SECTION 319 NONPOINT SOURCE POLLUTION CONTROL PROGRAM ASSESSMENT PROJECT FINAL REPORT DRAFT

GRASS, ENOS, AND LEFT HAND CREEK NONPOINT SOURCE REDUCTION PROJECT PHASE III: Using Cooperative Grazing Management to Reduce Sediment Loading and Improve Riparian and Aquatic Habitat
PROJECT NO. NPS2013B

by

The Nature Conservancy
NW Wyoming Program
Cody, Wyoming

December 2016

This project was conducted in cooperation with the State of Wyoming Department of Environmental Quality, United States Environmental Protection Agency Region 8, Natural Resource Conservation Service, Bureau of Land Management, and the LU Ranch.

Grant No.: C900863013

1.0 Executive Summary

PROJECT TITLE: GRASS, ENOS, AND LEFT HAND CREEK NONPOINT SOURCE REDUCTION PROJECT – III: Using Cooperative Grazing Management to Reduce Sediment Loading and Improve Riparian and Aquatic Habitat

PROJECT START DATE: Aug 13, 2013 PROJECT COMPLETION DATE: Dec. 31, 2016

Table 1. Project Budget Summary

Total 319 or 205(j) Funds Awarded	$100,000.00
Total 319 or 205(j) Funds Expended	$100.000.00
Total Nonfederal Match Commitment	$67,820.00
Total Nonfederal Match Expended	$80,896.48
Total Project Budget	$167,820.00
Total Project Expenditures	$180,896.48

SUMMARY OF ACCOMPLISHMENTS:

Launched in 2008 with BMP implementation initiated in 2010, this project aimed to reduce sediment loading and mean temperatures in project area streams, and to maintain or improve riparian and aquatic habitat through the implementation of livestock Best Management Practices (BMPs). Project and administrative costs stayed within budget in Phase III and we significantly exceeded most BMP implementation goals. We decided against expanding water quality monitoring into new drainages in Phase III after discovering that many of the streams in the BMP implementation area were ephemeral.

In Phase III, we developed 7 springs, laid 8 miles of pipeline and installed 23 water tanks (significantly exceeding our goal to develop 3 springs, 5 miles of pipe and 7 tanks). These new water systems directly impact 11,740 acres of rangeland and riparian areas. We also removed conifers encroaching on riparian and spring sites on 265 acres (exceeding our goal to remove 10 acres of conifers), and we removed over 10 miles of wildlife-unfriendly fences. The spring protection fences planned in Phase III were completed in Phase II.

Water quality monitoring and BMP modeling revealed significantly reduced bank erosion on project area streams where BMPs were implemented. For the six-year period between 2010-2015, we estimate that sediment loading in Grass Creek has been reduced by an estimated 1,779.3 tons/yr. Over the same six-year period, sediment loading on Little Grass Creek was reduced by an estimated 401.9 tons/year, and on Left Hand Creek reductions reached 107.6 tons/year. In all, we estimate that between 2010 and 2016, erosion into project area streams was reduced by 2,368,6 tons/year, nitrogen was reduced by 2,051.0 lbs/year and phosphorus was reduced by 272.6 lbs/year.

We also observed improvements in range condition, aquatic macroinvertebrate diversity and abundance, average pebble size, and the prevalence of bare ground.

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2.0 Background

Over the past decade, landowners throughout the Cottonwood and Grass Creek watersheds have made significant strides to protect the resources within their watersheds. In 2004, the landowners formed the Cottonwood Creek/Grass Creek Coordinated Resource Management group (CRM), which sought to address invasive species control. In 2006, the group received a $300,000 grant to conduct a Level I Watershed Management Plan study, which was completed in 2007. The study revealed both watersheds as having been significantly grazed by domestic livestock in the late 1800s, significantly degrading the rangeland. In 2007, the CRM became formally organized as the Cottonwood/Grass Creek Watershed Improvement District (WID). In 2010, the WID completed a Level II watershed study to assess water storage challenges and opportunities in the region.

The Level I study concluded that the Cottonwood and Grass Creek watersheds were heavily grazed by domestic livestock (both cattle and sheep) in the late 1800s, and that the rangeland suffered significant degradation and damage during that time. Though some areas within the watersheds have substantially recovered, many remain significantly damaged and degraded. While changes in range management have yielded improved ecological range conditions ranging from "high fair" to "good," riparian zones continue to be damaged by wildlife and livestock relying on these areas for water, feed values, and cover. Riparian zones within the watersheds continue to exhibit geomorphic stream instability and high rates of in-stream sedimentation, with the Level I report noting that:

> The single most important factor needed to facilitate improved grazing management and thereby achieve the associated benefits to the watershed is well-distributed, reliable livestock water. In addition to restoration of more healthy conditions in currently impacted riparian areas, continuing improvements in overall range management will contribute to the maintenance, recovery or improvement of a variety of interrelated aspects of watershed function, including but not necessarily limited to:
>
> - Improved infiltration of snowmelt and rainfall;
> - Retention of soil moisture;
> - Groundwater recharge;
> - Sustained release of soil moisture and groundwater as seeps/springs; and
> - Stabilization of soils against erosion into streams.

WDEQ classifies the entire length of Grass Creek as a Class 2AB stream, with designated uses for "drinking water supplies, non-game fisheries, cold-water fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic values" (WDEQ 2010). WDEQ has four existing monitoring stations on Grass Creek (WB36, WB37, WB38, and WB186); these stations were sampled in 1998, 2003 and/or 2005.

When last monitored, the upstream stations on Grass Creek (WB37 and WB38) appeared to be in better condition than the lower stations, but the upper reaches of Grass Creek are not without problems, only ranking "fair" biologically. In 2005, WDEQ reported that the creek generally suffered from unstable banks and down-cutting: "The unstable banks appear to be due to lateral

movement of the channel in response to historic land uses…in 2003, a lower than expected habitat score was attributed to pool substrate comprised of fine particles (sand, mud, clay), elevated sediment deposition, marginal channel sinuosity, and a narrow riparian zone width." The reach above the first major irrigation canal in NENE of Sec. 23, T46N, R99W, just upstream of the oil field, was supporting aquatic life uses (Category 2). The downstream stations, near the Grass Creek oil field and Highway 120, were in poor to very poor condition biologically (WY DEQ 2005). Downstream of the irrigation diversion, aquatic life uses were not supported due to flow alterations (Category 4C) (WDEQ 2003; 2005).

Primary land uses in the Grass Creek watershed are livestock grazing and mineral development, with irrigated agriculture being a secondary land use. Historic land uses have resulted in lateral movement of the stream channels, and steeply eroded streambanks in some reaches. In the stream segments within the project area, sediment is the primary nonpoint source pollutant of concern (WDEQ 2005).

Enos Creek and Left Hand Creeks are streams within the Gooseberry Creek-Enos Creek HUC. WDEQ has not made designated use support determinations for either Enos or Left Hand Creeks, but did collect data from a statewide probability site on Enos Creek (43.96845556, -108.76299720) in 2008. BLM reports on Enos Creek (2000, 2004) indicate that fires in the watershed in 2000 were causing excessive run-off and riparian-wetland degradation and that the system was vertically unstable. Natural surface or subsurface flow patterns were altered by hoof action disturbance. In 2006, the BLM classified Left Hand Creek as "functioning at risk" with a downward trend due to degradation attributed to livestock.

Cottonwood Creek receives discharge water from the Hamilton Dome Oil Field, resulting in high concentrations of both chloride and selenium. Because the discharge water is used for irrigation and the oil field is an important part of the local economy, a Use Attainability Analysis (UAA) was conducted and approved on Cottonwood Creek. WDEQ classifies the main stem of Cottonwood Creek as Class 2AB surface water, which supports cold water fish, aquatic life, and wildlife uses. As a Category 2 body of water on the WDEQ's 305(b) list, available data and information for Cottonwood Creek indicate that at least one designated use is supported, while one or more other uses are either indeterminate or not assessed. The CRM worked for years to rid Cottonwood Creek drainage of Russian olive and tamarisk (salt cedar) which had heavily infested this body of water.

The major objective of the Grass Creek Stewardship Project is to improve overall stream health by reducing livestock activity in riparian areas. Primarily, this is accomplished through the development and implementation of BMPs enabling livestock to graze in areas of rangeland away from riparian zones. The initial phase of this project was launched on the LU Ranch following a request by its owner for assistance from The Nature Conservancy in establishing a comprehensive range monitoring program for the ranch. During Phase I, we collected baseline data and implemented a small number of BMPs on the 150,000-acre LU Ranch. We implemented all Phase I BMPs on Grass Creek. Phase I also included the development of the Phase I Grass, Enos, and Left Hand Creek Non-Point Source Reduction Project Sampling and Analysis Plan (2010), to be implemented during subsequent project phases. The secondary objective of this project is to assess the suitability of project area streams as restoration sites for

Yellowstone Cutthroat Trout. As this is a long-term restoration project, and complete results of this project will not be immediate, a comprehensive assessment of this objective will not be possible for several years.

Our Phase III work expanded the area of BMP implementation established in Phases I and II. The primary emphasis of this phase was to implement a significant number of BMPs in the project area. In Phase III, the area of BMP implementation focused on the Wagonhound, Prospect and Cottonwood Creek drainages, although we also completed significant off-creek water developments in the Grass and Little Grass Creek drainages.

In Phase III, we contributed to the development of 6 off-creek water systems, that include 7 spring developments, 8 miles of pipeline and 23 water tanks. This was a significant increase over what we had planned and the landowners continue to work to expand these systems using their own resources.

During Phase III, the final phase of this project, we removed ~265 acres of conifers encroaching on springs and riparian areas on the Hillberry Ranches. As stated in the Phase III project proposal, we intended to remove 100 acres of conifers and install ~4 miles of fencing during Phase III. We completed much of the spring protection fencing planned for Phase III in Phase II. This enabled us to exceed our original conifer control goals.

With the help of work crews from Montana and Wyoming Conservation Corps (MCC and WCC) we removed over 10 miles of wildlife-unfriendly fences. This will allow the landowner to consolidate several pastures and improve grazing rotations; these management activities were supported by the range monitoring established through this project.

In Phase III, the range and water quality monitoring initiated in Phases I and II on the LU and Hillberry Ranches continued.

One project amendment for Phase III was granted in August of 2015 which allowed for an extension of the project from the original end date of December 31, 2015 to December 31, 2016. Following protocol established under our approved Sampling and Analysis Plan (2010), we also monitored water quality and changes in riparian vegetation communities between 2013 and 2016 in the project area.

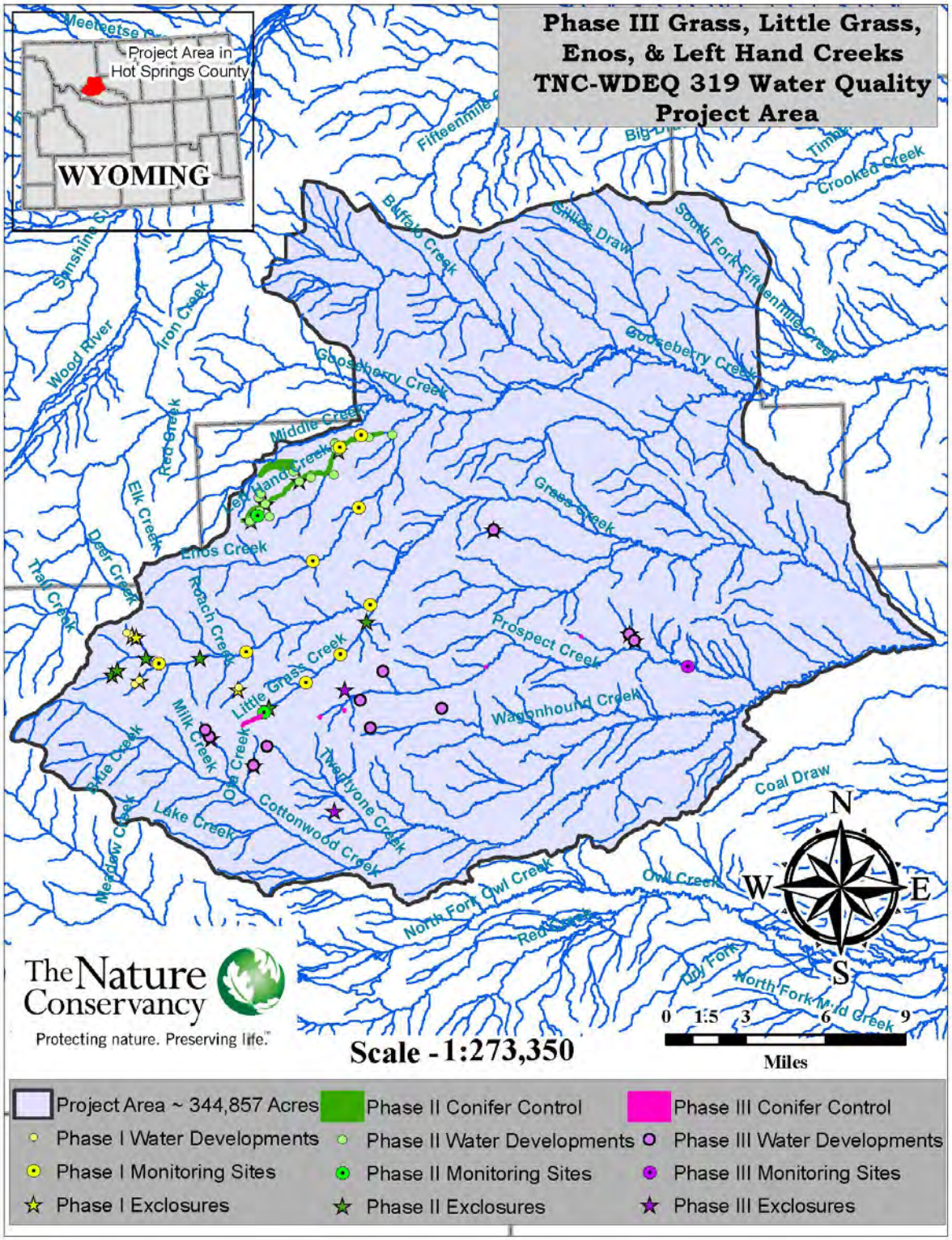


Figure 1. The Phase III project area on the LU and Hillberry Ranches.

The project area covers almost 345,000 acres and encompasses the drainages of two major tributaries of the Bighorn River: Gooseberry Creek and Cottonwood Creek (Figure 1). Phase I of this project commenced in 2008 on Grass, Little Grass, Enos, and Left Hand Creeks. The entire lengths of Grass Creek and Enos Creek are classified as Class 2AB waters whereas Little Grass and Left Hand Creeks are classified as Class 3B waters. Designated uses assigned to Class 2AB waters are coldwater fisheries, non-game fisheries, drinking water, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value (WDEQ/WQD 2013). Designated uses assigned to Class 3B waters are similar to Class 2AB less drinking water, fish consumption, coldwater fisheries and non-game fisheries (WDEQ/WQD 2013). In Phase II (begun in 2012), implementation of Best Management Practices (BMPs) for water quality improvement expanded from Grass Creek to Left Hand and Little Grass Creeks. Range monitoring was also expanded to the Hillberry Ranches. Phase III saw the continuation of work on the Hillberry Ranches, including the development of several off-creek water developments, removal of 10 miles of wildlife-unfriendly fencing, and 265 acres of conifer control.

The Nature Conservancy has served as the lead on this project, providing project management and oversight, securing and managing funding, and involving numerous project partners in project planning and implementation. Representatives of the LU and Hillberry Ranches, the Natural Resource Conservation Service (NRCS), the Bureau of Land Management (BLM), the Wyoming Department of Agriculture, the University of Wyoming Cooperative Extension, the University of Wyoming Conservation Corps (WCC), Wyoming State Forestry, the Wyoming Game and Fish Department (WGFD), Hot Springs Weed and Pest District, the Cottonwood / Grass Creek Coordinated Resource Management Group, and the Hot Springs Conservation District have worked with The Nature Conservancy to develop and accomplish project goals. In addition to the Wyoming Department of Environmental Quality (WDEQ), funding was provided by the Wyoming Sage-Grouse Conservation Fund, the Wyoming Wildlife and Natural Resource Trust Fund, Marathon Oil, and the LU Ranch. Many of the partners also provided technical assistance, in-kind labor, equipment, and materials.

3.0 Goals and Outcomes

The primary goal of the project was to improve overall stream health by reducing livestock activity in riparian areas. We assessed this improvement throughout the project area using several water quality and range monitoring methods to measure or model sediment inputs and mean stream temperatures. We also sought to maintain or improve riparian and aquatic habitat through improved livestock distribution, monitoring, and adaptive management. The secondary objective of this project was to assess the suitability of project area streams as restoration sites for Yellowstone cutthroat trout (YCT). As this is a long-term restoration project, and some results of this project will not be immediate, a comprehensive assessment of these streams as YCT restoration sites will not be possible for several years. We primarily accomplished project goals through the development and implementation of BMPs encouraging livestock to graze in areas of rangeland outside of riparian zones.

