

SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM
WATERSHED PROJECT FINAL REPORT

Nonpoint Source Pollution Reduction in Lower Bear Creek

by

Groundwork Denver

02/06/2019 FINAL

This project was conducted in cooperation with the State of Colorado and the United States Environmental Protection Agency, Region 8.

Grant # CT FAAA 201700001343

EXECUTIVE SUMMARY

PROJECT TITLE Nonpoint Source Pollution Reduction in Lower Bear Creek

PROJECT START DATE 08/15/2016

PROJECT COMPLETION DATE 09/30/2018

FUNDING:	TOTAL BUDGET	<u>\$119,636</u>
	TOTAL EPA GRANT	<u>\$71,588</u>
	TOTAL EXPENDITURES OF EPA FUNDS	<u>\$71,588</u>
	TOTAL SECTION 319 MATCH ACCRUED	<u>\$117,865</u>
	BUDGET REVISIONS	<u>\$13,909</u>
	TOTAL EXPENDITURES	<u>\$189,453</u>

SUMMARY ACCOMPLISHMENTS

With 319 funding provided by EPA and the Colorado Department of Health and Environment (CDPHE) from August 15, 2016 through September 30, 2018, Groundwork Denver conducted a comparative investigation of the efficacy of best management practices in the mitigation of nonpoint source pollution in Lower Bear Creek and implemented best management practices (BMPs) referenced in the 2014 Lower Bear Creek Watershed Plan. The project took place within the Bear Creek Watershed (COSPBE02) within the section of creek most impaired by high counts of *E. coli*. The structural BMP (which was not paid for by this grant) occurred just upstream of the transition zone—the area where *E. coli* levels increase dramatically—whereas the non-structural maintenance BMPs took place slightly downstream of the Harvey Park South neighborhood.

The Environmental Goal of the project was to reduce nonpoint source pollution loading of *E. coli*, nutrients, and trash in Bear Creek and to test two types of BMPs (structural and non-structural) for future implementation to remove Lower Bear Creek from the 303 (d) and Monitoring and Evaluation lists. Data from five years of continuous in-stream sampling shows that *E. coli* levels were not affected by the BMPs. Groundwork Denver successfully implemented, or oversaw the implementation of, both BMPs in the affected watershed. The Programmatic Goal of this project was to implement and evaluate structural and non-structural BMPs recommended in the Lower Bear Creek Watershed Plan to achieve the Environmental Goal. Groundwork was successful in reducing residential nonpoint source runoff inputs by increasing the number of irrigation audits completed in the watershed and bringing community and youth participation to the structural BMP. Youth also participated in visual assessments and pre-canvassing for irrigation audits.

One of the major accomplishments of the project was the increased community knowledge, leadership, and action within the watershed that resulted from diverse and community-led outreach and education efforts. Along with an increased understanding of nonpoint sources and creek health, relationships and trust between stakeholders has been established. Community members and youth leaders participated in all aspects of the project, sharpening their knowledge and skills as future decision makers in the community. From a watershed perspective, the health of the creek has been improved as well. Over the past three years of this grant, Groundwork Denver has been able to continue implementation and refine a trusted sampling technique, contributing to an increase in waterbody knowledge and useful data.

The structural BMP was implemented by Denver Parks and Recreation on November 4th, 2017. The removal of non-native Kentucky bluegrass made way for seeding of native tall grasses that are better able to capture and uptake excess nutrients and contaminants within the watershed. The implementation took place between the pedestrian path within Bear Valley park and the creek banks. The non-structural maintenance BMP was completed under budget in 2017, allowing Groundwork Denver to extend that grant for six months. This supported the completion of 33 additional irrigation audits, totaling 84 audits. Reception of irrigation audits has been overwhelmingly positive in a community that has a high population of elderly residents on fixed incomes who lack the knowledge, resources, and physical ability to make sprinkler repairs on their own. Of the 84 audits completed, all were funded by 319 Nonpoint Source funds. This project is relevant to the state NPS program because stakeholders will be able to reference the BMP comparison and future recommendations when choosing an effective BMP for their watershed.

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1.0 INTRODUCTION

Identification of Watershed

Lower Bear Creek (Water Body Identification (WBID): COSPBE02; Hydrologic Unit Code (HUC) 12: 101900020809) is a perennial stream that extends from its upstream extent at the Bear Creek Reservoir discharge in Lakewood, 8.2 miles to the confluence with the South Platte River in the City of Sheridan. Major cross streets in the Lower Bear Creek watershed are Highway 285, Kipling Parkway to the west, and Federal Boulevard to the east. Map 1 on page 9 shows the HUC12 boundary, project boundary, and cross streets.

This section of Bear Creek is listed as segment COSPBE02 in the Bear Creek Basin (Regulation 38, Colorado WQCC 2009), and in the Colorado 303(d) list. This segment lies in the Upper South Platte 8-digit Hydrologic Unit Code (HUC) 10190002. Bear Creek is a perennial stream with flow control at the Bear Creek Dam 8.2 miles from its confluence with the South Platte River. The headwaters for Bear Creek are on the eastern slopes of Mount Evans in Clear Creek County, approximately 40 miles upstream from the start of segment 2. In 2014, monthly flow discharge was greatest in April, May, and June, with very low flows from October through December. Generally, data gathered during the watershed planning process in 2013 and 2014 show that greater flow from the dam results in better water quality in Lower Bear Creek.

Because the watershed is entirely urbanized, it is defined mostly by the stormwater drainage area, which encompasses about 35 square miles of mostly urban area. Close-in to Bear Creek, approximately a 6 mile stretch in Denver and Lakewood, it is surrounded by 512 acres of natural areas and parks. The watershed includes three golf courses, several small parks, lakes, and school grounds. The majority of the structures in the watershed are residential, single-family residences. There are two large commercial shopping centers in very close proximity to the creek. The 160-acre Fort Logan Cemetery is within 1,000 feet of the creek. There are a few industrial sites very close to the Sheridan section of the creek. The Denver and Sheridan sections of the Bear Creek are in very close proximity to HWY 285 (Hampden Blvd), a highway with a high volume of traffic (over 31,000 vehicles per day). The Denver section of the watershed includes four neighborhoods (Bear Valley, Harvey Park South, Fort Logan, and Marston). The population is about 37,000 with 16,000 households, most of whom reside in single family and duplex structures. About 65% of the homes are owner-occupied and 25% are rentals.

Denver Natural Areas has catalogued the geology of the sections of the watershed that are within the Bear Creek and Bear Valley Natural Areas that border Bear Creek. This includes Post-Piney Creek alluvium, Piney Creek alluvium, Louviers alluvium, and Denver and Arapahoe formations.

Aquatic habitat is found in Bear Creek, in two ponds south of Bear Creek and east of Raleigh Street, along an unnamed creek flowing north from Marston Reservoir. Additional habitats are found in small streams flowing from seeps north of Kenyon Avenue. In Bear Creek itself, the vegetation in most areas of aquatic habitat is poorly developed due to extensive shading by crack willows. In some areas, down-cutting of the stream has removed the creek alluvium necessary for many rooted plants. In areas of quieter water, crayfish are common. Fish, mostly fathead minnows and creek chubs, are present.

Stream bank stability and erosion vary along the 8.2 mile stretch of the watershed. Much of the Sheridan section has been heavily rip-rapped. Other sections, such as downstream of a pedestrian bridge at Raleigh Street in Denver, have also been extensively channelized. Social trails throughout the natural areas have caused erosion in some areas. Historically, the floodplain of Bear Creek has contained sand and gravel deposited by the creek over a very long period. The Bear Creek Dam and Reservoir now prevents most flooding, as well as the replacement of sediments in the stream. As a result, the sandbars and the stream channel are eroding. Large areas of the channel now flow over bedrock instead of gravel and cobbles. From Lowell Boulevard to the South Platte River, the creek is deeply incised.

Water Quality Problems

The Bear Creek Watershed is part of a source water protection area (#4 South Platte Watershed) designated by the Urban Waters Federal Partnership. It is also a watershed critical to sources of drinking water designated by the Environmental Protection Agency (EPA). The section including the last eight miles of Bear Creek, before it feeds the South Platte River, is on Colorado's 303(d) list for *E. coli* impairment. Groundwork Denver, with support from Metro State University (MSU) and the cities of Denver, Sheridan, and Lakewood, conducted in-stream water quality testing and narrowed the location of likely pollution sources to the last three miles of Bear Creek. In addition, sampling with Colorado River Watch also shows elevated levels of nitrogen and phosphorous. Other contaminants include nutrients, oil, grease, metals, pesticides, and trash. Likely sources of non-point source contamination include urban runoff, wildlife, and domestic dogs. Bear Creek is surrounded by highly urbanized land uses such as U.S. Highway 285 (with over 31,000 vehicles a day), vast parking lots, and several thousand individual residential lots. In response to this impairment, the CDPHE supported a planning process, with funding from the EPA and spearheaded by Groundwork Denver, resulting in the "Lower Bear Creek Watershed Plan."

The water quality in Segment 2 of Bear Creek exceeds State standards that are protective of recreational use and is on the Monitoring and Evaluation list for aquatic life. Lower Bear Creek's designated uses as identified in Regulation 38 (Stream Classifications and Water Quality Standards) are Aquatic Life Warm I, Recreation E, Water Supply, and Agriculture. Recreation E describes any activity where people are in direct contact with the water, including wading, water play by children, tubing, and swimming. In 2010, the water was listed on Colorado's 303(d) list as being impaired due to *E. coli*. Impairment for recreational use indicates that there may be a potential health hazard for those in contact with the creek. A Total Maximum Daily Load (TMDL) for *E. coli* is required by Clean Water Act Section 303(d) within twelve years of listing if water quality does not improve. Clean Water Act Section 303(d) requires each State to identify waters that do not meet standards for their designated use and develop a Total Maximum Daily Load (TMDL) for identified contaminants.

