Print Form | Submit by Email | Reset Form

Annual Report

This Annual Report shows information the Division has for your mine. Submit the completed document and any additional information identified in the Appendices to the Division by the date specified in the cover letter. During a complete inspection an inspector will check and verify the information.

GENERAL INFORMATION

Company Name	Canyon Fuel Company LLC	Mine Name	Skyline Mine
Permit Number	C/007/0005	Permit expiration Date	April 30, 2017
Operator Name	Skyline Mine - Gregg Galecki	Phone Number	+1 (435) 448-2636
Mailing Address	HC 35 Box 380	Email	ggalecki@bowieresources.com
City	Helper		
State	Utah	Zip Code	84526

		DOGM File Location or Annual Report Location
Excess Spoil Piles	☐ Required ☒ Not Required	
Refuse Piles	☒ Required ☐ Not Required	Submitted quarterly in electronic format on 5/1/15 (1st), 8/12/15 (2nd), 11/18/15 (3rd), and 2/22/16 (4th), respectively.
Impoundments	☒ Required ☐ Not Required	Submitted quarterly in electronic format on 4/22/15 (1st), 8/7/15 (2nd), 11/13/15 (3rd), and 2/22/16 (4th), respectively.
Other:		

OPERATOR COMMENTS

REVIEWER COMMENTS ☐ Met Requirements ☐ Did Not meet Requirements

COMMITMENTS AND CONDITIONS

The Permittee is responsible for ensuring annual technical commitments in the Mining and Reclamation Plan and conditions accepted with the permit are completed throughout the year. The Division has identified these commitments below and has provided space for you to report what you have done during the past year for each commitment. If additional written response is required, it should be filed as an attachment to this report.

Title: WASTE ROCK SAMPLING
Objective: To document chemical characteristics and support reclamation plan using less than four feet of cover and to protect surface and groundwater.
Frequency: During periods of deposition at the waste rock site.
Status: Quarterly sampling, one sample per 2000 tons hauled to the disposal site.
Reports: Annual report
Citation: MRP, Volume 3, Section 4.4, page 4-30, 2nd paragraph and 1988 Soils Guidelines Table 6.

Operator Comments

A total of approximately 4,928 tons of material were hauled to the waste rock site in 2015. Two (2) samples were collected and analyzed by Inter-Mountain labs. Sample report titled, "Waste Rock Samples 2015".

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: RAPTOR SURVEYS
Objective: To monitor known nest locations and identify new raptor nests that could be impacted from subsidence or new surface facilities. Damaged nests will be replaced immediately with an artificial structure in consultation with DWR.
Frequency: Annually and according to the Division's Raptor Survey Guidelines
Status: Ongoing
Reports: As Available
Citation: MRP, Chapter 4, Section 4.18, page 4-103

Operator Comments

A .pdf file report titled, "2015 Power line & Vent Report 08.16.15" outline the raptor survey for Swens Canyon and the Power line corridor. A juvenile norther goshawk nest was located near the power line corridor that may need to be mitigated during construction. Wildlife biologist Mace Crane indicated he wouldn't be surprised if the nest was not used again in the future due to the size of the tree and location. A second .pdf file report titled, "2015 NOG Bleeder SHaft and Subsidence Report 8.16.15.pdf"(outlines the raptor survey in Woods Canyon, identifying any nests potentially affected by subsidence related to current mining activities.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: MACROINVERTEBRATE SURVEYS
Objective: To determine if mining and mining related activities are impacting Eccles Creek.
Frequency: Conduct studies in the fall for two consecutive years then two years off.
Status: Surveys due for 2015/2016 then 2019/2020
Reports: Annual
Citation: MRP, Appendix A-3, Volume 2, Volume 1A, Section 2.8, pages 2-70-2-71C Section 2.8, table 2.8-1a

Operator Comments

A .pdf file report titled "Final Eccles Creek Report_2015" provides macroinvertebrate data working towards indexing the health of Eccles Creek.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: NORTH LEASE VEGETATION SURVEY
Objective: To determine the effects of longwall mining on riparian vegetation along Winter Quarters and Woods Canyon stream channels.
Frequency: Baseline survey of entire length of channels in 2005. Survey two years prior and during undermining of channel lengths and follow-up surveys two years after undermining.
Status: Ongoing, Please include a discussion of possible impacts from mining on riparian vegetation in report from qualified biologist.
Reports: Annual
Citation: MRP, Volume 1A, Section 2.7, pages 2-61d; A-2 volume 2, and A-3 Volume 2

Operator Comments

The riparian vegetation survey titled, "canyon16.WQ15.rip.rpt.FINAL" is attached to this report.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: FISH SURVEY
Objective: To determine if mining and mining related activities are impacting fish in Eccles Creek.
Frequency: In the fall every three years.
Status: Survey due 2016
Reports: Every three years
Citation: MRP, Volume 1A, Section 2.8, page 2-71d.