To most clearly communicate the scale of our accomplishments during this project, we have broken down our goals and accomplishments for the entire Grass Creek Project by project phase.

Phase I

Goals

In our Phase I Project Implementation Plan (PIP), our stated goals included:

1) Developing a coordinated monitoring plan of riparian habitat to measure improvements in areas of recent off-channel water development and establishing a baseline prior to more widespread implementation of BMPs designed to improve surface water designated uses, specifically cold water fisheries, aquatic life, wildlife, contact recreation, and agriculture.
2) Maintaining or improving aquatic habitat quality at sites of off-channel water development, and demonstrating improved Wyoming Stream Integrity Index (WSII) scores at established monitoring sites within two years.
3) Demonstrating an improving trend in riparian vegetation condition in stream reaches with new off-channel water when compared to those without recent improvements. This would include developing a fine scale map of current riparian invasives and attaining a minimum 25% reduction in total invasive species cover for both riparian and immediately adjacent upland areas.
4) Providing hands-on training for monitoring water quality, rangeland, and watershed health, riparian and aquatic habitat, and livestock utilization to landowners in Gooseberry Creek and Cottonwood/Grass Creek watersheds. Establishing volunteer monitoring through LU Ranch staff to monitor during project and develop understanding and ownership for ongoing voluntary, landowner-driven monitoring that can continue after project completion.

Outcomes

1. The Nature Conservancy (2010) Sampling and Analysis Plan (SAP) for the water quality monitoring program was reviewed and approved by WDEQ in May of 2010. We then established 9 monitoring sites for the project on Grass Creek (3), Little Grass Creek (2), Enos Creek (2), and Left Hand Creek (2). Data collected on Little Grass, Enos, and Left Hand Creeks served as baseline data preceding BMP implementation. Data collected on Grass Creek yielded one year of baseline data (2010) and one year of data following BMP implementation (2011).
2. From 2010 to 2011 we found that WSII scores increased at all monitoring site, except for EC1, GC1, and LH1. Scores at EC1 in 2010 and 2011 were nearly identical. Decreasing scores at GC1 were attributed to increased overland flows and sediment inputs due to logging operations, although periodic mass-wasting of the terrace wall may also have contributed. No other datasets revealed discernible trends, likely due to the short period of monitoring.
3. TNC provided funding to Hot Springs Weed & Pest (HSWP) to treat and map noxious plant species in riparian areas on the four primary project area drainages. HSWP conducted systematic surveys in 2009, and treated all occurrences of noxious weeds on these sites in 2009 and 2010. They also performed follow-up treatments in 2011. Comparing vegetation data from 2010 and 2011 was challenging due to differences in

identification methods in between years. By Phase II, we had devised a solution to this issue and were able to compare the data.

4. TNC hosted an upland and riparian monitoring workshop. TNC and the LU Ranch also hosted a group from Round River Conservation Studies to learn about the project, hired a Wyoming Conservation Corps crew to assist with BMP implementation, and hosted a volunteer day. Following Phase I monitoring, we determined that monitoring and data analysis requirements would likely be too extensive for LU Ranch staff and could be more thoroughly handled by TNC staff.

Phase II

Goals

In our Phase II PIP, our stated goals were to develop new off-creek water sources, protect newly-developed springs, treat new riparian weed infestations, and expand range and water quality monitoring programs established in Phase I. Additionally, we aimed to control conifers encroaching into riparian areas and to plant 3,000 cottonwood, willow, and red osier dogwood pole cuttings in riparian areas on Grass and Little Grass Creeks.

Our specific objectives by drainage were:

Grass and Little Grass Creeks

1. Continue to reduce sedimentation through installation of riparian fencing, replacement of non-desirable plants with native, woody species in riparian areas.
2. Encourage beaver migration into the upper elevations of these drainages by maintaining existing aspen stands and reestablishing willow and cottonwood in riparian areas.
3. Expand range and water quality monitoring begun in Phase I.

Enos and Left Hand Creeks

1. Develop 12 new off-creek water sources on Left Hand Creek, and herd cattle from riparian areas to new tanks.
2. Treat juniper/conifer species encroaching into riparian areas on both creeks, complementing recent NRCS conifer control on Enos Creek.
3. Expand range and water quality monitoring begun in Phase I.

Cottonwood Creek:

1. Initiate range monitoring on the 56,000-acre (deeded + leased) Spring Gulch Cattle Company in anticipation of implementing BMPs in this drainage in the future.

Outcomes

Grass and Little Grass Creeks

1. Installed two riparian exclosures protecting a total of 7.3 acres on Grass Creek; and 2 riparian exclosures protecting a total of 30.4 acres, 1 aspen exclosure protecting 15 acres, and 1 spring protection fence protecting 5.3 acres on Little Grass Creek.
2. Planted approximately 3,800 willow cuttings inside exclosures on Grass and Little Grass Creeks.
3. Continued water quality monitoring begun in Phase I, and expanded range monitoring to the Hillberry Ranches. Water quality monitoring was not expanded; several potential locations were found to be on ephemeral streams, and others were in locations too remote to be monitored in a timely fashion.

Enos and Left Hand Creeks

1. Developed 15 off-creek water sources in the Left Hand Creek drainage and herded cattle from riparian areas.
2. Constructed 3 spring protection fences totaling 2.2 acres.
3. Removed 90 acres of invasive conifers from Left Hand Creek, 215 acres from Middle Creek in the Left Hand drainage, and 43 acres from riparian areas and aspen stands on Little Grass Creek for a total of 356 acres. We additionally treated ~64 acres of Canada and musk thistle on Left Hand Creek.
4. No new monitoring sites were added on Left Hand Creek because the majority of the stream is spring fed for short distances, and then becomes ephemeral.

Cottonwood Creek

1. Initiated range monitoring on the 56,000 acre Hillberry Ranches, the analyzed results of which are included in this report. Additionally, we began implementing BMPs in this drainage, including the construction of three water systems on Cottonwood Creek tributaries on the Hillberry Ranches.

Phase III

Goals

In our Phase III PIP, our stated goals were to:

1. Develop 3 springs in the Prospect, Wagonhound, Twenty One, or Cottonwood Creek drainages; distribute spring water through 5 miles of pipeline to 7 tire tanks.
2. Protect the newly-developed springs with electric fences, and control conifers encroaching into the spring sites.
3. Expand the water quality monitoring program established in Phases I and II to include new monitoring sites on Prospect Creek on the Hillberry Ranches.

Outcomes

1. Developed 6 off-creek water sources in Prospect, Cottonwood, Grass and Little Grass drainages and that included 7 springs, 8 miles of pipeline and 23 water tanks. (Planned water systems in Wagonhound Creek were completed in Phase II).

2. We protected springs developed in Phase II at Elk Mountain Spring, Prospect Spring, and an aspen stand on Little Grass Creek. The LU protected the spring at the Beef Pasture water development. We removed 265 acres of conifers encroaching into spring sites, riparian areas, and rangeland. Additionally, we removed over 10 miles of wildlife-unfriendly fencing in Phase III in the Little Grass, Prospect and Cottonwood drainages.
3. We decided not to add additional water quality monitoring sites in the Phase III BMP implementation area because most of the streams there are ephemeral.

Phase III PROJECT PRODUCT SUMMARY

Product Outcome: The primary outcome for this project was to reduce sediment loading and mean temperature in stream channels, and to maintain or improve riparian and aquatic habitat through improved livestock distribution, monitoring and adaptive management at selected sites.

Target 1: Efficient Project Administration.

Target 2: Implementation of Grazing BMPs to improve surface water designated uses.

Target 3: Continue and expand water quality monitoring within project area.

Target 4: Complete final report.

4.0 Task Activities

The combined efforts of Phase I, III and III of this project helped to implement the Wyoming Nonpoint Source Management Plan in several ways, including through the:

- implementation of livestock BMPs to reduce erosion,
- improvement of riparian habitat through native vegetation plantings and livestock exclusion,
- removal of non-desirable species from riparian areas,
- continuation of appropriate livestock grazing across the project area,
- continuation of comprehensive range and water quality monitoring programs, and
- demonstration of range and water quality monitoring techniques.

Phase III planned and actual milestones for tasks are presented in Table 2. These are based on the amended grant agreement that allowed a one-year extension on the grant through 2016. While we requested an additional year to implement BMPs in Phase III, we did not request additional resources for water quality monitoring. As a result, we only collected Rosgen stream bank erosion data in 2016.

Table 2: Task Descriptions and Project Deliverables.

Task #	Task Title	Task Description	Actual Deliverables
1	Project Administration	1 Final Report, 8 Quarterly Reports	1 Final Report, 2 Annual Reports, 8 Quarterly Reports

2	Implementation of Grazing Management BMPs	Development of 3 springs, installation of 5 miles of pipeline, and 7 tire tanks.10 acres of conifer control. 2.5 miles of fences protecting riparian and spring habitat.	Developed 6 off-creek water systems including 7 springs, 8 miles of pipeline, and 23 tire tanks in the Prospect, Cottonwood, Grass and Little Grass drainages. Completed 265 acres of conifer control, Removed 10 miles of fence in the Little Grass, Prospect and Cottonwood drainages. (Spring protection fences were completed in Phase II).
3	Monitoring	Continue water quality monitoring on Grass, Little Grass, Enos, and Left Hand Creeks on the LU Ranch; expand monitoring on Hillberry Ranches (Prospect Creek)	Water quality and range monitoring established in Phases I and II was left continued in Phase through 2015. In 2016 (our extension year), we completed only very limited monitoring as we had limited funding remaining for it. We did not add water quality monitoring sites in Phase III due to limitations on staff time and on the ephemeral nature of many of the streams in the Phase III BMP implementation area.
4	Final Report Production	Complete final report, analyzing and summarizing water quality monitoring data collected in Phase III.	1 Final Report, including an analysis of Phase III water quality monitoring data.

Task 1: Administration

The Nature Conservancy's Northwest Wyoming Program Director and Grants Specialist worked together to administer this grant project, including timely submission of reports and reimbursement requests, records retention, and completion of all tasks.

Task 2: Best Management Practice Implementation

In Phase III, we continued to work to improve the distribution of off-creek water sources in project area drainages – widely considered to be among the most important things we could do to improve the water quality and wildlife habitat in the area, and the sustainability of the ranching operations. Exceeding our original task goal to develop 3 springs, 5 miles of pipeline and 7 tire tanks, we developed 7 springs, 8 miles of pipeline, and 23 tanks. All six systems developed in Phase III are gravity fed and together impact a total of 11,740 acres.

In Phase III, we also significantly exceeded our goal for conifer control. This was possible for two reasons. First, we implement some of the Phase III BMPs in Phase II (primarily spring protection). And second, we decided not to expand our water quality monitoring efforts in Phase III due to the ephemeral nature of many of the streams in the Phase III area of BMP

implementation. These factors enabled us to apply additional resources to BMP implementation in Phase III.

Task 3: Monitoring

Range Monitoring

During Phase III, as in Phase II, we collected data on both the LU and Hillberry Ranches. The LU Ranch continued to collect data in accordance with their monitoring plan established during Phase I of the project. The data collected helped the ranch to identify areas that were being under or over utilized to ensure proper grazing rotation and grass utilization. The Hillberry Ranches are likewise using their data to help make informed management decisions and to supplement the range monitoring data collected by the BLM on the ranch's public land leases.

Water Quality Monitoring

In Phase III of the project, we continued to track changes in riparian vegetation, sediment, and water temperature at the nine previously established sites on Grass, Little Grass, Enos, and Left Hand Creeks. As described more fully in Section 6.0, over the course of all three phases of the project, the implementation of grazing BMPs reduced the impacts of cattle to riparian areas. Bare ground and noxious weeds decreased at several of our monitoring sites. The diversity and the proportion of sensitive taxa in the macroinvertebrate communities increased throughout the project area as measured by multiple indices. Over all three project phases, sediment loading was reduced by 2,368.6 tons/year throughout the project area, while nitrogen inputs were reduced by 2,051.0 lbs/year and phosphorus was reduced by 272.6 lbs per year.

Task 4: Complete Final Report

TNC analyzed changes in water quality associated with the project; data collected may be used by landowners and agencies to support management decisions, and was a continuation of the information collected in Phase I of the project.

Outreach

In Phase I, the range monitoring program only existed on the LU Ranch. TNC met its outreach goal by hosting a range monitoring workshop for area landowners. In Phase II, we expanded the range monitoring program to the adjacent Hillberry Ranches. The Hillberry Ranches hired local range consultants to help establish monitoring sites, collect the range monitoring data, and to teach the methods to (and share the data with) the ranch's lessees so they can better judge utilization levels and grazing rotations. We also shared information about this project, and about range and water quality monitoring, at the 2013, 2014, 2015 and 2016 Cody Wild West River Fest events held in Cody, Wyoming.

5.0 BMP Implementation: Implementation of Water Quality Improvement Practices

Off Creek Water Developments

In Phase III, we planned to develop 3 springs in the Prospect, Wagonhound, Twenty-One, or Cottonwood Creek drainages, with those developed springs feeding up to 7 new tanks distributed

across the landscape with 5 miles of pipeline. We significantly exceed those goals by developing 6 water systems with 23 water tanks fed by 7 springs pumped through 8 miles of pipe. Seven (7) tanks were installed on the LU Ranch (Figure 2) and sixteen (16) tanks were installed on the Hillberry Ranches (Figures 3 and 4) and). All new water tanks were equipped with wildlife escape ramps and float valves that enable excess water to overflow back into riparian areas.

One of the six water systems developed in Phase III was on the LU Ranch. The Beef Pasture development, located at the confluence of Grass Creek and Thompson Draw, contributes significantly to the efficiency of the livestock operation on the LU as well as the health of the Grass Creek drainage (Figure 2). This water system includes one spring development, 3 tanks in the weaning lots, and 2 additional tanks in each of two pastures. The ranch also fenced the nearby riparian area to exclude cattle from the stream while they're being held or pregnancy-tested (600 head twice a year). This development provides off-creek water to 500 acres of native rangeland. The LU used their own resources to build a riparian fence adjacent to these pastures to reduce livestock pressure on the stream in this area.

Five water systems were installed or expanded on the Hillberry Ranches in Phase III (Figures 3 and 4). The first Hillberry Ranches water development, at Coal Mine Spring in the Little Grass Creek drainage, includes one spring development, one tank, a half mile of pipe and provides water to a 500-acre pasture. Another Little Grass Creek system, Elk Mountain/21 Creek, expands a spring development completed in Phase II of the project; ten tanks were added in Phase III, providing livestock water to over 7,000 acres of native rangeland. The third and fourth developments, at Kester Coulee in the Cottonwood Creek drainage, include 2 spring developments, 2 livestock water tanks, and over a mile of pipeline that provides off-creek water to about 1,600 acres. The final development, in the Prospect Creek drainage, includes 1 spring development, 3 tanks and over three miles of pipe to water over 2,100 acres of native range.

The water developments on the Hillberry Ranches contribute to the viability and sustainability of that operation. Previously, this traditional cow/calf operation was forced to raise or buy hay for winter feed. But the development of these off-creek water sources has enabled the ranch to graze year-round. The result is a more sustainable cattle operation, a healthier range, and improved water quality.

Conifer Control

Widespread fire suppression efforts in the Rockies have enabled significant expansion of shade tolerant coniferous species like juniper and Douglas fir. In the project area, these species have encroached into riparian areas, aspen stands, and spring sites where they outcompete native species for resources. By increasing the proportion of native vegetation in riparian areas and around springs, this work increases the health of these habitats and improves water quality by 1) increasing the volume of available water, and 2) better filtering run-off and stabilizing stream banks.

To increase the health of these habitats, in Phase III we planned to remove conifers from 10 acres around springs. With the help of partners, we also significantly exceeded this goal by treating over 265 acres, including at all spring sites developed in Phase III (Figure 5).

Although we significantly exceeded our conifer control goal, it is difficult to prove that this work achieved our objective of water quality improvement because our water quality monitoring methods were not designed to directly measure the impacts of this work. If we had been measuring flow rates, for example, we may have recorded increased flow following conifer control. In addition, it may take some time for the benefits to be fully realized in these watersheds and follow-up monitoring in the years to come, as we suggest in the Recommendations section, may reveal the longer-term impacts of this work.

Fencing

In the Phase III PIP, we committed to protecting all newly-developed springs with electric fences. We completed most of these in Phase II, including fences protecting the spring developments at Elk Mountain Spring, Prospect Spring, and an aspen stand on Little Grass Creek. The LU protected the spring developed at the Beef Pasture water development. In Phase III, we focused our grant funds on water developments, conifer control and fence removal.

In Phase III, we removed over 10 miles of redundant, wildlife-unfriendly fencing in the Little Grass, Prospect and Cottonwood drainages. Crews from the Wyoming and Montana Conservation Corps completed this work on the Hillberry Ranches in the summer of 2016. The removal of these fences contributes to the health of the range and riparian areas by allowing greater flexibility in the management of livestock herds – a goal of the rangeland monitoring established in Phase I of the project. Fence removal also reduces entanglement threats to wildlife and livestock.

Table 3. Best management practices implemented in Phase III.