Consistency with the State NPS Management Program and Other State Programs

The project addressed the Colorado NPS Management Plan objective to restore nonpoint source water quality in impaired waterbodies. The Colorado NPS Management Plan also stresses the importance of watershed planning. This project was a result of a watershed planning process that was completed for Lower Bear Creek in 2014. The Management Plan also emphasizes

implementation projects with clear results, education and outreach components, and monitoring, all of which played an integral role in the project.

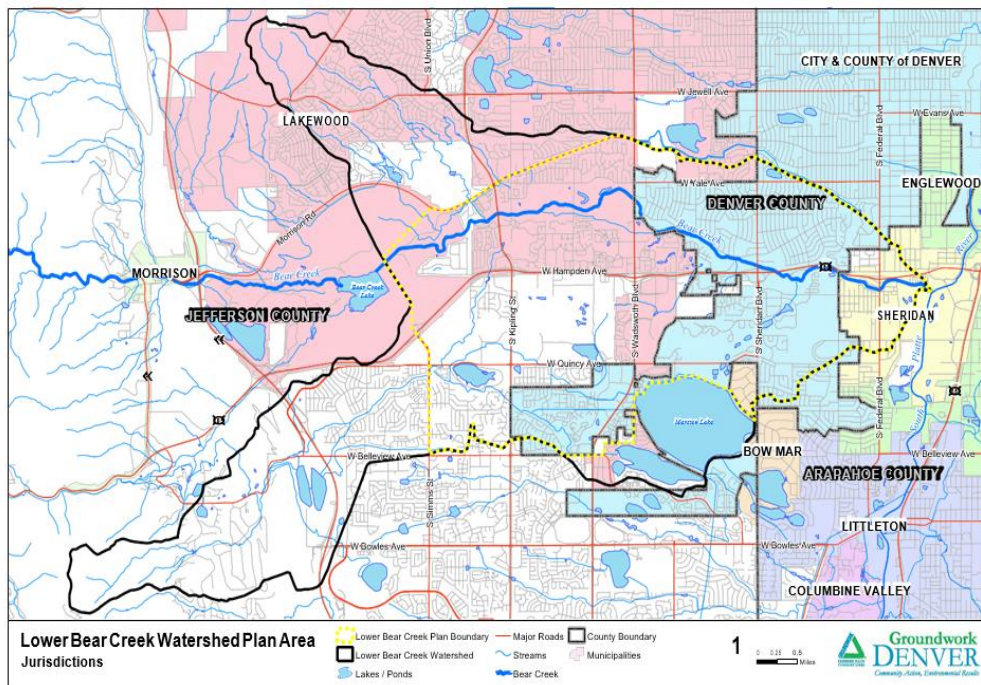
The project was needed to address the contamination in Lower Bear Creek, which exceeds standards that are protective for recreational use for *E. coli*, as well as other potential contaminants, including nutrients. Bear Creek is a perennial stream in a heavily used urban area, increasing the likelihood of health impacts due to the impairment.

The structural BMP was aimed at cleaning the storm water before it entered the creek. The non-structural maintenance BMP and education was aimed at reducing pollution that is washed from the watershed into the storm water system and into the creek.

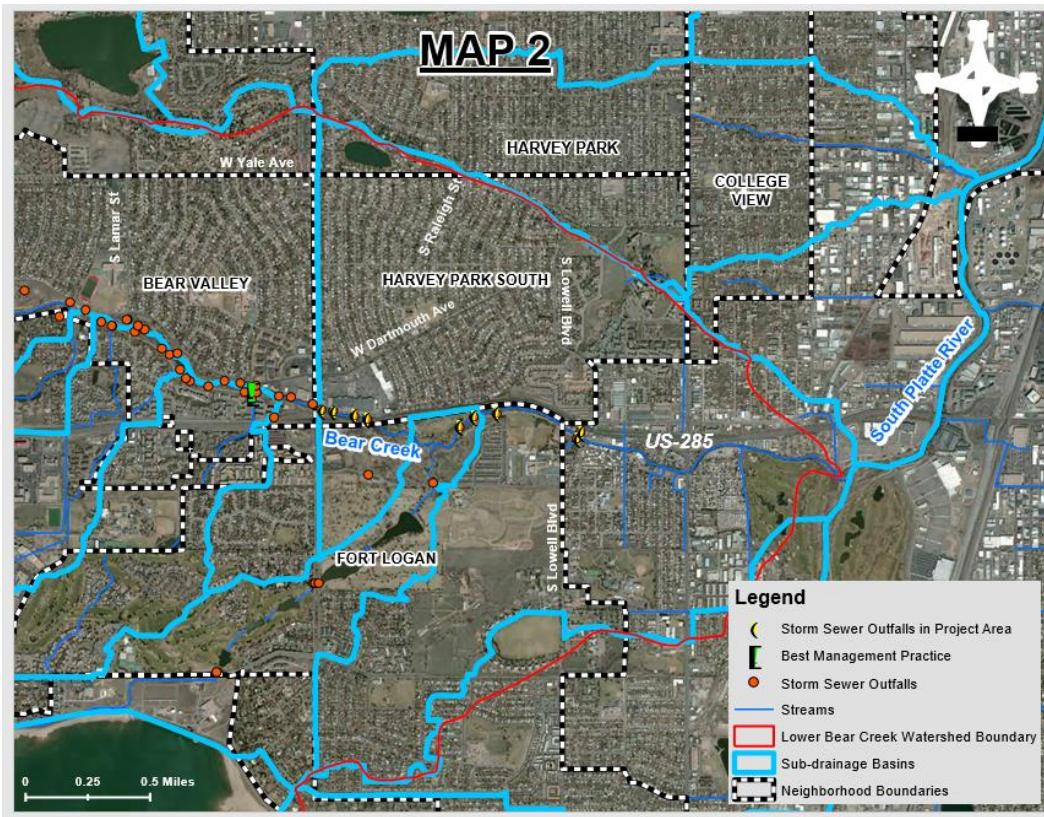
General Project Description

This project was a comparative investigation of the efficacy of best management practices in the mitigation of nonpoint source pollution in Lower Bear Creek and implemented the non-structural best management practices (BMP) referenced in the 2014 Lower Bear Creek Watershed Plan. Two distinct BMP strategies were implemented: 1) a structural BMP (not paid for by this project, but the effectiveness was measured) and 2) non-structural maintenance BMP with an education component along the segment prioritized by the Water Quality Control Division (WQCD) for an *E. coli* Total Maximum Daily Load (TMDL). The efficacy of each strategy was measured using in-stream water quality monitoring and a comparative analysis. The project design interfaced productively with and did not supplant Denver’s MS4 permit requirements.

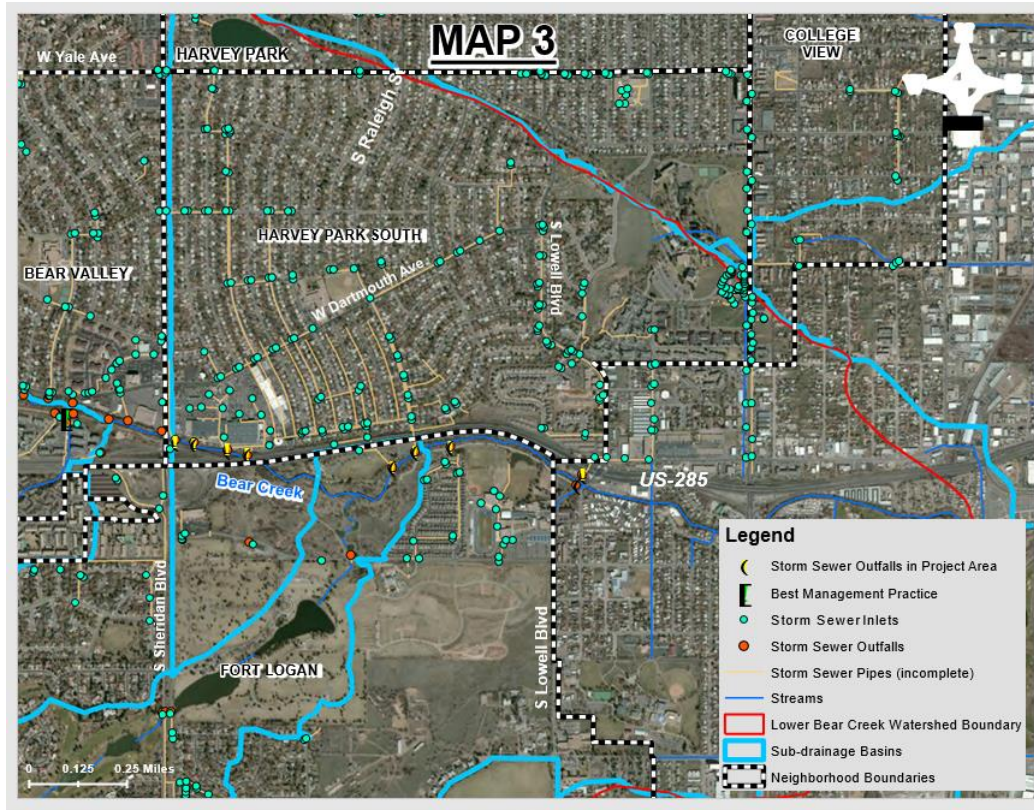
Maps Showing Location and Size of Watershed