Operator Comments

An electro-fish survey will be conducted in 2016.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: Topsoil nutrient sampling during construction of the NOG Bleeder
Objective: Determine N:P:K status of salvaged topsoils, because this analysis was not included with the soil survey
Frequency: once Fall 2015 or if construction is delayed, prior to construction
Status: Submit with 2015 annual report
Reports: Annual
Citation: Conditional approval of NOG Bleeder Shaft Task 4883. Outgoing folder 9212015.4883.doc

Operator Comments

Construction has not been initiated at the North of Graben Bleeder site. N:P:K analysis of the topsoil will be conducted at the site prior to construction.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: SUBSIDENCE MONITORING
Objective: To document the amount of subsidence that has occurred.
Frequency: Annually
Status: Ongoing
Reports: Annual Update of Drawing 4.17.3-1 and digitized area survey information and results of on the ground visual inspection.
Citation: MRP, Chapter 4, page 4-97 thru 4-99a

Operator Comments

The Cumulative Subsidence 1982-2015 map has been submitted with this report. Note that the 2015 data is identified as PRELIMINARY. The information is labeled in this manner due to the survey showing subsidence outside the anticipated 'angle-of-draw' zones typically seen. This will be field checked with established data points located in the field in 2016. Both ground and aerial (helicopter) visual inspections of the subsided areas did not identify any adverse surface impacts related to subidence.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: SUBSOIL SAMPLING AT WASTE ROCK SITE
Objective: To provide chemical characteristics of purchased subsoil.
Frequency: Once. Sample purchased subsoil for parameters in Table 1 of the Utah 1988 Guidelines.
Status: Ongoing with contemporaneous reclamation at the waste rock site.
Reports: None specified. Suggest verbal communication with Division and lab analysis to be included in bond release application.
Citation: MRP, Volume 3, Section 4.6.4.1, page 4-38a, 3rd paragraph, and page 4-38b.

Operator Comments

No subsoil was purchased that was used in contemporaneous reclamation in 2015.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: AGE-MONITORING OF WATER
Objective: To understand the possible sources of groundwater inflows.
Frequency: When inflows of 800 gpm are encountered.
Status: No significant inflows in the North Lease.
Reports: Immediately notify Division
Citation: MRP, Volume 1, page 2-35b, paragraph 2.

Operator Comments

No significant inflows of 800 gpm were encountered during mining in 2015.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: SAMPLING PRIOR TO SLURRY PLACEMENT IN ABANDONED UNDERGROUND WORKINGS
Objective: Protection of groundwater
Frequency: Every 450 feet of advance
Status: Report if placed slurry in abandoned underground workings.
Reports: Notification if parameters are out of compliance with Guidelines for Topsoil and Overburden.
Citation: MRP, Volume 2, Incorporation of 97K-1 and Section 1.2 (at the end of section 3.2).

Operator Comments

No slurry was place underground in 2015.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

FUTURE COMMITMENTS AND CONDITIONS

The following commitments are not required for the current annual report year, but will be required by the permittee in the future as indicated by the "status" field. These commitments are included for information only, and do not currently require action. If you feel that the commitment is no longer relevant or needs to be revised, please contact the Division.

Title: TOPSOIL SAMPLING
Objective: To determine fertilizer application rate.
Frequency: At final reclamation sample redistributed topsoil for N, P, K, Fe, Mg, Mn, Zn, Ca and pH.
Status: At final reclamation
Reports: None specified. Suggest verbal communication with Division and lab analyses to be included in bond release application.
Citation: MRP, Volume 3, Section 4.5, page 4-32, 2nd paragraph.

Title: SAMPLING OF WASTE ROCK IN TEMPORARY STOCKPILES
Objective: Protection of surface and groundwater
Frequency: one sample per 2000 tons of temporary stockpiled material if remains in temporary location longer than three months.
Status: Ongoing
Reports: Not specified. Assumed to be the same as disposal site sampling (previous paragraph on same page.)
Citation: MRP, Volume 3, page 4-30, 3rd paragraph, and 1988 Soils guidelines, table 6.

OPERATOR COMMENTS (OPTIONAL)

REVIEWER COMMENTS

REPORTING OF OTHER TECHNICAL DATA

Please list other technical data or information that was not included in the form above, but is required under the approved plan, which must be periodically submitted to the Division.