Best Management Practice	**Date Constructed**	**Drainage**	**Acres of Impact**
Conifer Control			
Elk Mountain	Jul-15	Little Grass	15
Prospect Spring	Jul-15	Prospect	15
Pershal Spring	Jul-15	Prospect	10
Iron Spring	Sep-15	Cottonwood	3
Prospect Canyon Spring	Sep-15	Prospect	8
Cottonwood Spring	Sep-15	Cottonwood	9
Coal Mine Spring	Sep-15	Little Grass	5
Spring Gulch	Mar-16	Wagonhound	60
HD Quarter Circle	Mar-16	Lower Prospect	65

Prospect Land and Cattle	Mar-16	Upper Prospect	75
Subtotal - Acres with conifers removed			265
Off-Creek Water Developments			
Water System 1			
Tank #1 Coal Mine Spring	Nov-14	Little Grass	500
Water System 2			
Tank #2 Kester Coulee North	Nov-14	Cottonwood	600
Water System 3			
Tank #3 Kester Coulee South	Nov-14	Cottonwood	1,000
Water System 4			
Tank #4 Prospect/ Wagonhound 1	Nov-14	Prospect	700
Tank #5 Prospect/Wagonhound 2	Nov-14	Prospect	800
Tank #6 Prospect/ Wagonhound 3	Nov-14	Prospect	600
Water System 5			
Tank #7 Elk Mntn/21 Creek	Dec-15	Little Grass	7,040
Tank #8 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #9 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #10 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #11 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #12 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #13 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #14 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #15 Elk Mntn/21 Creek	Dec-15	Little Grass	-
Tank #16 Elk Mntn/21 Creek	Dec-15	Little Grass	-

Water System 6			
Tank #20 Beef Pasture	Aug-16	Grass Creek	500
Tank #21 Beef Pasture	Aug-16	Grass Creek	-
Tank #22 Beef Pasture	Aug-16	Grass Creek	-
Tank #23 Beef Pasture	Aug-16	Grass Creek	-
Tank #24 Beef Pasture	Aug-16	Grass Creek	-
Tank #25 Beef Pasture	Aug-16	Grass Creek	-
Tank #26 Beef Pasture	Aug-16	Grass Creek	-
Subtotal - Acres with off-creek water			11,740

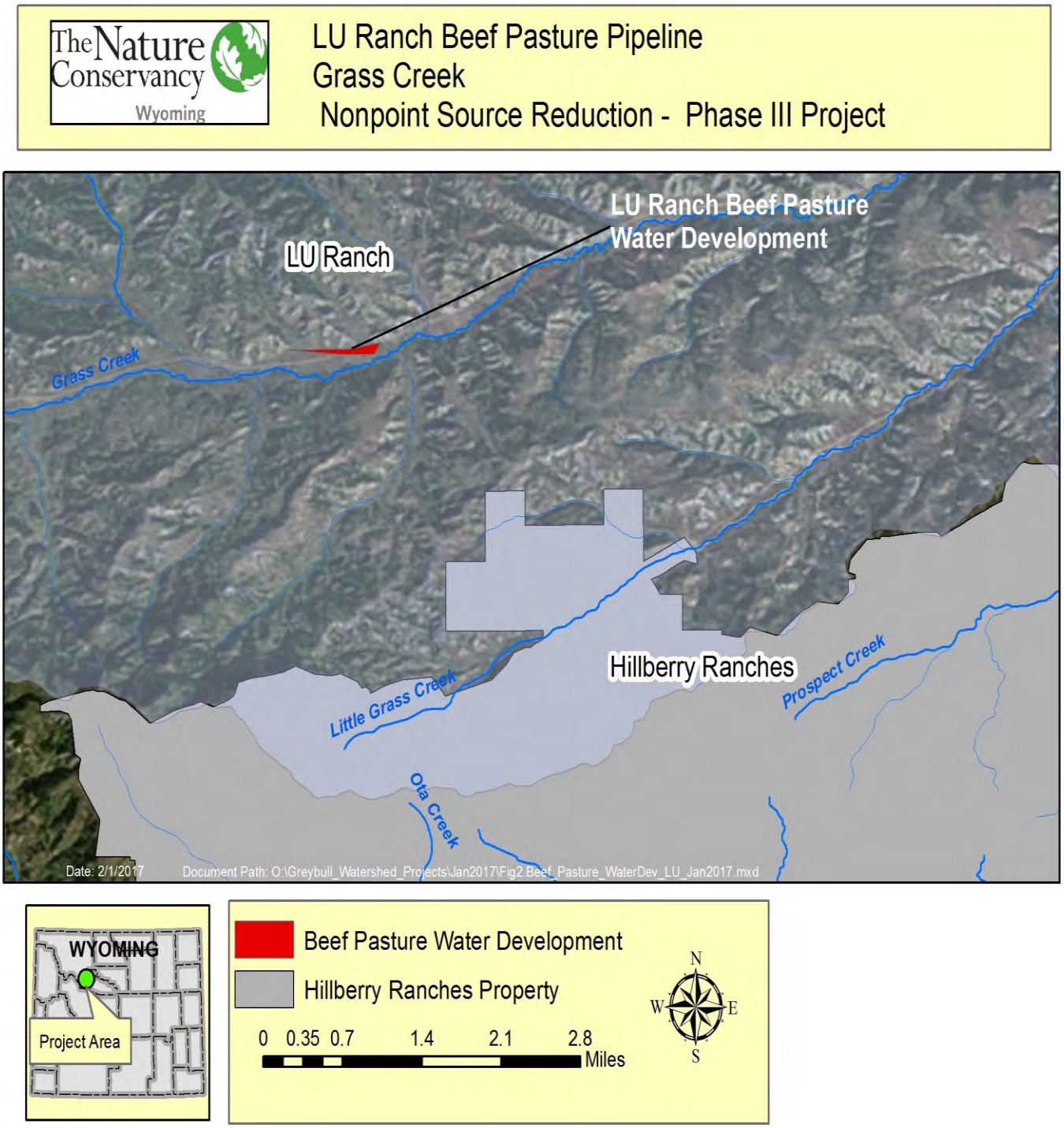


Figure 2. The Beef Pasture water development on the LU Ranch.

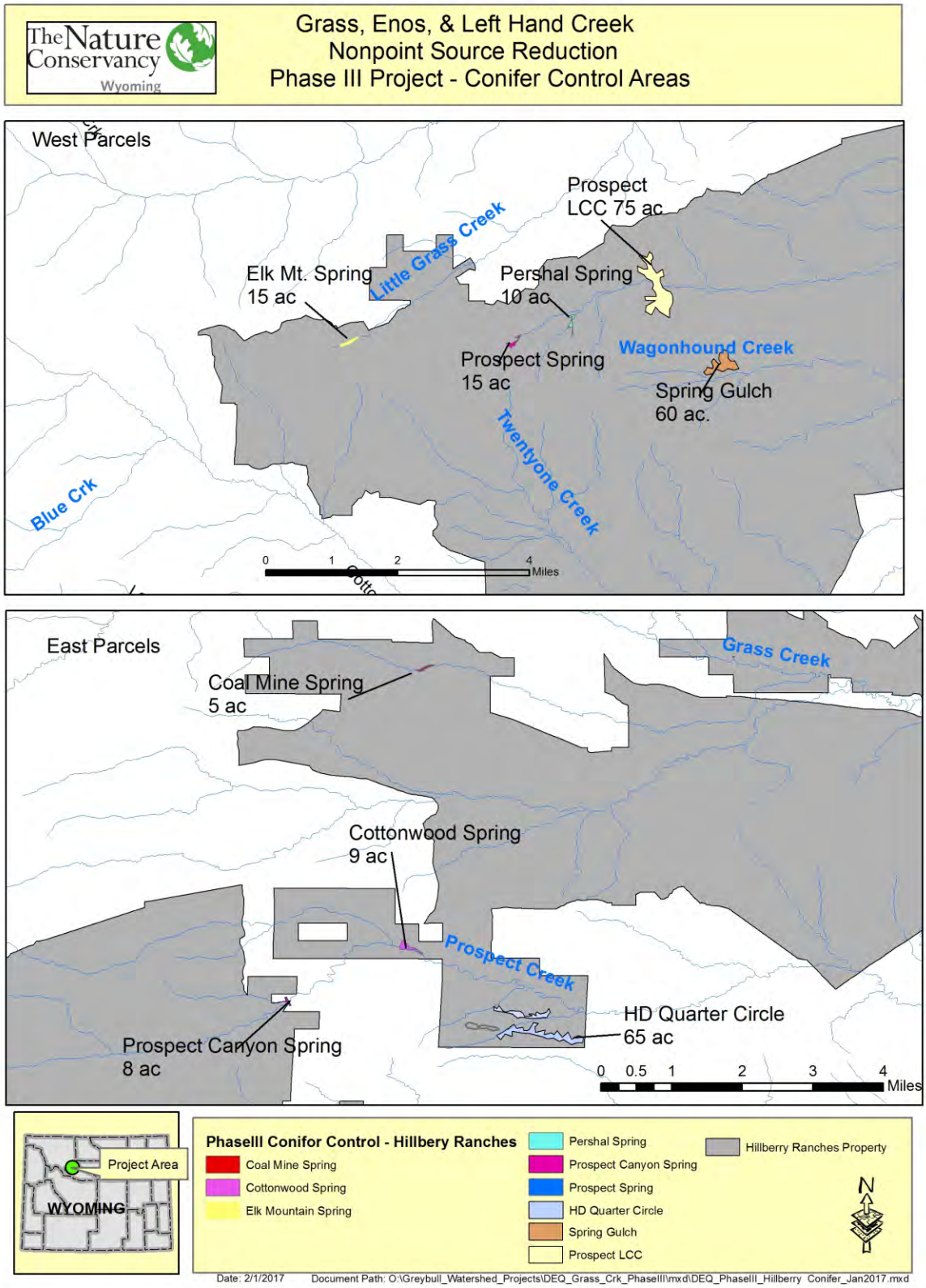


Figure 3. Conifer control completed on the Hillberry Ranches in Phase III.

Water Quality Improvement through Measured or Estimated Load Reductions

We used STEPL to estimate the sediment, nitrogen and phosphorus reductions achieved in Phases I-III for the Grass, Little Grass, Left Hand, Cottonwood, Prospect and Wagonhound Creek drainages (Table 4). These calculations are made based on several factors including distance of BMP from the stream, bank heights, and use efficiency of the BMP. Sediment loads from stream bank erosion were also measured for Grass, Left Hand, and Little Grass Creeks using the Rosgen method. Monitoring sites representing different stream type were used to calculate erosion rates by tons/year/foot. These rates were multiplied by the total length of each stream type to yield the estimated erosion rate for the year for those streams.

Grass Creek

Three different erosion types were identified for Grass Creek; these are based on the three water quality monitoring sites. The lengths of these erosion types were used to calculate total erosion for portion of the Grass Creek impacted by the project practices. We estimate that 7.7 miles of Grass Creek are represented by GC1 (Type 1), 2.4 miles of stream are represented by GC2 (Type 2), and 5.0 miles of Grass Creek are represented by GC3 (Type 3) (Figure 4). These lengths were multiplied by the erosion rates measured at the corresponding monitoring sites to yield estimates of total erosion occurring on Grass Creek.

Over the course of the project, we have implemented BMPs throughout the Grass Creek drainage, and we have measured erosion rates at three monitoring sites. Between 2010 and 2016, except for localized increases in 2015, we observed significant declines in total erosion in all Grass Creek stream types year after year (Table 5). However, between 2015 and 2016, we observed what we believe to be periodic mass wasting of the terrace/valley wall associated with normal freeze/thaw cycles. The study bank along a 60-foot length of the upper Grass Creek site went from a 6-year average of less than 2 feet tall to a vertical, sparsely vegetated, 19-foot tall bank. High terrace/valley walls like this can contribute sediment episodically as they gradually slough. these changes could not have been caused by flooding or livestock activity in this portion of the drainage. Over that period, neither stocking rates nor livestock retention times in adjacent pastures increased. Further, mechanical control of encroaching conifers has not been undertaken in this portion of the project area. Commercial logging activity in upper Grass Creek and its tributaries has been significant in recent years and may be contributing. Trees intercept rain and dissipate rainfall energy, thereby reducing the volume and energy of rain reaching the forest floor where the litter layer slows water movement and facilitates infiltration into the soil. When trees are removed, rain reaches the soil in higher volumes and with greater energy, thereby increasing runoff. It may be that logging operations contributed to the increased erosion observed in the upper Grass Creek drainage. However, logging is unlikely the primary cause for the erosion.

Because the erosion of the single steep bank is highly unlikely to have been caused by livestock activity, we have presented the data from GC1 using the average study bank height observed over the course of the study (Tables 4 and 5). This approach focused on that portion of the stream bank that could be eroded due to high flows and that may be influenced by livestock management. Over the course of the study, we estimate a decrease in erosion of 666 tons per year in Grass Creek Type 1 stream segments, almost 190 tons per year in Type 2 segments, and

almost 900 tons per years in Type 3 segments (Table 5). In total, we estimate a reduction of almost 1,780 tons per year during the project (Table 4). This is roughly equivalent to 178 commercial dump truckloads per year.

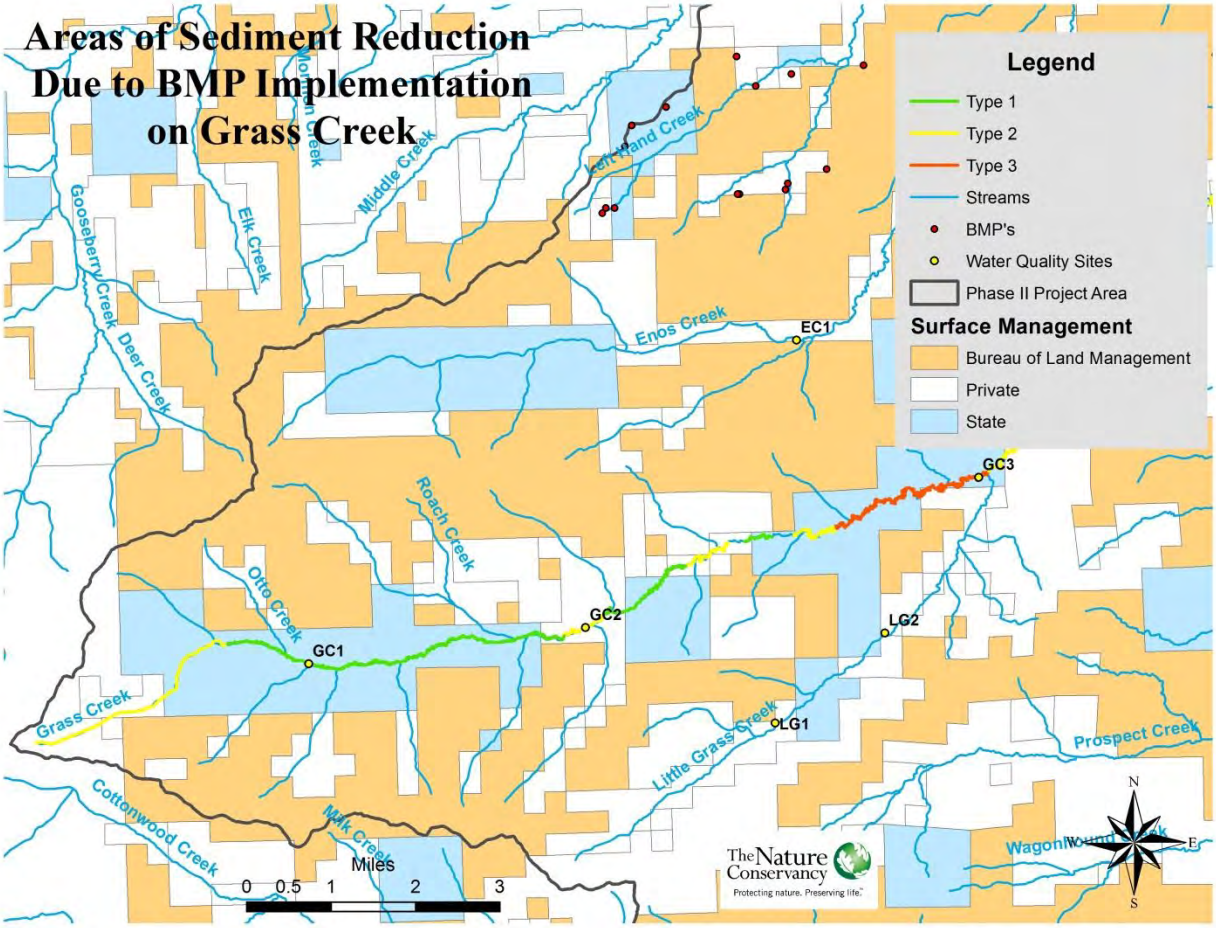


Figure 4. Erosion types on Grass Creek.