MAP 1



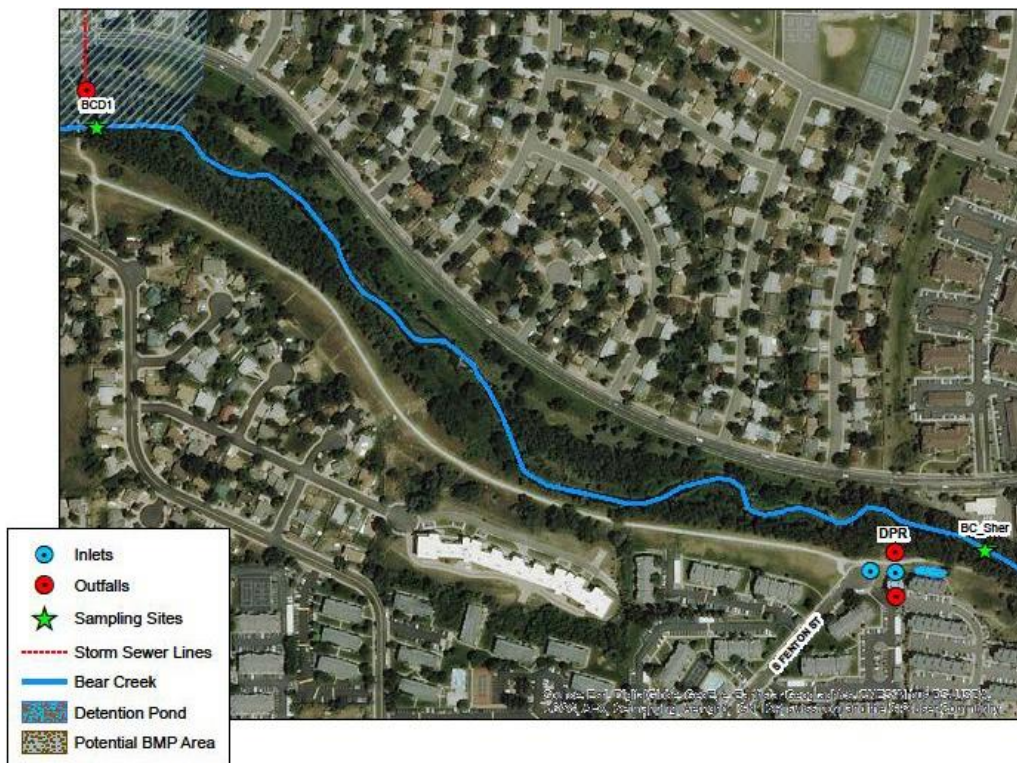
MAP 2



MAP 3



MAP 4: Location of structural BMP outfall, and upstream and downstream sampling locations



MAP 5: Close-up of structural BMP outfall, and upstream and downstream sampling locations.



MAP 6: Location of non-structural maintenance BMP drainage basin, outfalls, and upstream and downstream sampling locations.

2.0 PROJECT GOALS, OBJECTIVES, AND ACTIVITIES

Goal 1.1	<i>Non-structural Maintenance BMP Design and Implementation</i>
Objective 1	Strengthen or establish partnerships with residents in Lower Bear Creek in order to decrease irrigation overspray, controlling runoff that adds to nonpoint source pollution from yards and streets.
	Task 1. Irrigation Audit Training
	Product 1 Certified Landscape Irrigation Auditor (CLIA) training completion.
	Product 2 IA-certified professional verification of sample audits conducted by Groundwork Denver staff following CLIA training.
	Task 2. Pre-BMP Visual Assessment: Evaluate irrigation overspray in neighborhoods within the project area and inspect project area storm sewer outfalls during dry weather, leading to the determination of prioritized areas for irrigation audits.
	Product 3 Visual evaluation records that include date, time, address, estimate of irrigation overspray (low, moderate, high), condition of project area storm sewer outfalls during dry weather, and photographs of public areas, if feasible.
	Product 4 GIS maps of residences with irrigation overspray and general estimates of levels of overspray and storm sewer outfalls that are active during dry weather within the project area.
	Product 5 List of prioritized areas and residences for irrigation audits.

	Task 3. Door-to-Door Outreach: Invite residents in the prioritized areas to receive a free irrigation overspray audit by sharing information about the connection between overspray and nonpoint source pollution through a brief survey and follow up brochure. The survey will be conducted at the door and will be used to gauge resident knowledge about overspray and nonpoint source pollution, and their behaviors related to the same.
	Product 6 Brochure identifying ways residents can protect urban water. The brochure will focus on irrigation overspray as it relates to pollutants entering Bear Creek. The brochure will be provided after completion of the survey when residents are home and participate in the survey and are left at the door where residents are not home or when residents refuse to take the survey.
	Product 7 Pre-irrigation audit survey and survey results. The survey will gauge residents' knowledge and behaviors related to urban water and the relationship between lawn watering overspray and runoff to urban waterways and will include a section to sign up for an irrigation audit.
	Product 8 List of residents and locations participating in the irrigation audit with correlated survey results. Participating resident locations will also be overlaid on GIS maps produced in Task 2.
	Task 4. Irrigation audits and improvements: Perform irrigation audits and minor improvements. Should irrigation systems require more than minor adjustments, Groundwork Denver irrigation auditors will provide residents with recommendations for finding a qualified repair professional.
	Product 9 Results of irrigation audits and types of improvements conducted by address.
	Product 10 Updated maps indicating locations of irrigation improvements.
	Task 5. Newsletter: Communicate project progress to drainage-basin audience. A newsletter with educational information will be mailed or emailed to 1,000 households (including those participating in the irrigation audits) in the drainage basin five times during the project period.
	Product 11 Five newsletters distributed to at least 1,000 residents in the drainage basin.
	Task 6. Post-BMP Visual Evaluation: Conduct follow-up visual inspections at residences that received irrigation improvements to evaluate if they are still functioning and administer post-audit survey.
	Product 12 Updated notes and maps indicating which homes that received irrigation improvements are still in alignment.
	Product 13 Post audit survey and survey results and analysis including changes in knowledge and behaviors regarding irrigation overspray and nonpoint source pollution.
Goal 2.1	Structural BMP Design and Installation.
Objective 2	Install structural BMP to improve recreational use attainment in Denver reach of Lower Bear Creek.
Goal 3.1	Water Quality Monitoring, Evaluation, and Data Management.

Objective 3	Monitor water quality in Lower Bear Creek prior to and after implementation of the structural BMP (Denver) and irrigation overspray adjustments (Groundwork Denver).
	Task 7. <i>E. coli</i> Monitoring, Evaluation and Data Management: Collect <i>E. coli</i> water quality data to help evaluate effectiveness of non-structural and structural project BMPs (structural BMP constructed by Denver as part of project match).
	Product 14 WQCD-approved SAP for monitoring conducted by Groundwork Denver staff.
	Product 15 <i>E. coli</i> monitoring data distributed to current and future partners, made available on the Groundwork Denver website and uploaded to STORET.
	Product 16 Comparative analysis of BMP effectiveness. Groundwork Denver will document the reduction in 60 day rolling average in-stream <i>E. coli</i> data for each BMP. Percentage reduction in 60 day rolling averages for each BMP will be the measure of comparison for each BMP.
	Task 8. River Watch Monitoring, Evaluation and Data Management: River Watch Monitoring, Evaluation and Data Management: Collect metals (monthly), nutrients (high flow in spring, low flow in winter) and macroinvertebrates (collected once per year based on Aquatic Life Use Attainment policy prepared by the WQCC) samples (River Watch).
	Product 17 River Watch metals (monthly), nutrients (bi-annually), and macroinvertebrate (annually) data.
	Task 9. Trash survey: Collect information about the presence, type and quantity of trash at outfalls impacted by the non-structural BMP.
	Product 18 WQCD-approved SAPP based on the City and County of Denver trash survey protocols.
	Product 19 Pre and post BMP implementation trash survey data and analysis of those data as they relate to the non-structural BMP.
Goal 4.1	Groundwork Denver will manage project communication, completion of Tasks and Products, and financial documentation in a timely and transparent manner with the NPS Coordinator.
Objective 4	Project Administration, Reporting, Financial Management.
	Task 10. Reporting, Communication, and Financial Management: Conduct project management and communication, and financial oversight with clarity and consistency.
	Product 20 Progress, semi-annual, and final reports.
	Product 21 Financial reports submitted with draw requests.