Please list attachments:

Reviewer Comments

MAPS

Copies of mine maps, current and up-to-date, are to be provided to the Division as an attachment to this report in accordance with the requirements of R645-301-525.240. The map copies shall be made in accordance with 30 CFR 75.1200 as required by MSHA. Mine maps are not considered confidential.

Map Name	Map Number	Included		Confidential	
		Yes	No	Yes	No
Cumulative Subsidence 1982-2015 2015 Preliminary	Cumulative Subsidence 2015	☒	☐	☐	☒
2016 5-year Timing		☒	☐	☐	☒
As mined 2015		☒	☐	☐	☒
		☐	☐	☐	☐
		☐	☐	☐	☐

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Please note that mine maps are not confidential per R645-300-124.300. Confidentiality is limited to the information specified in R645-300-124.310, R645-300-320, and R645-300-124.330.

2014 Wildlife Survey Report

NOG Graben Bleeder Shaft

Northern Goshawk Protocol, Raptors,
American three-toed woodpecker, and
General Wildlife Survey

Prepared for:

Skyline Mine
Gregg Galecki
Environmental Engineer
Canyon Fuel Company, LLC

Prepared By:

Alpine Ecological
HC 80 Box 570
Greenwich, UT 84732

3.28.15

1.0 Introduction

The following narrative is submitted pursuant to requirements regulating potential impacts to terrestrial threatened, endangered, candidate and sensitive species and their associated habitats. The following report details the results of wildlife surveys conducted for the NOG Graben Bleeder Shaft Project; surveys included northern goshawk (*Accipiter gentilis*), American three-toed woodpecker (*Picoides dorsalis*), general raptor, and general wildlife surveys No other special status wildlife species were identified as a result of the pre-field research. The areas surveyed are displayed on Figure 1.

Pre-field research was completed by Alpine wildlife biologists who utilized GIS data from the Utah Division of Wildlife Resources' (UDWR) Utah Threatened, Endangered, and Sensitive Species Occurrences shapefiles and mapping services. Research included historic records, species ecology, life history, known distributions, and habitat requirements.

2.0 Project Description

Skyline Mine proposed to construct a bleeder shaft in the Granger Ridge Area. As required by UDOGM, northern goshawk, American three-toed woodpecker, general raptor, and general wildlife surveys were conducted around the proposed shaft site and associated buffer area (Survey Area).

3.0 Habitat

South and East facing slopes, at higher elevations are dominated by quaking aspen communities with large open areas. These open areas are typically grass and tall forb communities. The North and West facing slopes are dominated by conifer communities. The tree species within the conifer community are mostly dead or dying, and the area has an abundance of deadfall due to beetle infestations. Because of the deadfall and dead trees the forbs and grasses within the conifer communities are very diverse and most areas have a solid understory. The tops of the ridges in the survey area vary with some being dominated by shrub communities such as mountain big sagebrush, elderberry or chokecherry while others are dominated by grass and tall forb communities.

4.0 Methodology

Northern Goshawk broadcast acoustical surveys were conducted following U.S. Department of Agriculture (USDA) Forest Service, 2006, Northern Goshawk Inventory and Monitoring Technical Guide pp.3.13-15. Using GIS, survey transects were established 250 meters apart throughout the survey area which extended 0.5 miles beyond the project footprint. Broadcast calling stations were then established every 200 meters along each transect. Upon arrival at each broadcast calling station, the surveyor looked and listened before broadcasting the pre-recorded alarm calls. Utilizing FoxPro game calls, pre-recorded northern goshawk alarm calls were broadcast for approximately 10 seconds followed by 30 seconds of looking and listening. After turning 120 degrees the

