	2009	Granite at Granite Park			>2419.6	
	2009	Granite at Watson Woods			>2419.6	
	2009	Manzanita at White Spar Rd			856.4	
	2010	Manzanita at Timber Ridge			>2419.6	
	2010	Butte at Strickland Park			1046.2	
	2010	Butte at Lincoln Rd			1046.2	
	2010	Miller at Lincoln Rd			>2419.6	
	2010	Gurley Bridge NE			235.9	

	2010	Gurley Bridge SE			290.9	
	2010	Gurley Bridge NW			>2419.6	
	2010	Upstream of Gurley Bridge			770.1	
	2010	Downstream of Gurley Bridge			579.4	
	2010	Granite at Granite Park			2419.6	
	2010	North Fork Granite at 6th St			>2419.6	
Jan	2008	Granite at Ponderosa Rd	4.14	3.70		
	2008	Aspen at Forest Service Boundary		1.86		
	2008	Aspen at Rancho Vista Rd	7.16	2.89		
	2008	Aspen at Park Rd	12.27	1.89	387.3	
	2008	Government below Oak Knoll	3.16	1.76	866.4	
	2008	Slaughterhouse above Granite			1732.9	
	2008	Manzanita at White Spar Rd	4.57	2.56	344.0	
	2008	Miller at Thumb Butte Park		1.72		
	2008	Butte at Lincoln Rd			631.1	
	2008	Miller at Lincoln Rd		1.16	>2419.6	
	2008	Granite at Watson Woods		1.04	>2419.6	
	2008	Miller at Lincoln Rd			344.8	
	2008	Willow at Pleasant Valley Rd		2.37		
	2008	Government below Oak Knoll			238.2	
	2008	Butte at Lincoln Rd			260.3	
	2008	Miller at Lincoln Rd			275.5	
	2008	Willow at Pleasant Valley Rd			307.6	
	2008	Miller at Oregon Rd.			313.0	
	2008	Granite at Watson Woods			344.1	
	2008	Manzanita at White Spar Rd			1299.7	
	2008	Granite at Granite Park			1553.1	
	2008	Granite at Watson Woods			1986.3	
	2008	Miller at Lincoln Rd			>2419.6	
	2010	Manzanita at White Spar Rd	3.3			
	2010	Miller at Pine Rd	2.97			
	2010	North Fork Granite at 6th St	3.63			
	2010	Willow Aqueduct at P V Rd	10.96			
	2010	Granite at Watson Woods	3.03		261.3	
Feb	2008	Government below Oak Knoll			307.6	
Mar	2010	Miller at Lincoln Rd	3.21		2419.6	
	2012	Granite at Granite Park			767.0	
	2012	North Fork Granite at 6th St	2.88			
	2012	Butte at Lincoln Rd	5.05			
Apr	Samples collected but no SSM exceedences					
May						
Jun						
Jul	2010	North Fork Granite at 6th St			>2419.6	
	2010	Granite at Granite Park			>2419.6	
	2013	Aspen at Middlebrook Rd			1299.7	
Aug	2010	Granite at Ponderosa Rd			1413.6	