2.1 Planned and Actual Milestones, Products, and Completion Dates

Objective 1: Non-structural Maintenance BMP design
Task 1: Irrigation and Audit Training

Anticipated Product 1: Certified Landscape Irrigation Auditor (CLIA) training completion.	
Actual Product	Date
A final training session for the Irrigation Audit Team was conducted in July before canvassing and irrigation audits.	07/10/17
Joseph Cordova, Tangier Barnes Wright, and Lauren O'Connor were trained as new irrigation auditors for the season.	05/30/18
6 total Certified Landscape Irrigation Auditor trainings were completed by a total of 3 Groundwork Denver staff.	09/30/18
Anticipated Product 2: IA-certified professional verification of sample audits conducted by Groundwork Denver staff following CLIA training	
Actual Product	Date
Professional verification conducted by the Center for Resource Conservation	07/12/18
IA-certified professional verification of sample audits was conducted by GWD staff following CLIA training.	09/30/18
Task 2: Pre-BMP Visual Assessment: Evaluate irrigation overspray in neighborhoods within the project area and inspect project area storm sewer outfalls during dry weather, leading to the determination of prioritized areas for irrigation audits.	
Anticipated Product 3: Visual evaluation records that include date, time, address, estimate of irrigation overspray (low, moderate, high), condition of project area storm sewer outfalls during dry weather, and photographs of public areas, if feasible.	
Anticipated Product 4: GIS maps of residences with irrigation overspray and general estimates of levels of overspray and storm sewer outfalls that are active during dry weather within the project area.	
Anticipated Product 5: List of prioritized areas and residences for irrigation audits.	
Actual Product	Date
Groundwork Denver identified the neighborhood area that contributes to two storm sewer outfalls that were studied. Groundwork Denver developed canvassing map routes for these areas for the observations.	8/15/15-12/31/16
Overspray investigations were conducted at all 1,651 houses in Harvey Park South.	06/30/17
Pre-canvassing visual assessments continued from June into July. While some homes were identified as priorities for canvassing because of overspray, canvassing did not necessarily result in an audit at the residence. While the pre-canvassing team did investigate the neighborhood at times when people were most likely to have their systems on (early morning, late evening), we did not notice irrigation systems at all houses. Canvassing each home ensured we had some form of contact on two different occasions. Visual evaluation records, maps and prioritized areas were included in the 2017 final report.	06/01/17-07/30/17
A trash survey was carried out on 10/16/2017 at the two direct outfalls of the Harvey Park neighborhood. Generally, a good deal of trash was observed in the terrace of the outfall. Largely food items (wrappers, etc.) accounted for the observed trash.	10/16/17

Storm sewer outfalls were inspected.	08/15/17
Storm sewer outfalls were inspected (see appendix A).	08/21/18
<p>Task 3: Door-to-Door Outreach: Invite residents in the prioritized areas to receive a free irrigation overspray audit by sharing information about the connection between overspray and nonpoint source pollution through a brief survey and follow up brochure. The survey will be conducted at the door and will be used to gauge resident knowledge about overspray and nonpoint source pollution, and their behaviors related to the same.</p>	
<p>Anticipated Product 6: Brochure identifying ways residents can protect urban water. Brochure will focus on irrigation overspray as it relates to pollutants entering in Bear Creek. The brochure will be provided after completion of the survey when residents are home and participate in the survey, and are left at the door where residents are not home or when residents refuse to take the survey.</p>	
<p>Anticipated Product 7: Pre-irrigation audit survey (see appendix B) and survey results. The survey will gauge residents' knowledge and behaviors related to urban water and the relationship between lawn watering overspray and runoff to urban waterways and will include a section to sign up for an irrigation audit (see appendix C).</p>	
Actual Product	Date
Every home in the Harvey Park South neighborhood (Total # Homes = 1,651) were canvassed at least 2 times during the reporting period. Fliers used in door-to-door outreach are included with this report (see appendix D). Survey results and maps identifying houses that were canvassed and had an audit were submitted in the 2017 year-end report.	07/01/17-09/30/17
Two door-to-door outreach efforts were completed in September of 2017. A brochure from previous watershed projects was used as the initial canvassing material. On the second attempt of canvassing, a new brochure was generated. Of the 1,651 homes in Harvey Park South, our canvassing team communicated with 692 directly (41.9%). During canvassing observations of irrigation systems or downspouts to concrete were recorded. 61 % of homes were observed to have downspouts directed toward concrete, and 55% were observed to have automatic sprinkler systems.	09/01/17
The sprinkler audit flyer was put in the community newsletter (see appendix E). Groundwork Denver met its quota for sufficient audit signups for summer 2018.	03/31/18
Updated version of our "You are a Clean Water Partner!" brochure was created. Groundwork Denver modified the format to update proper contact information (see appendix F).	04/28/18
<p>Anticipated Product 8: List of residents and locations participating in the irrigation audit with correlated survey results. Participating resident locations will also be overlaid on GIS maps produced in Task 2.</p>	
Actual Product	Date
Survey results and maps identifying houses that were canvassed and had an audit were submitted in the 2017 year-end report.	12/31/17

Survey results were analyzed and incorporated into the audit report for Task 4.	10/01/17-12/31/17
Task 4: Irrigation audits and improvements: Perform irrigation audits and minor improvements. Should irrigation systems require more than minor adjustments, Groundwork Denver irrigation auditors will provide residents with recommendations for finding a qualified repair professional.	
Anticipated Product 9: Results of irrigation audits and types of improvements conducted by address.	
Anticipated Product 10: Updated maps indicating locations of irrigation improvements.	
Actual Product	Date
Fifty irrigation audits were conducted between July and September (see appendix G). Repairs varied from minor adjustments to align heads, to replacing heads and creating new irrigation schedules. Initial follow-up feedback indicates canvassers and auditors provided exceptional service and helped reduce water consumption bills. Maps and detailed results of audits were included in the 2017 year-end report.	07/01/17-10/11/17
An irrigation audit report was completed, which includes maps of irrigation improvements.	10/01/17-12/31/17
Irrigation audits have begun for the season. A complete list will be submitted with the October/September report. New map was submitted with October/September report. To date, we have 54 irrigation audits requested, 21 scheduled, and 8 completed.	04/01/18-06/30/18
Irrigation audits have begun for the season. See appendix G for map of completed audits. To date, we have completed 33 additional audits. A summary report of irrigation audits and outcomes was produced by Groundwork Denver. The report outlines efforts, trends, and observations from irrigation audits carried out, and contains maps identifying homes receiving audits. Further, the report summarizes improvements and repairs made at homes with irrigation audits.	07/01/18-09/30/18
Task 5: Newsletter: Communicate project progress to drainage-basin audience. A newsletter with educational information will be mailed or emailed to 1,000 households (including those participating in the irrigation audits) in the drainage basin five times during the project period.	
Anticipated Product 11: Five newsletters distributed to at least 1,000 residents in the drainage basin.	
Actual Product	Date
The first newsletter for Harvey Park South residents was drafted during the reporting period. Stories focused on irrigation audits, how to use fall leaves instead of throwing them in the trash, and do-it-yourself sprinkler repair tips.	07/01/17

<p>The first newsletter for Harvey Park South residents was sent out to 1,500 homes. Stories focused on introducing a watershed and how a home contributes to watershed health. The seasonal newsletter highlighted alternatives to deicers and salts, how to reduce use of these products, and their impact on the watershed (see appendix H).</p>	<p>10/01/17</p>
<p>The second newsletter for Harvey Park South residents was sent out to 1,500 homes. Stories focused on introducing a watershed and how a home contributes to watershed health. The seasonal newsletter highlighted alternatives to deicers and salts, how to reduce use of these products, and their impact on the watershed (see appendix I).</p> <p>The third newsletter was released in the community "Harvey Park Newsletter" in Spring 2018. The article connected sprinkler inefficiencies with watershed health and gave a review of last summer's success. GWD had sufficient audit signups for summer 2018 audit season (see appendix J).</p> <p>Additional education on nonpoint source pollution and creek health is being relayed via a unique youth-led "Paleta Cart" project. The ice cream cart, designed by a local artist, carries free dog waste bags, a watershed quiz, pollutant information and what people can do in their homes to protect watershed health. Sprinkler coupons, informational flyers, and sampling materials were also given out or displayed.</p>	<p>03/25/18</p>
<p>A follow up article in the Harvey Park newsletter (delivered July 1) and on the Harvey Park Facebook page reminded neighbors to sign up for irrigation audits and gave tips on how to protect the watershed at home (see appendix K).</p>	<p>07/01/18</p>
<p>A fall article was issued in the Harvey Park newsletter and via social media telling residents how to use features on their clocks to reduce watering for the late season (see appendix L).</p>	<p>08/16/18</p>
<p>Task 6: Post-BMP Visual Evaluation: Conduct follow-up visual inspections at residences that received irrigation improvements to evaluate if they are still functioning and administer post audit survey.</p>	
<p>Anticipated Product 12: Updated notes and maps indicating which homes that received irrigation improvements are still in alignment.</p>	
<p>Actual Product</p>	<p>Date</p>
<p>List of residences that received audits is attached. Phone surveys were conducted in lieu of visual evaluations.</p>	<p>07/01/18-09/30/18</p>
<p>Anticipated Product 13: Post-audit survey, survey results, and analysis including changes in knowledge and behaviors regarding irrigation overspray and nonpoint source pollution.</p>	
<p>Actual Product</p>	<p>Date</p>
<p>Post audit surveys completed (see appendix M).</p>	<p>09/30/18</p>
<p>Objective 2: Install structural BMP to improve recreational use attainment in Denver reach of Lower Bear Creek.</p>	
<p>Objective 3: Monitor water quality in Lower Bear Creek prior to and after implementation of the structural BMP (Denver) and irrigation overspray adjustments (Groundwork Denver).</p>	