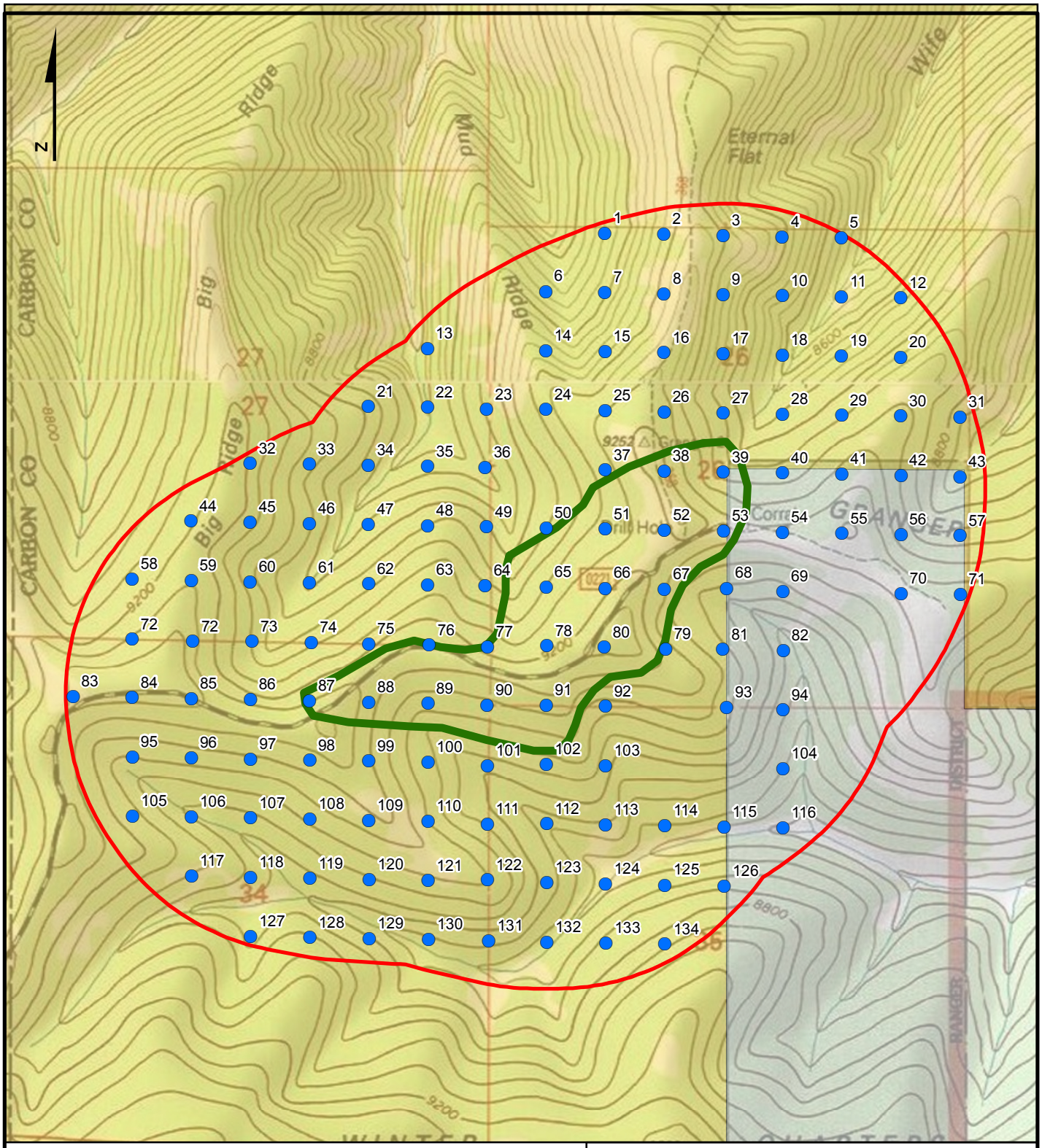
sequence was then repeated. Once the sequence of 10 seconds of calling and 30 seconds of looking and listening was completed 3 times and no response was elicited the surveyor then repeated the sequence before moving to the next calling station. Surveys were timed in accordance to the survey requirements outlined in the 2006 Technical Guide and were based on local knowledge of nesting chronologies in the area and coordination with the US Forest Service. Additionally, surveyors searched for foraging raptors between calling stations when vantage points were available. This survey was conducted twice as outlined in the protocol. There are a 134 call stations within the Survey Area.

American three-toed woodpecker surveys are conducted simultaneously with the northern goshawk survey in areas of suitable habitat. Biologists listened for drumming activity while at the call stations and inventoried for three-toed woodpeckers in suitable habitat while walking linear transects between call stations.

General raptor and wildlife surveys were conducted along transects designed during the northern goshawk protocol surveys.

5.0 Survey Results

There were no raptor observations documented within the Survey Area. Red tailed hawks were observed, on two separate occasions, soaring to the east of the Survey Area, while biologists traveled along the Granger Ridge Road. Common ravens (*Corvus corax*) were also observed along Granger Ridge Road and within the Survey Area. There were no other raptor species observed during the course of the inventory. No other special status species were observed during the course of the inventory. There were no audio or visual observations of American three-toed woodpecker during the course of the 2014 surveys.