Left Hand Creek

Three different erosion types were identified for Left Hand Creek (Figure 5). Approximately 1.7 miles of Left Hand Creek are represented by Type 1, 1.2 miles are represented by Type 2, and 9.2 miles are represented by Type 3. A single erosion rate was measured at LH1; erosion on Type 1 is calculated from the erosion rate measured at LH1. Erosion rates at Type 2, which differs from Type 1 only in bank heights, were calculated using the STEPL model. Type 3 erosion rates are also based on LH1 measurements, but because these portions of the stream were only observed to flow completely about every four years; the rates measured at LH1 were divided by four to yield erosion estimates for Type 3 stream segments.

On Left Hand Creek, where BMPs were implemented throughout the drainage, we calculate a total sediment reduction of 107.6 tons/year from 2010 to 2016 (roughly equivalent to 10 commercial dump truck loads per year) (Tables 4 and 5). Over the same period, we also reduced

nitrogen inputs on Left Hand by an estimated 53.6 lbs/year and phosphorus by 20.5 lbs/year (Table 4).

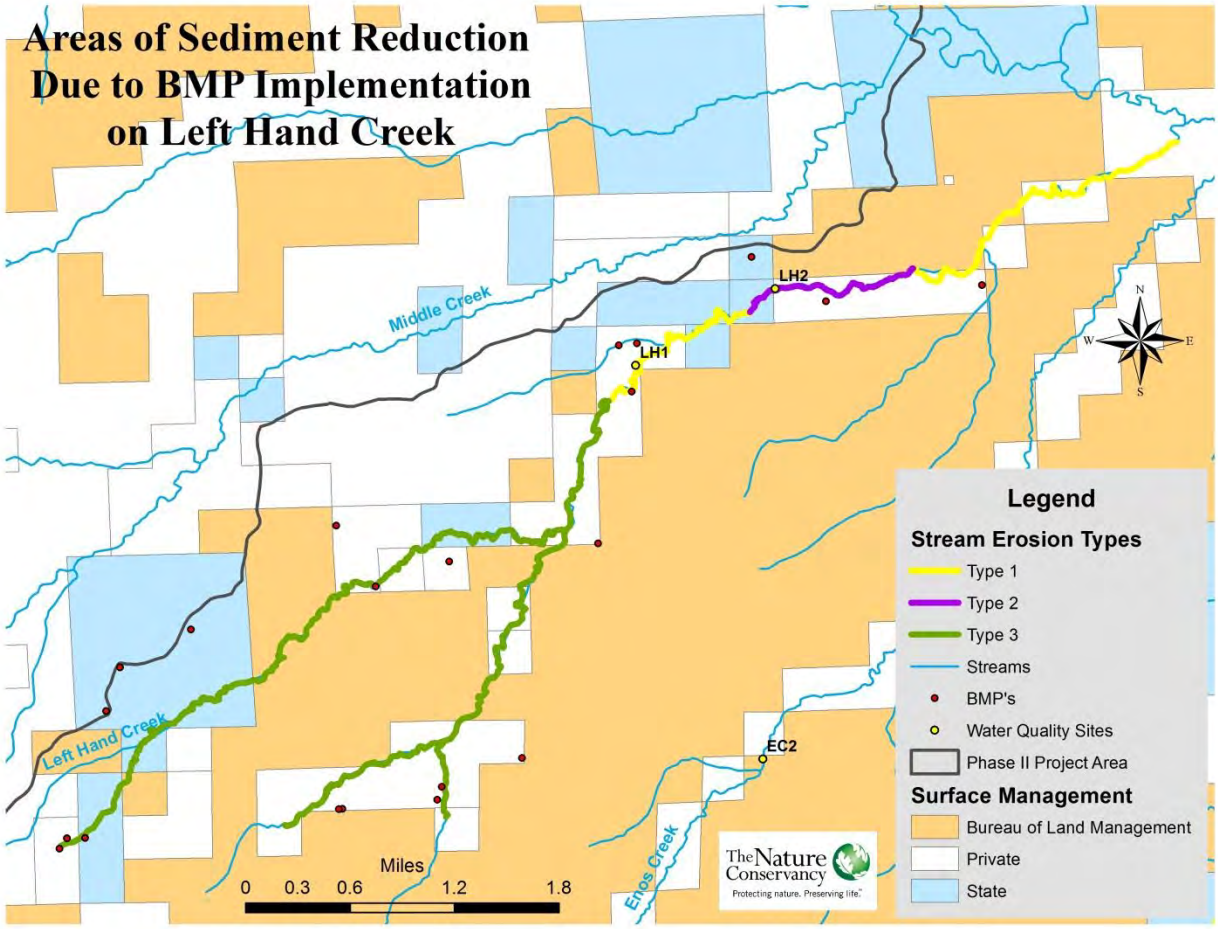


Figure 5. Left Hand Creek stream erosion types.

Little Grass Creek

Two different erosion types were identified for Little Grass Creek (Figure 6). Approximately 7.7 miles of Little Grass Creek are represented by Type 1 and 2.4 miles are represented by Type 2. Erosion rates were measured for each type at LG1 and LG2, respectively.

On Little Grass Creek, we calculate a total sediment reduction of 401.9 tons/year between 2010 to 2016 (roughly equivalent to 40 commercial dump truck loads per year) (Tables 4 and 5). Over the same period, we also reduced nitrogen inputs on Little Grass by an estimated 1,067.9 lbs/year and phosphorus by 116.9 lbs/year (Table 4).

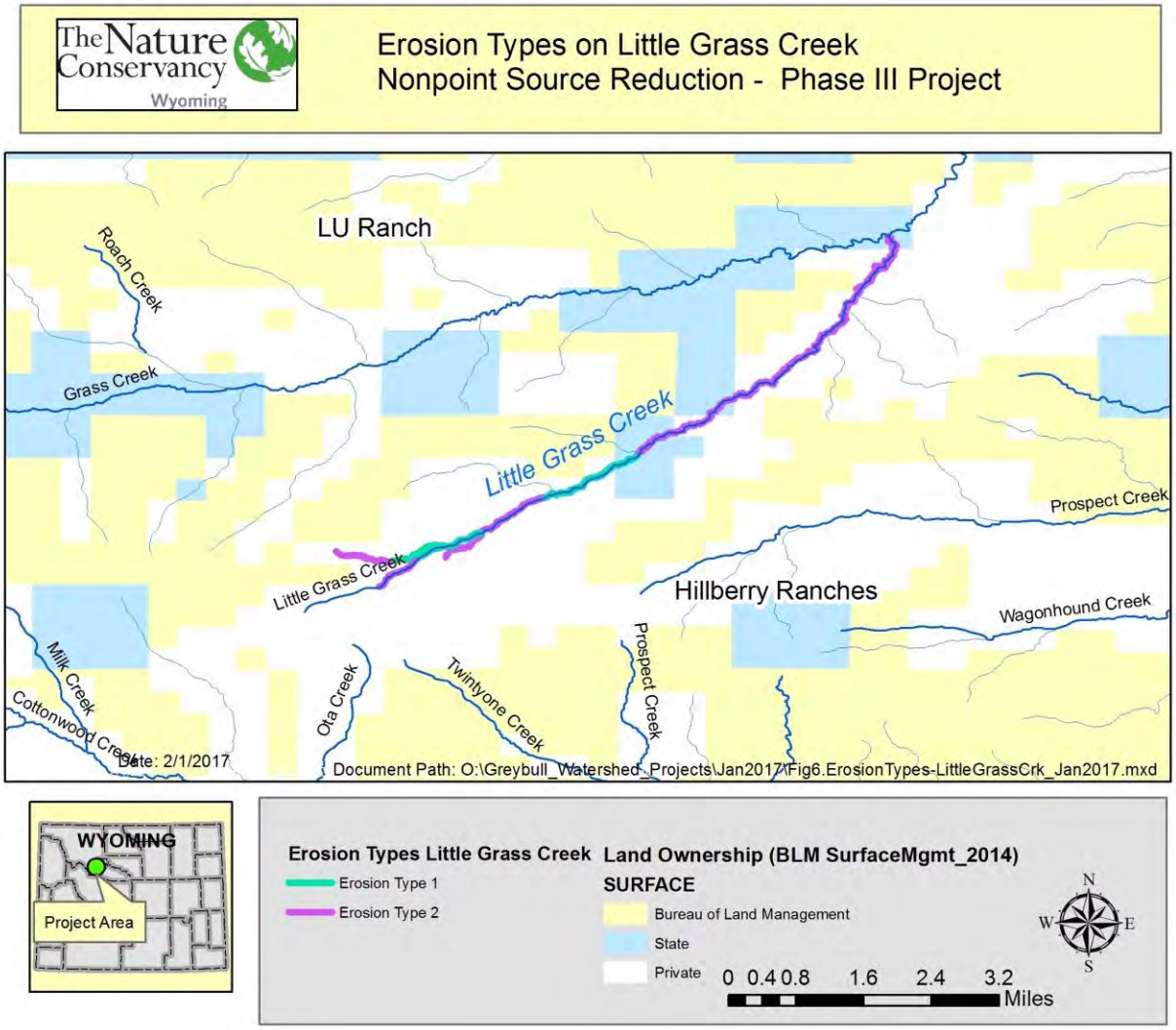


Figure 6. Erosion Types on Little Grass Creek.

Table 4. Summary of BMPs Implemented and Pollutant Reductions Estimated in Phase II. Sediment, Nitrogen, and Phosphorus reductions were estimated using STEPL.

	Phase Completed	Date Constructed / Years Measured	Estimated Acres/Miles Affected	Estimated Pollutant Reductions		
				Sediment (tons/yr)	N (lbs/yr)	P (lbs/yr)
Grass Creek						
Off-Creek Water Developments			Acres			
Tanks #1 and #2 Otto/Sanford	I	Aug-10	52.9	-5.1	-5.0	-1.8
Tanks #3 and #4 Hess	I	Aug-10	25.1	-4.2	-4.0	-1.5
Tank #5 Thompson	I	Aug-10	12.8	-4.5	-4.0	-1.6
Tanks #17-23 Beef Pasture	III	Aug-16	500.0	-8.7	-55.0	-9.6
			590.8			
Exclosures			Acres			
Excl #1 Otto/Sanford	I	Jun-11	3.4	-1.9	-5.0	-1.3
Excl #2 Otto/Sanford	I	Jun-11	2.3	-1.3	-4.0	-1.0
Excl #3 Hess	I	Jun-11	0.7	-0.4	-1.0	-0.3
Excl #4 Thompson	I	Jun-11	0.5	-0.3	-2.0	-0.4
Excl #3 Upper Riparian	II	Apr-13	3.4	-0.4	-2.2	-0.6
Excl #4 Lower Riparian	II	Apr-13	3.9	-0.5	-2.6	-0.6
			14.2			
Mean Stream Bank Erosion Reduction in Segments influenced by BMPs (tons/yr)			Miles			
GC Type 1 (steep left bank removed)	I-III	2010 - 2016	7.7	-666.0	-	-
GC Type 2	I-III	2010 - 2016	2.4	-189.7	-	-
GC Type 3	I-III	2010 - 2016	5.0	-896.3	-	-
Pollutant Reduction Subtotals				-1779.3	-84.8	-18.7
Little Grass Creek						
Off-Creek Water Developments			Acres			
Tank #16 Elk Mntn	II	Aug-13	618.0	-10.4	-227.4	-27.3
Tank #1 Coal Mine Spring	III	Nov-14	500.0	-8.7	-189.9	-22.9

Tanks #7-16 Elk Mntn/21 Crk	III	Dec-15	7,040.0	-70.6	-634.6	-59.6
			8,158.0			
Exclosures			Acres			
Excl #1 Upper Riparian	II	Nov-12	27.0	-2.6	-1.6	-3.8
Excl #2 Lower Riparian	II	Nov-12	3.4	-0.4	-2.2	-0.6
Excl #6 Aspen	II	Oct-14	15.0	-1.5	-9.0	-2.2
Excl #10 Elk Mntn Spring	II	Aug-15	5.3	-0.3	-3.2	-0.5
			50.7			
Mean Stream Bank Erosion Reduction in Segments influenced by BMPs (tons/yr)			Miles			
LG Type 1	I-III	2010-2016	7.7	-298.2		
LG Type 2	I-III	2010-2016	2.4	-9.2		
Pollutant Reduction Subtotals				-401.9	-1,067.9	-116.9
Left Hand Creek						
Off-Creek Water Developments			Acres			
Tank #1 State West	II	Jun-13	8.6	-1.2	-2.2	-0.8
Tank #2 State West	II	Jun-13	6.1	-1.2	-2.2	-0.8
Tank #3 State North	II	Sep-13	55.0	-1.0	-1.8	-0.8
Tank #4 State North	II	Sep-13	61.0	-0.7	-1.2	-0.4
Tank #5 State North	II	Sep-13	78.7	-0.9	-1.6	-0.6
Tank #6 WCC	II	May-13	91.5	-1.1	-2.0	-0.8
Tank #7 WCC	II	May-13	12.5	-0.7	-1.2	-0.4
Tank #8 WCC	II	May-13	25.1	-0.5	-0.8	-0.4
Tank #9 Lek	II	Aug-13	22.6	-4.0	-7.2	-2.8
Tank #10 Lek	II	Aug-13	49.5	-3.3	-6.0	-2.4
Tank #11 Lek	II	Aug-13	13.4	-4.6	-8.2	-3.2
Tank #12 Lek	II	Aug-13	47.7	-6.7	-12.4	-4.8
Tank #13 Solar	II	Oct-13	78.6	-0.7	-1.4	-0.6
Tank #14 Solar	II	Oct-13	36.0	-1.1	-2.0	-0.8
Tank #15 Solar	II	Oct-13	4.7	-0.8	-1.4	-0.6
			591.0			
Exclosures			Acres			
Excl #7 State N	II	Nov-15	0.5	-0.1	-0.6	-0.1
Excl #8 Lek spring	II	Nov-15	0.5	-0.1	-0.6	-0.1
Excl #9 WCC Spring	II	Nov-15	1.2	-0.1	-0.8	-0.1
			2.2			
Mean Stream Bank Erosion			Miles			

Reduction in Segments influenced by BMPs (tons/yr)						
LH Type 1	I-III	2010 - 2016	1.7	-26.1		
LH Type 2	I-III	2010 - 2016	1.2	-17.5		
LH Type 3	I-III	2010 - 2016	9.2	-35.4		
Pollutant Reduction Subtotals				-107.6	-53.6	-20.5
Cottonwood Creek						
Off-Creek Water Developments			Acres			
Tank #2 Kester Coulee North	III	Nov-14	1,000.0	-15.2	-104.4	-15.5
Tank #3 Kester Coulee South	III	Nov-14	600.0	-10.1	-65.1	-10.9
			1,600.0			
Pollutant Reduction Subtotals				-25.3	-169.5	-26.3
Prospect Creek (Cottonwood Ck tributary)						
Off-Creek Water Developments			Acres			
Tank #4 Prospect/Wagonhound 1	III	Nov-14	700.0	-11.4	-75.1	-12.1
Tank #5 Prospect/Wagonhound 2	III	Nov-14	800.0	-12.7	-84.9	-13.3
Tank #6 Prospect/Wagonhound 3	III	Nov-14	600.0	-10.1	-65.1	-10.9
			2,100.0			
Pollutant Reduction Subtotals				-34.2	-225.1	-36.2
Wagonhound Creek (Cottonwood Ck tributary)						
Off-Creek Water Developments			Acres			
Tank #17 Wagonhound	II	Nov-13	1,120.0	-16.7	-405.5	-47.0
Tank #18 Ojinaga	II	Nov-13	39.0	-1.3	-16.5	-2.6
Tank #19 West Dugout	II	Nov-13	46.0	-1.5	-19.4	-3.0
			1,250.0			
			Acres			
Exclosures						
Excl #5 Prospect Riparian /Aspen	II	Aug-12	15.0	-0.8	-8.7	-1.4
			15.0			
Pollutant Reduction Subtotals				-20.3	-450.1	-54.0

Pollutant Reduction Totals in Phases I-III (excluding GC1 steep bank)	**-2,368.6**	**-2,051.0**	**-272.6**

Acres Directly Impacted by BMPs				
Water Developments	I-III:	14,244.8	Phase III:	11,740.0
Exclosures	I-III:	82.1	Phase III:	0.0

TABLE 5. Measured sediment reductions (in tons/yr) on stream reaches where BMPs were focused based on the Rosgen monitoring sites and data collected from 2010 to 2016.