<p>Task 7: <i>E. coli</i> Monitoring, Evaluation and Data Management: Collect <i>E. coli</i> water quality data to help evaluate effectiveness of non-structural and structural project BMPs (structural BMP constructed by Denver as part of project match).</p>	
<p>Anticipated Product 14: WQCD-approved SAP for monitoring conducted by Groundwork Denver staff.</p>	
<p>Anticipated Product 15: <i>E. coli</i> monitoring data: <i>E. coli</i> monitoring data distributed to current and future partners, made available on the Groundwork Denver website and uploaded to STORET.</p>	
<p>Anticipated Product 16: Comparative analysis of BMP effectiveness. We will document the reduction in 60 day rolling average in-stream <i>E. coli</i> data for each BMP. Percentage reduction in 60 day rolling averages for each BMP will be the measure of comparison for each BMP.</p>	
Actual Product	Date
<p>The SAP was approved for <i>E. coli</i> Monitoring.</p> <p>Samples were collected from 1 to 4 times per month at 13 sampling locations August 2015 through December 2016.</p> <p>Samples were analyzed at a laboratory at Metro State University.</p>	<p>8/15/15-12/31/16</p>
<p>Samples were collected 4 or 5 times each month for a total of 13 sample dates between July and September 2017.</p> <p>Results are available to watershed partners via Dropbox.</p>	<p>07/01/17-09/30/17</p>
<p>Samples were collected 4 or 5 times each month for a total of 13 sample dates between October and December 2017. Results are available to watershed partners via Dropbox.</p> <p>Samples were analyzed at a laboratory at Metro State University and at the EPA Region 8 Laboratory.</p> <p>Groundwork Denver staff applied for STORET credentials in March and did not receive a response from the EPA.</p>	<p>10/01/17-12/31/17</p>
<p>Samples were collected 4 times each month for a total of 9 sample dates between April 1 and June 30.</p> <p>Results made available to watershed partners via Dropbox.</p> <p>Applied March for STORET credentials, did not receive a response from the EPA.</p> <p>Samples were analyzed at a laboratory at Metro State University and at the EPA Region 8 Laboratory.</p> <p>One new staff member was trained in <i>E. coli</i> sampling, processing samples, and reading samples in June 2018.</p>	<p>04/01/18-06/30/18</p>

<p>Samples were collected 4 times each month for a total of 9 sample dates between July 1 and September 30.</p> <p>Results are available to watershed partners via Dropbox.</p>	<p>07/01/18-09/30/18</p>
<p>Task 8: River Watch Monitoring, Evaluation and Data Management: River Watch Monitoring, Evaluation and Data Management: Collect metals (monthly), nutrients (high flow in spring, low flow in winter) and macroinvertebrates (collected once per year based on Aquatic Life Use Attainment policy prepared by the WQCC) samples (River Watch).</p>	
<p>Anticipated Product 17: River watch samples conducted monthly</p>	
<p>Actual Product</p>	<p>Date</p>
<p>River Watch samples were collected each month from August 2015 through December 2016, except April and May 2016.</p>	<p>8/15/15-12/31/16</p>
<p>River Watch samples were collected once in August and once in September during the reporting period.</p>	<p>07/01/17-09/30/17</p>
<p>River Watch samples were collected once in October, November, and December during the reporting period.</p>	<p>10/01/17-12/31/17</p>
<p>River Watch samples were collected once in January, February, and March, during the reporting period.</p>	<p>01/01/18-03/31/18</p>
<p>River Watch samples were collected once in April, May, and June, during the reporting period. June dates were completed in conjunction with the Groundwork Denver Blue Team. High school youth participated in the collection, titration, and reading of samples. All youth live in the Bear Creek watershed and understand and can articulate the impacts and causes of nonpoint source pollution.</p>	<p>04/01/18-06/30/18</p>
<p>River Watch samples were collected once in July, August, and September during the reporting period. All dates were completed in conjunction with the Groundwork Denver Blue Team. High school youth participated in the collection, titration, and reading of samples. All youth live in the Bear Creek watershed and understand and can articulate the impacts and causes of nonpoint source pollution. Youth had the opportunity to travel to Western Colorado for a week-long training on how to collect River Watch water samples. The training was put on by CO Fish and Wildlife, which also manages the River Watch program.</p>	<p>07/01/18-09/30/18</p>
<p>Task 9. Trash survey: Collect information about the presence, type and quantity of trash at outfalls impacted by the non-structural BMP.</p>	
<p>Anticipated Product 18: WQCD-approved SAPP based on the City and County of Denver trash survey protocols.</p>	
<p>Anticipated Product 19: Pre and post BMP implementation trash survey data and analysis of those data as they relate to the non-structural BMP.</p>	
<p>Actual Product</p>	<p>Date</p>
<p>Trash Inventory SAPP was drafted and circulated to stakeholders.</p>	<p>09/16/16</p>
<p>Pre-BMP trash survey completed.</p>	<p>10/16/17</p>
<p>Objective 4: Project Administration, Reporting, Financial Management.</p>	

Task 10: Reporting, Communication and Financial Management: Conduct project management and communication, and financial oversight with clarity and consistency.	
Anticipated Product 20: Progress, semi- annual, and final report.	
Anticipated Product 21: Financial reports submitted with draw-down requests.	
Actual Product	Date
Progress report for 7-1-2017 through 9-30-2017 submitted.	07/01/17-09/30/17
Progress report for 10-1-2017 through 12-31-2017 submitted.	10/01/17-12/31/17
Progress report for 01-1-2018- 03-31-2018 submitted.	01/01/18-03/31/18
Progress report for 04-01-2018 to 06-30-2018 2018 submitted.	04/01/18-06/30/18
Semi-annual report for 07-01-2018 to 12-31-2018 submitted.	07/01/18-12/31/18

Note: 319 funds did not pay for any of the sampling or other activities prior to the start and approval of the SAPP.

2.2 Evaluation of Goal Achievement and Relationship to State NPS Management Plan

The Environmental Goal of this project was to reduce nonpoint source pollution loading of *E. coli*, nutrients, and trash in Bear Creek and to test the effectiveness of the structural and non-structural BMPs for future implementation with the goal of removing Lower Bear Creek from the 303 (d) and Monitoring and Evaluation lists. Data from five years of continuous in-stream sampling shows that *E. coli* levels in Bear Creek did not recede due to either of the BMP implementations. In fact, *E. coli* levels in 2018 increased in Bear Creek, likely due to decreased water levels in a year with low snow pack. However, by percentage, *E. coli* increased less below the structural BMP than the non-structural runoff reduction BMP. The confounding factors mentioned above make this inconclusive, but the difference is significant, and outside of a standard deviation at the structural BMP. Groundwork Denver successfully implemented, or oversaw the implementation of, both BMPs in the affected watershed.

The project contributed to controlling nonpoint source pollution as a part of an integrated watershed-wide approach by:

1. Increasing the number and diversity of participants throughout the watershed who are invested in working to reduce nonpoint source pollution in the community.
2. Increasing public awareness about nonpoint source pollution sources and pollutants (see appendix O).
3. Building relationships and trust between residents and NPS solution driven participants through the process of evaluating two BMPs for efficacy.
4. Inspiring and empowering young, local environmental leaders.

Forty-seven percent (47%) of residents living in the watershed reported that they were unaware that water containing nonpoint source pollution from their property is not filtered or cleaned before entering the creek. Through canvassing, events, and publications, Groundwork Denver

increased the community's awareness of habits that influence watershed health and changes that can be made at home. As a result of the project, residents living in the watershed became empowered with the information they needed to decrease harmful activities, become "clean water partners," and create a healthier community.

Groundwork Denver has led four summers of the "Blue Team," a youth employment program specifically focused on watershed health around Bear Creek. The Blue Team participated in the labor for the structural BMP, canvassed over 7,000 homes, interacted with over 2,400 community members through neighborhood events, and led events to educate the community about home solutions that decrease nonpoint source pollutants. They engaged with residents, peers, and even young children in both English and Spanish, working to raise awareness and educate the community about their role in contributing to nonpoint source pollution, as well as the role they can play in the solution. In short, Groundwork Denver's hands-on work with the community has had a marked impact on public trust in city, state, and non-profit participants working to improve the water quality of Bear Creek. Groundwork Denver's multimodal outreach strategies have engaged diverse residents in the impacted neighborhoods, many of whom have not historically been part of the solution to environmental degradation in their communities, and key community stakeholders in conversations about potential solutions for Bear Creek and for broader issues of environmental health.

2.3 Supplemental Information

Additional milestones that demonstrate the progress made relevant to the proposed work since Groundwork Denver's involvement began in the early 2000's include:

- Early 2000's: Groundwork Denver Green Teams assist with invasive species removal along Bear Creek.
- 2010: Lower Bear Creek stretch of water listed for *E. coli*.
- 2012: CDPHE funds Groundwork to create Nonpoint Source Watershed Plan; Water Quality Sampling Program established with help from EPA Region 8 & Metro State University Biology.
- 2014: Watershed residents, environmental scientists, and other partners submit Nonpoint Source Watershed Plan.
- 2015: Stormwater Managers from Lakewood, Denver, and Sheridan unite to form Alternative Plan.
- 2016: Lakewood sites removed from listing.
- 2017: New project designed to establish human-specific pollution contributions to Bear Creek including Sucralose and Bacteroides.

3.0 BEST MANAGEMENT PRACTICES DEVELOPED AND/OR REVISED

3.1 Best Management Practices

Groundwork Denver received 2015 Nonpoint Source Implementation funds from the Water Quality Control Division to compare water quality impacts from one structural BMP and one non-structural BMP in the reach of Bear Creek that flows through Denver. The structural BMP was implemented on the north side of Bear Creek near Kennedy High School, and maintained by Denver Parks and Recreation. The non-structural BMP was managed by Groundwork Denver and focused on irrigation overspray and runoff reduction nonpoint source pollution in the Harvey Park/Harvey

Park South neighborhoods. Ongoing water quality monitoring provides data on the relative improvements of each BMP on the reduction of *E. coli* and nutrients.