BASE MAP:1:24,000 USGS Quad (Accessed at ArcGIS Online)

Goshawk Call Stations
0.5-Mile Buffer
Potential Shaft Location
Ownership
BLM
Private

1,000 500 0 Meters

1 in = 473 meters

NOG Bleeder Shaft

FIGURE - 1

DATE DRAWN 07/30/2014

2015 Wildlife Survey Report

NOG Bleeder Shaft,
And
Potential Subsidence Area Projects

Northern Goshawk, other Raptors, and
General Wildlife Surveys

Prepared for:

Skyline Mine
Gregg Galecki
Environmental Engineer
Canyon Fuel Company, LLC

Prepared By:
Alpine Ecological
HC 80 Box 570
Greenwich, UT 84732

08.15.2015

1.0 Introduction

The following narrative is submitted pursuant to requirements regulating potential impacts to threatened, endangered, candidate and sensitive species and their associated habitats. The following report details the results of the northern goshawk (*Accipiter gentilis*), American three-toed woodpecker (*Picoides dorsalis*), general raptor, and general wildlife surveys conducted for the NOG Bleeder Shaft and Potential Subsidence Area Projects. No other special status species were identified to have suitable habitat within these project areas. The areas surveyed are displayed on Figure 1.

Pre-field research was completed by Alpine wildlife biologists who utilized GIS data from the Utah Division of Wildlife Resources' (UDWR) Utah Threatened, Endangered, and Sensitive Species Occurrences shapefiles and mapping services. The US Fish and Wildlife Services' species by County list was reviewed and a search was conducted in the Information, Planning and Consultation System (IPaC). Research included species occurrences, historic records, species ecology, life histories, known distributions, and habitat requirements. Coordination with the UDOGM and the Forest Service Wildlife Biologists was conducted in the spring prior to survey initiation. Survey requirements were discussed and are in accordance with the Northern Goshawk Technical Guide. American three-toed woodpecker surveys were conducted using the same methodology as the Forest Service; conducted along northern goshawk transects in suitable habitat. Northern goshawk protocol surveys, nesting raptor surveys, American three-toed woodpecker, and general wildlife surveys have been conducted in or near the project area by private and federal biologists over the past several years.

There are no threatened, endangered, or candidate species known to occur within the project area. State or Federally listed sensitive species which were identified as species of concern included raptors, with emphasis on northern goshawk and golden eagle, and American three-toed woodpecker. The remaining listed species were dismissed from further consideration, as a result of the multiple agency review, because there is no suitable habitat present within the project area or the project is outside of the species known distribution.

2.0 Project Description

The 2015 wildlife survey covered the 2015, 2016, and 2017 mining panels and the NOG Bleeder Shaft locations and a 0.5 mile buffer (Figure 1). These surveys were combined as the surveys overlapped one another. Northern goshawk protocol surveys, general raptor surveys, American three-toed woodpecker, and general wildlife surveys were conducted in and around the areas displayed on Figure 1. This report represents the second year of surveys for the NOG Bleeder Shaft Project. The potential subsidence area survey includes 2015, 2016, and 2017 mine panels. This survey area was discussed and approved by UDOGM and USFS biologist on a pre-survey coordination call in the spring of 2015.

3.0 General Habitat Overview

The vegetation across the survey area is very diverse and is somewhat consistent throughout the survey area. Vegetation is dependent on elevation, slope, and available water resources. Riparian areas are dominated by typical high elevation riparian species.

The bottoms of the valleys that are drier are dominated by mountain big sagebrush and silver sagebrush communities. South and East facing slopes, at higher elevations are dominated by quaking aspen communities. However, there are some areas that are open on South and East facing slopes. These open areas are typically grass and tall forb communities. However, a significant number of the open areas are dominated by false hellebore. The North and West facing slopes are dominated by conifer communities. The tree species within the conifer community are mostly dead or dying, and most areas have an abundance of deadfall due to beetle infestations. Because of the deadfall and dead trees the forbs and grasses within the conifer communities are very diverse and most areas have a solid understory. The tops of the ridges in the survey area vary with some being dominated by shrub communities such as mountain big sagebrush, elderberry or chokecherry while others are dominated by grass and tall forb communities. Some of the ridge tops are dominated by cluster tarweed.

4.0 Methodology

Northern Goshawk broadcast acoustical surveys were conducted following U.S. Department of Agriculture (USDA) Forest Service, 2006, Northern Goshawk Inventory and Monitoring Technical Guide pp.3.13-15. Using GIS, survey transects were established 250 meters apart throughout the survey area which extended 0.5 miles beyond the project footprint. Broadcast calling stations were then established every 200 meters along each transect. Calling stations were then overlaid on NAIP aerial imagery in a GIS and call stations not located in suitable habitat were removed from the survey. Upon arrival at each broadcast calling station, the surveyor looked and listened before broadcasting the pre-recorded alarm calls. Utilizing FoxPro game calls, pre-recorded northern goshawk alarm calls were broadcast for approximately 10 seconds followed by 30 seconds of looking and listening. After turning 120 degrees the sequence was then repeated. Once the sequence of 10 seconds of calling and 30 seconds of looking and listening was completed 3 times and no response was elicited the surveyor then repeated the sequence before moving to the next calling station. Surveys were timed in accordance to the survey requirements outlined in the 2006 Technical Guide and were based on local knowledge of nesting chronologies in the area and coordination with the US Forest Service. Additionally, surveyors searched for foraging raptors between calling stations when vantage points were available. Consultation with the USFS and UDOGM was conducted concerning survey timing and the survey area. The survey was within the seasonal guidelines as defined in the 2006 Technical Guide and was conducted across the approved survey area.