		Total Erosion (tons/yr)							
Stream Type	Length (mi)	2010	2011	2012	2013	2014	2015	2016	Change from 2010-2016
GC1 Type[1]	7.7	1,830	1,120	988	760	486	1,566	1,164	-666.0
GC2 Type	2.4	337	262	201	165	168	163	147	-189.7
GC3 Type	5.0	1,290	1,781	1,397	1,048	793	1,839	394	-896.3
LH Type 1	1.7	36	49	7	33	13	6	10	-26.1
LH Type 2[2]	1.2	25	33	6	24	9	4	7	-17.5
LH Type 3[3]	9.2	49	66	10	45	18	8	14	-35.4
LG Type 1	7.7	384	263	225	195	238	267	86	-298.2
LG Type 2	2.4	17	17	17	8	10	4	8	-9.2
								Total	-2,138.5

[1] *with an average study bank height used to normalize one steeply eroded left bank*
[2] *STEPL model used to account for different bank lengths in Type 2 segments*
[3] *erosion rates divided by 4 to reflect the ephemeral nature of the lower stream segments*

6.0 Monitoring Results

Water Quality Monitoring

In Phase III of the project, we proceeded with the water quality monitoring program that we designed and implemented in Phase I and continued to employ during Phase II. Our goal with this program has been to track any changes in water quality that might occur following the implementation of project BMPs. The Nature Conservancy Sampling and Analysis Plan for the water quality monitoring program was reviewed and approved by the WDEQ prior to the initiation of monitoring (TNC 2010). Additional details about monitoring methods and equipment can be found in that document, which is both on file with the WDEQ and available by request. Methods and complete results are included in this report in *Appendix A.*

We established nine (9) monitoring sites in Phase I, which we again used for sampling during Phases II and III. While we had intended to add a few monitoring points in Phase II, after

learning of the ephemeral nature of many of the streams in the expanded project area compounded with the long travel times to these remote areas, we decided that adding additional water quality monitoring sites was impractical.

We established three (3) water quality monitoring sites on Grass Creek, and two (2) each on Little Grass, Enos and Left Hand Creeks (Figures 8 & 9). Little Grass Creek data yields one year of baseline information before riparian fences were built in 2013 and 2014. The three Grass Creek sites each yielded one year of baseline data (2010) and six years of data following BMP implementation from 2011 to 2016. The two Left Hand Creek sites yielded three years of baseline data and three years of data following stock tank installations in 2013. We have not implemented any BMPs on Enos Creek, thus all data collected from this site is baseline data.

We performed data collection for the water quality monitoring portion of this project per the schedule found in Table 6. From June-September from 2012 through 2015, we collected physicochemical and physical water quality data. Physicochemical data, including temperature, pH, conductivity, and dissolved oxygen, were collected at the end of June, July, August, and September. Physical data were collected in July or August and included measurements of bank erosion rates, riparian vegetation data from channel cross sections, and pebble counts. During Phase II, we also collected aquatic macroinvertebrate data in 2013 but not 2012 due to the high cost of sample analysis. For Phase III, we collected aquatic macroinvertebrate data in 2015. Lastly, we deployed two in-situ water temperature loggers per site at five sites, for a total of ten loggers. At each site, one logger measured pool temperature while the other measured riffle temperature. The loggers collected temperature data every hour from the end of June through September of each year. While we received a one-year extension on the project that allowed us additional time for BMP implementation, we did not receive additional resources for monitoring, although in 2016, we were still able to collect bank erosion data.

TABLE 6. Summary of 2012-2015 water quality monitoring data collection schedule, broken down by site.

Site ID	June	July	August	September
GC1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013 & 2015) Pebble Count Temperature Logger	Physicochemical Temperature Logger
GC2	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013 & 2015) Pebble Count Temperature Logger	Physicochemical Temperature Logger
GC3	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013 & 2015) Pebble Count Temperature Logger	Physicochemical Temperature Logger
LG1	Physicochemical	Physicochemical Cross-Section	Physicochemical Bank Erosion Data	Physicochemical

		Vegetation	Macroinvertebrate (2013 & 2015) Pebble Count	
LG2	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013 & 2015) Pebble Count Temperature Logger	Physicochemical Temperature Logger
EC1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Macroinvertebrate (2013 & 2015) Pebble Count Temperature Logger	Physicochemical Temperature Logger
EC2	-	Vegetation	-	-
LH1	Physicochemical	Physicochemical Cross-Section Vegetation Temperature Logger	Physicochemical Bank Erosion Data Pebble Count	Physicochemical
LH2	-	Vegetation	-	-

Analysis of Physicochemical Data

Grass Creek

The pH levels we recorded between 2010 and 2015 at all three Grass Creek sites fell within the required range for acceptable water quality in Wyoming (not less than 6.5 and not greater than 9.0) as detailed in the Wyoming Water Quality Rules and Regulations, Chapter 1 (WDEQ/WQD 2013). Levels varied from 8.0 to 9.0 across all three sites during the four years with no discernible trend. The highest pH levels were measured at the mid-elevation site in 2010.

Instantaneous dissolved oxygen levels seemed to improve on Grass Creek over the course of the study. Instantaneous dissolved oxygen levels dropped below the 8 mg/L one-day minimum for coldwater fisheries (WDEQ/WQD 2013) at some sites in some months in 2010, 2011, 2012, and once in 2013, but never in 2014 or 2015. Due to equipment malfunction and repair time, we do not have DO data for August 2011, June 2013, or June and July of 2015.

We expected instantaneous DO saturation at GC1 (2,198 m elevation) to be 76% (Table 7), however our measurements exceeded this value throughout the Phase II project period. At GC2, the mid-elevation Grass Creek site, DO saturation remained above the expected 78% even when it dropped below the one-day minimum for coldwater fisheries. At GC3, the low elevation site on Grass Creek, dissolved oxygen levels remained above 8 mg/L during all six years of sampling. Dissolved oxygen saturation levels at GC3 also stayed above our expectation of 79%, with our lowest measurement being 82.3% in September 2013.

Throughout the six years we measured conductivity, levels increased as we moved downstream on Grass Creek. They did not consistently decrease at any of our sites over time. GC1 measurements typically ranged between 248 and 350 μS/cm, although we measured one outlier

in August of 2014 (574 µS/cm). At GC2, measurements stayed between 296 and 445 µS/cm, except in August of 2014 (597 µS/cm). Throughout the course of the project, GC3 measurements stayed between 415 to 619 µS/cm, but again in August of 2014 we made an anomalous measurement at this site (317 µS/cm).

Little Grass Creek

Though Little Grass Creek is classified as a 3B stream and is not required to meet coldwater fishery standards, we still employ those standards to assess stream health. At LG1 and LG2, we recorded pH values ranging from 7.9 to 8.6 between 2010 and 2015. Throughout the project period, pH values measured at all sites fall within the acceptable range for Wyoming coldwater fisheries.

At the Little Grass sites, instantaneous dissolved oxygen fell below the 8 mg/L threshold every year of the study. 2015 was the only year of the study during which DO saturation did not drop below the expected level of 78% at our study sites on Little Grass Creek.

Conductivities at LG1, the upper Little Grass site, ranged from 464 to 599 over the course of the study. Conductivities at LG2, the lower site, ranged between 402 and 688 µS/cm.

Left Hand Creek

Left Hand Creek is also classified as a 3B stream. Much of it is spring fed and portions of it are ephemeral throughout most of the year. Site LH1 is located below a spring that was developed in 2012 to provide water to four stock tanks and the system was in operation starting in late 2013. During Phase I (2010-2011), we measured pH values ranging from 8.0 to 8.6. During Phase II (2012-2013), we measured the same range of 7.9 to 8.3. In Phase III (2014-2015), pH ranged from 8.0 to 8.2. These measurements fall within the acceptable range for Wyoming coldwater fisheries.

At LH1, we found that instantaneous DO measurements only fell below the 8 mg/L limit for coldwater fisheries once in in 2010, 2014 and 2015. Throughout the remainder of the study, DO measurements exceeded this minimum. DO saturation levels dropped below the expected 80% in 2010, 2013, 2014 and 2015.

During project period conductivity levels at LH1 on Left Hand Creek were significantly higher than those measured at any other site, suggesting a relatively high concentration of total dissolved solids in upper Left Hand Creek. In 2010, conductivity levels ranged from 1,395 to 1,471 µS/cm, which were the highest values of any site during Phase II. By 2015, conductivity levels had dropped, ranging from 1,171 µS/cm in June to 1,250 µS/cm in September.

Enos Creek

Throughout the project, pH levels on Enos Creek were found to be within acceptable limits for a class 2AB stream (WDEQ/WQD 2013, Chapter 1 criteria). During Phase I (2010-2011), we measured pH values ranging from 8.1 to 8.5. During Phase II (2012-2013), we measured the

same range of 8.1 to 8.3. In Phase III (2014-2015), pH in Enos Creek ranged from 7.9 to 8.2. These measurements fall within the acceptable range for Wyoming coldwater fisheries.

Instantaneous dissolved oxygen levels at EC1 consistently exceeded the coldwater fisheries one-day minimum over the course of the study, although in 2012 and 2014 we recorded measurement below the minimum at least once. The expect DO saturation level at EC1 is 79%. DO saturation fell below this level in 2010, 2014 and 2015.

Conductivity levels at EC1 ranged from 425 to 565 μS/cm in 2010, and from 427 to 601 μS/cm in 2015. Typically, conductivity increased from June to September and did not decrease between years of the project.

The complete physicochemical data set collected in project area streams from 2010 to 2016 can be found in *Appendix A*.

TABLE 7. Expected Dissolved Oxygen % Saturation at each Site

Site	Elevation (m)	Expected % DO
GC1	2198	76
GC2	2069	78
GC3	1920	79
LG1	2060	78
LG2	1989	79
LH1	1859	80
EC1	1981	79

Analysis of Stream Temperature Data

A secondary objective of the project was to reduce stream temperatures to increase the health of the coldwater fishery in project area streams. Warmer water contains less oxygen than colder water. As temperature rises and dissolved oxygen decreases, stress increases for fish. The consensus is that all three major trout species (brook, brown and rainbow) experience elevated stress at around 20°C, with that stress increasing rapidly as the temperature rises further.

From 2010 through 2014, we deployed remote stream temperature loggers to measure how many days the water temperature rose above the coldwater fisheries maximum of 20°C (WDEQ/WQD 2013). Additionally, we examined these data to determine if the number of days on which water temperature exceeded 20°C decreased from 2010 to 2014 (Table 8). Missing logger data was caused by logger malfunction, and we assume that the actual number of days exceeding the maximum at those sites was higher than that measured. Throughout the study period we measured water temperatures in all three drainages that were consistently too high to support healthy coldwater fisheries. Although several of our loggers were broken by 2014, we saw no consistent evidence of a decreasing stream temperature trend in project area streams over the course of the study. Complete daily high and low temperatures for 2010 through 2014 and comprehensive temperature logger data sets are included in *Appendix A*.

Over the course of the project we planted 3,800 willow pole cuttings to create more cover above the water column; however, we will likely not see the benefits from these plantings until the trees have had a chance to become established over the next several years. Higher stream temperatures

observed during the project period, especially in 2012, were likely due to drier conditions in the basin. During dry years, stream depths decrease, resulting in temperature loggers being deployed in shallower water. Deployment in shallow water results in temperature loggers being more impacted by air temperatures. Of the three creeks monitored, Enos Creek most often maintained stream temperatures suitable to support a coldwater fishery, but in 2012 and 2013, we measured many days above the maximum temperature criterion.

TABLE 8. Number of days during which water temperatures exceeded 20°C at each site.

Site ID	LOGGER ID	2010	2011	2012	2013	2014
GC1	GC1TL1 - Pool	25	38	65	18*	broken
	GC1TL2 - Riffle	24	39	61	44*	broken
GC2	GC2TL1 - Pool	47	9*	65	34*	5
	GC2TL2 - Riffle	38*	53	70	54*	broken
GC3	GC3TL1 - Pool	17	15	10	36*	26
	GC3TL2 - Riffle	20	18	47	39*	28
EC1	EC1TL1 - Riffle	0	0	28	18*	8
	EC1TL2 - Pool	0	1*	23	16*	4
LG2 **	LG2TL1 - Pool/Run	38*	8	56	15	14*
	LG2TL2 - Riffle	47	26	66	21*	14*

* Indicates that there were days during this monitoring season when loggers were not functioning.
** As a 3B stream, Little Grass is not expected to maintain water temperatures above the coldwater fisheries minimum.

One flaw with our project design is that many of our monitoring sites are located a significant distance from the implemented BMPs. None of our temperature loggers, for example, were deployed in areas where willow growth or cattle exclusion would directly impact them.

Analysis of Physical Data

Vegetation

One objective of the project was to decrease the prevalence of bare ground and the proportion of invasive species in and adjacent to the riparian area at our water quality monitoring sites. We established 9 vegetation transects perpendicular to project area streams to determine whether the BMPs implemented during the project period were contributing to the expansion of riparian vegetation.

In 2010, 2011, 2012, 2013 and 2015, we collected point-intercept data along these transects to record the presence of perennial, annual, native or invasive grasses or forbs, sedge/rush, shrubs/trees, litter, moss/lichen, rock, or bare ground. As the project progressed, we realized that we had made species identification errors early in the project, making conclusions about changes in species diversity over the course of the project difficult. For example, in 2010 we could not identify many of the perennial grasses and labeled them simply as PG. In 2012, we could identify many more specimens to species. If we compared the two data sets by species it could appear

(falsely) that species diversity had increased. Comparing the results by life form eliminated this error.

The transects spanned between 50 and 100 feet on either side of the riparian area. We expected to measure decreases in the proportion of both invasives and bare ground over time at all sites. For our analysis, we removed the litter, rocks and dung from consideration. The vegetation transect data are in *Appendix A*.

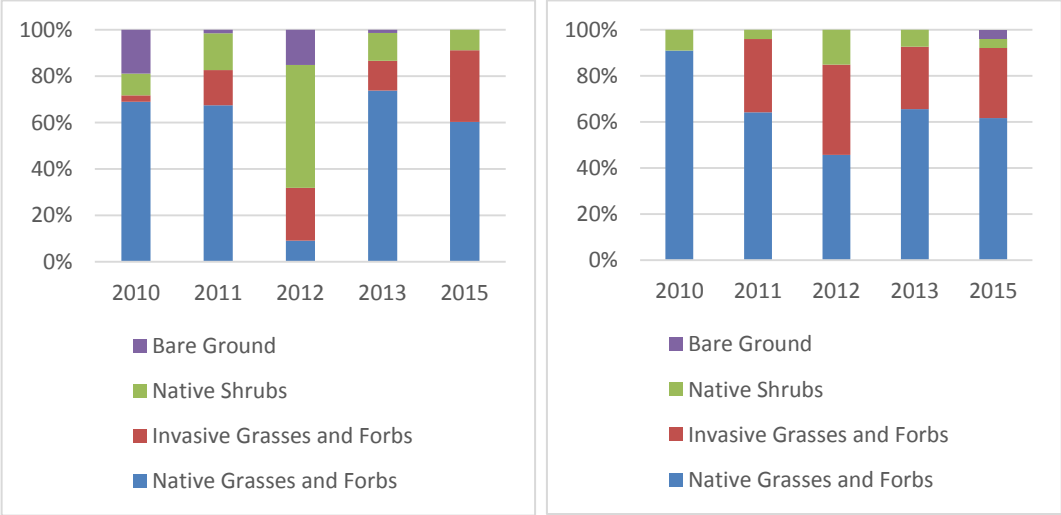
In the future, we would recommend follow-up monitoring of these vegetation transects to determine whether grazing management and the implementation of livestock BMPs has raised the water table and expanded the riparian area on project area streams.

Little Grass Creek

We observed two significant changes in the vegetation on Little Grass Creek between 2010 to 2015. At the upper elevation site, LG1, bare ground decreased, but the proportion of invasive grasses and forbs (primarily smooth brome and Kentucky bluegrass) increased. Bare ground at LG1 decreased from 18.9% in 2010 to zero in 2015. Over the same period, invasive species increased from 2.7% to 30.8% (Figure 7).

At the lower site, LG2, we observed a negligible increase in bare ground (0.0% to 4.0%) between 2010 and 2015. As at LG1, we also observed an increase in the proportion of invasive species (again, primarily smooth brome and Kentucky bluegrass) from 0.0% to 30.5% between 2010 and 2015 (Figure 8). It is important to note that in 2010, 62% and 83% (upper and lower, respectively) of the vegetation measured at the two sites could only be classified as perennial grass. While we have classified these as native species, it is possible that a portion of those were invasive and that the change in the relative proportion of invasives has not changed as much as we are reporting here.

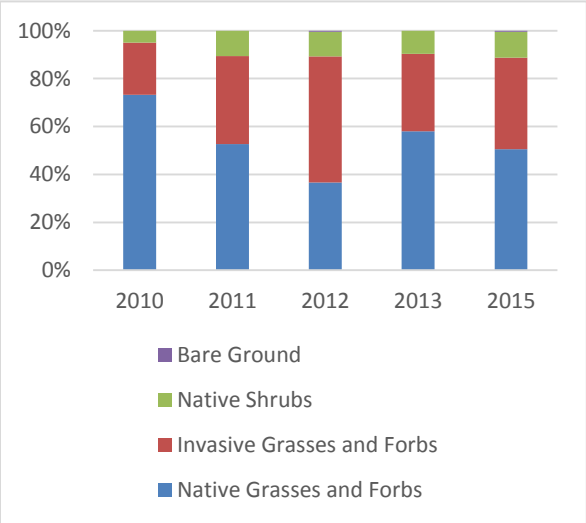
Figures 7 and 8. Percent cover by lifeform on Little Grass Creek at upper (LG1-left) and lower (LG2-right) elevation sites between 2010 and 2015. (Note – vegetation transects not read in 2014).