	2010	Miller at Lincoln Rd			1732.9	
	2010	North Fork Granite at 6th St			2419.6	
	2010	North Fork Granite at 1st St			2419.6	
	2013	Granite at Leroux Rd			727.0	
	2013	Granite at Granite Park			307.6	
	2013	North Granite at 6th St	2.50		2419.6	
	2013	Granite at Granite Park			1732.9	
	2013	Acker at M St	2.78		>2419.6	
	2013	Acker blw Yavapai College			>2419.6	
	2013	Government abv Granite	3.22	4.60	>2419.6	
	2013	Slaughterhouse above Granite			>2419.6	
	2013	Granite at Watson Woods			>2419.6	
	2013	Butte at Lincoln Rd			1986.3	
	2013	Miller at Lincoln Rd		1.50	>2419.6	
	2013	Granite at Leroux Rd			>2419.6	
	2013	Granite at Granite Park			>2419.6	
	2013	North Fork Granite at 6th St			>2419.6	
	2013	Acker at M St			>2419.6	
	2013	Acker blw Yavapai College			>2419.6	
	2013	Manzanita at White Spar Rd			2419.6	
	2013	Aspen at Park Rd			>2419.6	
	2013	Granite at Watson Woods			>2419.6	
	2014	Miller abv Butte			2,187	1-10
	2014	Aspen at Park Rd.			2,755	1-10
	2014	Acker blw Acker Park			1,616	1-10
	2014	Acker at Moeller St.			1,529	1-10
	2014	Granite at Watson Woods			1,274	1-10
	2014	Manzanita abv Granite			933	1-10
	2014	Butte abv Miller			1,017	1-10
	2014	Granite at Granite Park			933	1-10
	2014	Government abv Granite			886	1-10
	2014	Granite at Leroux St.			738	1-10
	2014	North Fork Granite at 6th St.			598	1-10
	2014	Slaughterhouse abv Granite			305	1-10
	2014	Granite abv Banning			402	1-10
	2014	Banning abv Granite			395	1-10
	2014	Government blw Oak Knoll			480	1-10
Sep	2013	Manzanita at White Spar Rd			436.0	
	2013	Aspen at Rancho Vista Rd			1454.0	1-1
	2013	Aspen at Middlebrook Rd			323.2	1-1
	2013	Granite at Leroux Rd			2599.4	1-1
	2013	Miller at Oregon Rd.			449.4	1-1
	2013	Granite at Granite Park			689.6	1-1
	2013	North Fork Granite at 6th St			279.2	1-1
	2013	Granite at Watson Woods			402.8	1-1
Oct	2010	Banning above Granite			>2419.6	

	2010	Manzanita at White Spar Rd			>2419.6	
	2010	Aspen at Park Rd			>2419.6	
	2010	Butte at Lincoln Rd			2419.6	
	2010	Miller at Lincoln Rd			>2419.6	
	2010	North Fork Granite at 6th St			>2419.6	
	2010	Granite at Granite Park			>2419.6	
	2010	Granite at Watson Woods			>2419.6	
	2010	Manzanita at White Spar Rd			275.5	
	2010	Butte at Lincoln Rd			307.6	
	2010	Granite at Granite Park	3.02		>2419.6	

Blue indicates winter storm flow and spring runoff; Yellow indicates summer monsoon season

Number of Single Sample Maximum Exceedances by Sample Site (2007 – 2013)

Site Name	*(> 3.0) TN	*(> 1.0) TP	*(> 235) *E. coli*
Granite at Ponderosa Rd	2	1	1
Granite above Banning			1
Banning above Granite			1
Granite above Manzanita			1
Manzanita at Timber Ridge			1
Manzanita at White Spar Rd	**4**	**1**	**9**
Aspen at Forest Service Boundary		1	
Aspen at Rancho Vista Rd	1	1	1
Aspen at Middlebrook Rd			**2**
Aspen at Park Rd	**1**	**1**	**4**
Granite at Leroux Rd			**4**
Upstream of Gurley Bridge			1
Gurley Bridge NE			1
Gurley Bridge NW			1
Gurley Bridge SE			1
Downstream of Gurley Bridge			1
Butte at Strickland Park			1
Butte at Lincoln Rd	**1**		**9**
Miller at Thumb Butte Park		1	
Miller at Pine Rd	1		
Miller at Oregon Rd.			**2**
Miller at Lincoln Rd	**1**	**2**	**11**
Granite at Granite Park	**1**		**11**
North Fork Granite at 6th St	**2**		**8**
Acker at Morello St			**2**
Acker blw Yavapai College			**2**
Government below Oak Knoll	**1**	**1**	**3**
Government abv Granite	1	1	1
Slaughterhouse above Granite			**3**
Granite at Watson Woods	**1**	**1**	**10**
Willow Aqueduct at P V Rd	1		
Willow at Pleasant Valley Rd		**1**	**2**