American three-toed woodpecker surveys are conducted simultaneously with the northern goshawk survey. Biologists listened for drumming activity while at the call stations and inventoried for three-toed woodpeckers in suitable habitat while walking linear transects between call stations. This methodology is also used by the USFS and was discussed and approved on a pre-survey conference call by USFS and UDOGM biologists.

General wildlife surveys include the identification of general terrestrial wildlife species and were conducted along transects between call stations. The results of the general survey are listed at the beginning of Section 5.

5.0 Survey Results

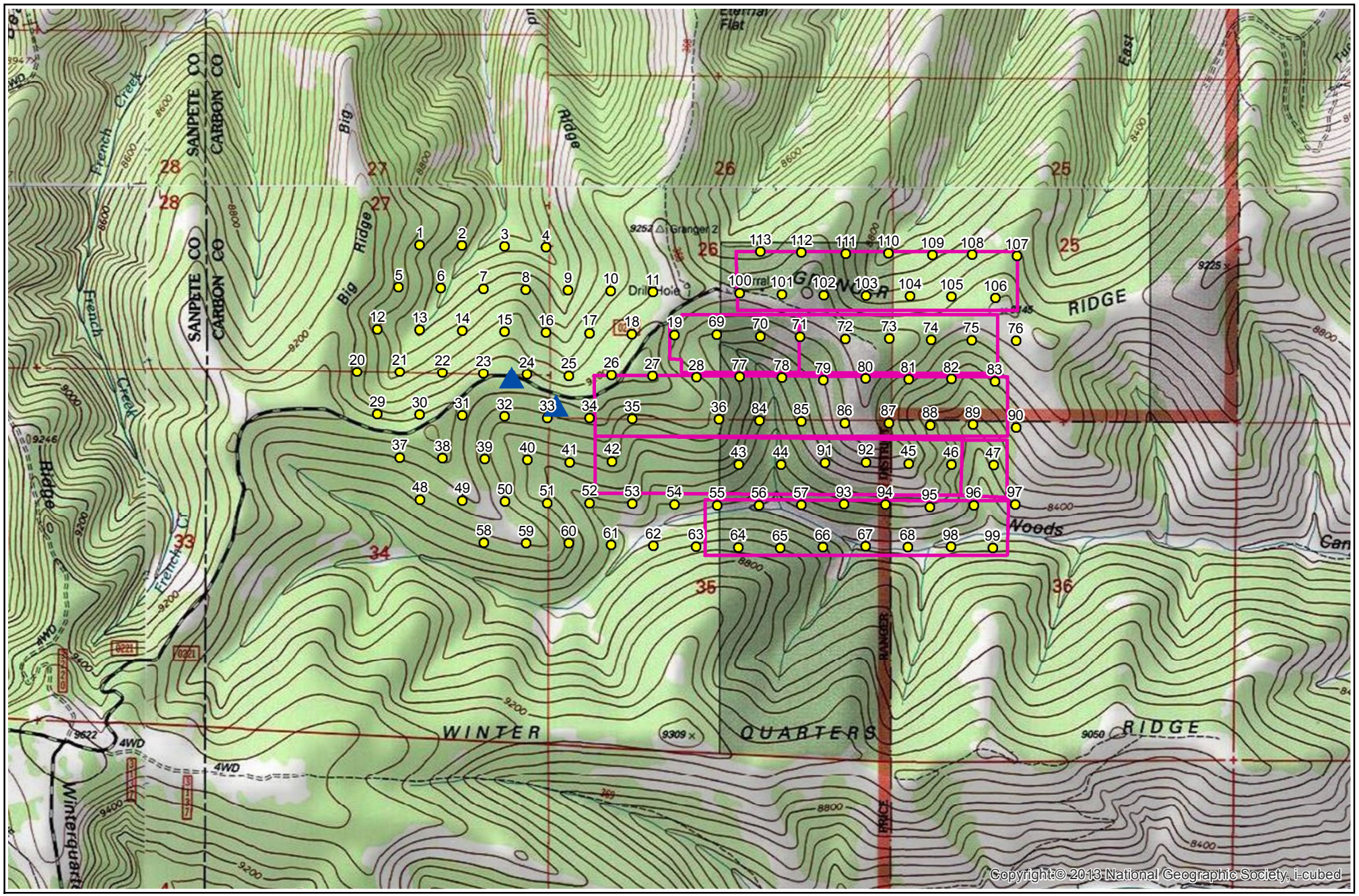
Species observed during the course of the inventories included, but are not limited to, common raven (*Corvus corax*), dark-eyed junco (*Junco hyemalis*), brown creeper (*Certhia americana),* black-capped chickadee (*Poecile atricapillus*), Clark's nutcracker (*Nucifraga columbiana*), American robin (*Turdus migratorius*), mountain chickadee (*Poecile gambeli*), ruby-crowned kinglet (*Regulus calendula),* dusky flycatcher (*Empidonax oberholseri),* (Rocky Mountain elk (*Cervus elaphus*), and mule deer (*Odocoileus hemionus*). Information such as species, call station observed, and type of observation (e.g., aural (A) or visual (V)) were documented for raptor species of concern; other species listed were observed and listed herein for reference only.