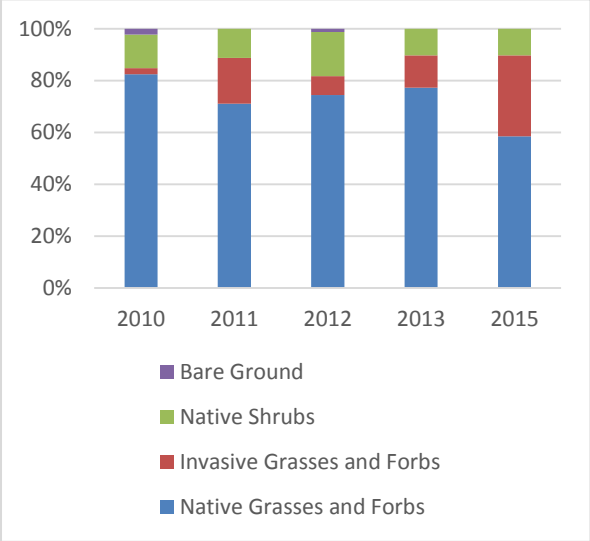


Grass Creek

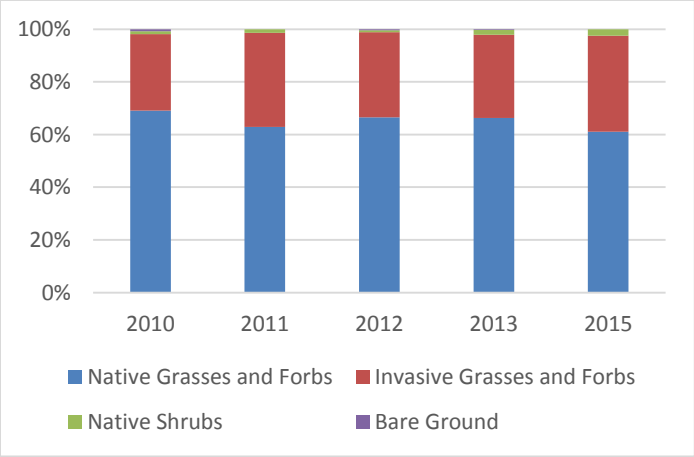
We measured little or no bare ground and increases in invasive cover on GC1, GC2, and GC3 throughout the project period (Figures 9, 10, and 11). At GC1, the high elevation site, the proportion of invasive grasses and forbs (primarily Kentucky bluegrass, Timothy and redtop) increased over the project period from 21.7% in 2010 to 38.2% in 2015 (Figure 9). At the mid-elevation site, GC2, invasives (smooth brome, wheat grass, white clover, and Kentucky bluegrass) increased from 2.3% in 2010 to 31.3% in 2015 (Figure 10). At the low elevation site, GC3, the proportion of invasives (Kentucky bluegrass, moist sowthistle and redtop) increased slightly from 28.9% in 2010 to 36.5% in 2015 (Figure 11).

Figures 9 and 10. Percent cover by lifeform on Grass Creek at upper (GC1-left) and middle (GC2-right) elevation sites between 2010 and 2015. (Note – vegetation transects not read in 2014).





Figures 11. Percent cover by lifeform on Grass Creek at the lowest elevation site (GC3) between 2010 and 2015. (Note – vegetation transects not read in 2014).

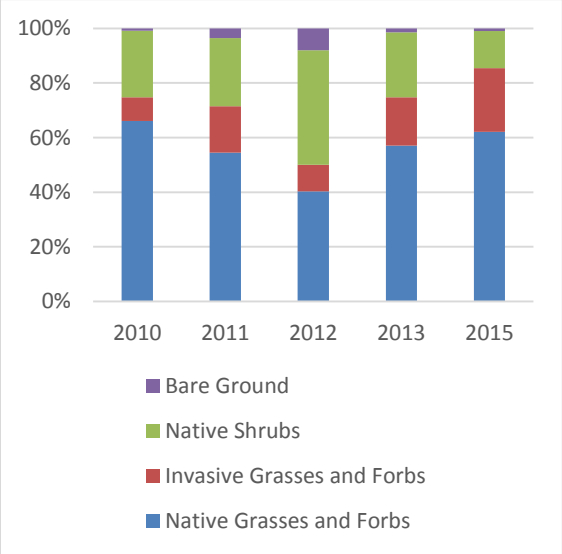


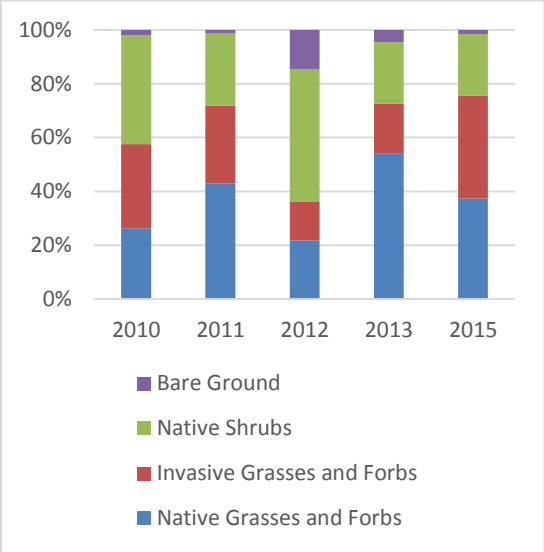
Left Hand

At LH1, the upper site on Left Hand Creek, the proportion of invasive grasses and forbs varied over the course of the project from 8.7% in 2010 to 17.0% in 2011 to 9.7% in 2012 to 17.8% in 2013 to 23.3% in 2015. Bare ground increased from less than 1% in 2010 to 8.1% in 2012 (a very dry year) to 1.0% in 2015 (Figure 12).

At LH2, the lower site, invasive grasses and forbs initially decreased from 31.3% in 2010 to 14.5% in 2012 before increasing to 32.1% in 2015 (Figure 13). The primary noxious grass at this site is cheatgrass (*Bromus tectorum)*. Its prevalence declined between 2010 (20.2%) and 2012 (0.0%) and then increased in 2013 (20.6%) before declining again in 2015 (9.8%). Its disappearance in 2012 is likely explained by the early drying and breakage of the plant which made it impossible to identify with certainty.

Figures 12 and 13. Percent cover by lifeform on Left Hand Creek at upper (LH1-left) and lower (LH2-right) elevation sites between 2010 and 2015. (Note – vegetation transects not read in 2014).



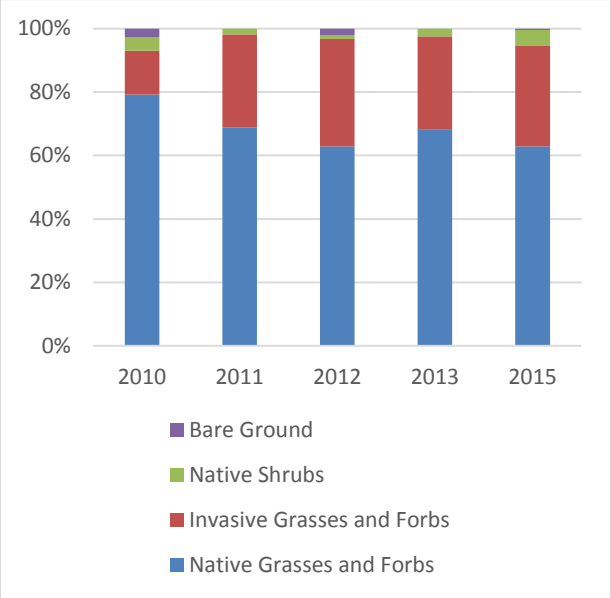


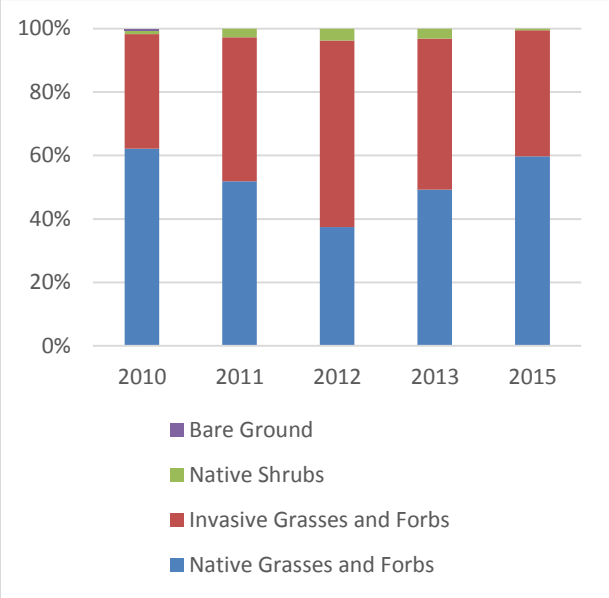
Enos Creek

At the upper Enos Creek site, EC1, the proportion of invasives increased from 2010 (13.9%, primarily redtop) to 2011 (29.4% - redtop and Kentucky bluegrass) where it nearly stabilized for the remainder of the study (Figure 14). Bare ground was minimal and stable at this site.

At the lower Enos Creek site, EC2, the proportion of invasives increased between 2010 (36.1% - redtop and sowthistle) and 2012 (58.8% - redtop, sowthistle and Kentucky bluegrass) before declining to 47.6% in 2013 and 39.7% in 2015 (Figure 15).

Figures 14 and 15. Percent cover by lifeform on Enos Creek at upper (EC1-left) and lower (EC2-right) elevation sites between 2010 and 2015. (Note – vegetation transects not read in 2014).





At some sites, we observed slight increases over the project in the invasive component of the upland flora, particularly Kentucky bluegrass, wheatgrass, and smooth brome. Timothy grass also increased in the riparian area at a few sites. Although cheat grass is expanding elsewhere in the project area, we only measured its presence (and increase) on the lower Left Hand Creek transect. Because our data in 2010 were limited by our familiarity with the species present on the transects, comparisons should be made between datasets from 2011 and 2015. We suspect that variation in the invasive component over time is probably related to variations in rainfall.

The certainty of our analysis is somewhat limited by information missing from 2010, our baseline for analysis. While we engaged the advice of experts in selecting the location and data collection methods for these transects, in retrospect, we should have also requested their help with the first transect readings in 2010. Our plant identification skills improved as the project progressed so we are more confident in the data collected in subsequent years than that from 2010.

We measured decreases in bare ground at several of our sites indicating improved vegetative condition over time. As range monitoring continues to provide the LU with better information about grass utilization, cattle become familiar with the locations of new off-creek water sources, and pole plantings become established in the riparian areas, we anticipate that additional monitoring of our vegetation transects would further reveal improving trends, particularly in riparian vegetation.

Stream Bank Erosion

We collected bank erosion data at seven water quality sites, as identified in Table 6. A complete description of our methods is available in *Appendix A*. Table 9 summarizes the erosion rates at each of these sites and changes we observed over the course of the project.

At the upper Grass Creek site, GC1, erosion rates decreased in the first five years that data were collected. Between 2010 and 2014, we measured a 70% decrease in erosion at this site which is nearest to where BMPs were implemented in Phase I. In 2015, the erosion rates increased back to levels measured at the start of the project. In 2016, the rate increased significantly due to a single, long, vertical, bare bank that was 19 feet tall. We could not explain how livestock grazing or other human impacts in this portion of the drainage could have caused this study bank to go from less than 2 feel tall to almost 20 feet tall. Because we concluded that changes in this bank are due to episodic mass-wasting of the high terrace/valley wall due to regular freeze-thaw cycles, we recalculated stream bank erosion on this bank using the average study bank height (1.8 ft) throughout the reach in 2016 (which was the same as the average study bank height at this site over the six years of the project). This approach allowed us to measure only that portion of the stream bank that could be eroded due to high flows and that may be influenced by livestock management. Using this approach, erosion at this site decreased by over 35% over the course of the study At the middle Grass Creek site, GC2, erosion decreased each year of the project. By 2016, the estimated erosion rate had declined by 56% as compared to 2010 levels.

At the lowest Grass Creek site, GC3, erosion decreased by 69% over the length of the project. The only BMP implemented near to GC3 was grazing management. Range monitoring may have influenced utilization and grazing timing at the site, resulting in erosion reductions. Overall, we measured significant erosion reduction at our two lower Grass Creek monitoring sites while measuring an increase at the upper site, although only during the final two years of the project.

The highest site on Little Grass Creek, LG1, showed significantly reduced erosion between 2010 and 2016. Erosion at the site decreased by 77% over the course of the project. At the lower Little Grass Creek site, LG2, erosion decreased by 56% between 2010 and 2016. Overall, erosion rates at our Little Grass Creek sites decreased significantly between 2010 and 2016.

Erosion rates at site EC1 on Enos Creek increased by about 19% over the six-year period. This is one of the two sites where we measured increased erosion rates over the life of the project. Except for GC1, all the other sites showed significant decreases in erosion rates over the course of this project. Enos Creek is also the only drainage where we measured erosion rates but did not implement any BMPs except grazing management.

On upper Left Hand Creek, at site LH1, we measured a decrease in erosion of 71% over the life of the project. Given that there is very limited human activity in this drainage other than ranching, the decreasing sediment loads suggest that the BMPs implemented here are positively impacting the stream. LH1 showed a moderate increase from 2010 to 2011, a significant decrease in 2012 (the drier year), and then an increase in 2013 back to 2010 levels. As explained in our Phase II final report, the 2013 increase was likely caused by a severe thunderstorm and flash flood in July that washed about 30 cubic feet of sediment and gravel into the stream from

the side drainage, deposited sediment and debris downstream, and washed out or covered much of the stream bank vegetation. In subsequent years, much of that sediment washed downstream where it has been slowly colonized by riparian vegetation. Erosion rates declined significantly in 2014, 2015 and 2016.

TABLE 9. Estimates of tons per year of sediment eroding from stream banks at each monitoring site from 2010 to 2016.

Site	2010	2011	2012	2013	2014	2015	2016	Change from 2010 to 2016	% Change 2010 to 2016
GC1	16.2	11.1	9.6	7.4	4.8	15.4	10.5	-5.8	**-35.5%**
GC2	9.6	7.4	5.7	4.7	4.8	4.6	4.2	-5.4	**-56.3%**
GC3	17.7	24.5	19.2	14.4	10.9	25.3	5.4	-12.3	**-69.5%**
LG1	3.5	2.4	2.0	1.8	2.2	2.4	0.8	-2.7	**-77.3%**
LG2	0.5	0.5	0.5	0.2	0.3	0.1	0.2	-0.3	**-54.0%**
EC1	5.6	9.6	10.2	9.8	9.1	10.0	6.7	1.1	**19.4%**
LH1	1.5	2.0	0.3	1.4	0.6	0.2	0.4	-1.1	**-71.0%**

Ratios of Study Bank to Bankfull Heights

At seven main monitoring sites (excluding EC2 and LH2), we measured study bank and bankfull heights at both the start and the end of each reach. The ratio of the study bank height to bankfull height (SB/BKF) can be used to indicate streambed stability, aggradation, or incision. TNC staff received training in 2010 (and a refresher in 2012) on how to properly take this measurement. In 2011 we took several measurements improperly, which caused our results to indicate significant incision that was not corroborated by our other data. Therefore, we will not use 2011 data for our analysis. We are confident that 2010, 2012, and 2013 data were taken correctly, so we have used those data for our analysis.

Measurements recorded at LG2, GC1, GC2, and GC3 all indicated that these sites were stable and were not incising or aggrading. In 2010 our measurements indicated that there may have been some incision occurring at LG1, but the ratios measured in 2012 and 2013 indicated increased stability. SB/BKF ratios at EC1 indicate that aggradation occurred in 2010 and 2012. In 2013, however, the site showed increased stability with similar top and bottom measurements. LH1 ratios also indicated that the stream was aggrading in 2010 and then stabilized in 2012 and 2013. The complete data table can be found in *Appendix* A of the Phase II Final Report for this project. We did not take these measurements during Phase III of the project.

Substrate Distribution

We collected substrate distribution data from a riffle within the study reach at each site at the same location every year. We performed a pebble count of 100 particles within each reach, classifying each particle by the length of its second-longest axis. Graphical results are presented

in *Appendix A*. We expected average particle size in project area streams to increase over time as erosion of fine sediment decreased following BMP implementation.

Little Grass

On upper Little Grass Creek, at site LG1, we observed a trend toward increasing particle size over the study period. Between 2010 and 2015, the proportion of sand and silt sampled varied considerably.

On lower Little Grass Creek, at site LG2, we observed a significant increase in particle size over the course of the project. In 2010 and 2011, 100% of the particles we sampled were sand and silt. By 2015, that figure had dropped to 40%.

Enos Creek

We found that particle size also increased on Enos Creek over the course of the project. Particle size increased between 2010 and 2012. In 2013, we observed a high proportion of fine sediment in the stream. We believe this pulse corresponded with extreme weather events in the drainage – a theory which is detailed elsewhere in this report. In 2014 and 2015, particle size increased again as excess sediment was remobilized downstream.