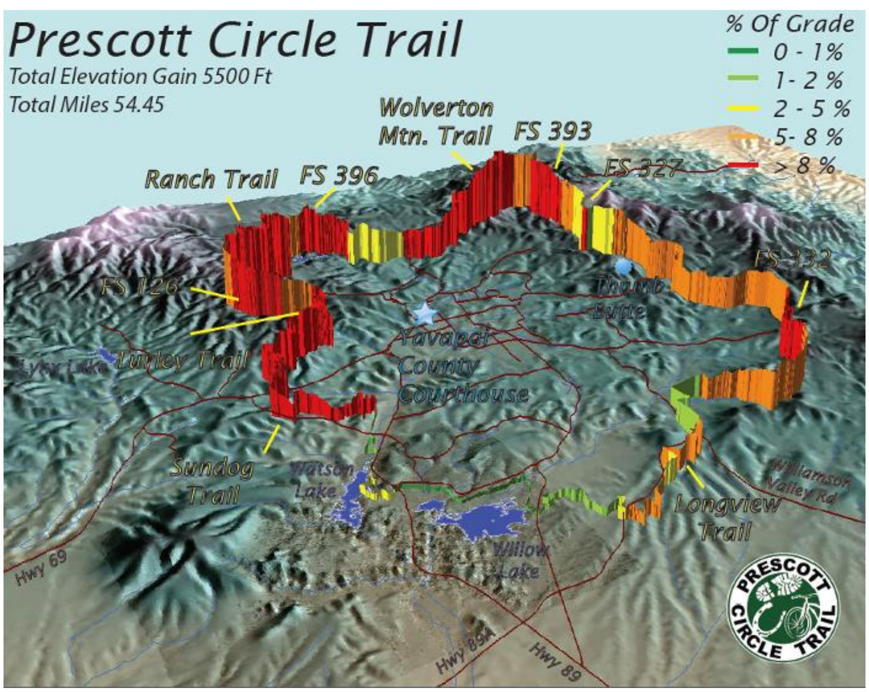
Bold indicates sites with two or more *E. coli* exceedances

APPENDIX B

Parks and trails are a nexus for recreational activity and vulnerable to waste disposal issues, particularly domestic animal waste. The various parks and 70 miles of trails within the watershed suggest a need for prioritization of these areas for BMPs. Listed below are parks and trails identified on the City of Prescott web site:

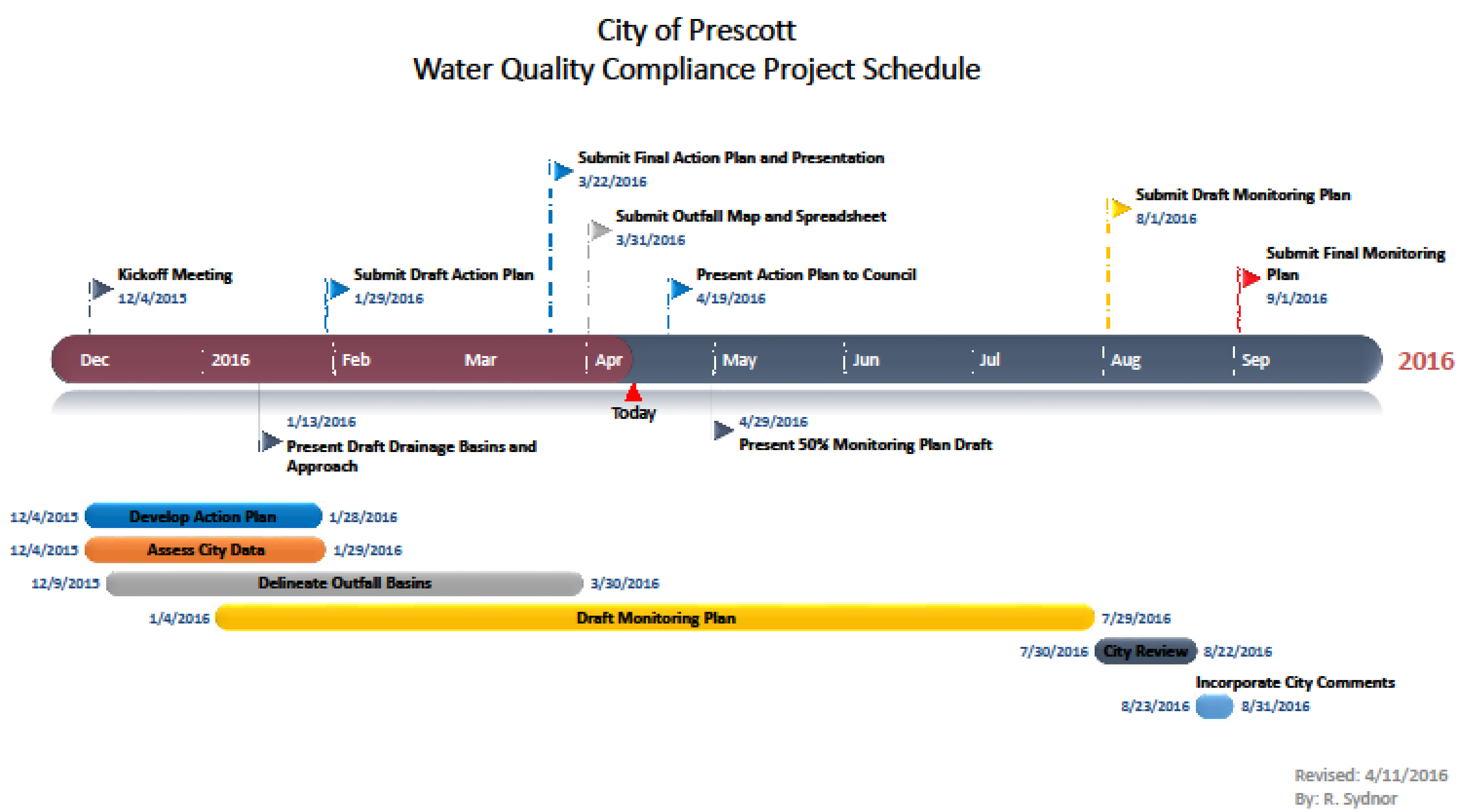
- **PARKS**
- A.C. Williams Granite Creek Park
- Acker Park
- Flinn Park
- Heritage Park
- Jim McCasland Willow Creek Park
- Ken Lindley Field and Park
- Kuebler Field
- Mike Fann Community Skate Park
- Pioneer Park
- Roughrider Park and Bill Valley Field
- Vista Park
- Willow Creek Park Dog Park
- Honor Island Park
- Leroux Mini-Park
- Peppertree Mini-Park
- Veteran's Memorial Island
- Goldwater Lake
- Watson Lake Park
- Willow Lake Park
- Community Nature Center
- Downtown Prescott Greenways Trail
- Prescott Peavine National Recreation Trail
- Stricklin Park
- Watson Woods Riparian Preserve
- White Spar Creekside Open Space Preserve