Table 1 summarizes the results of the survey by call station, raptor species, and type of observation.

Station#	Survey	Aural	Visual	Species	Notes
65	1		X	REHA	REHA
66	1	X	X	REHA	REHA calling
51	1	X	X	REHA	REHA flew south and is soaring over Winter Quarters Ridge
52	1	X	X	REHA	REHA soaring over Winter Quarters ridge.
53	1	X	X	REHA	REHA soaring over Winter Quarters ridge.
22	2		X	REHA	Individual soaring North of the survey area.
21	2		X	REHA	Individual soaring to the North, down the ridge a ways.
45	2		X	REHA	Soaring to the east down drainage

Red-tailed hawk was the only raptor species observed during the course of the surveys. Individuals were observed soaring over or near the project area during both surveys. There were no active nests documented within the survey area. There were no aural or visual observations of American three-toed woodpecker during the course of the 2015 surveys.

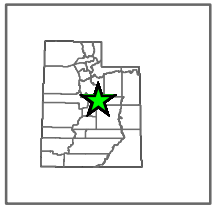
The vegetative communities within the Project Area are classified by the Utah Division of Wildlife Resources as crucial summer mule deer fawning habitat and crucial summer elk calving habitat. There were no individual cow elk (sign of calving) or individual deer (sign of fawning) documented within the survey area. Further there were no large groups of elk or deer observed during either survey. The single documented observation occurred during the second survey; two small bull elk were documented near call station 7.



2015 Call Stations

Shaft and Topoil Site

2015-17 Mine Panels



NOG Bleeder Shaft and Potential Subsidence Areas

FIGURE 1

08/15/15

1:24,000

2015 Wildlife Survey Report

Power Line,
Ventilation Pad,
And
Coal Pile Expansion Projects

Northern Goshawk, other Raptors, and
General Wildlife Surveys

Prepared for:

Skyline Mine
Gregg Galecki
Environmental Engineer
Canyon Fuel Company, LLC

Prepared By:
Alpine Ecological
HC 80 Box 570
Greenwich, UT 84732

08.03.2015

1.0 Introduction

The following narrative is submitted pursuant to requirements regulating potential impacts to threatened, endangered, candidate and sensitive species and their associated habitats. The following report details the results of the northern goshawk (*Accipiter gentilis*), American three-toed woodpecker (*Picoides dorsalis*), general raptor, and general wildlife surveys conducted for the Power line, Ventilation Pad, and the Coal Pile Expansion Projects. No other special status species were identified to have suitable habitat within these project areas. The areas surveyed are displayed on Figure 1.

Pre-field research was completed by Alpine wildlife biologists who utilized GIS data from the Utah Division of Wildlife Resources' (UDWR) Utah Threatened, Endangered, and Sensitive Species Occurrences shapefiles and mapping services. The US Fish and Wildlife Services' species by County list was reviewed and a search was conducted in their Information, Planning and Consultation System (IPaC). Research included species occurrences, historic records, species ecology, life histories, known distributions, and habitat requirements. Coordination with the UDOGM and the Forest Service Wildlife Biologists was conducted in the spring prior to survey initiation. Survey requirements were discussed and are in accordance with the Northern Goshawk technical guide. American three-toed woodpecker surveys were conducted using the same methodology as the Forest Service; conducted along northern goshawk transects in suitable habitat. Northern goshawk protocol surveys, nesting raptor surveys, American three-toed woodpecker, and general wildlife surveys have been conducted in or near the project area by private and federal biologists over the past several years.