Grass Creek

As in Enos Creek, particle sizes at all three Grass Creek sites increased throughout the study period. And as measured in Enos Creek, there was a pulse of finer sediment that washed through the system in 2013. That year at the upper sampling site, GC1, over half of the samples collected fell within the four smallest size classes. We measured something similar in 2012. In 2014 and 2015, particle size increased again.

At both the mid-elevation and low-elevation Grass Creek sites, GC2 and GC3, particle size stayed relatively constant before 2013, when the fine sediment entered the system. As observed in Enos Creek, spring flows remobilized the excess fine sediment downstream.
Particle size increased in 2014 and 2015.

Left Hand

In 2010 at LH1, we sampled a normal distribution of particle sizes, with most samples falling within the fine- and medium-gravel categories. In 2011, we observed a shift towards larger particle sizes, with most samples falling in the coarse- and very-coarse gravel categories. In 2012 and 2013, particle size distribution shifted dramatically toward the finer particle size classes, with most samples taken in both years falling into the silt and sand categories. In 2014, 69% of particles were sand. In 2015, the distribution was more normal again, although there was more silt that we'd measured in 2010 and 2011.

As expected, we observed a shift towards large particle sizes in most project area streams between the beginning and end of this project. This result may be at least partially explained by

the implementation of livestock BMPs throughout the project period. As livestock loiter less in riparian areas, streambanks stabilize, riparian vegetation establishes, and less fine sediment ends up in the stream channel. These trends point to improving conditions for aquatic life in project area streams.

In 2012 and 2013, we measured a pulse of fine sediment in some of the project area streams. As noted elsewhere in this report, drier conditions in 2012 resulted in relatively low vegetative cover at several sites in the project area. In 2013, 7 localized, severe thunderstorms occurred that impacted both Left Hand Creek and the upper to middle Grass Creek watershed. These storms occurred on July 13, July 28, August 7, August 9, August 12, August 22, and August 30 (NOAA, 2015). Records show that between these storm events, the area experienced frequent light rain, which likely dampened the highly erodible and (typically) dry soils within those watersheds. These damp conditions combined with the intense storm events likely resulted in overland flow that washed large volumes of fine sediment and small-to-mid-size gravel into the study streams.

Had the fine sediments been the result of streambed or bank erosion, we likely would have observed a marked increase in sand and silt in the Grass Creek sites, rather than the increase in small- and mid-size gravel that we observed. The observed shift in 2013 towards finer sediments in both Left Hand Creek and Grass Creek, coincident with several intense storms, suggests that the sediment shift in both watersheds may have been the result of isolated weather patterns, rather than bank instability.

A second potential contributing factor involves disturbances in both watersheds. On Grass Creek and its tributaries, significant beetle kill, a multi-year salvage logging operation, and several associated culvert replacements and other road repairs may have contributed to sediment movement in the drainage. Over the same period, the Left Hand Creek drainage has also seen disturbance due to the implementation of project BMPs. Bare ground exposed during the installation of off-creek water sources and the mechanical removal of encroaching conifers from riparian area could also have contributed fine sediment to the stream.

Analysis of Biological Data

We collected biological data from the same designated riffle within each study reach where we collected physical and physicochemical data. A complete description of the methods we used can be found in *Appendix A*. We compared results using Wyoming Stream Integrity Index (WSII) scores (Hargett, 2011). During Phase II, we collected macroinvertebrate samples from all study streams in 2013 except for Left Hand Creek (where severe flooding in the summer of 2013 removed our study riffle – see Phase II final report for details). WDEQ staff advised that a similar riffle be sampled on Left Hand Creek; however, the flood impacted all other suitable sites. Our last collection was made in 2015 during Phase III of the project. Figure 16 shows WSII scores yielded from macroinvertebrate samples collected between 2010 and 2015.

Grass Creek

Over the course of the project, only three samples from two sites have ever scored a Full Support rating for macroinvertebrates - at the upper Grass Creek site in 2015, and at the lower Grass

Creek site in 2010 and 2011. GCI showed small improvements between 2010 and 2013 before showing a large improvement in 2015. The improved scores at this site may reflect the beneficial impacts of BMPs implemented in the upper portions of the drainage in both Phases I and II.

In contrast to the upper site, the scores at the mid-elevation Grass Creek site, GC2, were stable in 2010 and 2011, declined in 2013, and then rebounded in 2015 to where they'd started. This is likely the result of the record high flows from the storm event that washed sediment into the stream and scoured the stream bottom. In subsequent years, the community rebounded as the excess sediment was washed downstream and insects recolonized the coarser substrate of the riffles. At the lowest site, GC3, scores improved initially before declining from Full Support Indeterminate range in 2013 and 2015. This site showed the most significant decline in conditions of any in the study area over the course of the project, perhaps reflecting the fact that no BMPs were implemented anywhere near this site during the project.

The middle Grass Creek site has remained in similar condition throughout the project period, while the lower Grass Creek site, GC3, has shown a decline in biological conditions since 2010. It is likely that we were observing the results of the excess sediment that entered the stream in 2013 gradually making its way downstream with the high spring flow. As our physical results have indicated improving bank and riparian conditions along Grass Creek, this sediment is likely a pre-existing excess sediment load that is being slowly processed by the stream.

Little Grass Creek

WSII scores for LG2 indicated improvement in the site's ability to support macroinvertebrate life initially, followed by decline in Phase II the project. The measurable decline we saw in biological conditions across Little Grass and Grass Creeks in 2013 was likely due to the intense thunderstorms described in our Substrate Distribution analysis. This hypothesis is further supported by the fact that WSII scores showed improvement from their 2013 levels in 2015.

Enos Creek

WSII scores for the Enos Creek site, EC1, indicated Partial or Non-Support throughout the study period with very little variation. No BMPs were implemented either above or near this site during the project.

Left Hand

Left Hand Creek, sampled in 2010, 2011 and 2015, showed declining biological condition over time, with the most significant decline measured in 2015. A flash flood triggered by localized storms prevented aquatic macroinvertebrate sampling in Left Hand Creek in 2013. The storms likely triggered an influx of overland flow into the streams, which we believe washed with it high amounts of fine sediments, which would have negatively impacted many aquatic macroinvertebrate communities. This hypothesis is further supported by the immense improvement in conditions at LG1, LG2, GC1, and GC2 between 2013 and 2015.

Our analysis also included an assessment of the prevalence of EPT taxa (*Ephemeroptera*, *Plecoptera*, and *Trichoptera* community attribute) in project area streams. The presence and prevalence of mayflies, stoneflies and caddisflies in a stream are a strong indicator of water quality because many taxa of these insects area sensitive to poor stream conditions. Between 2010 and 2015, the EPT metric for our aquatic macroinvertebrate samples has improved, indicating an increase in the diversity of sensitive taxa within the project area. Over the same period, our Hilsenhoff's Biotic Index (HBI) also improved. HBI measures the organic-pollution tolerances of taxa found in macroinvertebrate communities. Our improved HBI metric indicates an increasing component of sensitive taxa in the macroinvertebrate communities throughout the project area. Improvements in HBI suggest decreasing organic inputs, in this case organic inputs associated with sediment from eroding banks

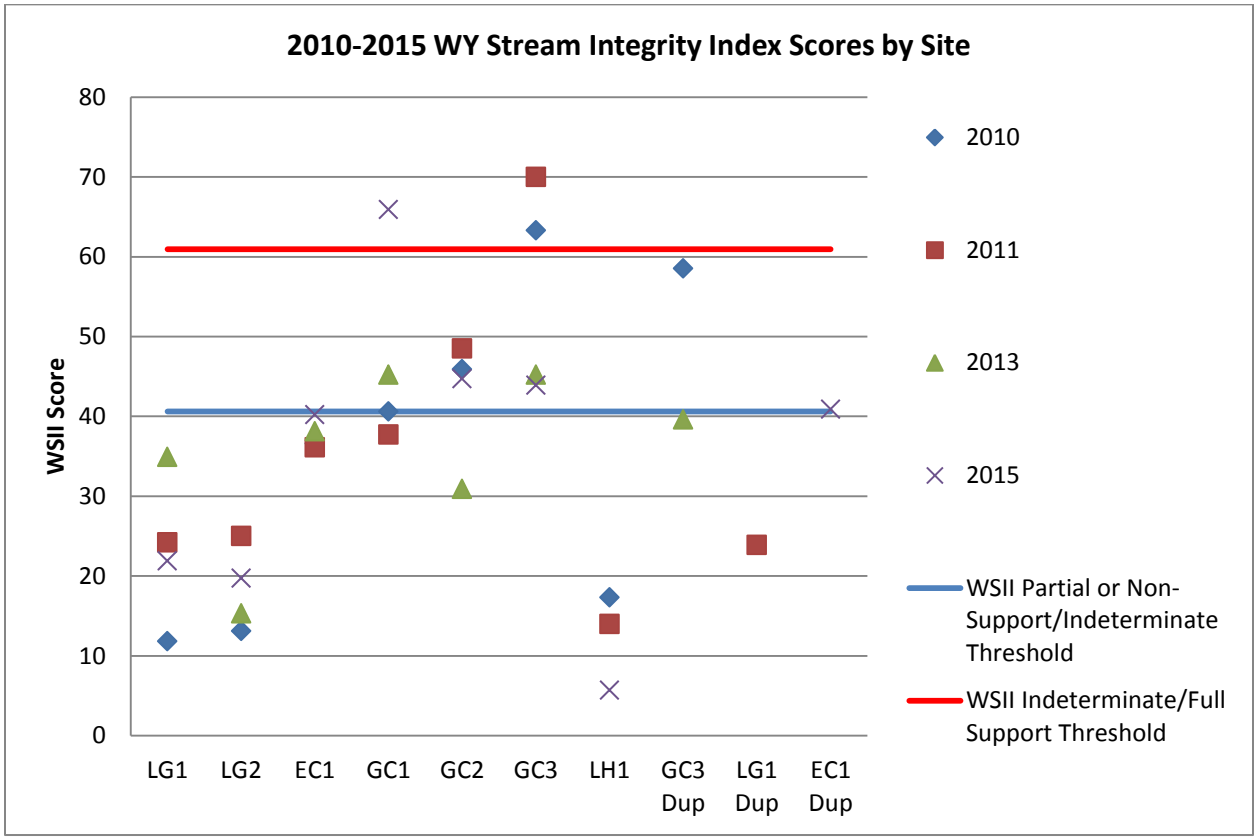


Figure 16. Categorized site scores from the WSII model. (*Note: The score from EC1 in 2010 is clustered with the scores from 2011 and 2013, so it is difficult to see the symbol on this figure.)*

Analysis of Range Monitoring Data

During Phase II of this project, we worked with landowners to establish range monitoring programs and to begin employing those methods in the field. Range monitoring transect locations are found on Figure 17. Methods and general summaries provided us by the landowners are included in this report.

The LU and Hillberry Ranches have shared their data with BLM range staff with whom they have worked to adjust their grazing and utilization rates over time. Because modifications to stocking rates or turn-out timing must be made in concert with BLM, change can be slow and improvements incremental. BLM comments on range condition on these ranches was provided in the Phase II final report for this project.

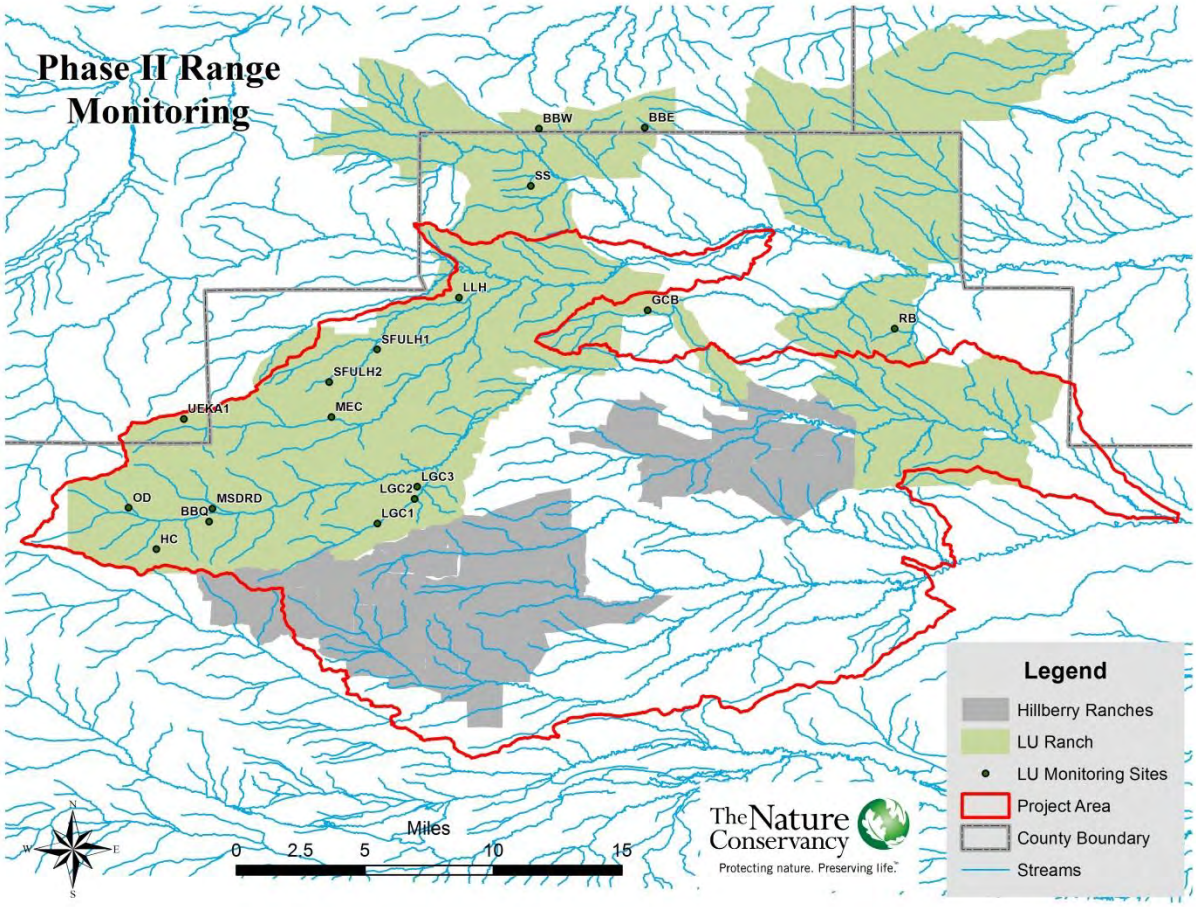


Figure 17. Range monitoring sites located on the LU Ranch and the monitoring area on Hillberry Ranches.

Hillberry Ranches

Ranch personnel were trained to monitor using the Landscape Appearance method to assess range health. One to three permanent transects were established in each pasture. Twelve to fifteen pastures are utilized annually; in each pasture, one permanent transect location is used to assess Landscape Appearance and take a photo, and then Landscape Appearance is determined at two to three random locations around the pasture. Additionally, plant species composition, soil and foliar cover were assessed for ten pastures in 2013. Because the Hillberry Ranches are only a few years into their monitoring, no trends will be assessed from their data.

LU Ranch

Data was collected on seventeen sites between 2010 and 2015. During each year, the landowners and ranch staff collected data on (1) Landscape Appearance to assess utilization of herbaceous plants, (2) Grazing Response Index (GRI) to quantify plant response to grazing, (3) photos taken along permanent photo transects to visually assess range conditions, and (4) plant lifeform count and bare ground assessments. In many years, weather prevented collecting all data at every site. For some sites, pre-turnout and post-removal photos were taken. The first and last photo available for every site is included in *Appendix B*.

TRENDS

Across all sites on LU Ranch, there was an overall increase in perennial grasses and forbs, and a decrease in shrubs and bare ground (Figure 18). Perennial grasses started with a higher level of occurrence than other plan lifeforms in 2010 and showed the largest increase over the last five years. However, there was a large amount of variation among sites, which makes it difficult to determine the magnitude of the trend.