Structural BMP:

Denver Parks and Recreation began a turf replacement BMP in early November of 2017. Turf was replaced by Denver Parks and Recreation in Bear Valley Park between the roads South Ivan Way and South Golden Way along West Dartmouth Avenue. The work was carried out between the trail rolling through the park and Bear Creek. The project included removing 0.65 acres of Kentucky bluegrass for replacement with taller native grasses. The intent was to slow water running through the turf and utilize native plants that have an increased capacity to take up excess nutrients and other contaminants. The project was completed on November 2017 and is being maintained by Denver Parks and Recreation. Results show that it had no effect on *E. coli* levels directly downstream.



Figure 1: Completion of structural BMP

Non-structural Maintenance BMP:

Groundwork Denver carried out 84 irrigation audits between July 2017 and October of 2018. The hypothesis was that high volumes of irrigation runoff on the steep slopes of Harvey Park was contributing to creek contamination including *E. coli*, nutrients, trash, oil, and other contaminants. To reduce the runoff, Groundwork Denver employees were trained to visually inspect and manually repair sprinkler systems that were spraying or leaking water into the streets and storm drains. Many of the repairs included a simple tweaking of spray direction to reduce overspray, while some more involved repairs required replacements of sprinkler parts. Throughout the process, residents were surveyed about their water and land use habits and educated about how their actions can affect Bear Creek, as well as what they can do to be a “clean water partner.” Residents reported high

levels of satisfaction with the program, and the relationships and education that were expanded have high value for future projects and creek health.

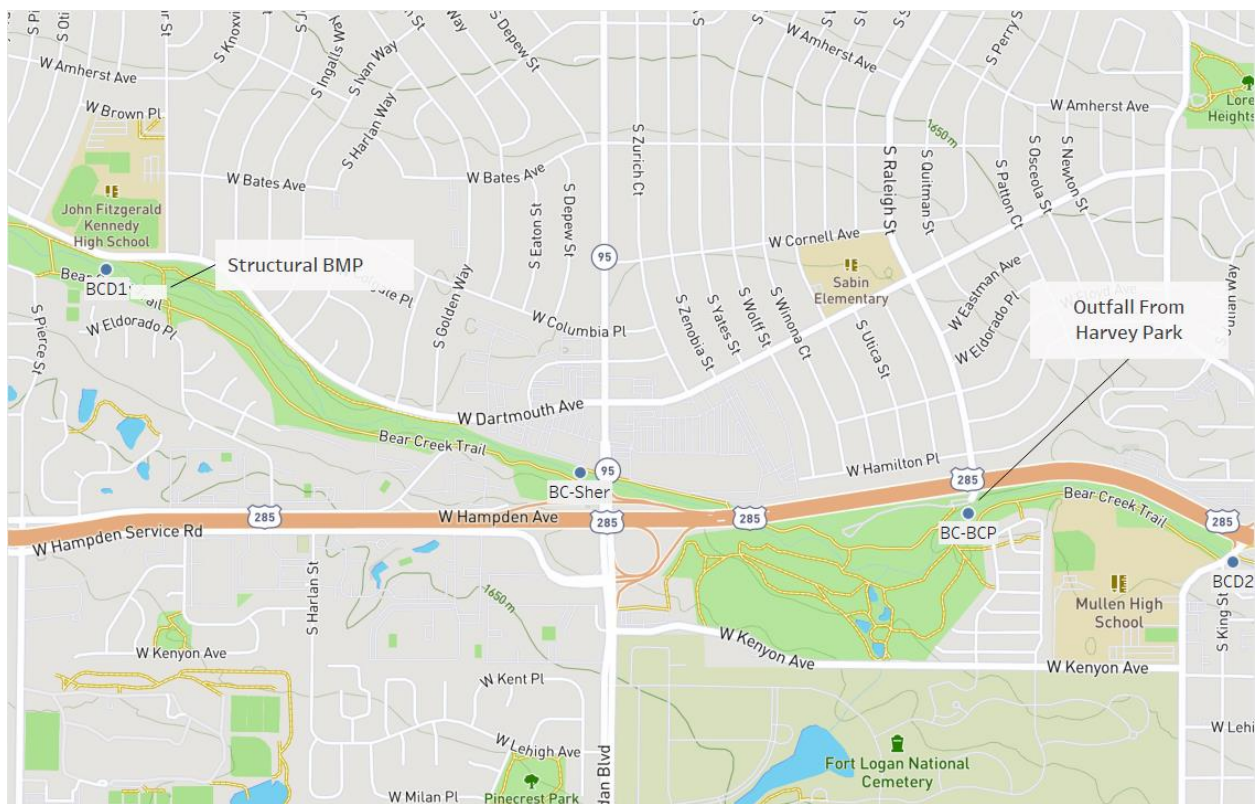
3.2 Detailed budget of how 319(h) dollars were spent

See appendix P for final budget table.

4.0 MONITORING RESULTS

4.1 BMP effectiveness evaluations

Groundwork Denver has sampled the stretch of Bear Creek below Bear Creek Reservoir since May of 2013. The sampling is carried out two times per month October through April and four times per month May through September. Sites are sampled for *E. coli*, Total Coliform, Oxidation Reduction Potential, Dissolved Oxygen, Turbidity and Specific Conductance. This report will reference data gathered directly upstream and downstream of two separate BMPs between the months of May and October 2018 to determine their impacts on water quality in the vicinity of the BMP. A map below identifies the relevant sites.



Map 7

Generally, water quality parameters along Bear Creek were more degraded in 2018 when compared with 2017, the year both BMPs were initiated. A portion of this can be attributed to lower flows leaving Bear Creek reservoir and larger portions of the total volume of water at sites tested for water quality coming from drainage/nonpoint sources. This confounds data analysis. The table

below calculates average flow in cubic feet per second (CFS) from drainage using the difference in flow from the Bear Creek Outfall and the site BCD2 on Bear Creek at Knox Ct.

All flows averaged in CFS		
Site	Before BMP	After BMP
BCD2 (at Knox Court)	45.00	27.75
Bear Creek Reservoir Outfall	37.42	14.94
Calculated flow from Drainage	7.58	12.81

Table 3

Below are graphs showing rolling 60 day averages for *E. coli* at each BMP. Year over year *E. coli* concentrations are higher in 2018 than 2017, before the BMPs were enacted. *E. coli* results above 2419.6 cells/100mL (the upper detection limit of the test) were listed with a result of 3000 cells/mL for calculation purposes.