- **TRAILS**
- Acker Park Trails
- Aspen Creek Trail
- Butte Creek Trail
- Centennial Trail
- Community Nature Center Trails Network
- Constellation Trails
- Embry Riddle-Jan Alfano Trails
- Flume Canyon, Watson Dam and Northshore Trails
- Goldwater Lake Trails
- Granite Creek Park
- Granite Gardens Trail System
- Greenways Trail System
- Lakeshore Trail
- Lakeside aka Fishing Trail and Explorer Trails
- Longview Trail
- Lower Granite Creek Discovery Trail
- Over the Hill Trail
- Pioneer Park Trails
- Prescott Circle Trail (Figure 2 on following page)
- Prescott Lakes and Vista Park Trails System
- Prescott Peavine National Recreation Trail
- Rancho Vista Trail
- Rodeo Grounds Trails
- Sundog to Lowes Hill Trail
- Watson Lake Loop Trail
- Watson Woods Trails
- Willow Dells Slickrock Trail Loops
- Willow Lake Loop Trail



Prescott Circle Trail, Showing Topographic Relief/Runoff Gradient
http://www.cityofprescott.net/services/parks/trails

APPENDIX C


City of Prescott
Water Quality Compliance Project Schedule
Submit Final Action Plan and Presentation
3/22/2016
Submit Outfall Map and Spreadsheet
3/31/2016
Submit Draft Monitoring Plan
8/1/2016
Submit Final Monitoring Plan
9/1/2016
Kickoff Meeting
12/4/2015
Submit Draft Action Plan
1/29/2016
Present Action Plan to Council
4/19/2016
Dec
2016
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
2016
Today
1/13/2016
Present Draft Drainage Basins and Approach
4/29/2016
Present 50% Monitoring Plan Draft
12/4/2015 Develop Action Plan 1/28/2016
12/4/2015 Assess City Data 1/29/2016
12/9/2015 Delineate Outfall Basins 3/30/2016
1/4/2016 Draft Monitoring Plan 7/29/2016
7/30/2016 City Review 8/22/2016
Incorporate City Comments
8/23/2016 8/31/2016
Revised: 4/11/2016
By: R. Sydnor