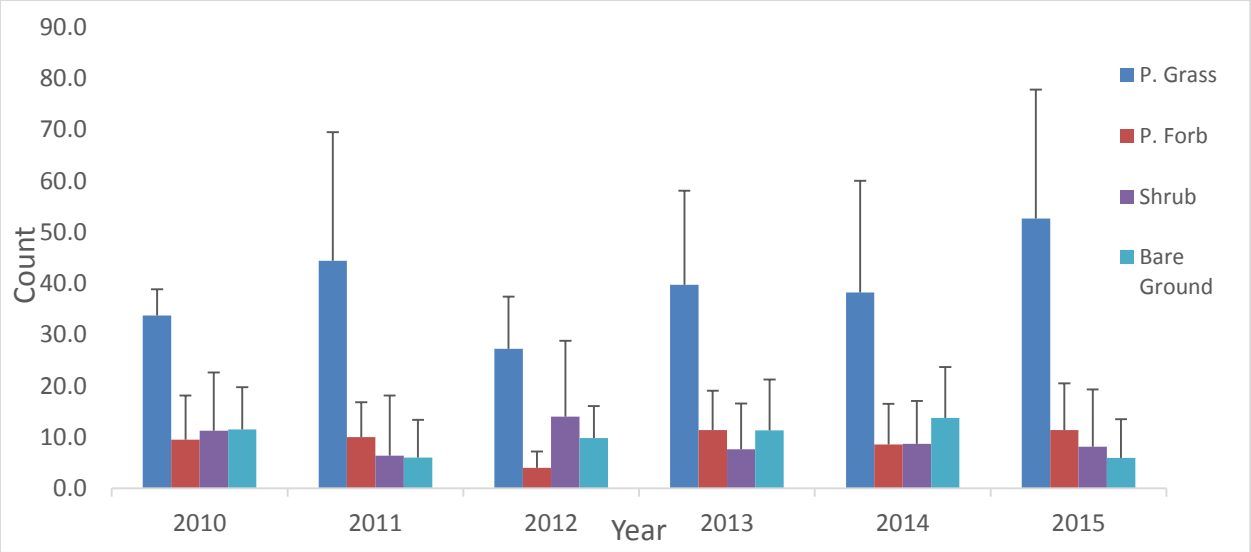


Figure 18: Count data for perennial grass, perennial forb, and shrub species, and bare ground at twenty sites on the LU Ranch.

The increase in perennial grass and forbs was greater than the decrease in bare ground (Table 10), suggesting that there was an overall increase in desirable plant species on the property. Annual forbs showed the greatest increase (245%) from 2010 to 2015, but is unlikely to be biologically significant given that the trend is based on an average change from one to two plants in a transect. The direction and magnitude of trends in lifeform change varied by pasture (Table

11). Grasses became more dominate between 2010 and 2015; grass to forb ratios increase from 3.5 (2010) to 4.6, and the grass to shrub ratio increased from 3 to 6.5.

Table 10. Percent change in the average count of plant lifeforms (perennial grass, perennial and annual forbs, shrubs) and bare ground on the LU Ranch between 2010 and 2015.

	2010	2015	Percent change
Perennial grass	33.8	52.6	56%
Perennial forb	9.5	11.4	20%
Annual forb	0.5	1.7	245%
Shrub	11.3	8.1	-28%
Bare ground	11.5	5.9	-48%

Table 11. Percent change in plant lifeform by pasture.

	Perennial Grass			Forbs			Shrubs		
Site	2010	2015	% Change	2010	2015	% Change	2010	2015	% Change
Buck Buttes West	31	25	-19.4	13	11	-15.4	10	18	80.0
Grass Creek 3	39	48	23.1	20	25	25.0	0	1	+
Rankin Basin*	37	29	-21.6	3	3	0.0	8	6	-25.0
South Shearing*	19	12	-36.8	10	2	-80.0	27	27	0.0
Upper Sanford Draw*	50	64	28.0	11	27	145.5	0	0	0.0
Upper Enos Creek 1*	61	82	34.4	20	11	-45.0	0	4	+

* Data for these pastures was based on 2014 (Rankin Basin) or 2011 values (South Shearing, Upper Sanford Draw, Upper Enos Creek 1).

Based on available grazing response index (GRI) numbers, it appears that the LU Ranch has been working towards reducing the impacts of grazing. Between 2010 and 2012, grazing use was

kept light to moderate for most pastures (Table 12). In 2012, the GRI showed a low level of negative impact to the range, but the year also had below average rainfall.

Table 12. Grazing response index (GRI) and grazing intensity (use level) for LU Ranch.

	2010		2011		2012	
Pasture	GRI	Use Level	GRI	Use Level	GRI	Use Level
Buck Buttes East			1	M	-2	M
Buck Buttes West			1	M	0	L
Gillies Draw			4	L	-1	M
Grass Creek Basin	1	M			0	L
Grass Creek 1	2	M			-2	H
Grass Creek 3	2	M			-3	M
Lower Left Hand	1	M	1	M	-3	M
Lower Left Hand Deeded					-1	L
Middle Enos					1	H
Mouth of Sanford Roach Ck					-2	M
Otto Draw			3	M	-2	H
Rankin Basin	3	M	5	L	2	M
Right Hand of Left Hand						
SFork Upper Left Hand 1	1	M	4	L	-1	L
Sfork Upper Left Hand 2	2	L			-1	M
South Shearing					-1	L
Up Sanford Draw			2	H		
Upper Enos KA 1	1	M			-1	M
AVERAGE	2	+1	3	+2	-1	+2

QUALITY ASSURANCE REPORTING

The collection and analysis of this data is consistent with the SAP developed for the project (TNC 2010). The SAP describes the proper way to collect and process data based on the *Quality Assurance Project Plan for Beneficial Use Reconnaissance Project Water Quality Monitoring* (WDEQ/WQD 2000) and the *Manual of Standard Operating Procedures for Sample Collection and Analysis* (WDEQ/WQD 2011). TNC field staff collected the data according to these procedures and the Conservancy's Stewardship Coordinator served as the quality assurance officer, checking procedures before and after data collection. Calculations for the quantitative portions of the project are in *Appendix C.*.

7.0 Partners

LOCAL GOVERNMENTS, INDUSTRY, ENVIRONMENTAL AND OTHER GROUPS; PUBLIC AT LARGE

Group	Involvement
LU Ranch	Collaborated on all aspects of the project to help improve wildlife habitat, water quality, range conditions, and the health of livestock operations on deeded land and federal grazing allotment.
Hillberry Ranches	Collaborated to establish range monitoring program and begin implementing BMPs on their ranches.
Hot Springs Weed & Pest	Sprayed the weed infestations in the Grass Creek Weed Management Area; provided expertise on treating weed infestations.
Marathon Oil	Provided volunteers for work-days and contributed cash match.
Round River Conservation Studies	Provided volunteer assistance with monitoring and BMP implementation.
Wyoming Conservation Corps	Provided in-kind labor.
Public At Large	Members of the public donated volunteer hours.

STATE AGENCIES

Group	Involvement
Wyoming DEQ	Assisted with planning, funding, technical training and provided informational support throughout the project
WY Game and Fish Department	Provided informational resources and technical assistance. Administered match funding from the WY Sage-grouse Conservation Fund and the Steel Jack Fencing initiative.
WY Department of Agriculture	Assisted with development of the range monitoring plan
Wyoming Conservation Corps	Worked for a week cutting conifers in riparian areas and helped develop a spring.
WY Wildlife and Natural Resource Trust Fund	Provided match funding.
University of WY Extension	Assisted with development of the range monitoring plan and taught the range monitoring workshop
Wyoming Honor Farm	Helped build riparian fences on Grass Creek and plant willows

FEDERAL AGENCIES

Group	Involvement
Natural Resource Conservation Service	Provided technical training, assistance with water quality and range monitoring, help with BMP implementation, and assistance at project work days
Bureau of Land Management	Crews assisted with conifer control on Left Hand Creek

8.0 Information and Education

The Nature Conservancy hosted both a Wyoming Conservation Corps (WCC) crew and Montana Conservation Corps (MCC) crew in 2015. WCC and MCC, service organizations following in the tradition of the Civilian Conservation Corps, provided crews that helped remove 71,091 feet of old redundant fencing and build 16,175 feet of 3 wire fence with solar chargers on the Hillberry Ranches.

TNC staff showcased the Grass Creek project at the 2014-16 Cody Wild West River Fest events. The annual festival, which was previously funded by the WDEQ 319 program, highlights the importance of water quality for recreation, fisheries, habitat, and livestock operations. Project handouts were distributed to many attendees of the annual events. Each year at the festival, participants can visit many booths that demonstrate water quality monitoring and improvement practices, many of which are used in this project.

9.0 Complications

As described in the Phase II final report for this project, road and stream-crossing repairs were undertaken periodically throughout the project period and sometimes added noticeably to stream turbidity. Likewise, logging operations to remove beetle-killed trees have been ongoing on upper Grass Creek and tributaries since 2011. While we are not able to determine the quantity of sediment inputs in the stream or the impacts on stream bank stability due to logging and road-building, it is our hope that our work to reduce bank erosion due to livestock is not being overwhelmed by these and other inputs outside our control, and that our work will continue to positively impact sediment loading in the project area.

In the early stages of the project, we had difficulty consistently identifying vegetation to species. As our familiarity with the project area vegetation increased, so did the number of species identified along our transects. We explained our remedy elsewhere in the report but we could have from the expert assistance with vegetation identification early in the project, unfortunately we had very limited funding in Phase I when we were establishing and reading the vegetation monitoring transects.

Additional types of data would be helpful in determining certain causes of declining stream health. Precipitation and flow data for each stream at various points over the life of the project would have been helpful, but, again, were not feasible due to financial and staffing constraints. For example, the decreased particle sizes seen at most of the sites in 2013 indicate that more sediment was moving through the system, but we cannot pinpoint the source of the sediment.

Possibilities include increased stream flows from storm activity or inputs from other activities like logging, ATV recreation, and camping (the ranch allows public hunting and recreation).

We established our water quality monitoring sites prior to selecting sites for BMP implementation; those monitoring sites may not all have been in close enough proximity to the BMP implementation sites to accurately assess the impacts of the BMPs. The Rosgen monitoring sites, in areas where BMPs were implemented, should have visible and measureable decreases in sediment loading because livestock should be utilizing the riparian areas less. Our temperature loggers were not located in sites targeted for revegetation, so even local stream temperature reductions due to the BMPs (which is all we could reasonably hope for at this point) are likely not reflected in our monitoring data sets.

In Phase I, we built two aspen stand enclosures that excluded both native and domesticated grazers and browsers. We also collected data in belt transects in both the fenced and nearby unfenced stands in similar condition. Unfortunately, we read the transects for the first time a couple of months after the fences were completed and after the positive impacts of the fences were already obvious, so were unable to capture a true baseline condition although the paired stands were essentially identical prior to fence construction. When we returned the re-read the transects after a year, we learned that loggers on state lands had used our paired control stands as a staging area for their logging operations, significantly impacting the unfenced aspen stands. Thus, we are unable to isolate the impacts of the fences although we can report that the aspen stands inside the fences show impressive regeneration and it should be possible to remove those fences within the next couple of years when a significant proportion of the saplings have exceeded 10 feet in height.

10.0 Recommendations

As we conclude the final phase of this project, TNC would recommend the following going forward:

1. Noxious Weed control. Weeds that increased because of some of the conifer control conducted in Phase II and Phase III of this project may require additional attention in the future.
2. Future Monitoring. Additional monitoring several years beyond the conclusion of this project would help demonstrate the impact of the BMPs that we have implemented.

11.0 Financial Summary

All Phases

	319 or 205(j) Funds Expended	Nonfederal Match Expended	Total NPS Expenditures	Other Federal Funds Expended
All Tasks	$433,577.68	$287,615.89	$721,193.57	$0.00

OTHER SOURCES OF FUNDS

Contributor	Amount
TNC Funds	$44,352.11
Wyoming Wildlife and Natural Trust	$153,379.11
LU Ranches	$45,874.04
Hot Springs Co. Weed & Pest District	$4,516.64
Wyoming Game and Fish	$35,132.17
Volunteer labor	$4,361.82
Total	**$287,615.89**

Phase I

Task #	Task Title	319 or 205(j) Funds Expended	Nonfederal Match Expended	Total NPS Expenditures	Other Federal Funds Expended
1	Administration	$2,324.00	$4,027.97	$6,351.97	$0.00
2	BMP Implementation	$22,444.65	$24,696.08	$47,140.73	$0.00
3	Weed Management	$6,679.52	$4,516.64	$11,916.16	$0.00
4	Monitoring/Outreach	$30,517.90	$9,759.46	$40,277.36	$0.00
	TOTALS	$61,966.07	$43,000.15	$104,966.22	$0.00

OTHER SOURCES OF FUNDS

Contributor	Amount
TNC Funds	$5,464.40
Wyoming Wildlife and Natural Trust	$900.00
LU Ranches	$28,824.51
Hot Springs Co. Weed & Pest District (in-kind)	$4,516.64
Volunteer labor	$3,294.60
Total	**$43,000.15**

Phase II

Task #	Task Title	319 or 205(j) Funds Expended	Nonfederal Match Expended	Total NPS Expenditures	Other Federal Funds Expended
1	Administration	$1,214.52	$10,976.46	$12,190.98	$0.00
2	BMP Implementation	$116,484.01	$101,877.66	$218,484.42	$0.00
3	Plant Control	$36,754.38	$37,142.63	$73,897.00	$0.00
4	Monitoring	$50,571.80	$11,469.08	$62,040.89	$0.00
5	Revegetation	$66,586.90	$2,253.44	$68,840.33	$0.00
	TOTALS	$271,611.61	$163,719.26	$435,330.87	$0.00

OTHER SOURCES OF FUNDS

Contributor	Amount
TNC Funds	$36,929.34
Wyoming Wildlife and Natural Resource Trust	$73,541.00
LU Ranch (cash + in-kind)	$4,949.53 + $12,100.00
Wyoming Game and Fish (cash + in-kind)	$24,832.17+ $10,300.00
Volunteer labor	$1,067.22
Total	**$163,719.26**

Phase III

Task #	Task Title	319 or 205(j) Funds Expended	Nonfederal Match Expended	Total NPS Expenditures	Other Federal Funds Expended
1	Administration	$9,777.67	$0.00	$9,777.67	$0.00
2	BMP Implementation	$62,550.85	$80,896.48	$143,447.33	$0.00
3	Monitoring	$25,452.95	$0.00	$25,452.96	$0.00
4	Final Report Production	$2,218.53	$0.00	$2,218.53	$0.00
	TOTALS	$100,000.00	$80,896.48	$180,896.48	$0.00

OTHER SOURCES OF FUNDS

Contributor	Amount
Wyoming Wildlife Natural Resource Trust	$78,938.11
TNC Funds	$1,958.37
Total	**$80,896.48**

12.0 LIST OF APPENDICES

- **Appendix A:** Water Quality Data and Analyses 2010-2016
- **Appendix B:** Range Monitoring Data
- **Appendix C:** Quality Assurance/Quality Control Calculations

LITERATURE CITED

Bureau of Land Management, Worland Field Office. 2000. Riparian Lentic Proper Functioning Condition Checklist for Enos Creek Tributary, Segment I0295.

Bureau of Land Management, Worland Field Office. 2004. Riparian Lentic Proper Functioning Condition Checklist for Enos Creek Tributary, Segment I0295X.

Bureau of Land Management, Worland Field Office. 2006. Riparian Lentic Proper Functioning Condition Checklist for Left Hand Creek, Segments P0208X and P0207X.

Dunham, J., G. Chandler, B. Reiman, and D. Martin. 2005. Measuring Stream Temperature with Digital Data Loggers: A User's Guide. USDA Technical Report.

Hargett, E.G. 2011. The Wyoming Stream Integrity Index (WSII) – Multimetric Indices for Assessment of Wadeable Streams and Large Rivers in Wyoming. Wyoming Department of Environmental Quality, Water Quality Division. Cheyenne, Wyoming.

Jones, Bobette E., David Burton, and Kenneth W. Tate. 2005. Effectiveness Monitoring of Aspen Regeneration on Managed Rangelands. United States Department of Agriculture.

National Oceanic and Atmospheric Administration's National Weather Service. 2015. Precipitation Records retrieved from http://w2.weather.gov/climate/

Rosgen, Dave. 2008. River Stability Field Guide. Copyright: Wildland Hydrology, Fort Collins, CO.

The Nature Conservancy. 2010. Grass, Enos, and Left Hand Creek Non-Point Source Reduction Project Sampling and Analysis Plan. Cody, WY.

The Nature Conservancy. 2015. *Monitoring Results for the Grass, Enos and Left Hand Creek Nonpoint Source Reduction Project.* Cody, WY 72 pp.

Jones, Bobette E., David Burton, and Kenneth W. Tate. 2005. *Effectiveness Monitoring of Aspen Regeneration on Managed Rangelands*: *a monitoring method to determine if management objectives are being met in aspen communities.* In Effectiveness Monitoring of Aspen Regeneration on Managed Rangelands, United States Department of Agriculture publications.

Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program. 2001. Quality Assurance Project Plan (QAPP) for Beneficial Use Reconnaissance Project (BURP) Water Quality Monitoring. Cheyenne, Wyoming.

Wyoming Department of Environmental Quality, Water Quality Division. 2011. Manual of Standard Operating Procedures for Sample Collection and Analysis. Cheyenne, WY.

Wyoming Department of Environmental Quality, Water Quality Division (Author: Eric Hargett). 2005. Grass Creek Monitoring and Assessment Report. Cheyenne, WY.

Wyoming Department of Environmental Quality, Water Quality Division. 2007. Wyoming Water Quality Assessment and Impaired Waters List (Integrated 305(b) and 303(d) Report).

Wyoming Department of Environmental Quality, Water Quality Division. 2013. Wyoming Water Quality Rules and Regulations, Chapter 1: Wyoming Surface Water Quality Standards. Cheyenne, WY.

YSI Incorporated. 2009. The Dissolved Oxygen Handbook: a practical guide to dissolved oxygen measurements. www.ysi.com/weknowdo <http://www.ysi.com/weknowdo>. Accessed 2/17/2012.