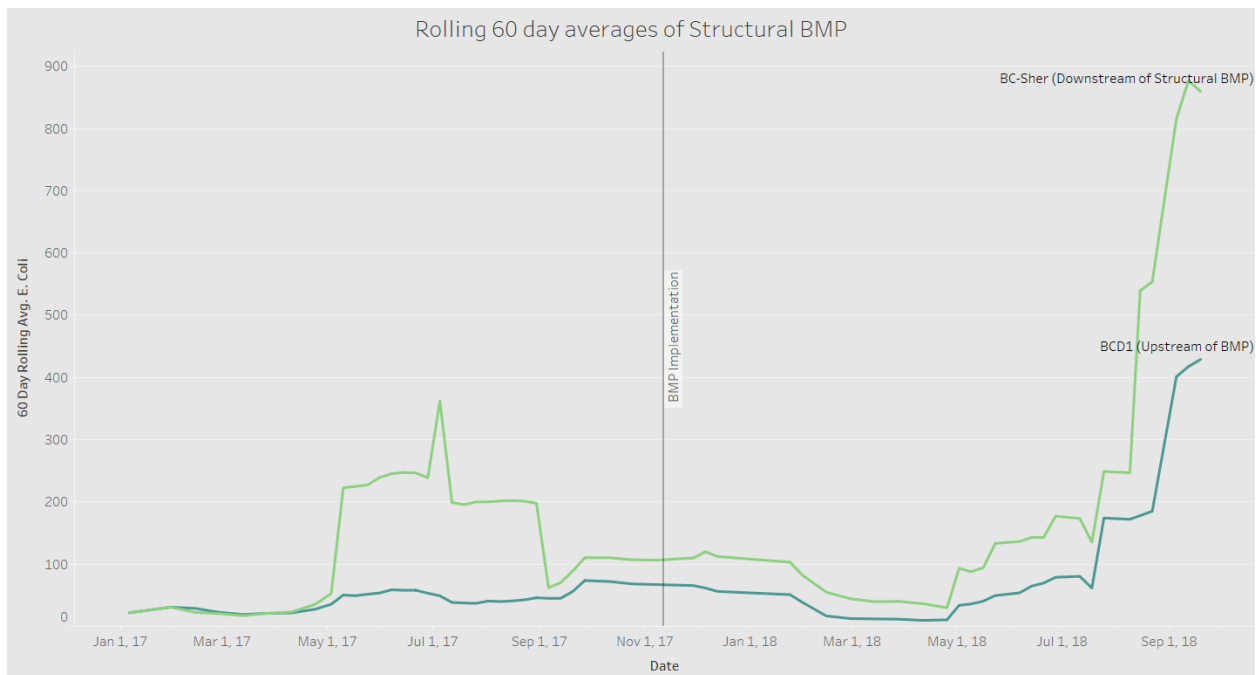


Figure 2

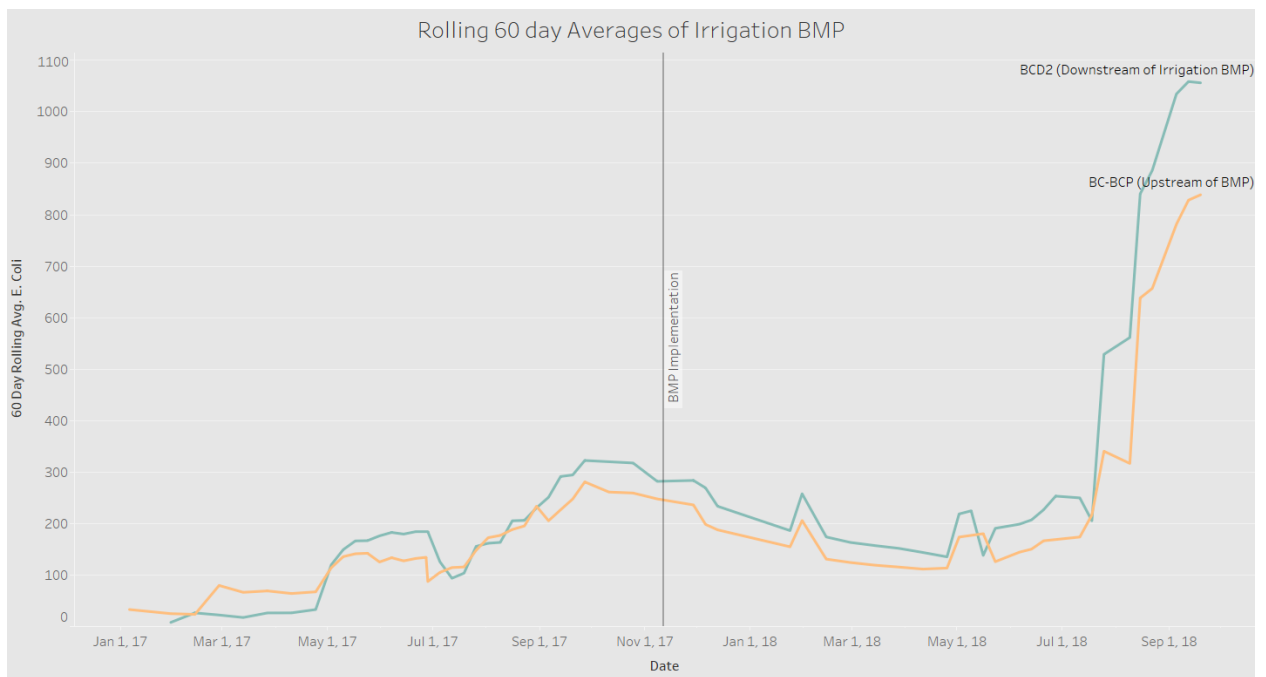


Figure 3

4.2 Surface water improvements

Below, average E. coli are compared for both BMPs.

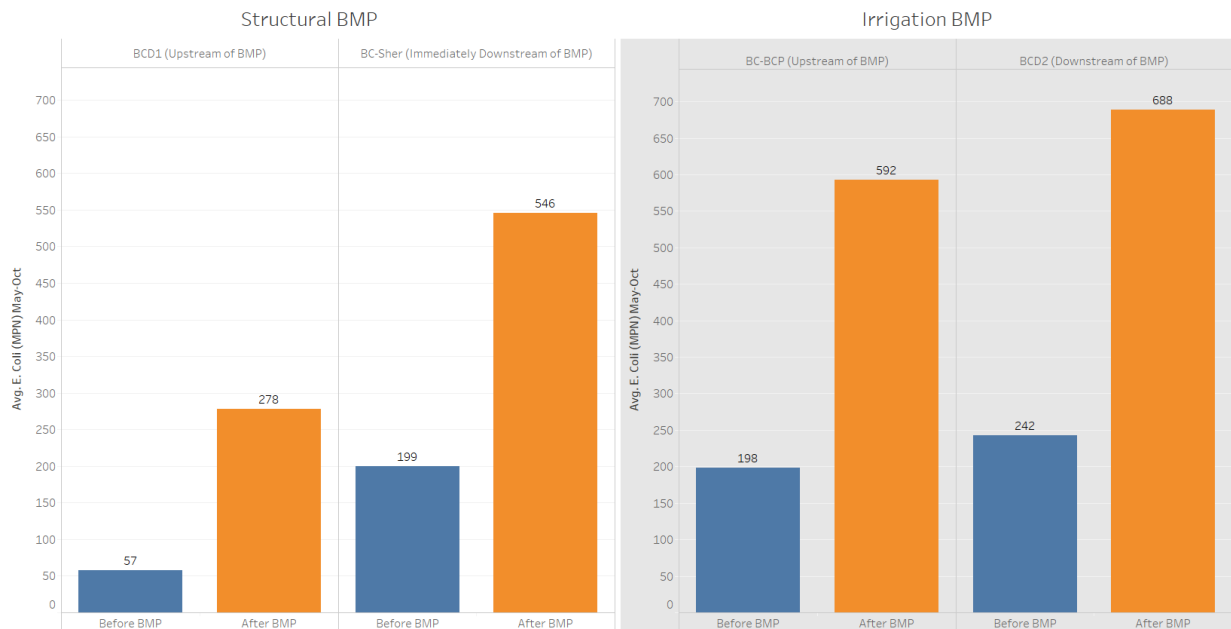


Figure 4

To determine the effectiveness of each BMP sites positioned upstream and downstream of each individual BMP were used for reference. The upstream site acts as control in that it should be unimpacted by BMP work. Then the average change year over year at the upstream site can be used to determine the impacts of the BMP. If the BMP had no effect one would expect the year over year change in *E. coli* to be nearly identical at both sites. Below, we calculated the percentage *E. coli* increased from the year before and after the BMP at the relevant sites using results from May - October which yield more variability in *E. coli*.

Site	Percent Average Increase of <i>E. coli</i>
BCD1 (Upstream of structural BMP)	488
BC-Sher (Immediately Downstream of structural BMP)	274
BC-BCP (Upstream of non-structural runoff reduction BMP)	122
BCD2 (Downstream of non-structural runoff reduction BMP)	116

Table 4

By percentage, *E. coli* increased less below the structural BMP than the non-structural runoff reduction BMP. The confounding factors mentioned above make this inconclusive, but the difference is significant, and outside of a standard deviation at the structural BMP. Going forward, the best way to measure BMP impacts would be at point of use by sampling runoff from the proposed area before and after the BMP emplacement.

To summarize, water quality results in the year after each BMP emplacement were significantly impacted by lower portions of the stream’s makeup coming from Bear Creek Reservoir. As a result, *E. coli* measurements increased stream wide, so using analytics like rolling averages would not be useful to determining the impacts of a BMP. Still, using average rates of year over year *E. coli* increase it appears the structural BMP had a larger impact than irrigation audits.

4.4 Groundwater improvements

This section is not applicable to the funded project.

4.6 Quality assurance reporting

Sampling is carried out using an EPA approved SAPP and QAPP. Monitoring was consistent with the SAPP and QAPP.

5.0 COORDINATION EFFORTS

5.1 Coordination from Other State Agencies

This section is not applicable to the funded project.

5.2 Other State Environmental Program Coordination

This section is not applicable to the funded project.

5.3 Federal Coordination

US Environmental Protection Agency (EPA):

E. coli water quality monitoring was supported by the EPA Region 8 Water Quality Unit and Lab and the MSU Biology Department. Both EPA and MSU have been partnering with Groundwork Denver since the watershed planning process began in 2013. The MSU lab and students conducting analysis were reviewed by the EPA Laboratory staff in December 2014 and met the requirements for laboratory analysis of *E. coli*. Groundwork Denver staff and MSU students conducted water quality monitoring bi-monthly throughout the year. Relevant training and field techniques for samplers were provided by EPA Water Quality Unit staff. Field parameters including temperature, pH, dissolved oxygen, and conductivity were recorded for *E. coli* sampling. Temperature, pH, dissolved oxygen, alkalinity, and hardness were recorded for River Watch sampling. Photographs were taken upstream, downstream, and as the samples are being collected at each site. *E. coli* load reduction estimates were not included in the Nonpoint Source Watershed Plan submitted to the WQCD in October 2014 because of lack of water quality and flow data. The accumulation of sufficient data, as well as discussions with TMDL staff at EPA Region 8, will inform the creation of these estimates.

US Fish and Wildlife Service River Watch:

River Watch Monitoring was conducted each month and supported state-wide water quality assessment and prioritization conducted by the Water Quality Control Commission (WQCC) and the Water Quality Control Division. Water samples were analyzed by Groundwork Denver staff, youth employees, and volunteers for hardness, alkalinity, and dissolved oxygen. River Watch scientists perform analyses of metals (monthly), nutrients (high flow in spring, low flow in winter), and macroinvertebrates (collected once per year based on Aquatic Life Use Attainment policy prepared by the WQCC). Data was entered into the River Watch database monthly and is publicly available at ColoradoRiverWatch.org when approved by River Watch staff. Groundwork Denver collected samples at two locations along Lower Bear Creek for over five years to provide baseline data for metals and nutrients, and to provide water quality data.

Youth from the Bear Creek watershed participating in River Watch through Groundwork Denver's youth employment program were able to attend a five-day training in Cedaredge, Colorado. There, they increased their knowledge of Colorado water systems and became confident in their ability to run and teach the EPA approved River Watch sampling methodologies. Youth were also able to try electrofishing and hold live fish for the first time.



FIGURE 5: Youth participating in water sampling.

5.4 USDA Programs

This section is not applicable to the funded project.

5.5 Accomplishments of Agency Coordination Meetings

Through the planning process for the “Lower Bear Creek Watershed Plan,” a group of stakeholders evolved into a collaborative that spans three municipalities (Lakewood, Denver, and Sheridan), and includes Groundwork Denver, MSU, and River Watch. This collaborative has been testing and sharing data since 2013. In exchange for water quality data, Sheridan, Lakewood, and Denver provide funding for water sampling. MSU and River Watch provide lead researchers, training, and supplies. MSU, Denver Water, the EPA, and River Watch analyze collected samples. The project also coordinated with and was supported by the Denver Department of Public Health and Environment and Denver Parks and Recreation. Both of these City Agencies were represented on the steering committee for the Lower Bear Creek Watershed Plan.

In 2015, the cities of Lakewood, Denver, and Sheridan, the Colorado Department of Transportation, as well as Colorado’s Water Quality Control Division and Groundwork Denver, joined together to create an Alternative Plan for water quality restoration for the impaired reach of urban Bear Creek near Denver, Colorado. The group designated itself the Lower Bear Creek Watershed Association (LBCWA). Coordinating efforts and resources to achieve in-stream water quality standards for Segment 2 of Bear Creek aligns with the recommendations provided by the US EPA in the Integrated Reporting and Listing Decisions memorandum released in August of 2015.

The Alternative Plan for water quality restoration will be an Addendum to the 2014 Nonpoint Source Watershed plan for urban Bear Creek. This plan was coordinated by Groundwork Denver and created with input from watershed residents as well as water quality professionals from Lakewood, Denver, Sheridan, Urban Drainage and Flood Control District, Trout Unlimited, and adjacent watershed groups. This project was born out of conversations of this association. Additional conversations with Denver Water’s conservation group occurred during the reporting period. Denver Water agreed to share 2016 block level water usage for Harvey Park. Using this data, Groundwork Denver was able to more thoroughly assess usage in Harvey Park South, as well as estimate the impact irrigation audits may have on storm water runoff and associated pollution.

5.6 Resources/Coordination from Federal Land Management Agencies

This section is not applicable to the funded project.

5.7 Other Sources of Funds

Cash match was provided by Groundwork Denver. Non-cash match for this project was provided by Metro State University and River Watch.

Source	Cash Match	Non-cash Match	Rate	Number/Units	Total Match
Metro State University		Volunteers for Data Collection	\$25.96/hr	2,175 hours	\$56,446.72
Metro State University		Sample Supplies	\$6.86/sample	1,870 samples	\$12,828.20
Metro State University		Value of Lab Analysis	\$22.00/sample	1,870 samples	\$41,140.00
River Watch		Volunteers for Data Collection	\$25.96/hr	286 hours	\$7,424.56
Groundwork Denver	\$25.58				\$25.58
Total Match					\$117,865.06

Table 5

6.0 SUMMARY OF PUBLIC PARTICIPATION

Groundwork Denver is a community-based organization that specializes in public involvement in environmental improvement projects. Through the watershed planning efforts Groundwork Denver has been engaged in for the last five years, it has developed a network of community constituency leaders within the watershed, including leaders of community-based organizations, youth-serving organizations, faith-based organizations, neighborhood associations, environmental organizations, and professional organizations. This network of leaders was engaged in the development of the watershed plan. Groundwork Denver informed these constituents about the project through meetings as well as ongoing opportunities for volunteering and education in the watershed. Groundwork Denver utilizes local media (newsletters, newspapers, websites, and social networking sites) to further engage the public.

Public involvement in the selected sub-drainage basin was essential to the success of the overspray BMP. Groundwork Denver conducted door-to-door outreach and asked for direct community involvement in reducing overspray, canvassing the entire neighborhood three times over two years. Neighbors were left with informational flyers, door hangers, and were engaged face-to-face in conversation. The project acknowledged and addressed the importance of incentivizing participation and valuing people's time. With time and experience, Groundwork Denver's tactics shifted, and each canvasser had their own approach. Emphasizing the source of funding was

important, as it was difficult for community members to believe that anything could be “free.” Thus, Groundwork Denver stressed the fact that that this was a program paid for by CDPHE aimed at protecting watershed health.

Public involvement also played a role in the implementation of the structural BMP. Groundwork Denver and Denver Parks and Recreation hosted public information meetings, gaining the support and partnership of District 2 Councilman Kevin Flynn in the process. These meetings were used to explain the purpose of the BMP, to educate nearby residents how they impact nonpoint source pollution, and to accept input into the ultimate design of the BMP. A volunteer tree planting along the banks of Bear Creek engaged residents and neighbors in the process of increasing watershed health and local ownership over the issue.

By hiring a program manager from the Harvey Park community, Groundwork Denver was able to provide local employment and access local networks of communication. The NextDoor and Facebook social media sights played an integral role in getting the word out to diverse groups of neighbors, and also increased the amount of trust canvassers were met with at the residents’ doors.

Groundwork Denver found an ally in the Harvey Park Sustainability team, which played an active role in the project through volunteerism and conversation on social media. The Sustainability Team is a sub-group of the non-profit neighborhood government organization called Harvey Park Community Organization. Access to free media through the Harvey Park Community Organization newsletter helped get the word out through a trusted neighborhood resource.

Additionally, Councilman Kevin Flynn has been a strong ally in environmental health, and supported the project by supplying food for community meetings and publishing articles written by Groundwork Denver about the creek health in his quarterly newsletter. Councilman Flynn’s newsletter drastically reduced cost and increased audience for public outreach, as it was delivered by hand to over 20,000 residents.

7.0 ASPECTS OF THE PROPOSAL THAT DID NOT WORK WELL

Along with the successes of the project, especially in effectively testing the efficacy of the BMPs, came a number of challenges, highlighting areas that did not work well. First, neither of the projects contributed significantly to reducing *E. coli* in the creek. This may be due to an unknown source that cannot be relieved with either BMP tested. Additionally, visual inspections of each completed audit were not completed at the end of the auditing season. Instead, staff asked residents to self-report sprinkler function during the end of the season survey. This deliverable was not completed for two reasons: 1) returning to each house would take far more staff time than anticipated, and far more staff time than was available at the end of the season; and 2) the Groundwork Denver’s Program Director left the organization to pursue other opportunities shortly after the end of the 2017 season. Before her replacement could learn all of the deliverables of this grant, winter had already arrived and sprinklers were closed down for the season.

In addition, one hinderance to meaningful data interpretation was the late implementation of the structural BMP. Denver Parks and Recreation was not able to put in the sod replacement until November of 2017, rather than earlier in the summer as anticipated. This meant that water quality data gathered by Groundwork Denver was not useful for BMP comparison until spring of 2018,

when the new grasses sprouted and took root. Instead of three seasons of data comparison, Groundwork Denver was only able to compare water quality data from the summer of 2018. Finally, geometric means were not shared on the Groundwork Denver website because calculations will be verified by MS4 managers later this year.

Groundwork Denver was not able to complete the post-BMP trash survey and analysis due to two staff transitions at the end of 2017. Moving forward in the next phase of our program, we plan to implement trash surveys seasonally to gather ongoing data. Data from the trash surveys will inform future strategies for trash reduction (i.e. increase trash cans around the local fast food restaurant, explore adding signage to reduce trash from passing vehicles, etc.).

8.0 FUTURE ACTIVITY RECOMMENDATIONS

Groundwork Denver will continue to work on nonpoint source pollution in the Bear Creek watershed. By leveraging Groundwork Denver's Blue Team program, which employs local youth to work on and engages residents in stewardship activities, the project will continue as youth conduct education, outreach, green infrastructure installations, clean ups, and monitoring focused on improving the water quality of Bear Creek. With funding from the National Fish and Wildlife Foundation, Groundwork Denver will continue efforts that address the environmental goals of the "Lower Bear Creek Watershed Plan" (2014), including reducing nonpoint source concentrations of *E. Coli* and investigating potential pollution contributions in Lower Bear Creek while providing low-income youth of color with green job training, leadership development, and a pathway to green careers and economic opportunity.

Groundwork Denver will shift its priorities to place a greater emphasis on community education and individual home improvements. In addition to irrigation audits, young people will engage the community through neighborhood door-to-door outreach, rain barrel workshops and installations, and community stewardship events. These activities will be communicated to 5,000 local community members, engage at least 210 volunteers, and sustain and create 34 seasonal positions for local-area youth who will conduct water quality monitoring, restoration work, and residential runoff capture improvements. The monitoring is along an 8-mile section of Bear Creek at 15 sites. The restoration efforts will be within the urbanized section of Bear Creek, restoring 50 acres of watershed and 4 miles of riparian area. The residential runoff reduction improvements will capture 60,720 gallons of water, and sprinkler improvements (conducted by staff or contractors) will reduce runoff by 29,250 gallons. Calculations were made using 1 gallon per minute (gpm) of water saved per audit carried out and multiplying by the number of minutes a system would be running during a week. One (1) gpm was a conservative estimate given the extent of some of the repairs.

The youth employees play an integral role in this project. Groundwork Denver's Green Team program addresses community priorities by providing paid employment to local youth within their community that includes science education, outdoor stewardship, recreation, and future employment opportunities. Personnel from the partners help train, work with, and develop impactful activities for these low-income, high-needs youth. During Groundwork Denver's 2017 project, almost two-thirds of youth employees were members of very low-income families earning less than 30% of the area median income. Almost all of the participants (96%) were youth of color, and all come from Sheridan High School.

Addressing a high priority of the community, the project will provide green jobs training and direct economic opportunity for 34 low-income youth. At the same time, this project will bring immediate

benefits to these communities which include: increasing awareness of the waterway and water quality as a result of outreach to 5,000 area households; helping residents implement runoff reduction improvements through 60 rain barrel installations and 50 sprinkler audits/repairs; working on cleaning up and restoring the riparian habitat along Bear Creek by engaging 210 community volunteers; and ultimately, improving water quality in Bear Creek.

Literature Cited

See appendix Q for research cited.

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