There are no threatened, endangered, or candidate species known to occur within the project area. State or Federally listed sensitive species which were identified as species of concern included all raptors, with emphasis on northern goshawk and golden eagle, and American three-toed woodpecker. The remaining listed species were dismissed from further consideration, as a result of the multiple agency review, because there is no suitable habitat or the project is outside of the species known distribution.

2.0 Project Description

The 2015 wildlife survey included the following areas: the remaining call stations for the potential power line route, Swen's Canyon ventilation shaft, and the coal pile expansion area (Figure 1). The majority of the call stations for the power line and ventilation shaft were called for two consecutive years in 2013 and 2015. A shift in the route of the power line required additional call stations to the south of the original route. This survey is the second consecutive year these call stations have been called. Northern goshawk protocol surveys, general raptor surveys, American three-toed woodpecker, and general wildlife surveys were conducted in and around the areas displayed on Figure 1.

3.0 General Habitat Overview

The vegetation across the survey area is very diverse and is somewhat consistent throughout the survey area. Vegetation is dependent on elevation, slope, and available water resources. Riparian areas are dominated by typical high elevation riparian species. The bottoms of the valleys that are drier are dominated by mountain big sagebrush and

silver sagebrush communities. South and East facing slopes, at higher elevations are dominated by quaking aspen communities. However, there are some areas that are open on South and East facing slopes. These open areas are typically grass and tall forb communities. However, a significant number of the open areas are dominated by false hellebore. The North and West facing slopes are dominated by conifer communities. The tree species within the conifer community are mostly dead or dying, and most areas have an abundance of deadfall due to beetle infestations. Because of the deadfall and dead trees the forbs and grasses within the conifer communities are very diverse and most areas have a solid understory. The tops of the ridges in the survey area vary with some being dominated by shrub communities such as mountain big sagebrush, elderberry or chokecherry while others are dominated by grass and tall forb communities. Some of the ridge tops are dominated by cluster tarweed.

4.0 Methodology

Northern Goshawk broadcast acoustical surveys were conducted following U.S. Department of Agriculture (USDA) Forest Service, 2006, Northern Goshawk Inventory and Monitoring Technical Guide pp.3.13-15. Using GIS, survey transects were established 250 meters apart throughout the survey area which extended 0.5 miles beyond the project footprint. Broadcast calling stations were then established every 200 meters along each transect. Calling stations were then overlaid on NAIP aerial imagery in a GIS and call stations not located in suitable habitat were removed from the survey. Upon arrival at each broadcast calling station, the surveyor looked and listened before broadcasting the pre-recorded alarm calls. Utilizing FoxPro game calls, pre-recorded northern goshawk alarm calls were broadcast for approximately 10 seconds followed by 30 seconds of looking and listening. After turning 120 degrees the sequence was then repeated. Once the sequence of 10 seconds of calling and 30 seconds of looking and listening was completed 3 times and no response was elicited the surveyor then repeated the sequence before moving to the next calling station. Surveys were timed in accordance to the survey requirements outlined in the 2006 Technical Guide and were based on local knowledge of nesting chronologies in the area and coordination with the US Forest Service. Additionally, surveyors searched for foraging raptors between calling stations when vantage points were available. Consultation with the USFS and UDOGM was conducted concerning survey timing and was within the seasonal guidelines as defined in the 2006 Technical Guide. The project area has had two years of consecutive surveys conducted over a vast majority of the project. The focus of the 2015 surveys was to complete a small number of call stations created due to an alignment adjustment made in 2014. These call stations were first called in 2014 and the survey in 2015 was the second year of surveys.

American three-toed woodpecker surveys are conducted simultaneously with the northern goshawk survey. Biologists listened for drumming activity while at the call stations and inventoried for three-toed woodpeckers in suitable habitat while walking linear transects between call stations. This methodology is also used by the USFS and was discussed and approved on a pre-survey conference call by USFS and UDOGM biologists.

General wildlife surveys include the identification of general terrestrial wildlife species and were conducted along transects between call stations. The results of the general survey are listed at the beginning of Section 5.

5.0 Survey Results

Species observed during the course of the inventories included, but are not limited to, red-tailed hawk (*Buteo jamaicensis*) (REHA), common raven (*Corvus corax*) (CORA), dark-eyed junco (*Junco hyemalis*), brown creeper (*Certhia americana)*, black-capped chickadee (*Poecile atricapillus*), lazuli bunting (*Passerina amoena*), Stellar's jay (*Cyanocitta stelleri*), red-naped sapsucker (*Sphyrapicus nuchalis*), Clark's nutcracker (*Nucifraga columbiana*), American robin (*Turdus migratorius*), dusky blue grouse (*Dendragapus obscurus*), mountain chickadee (*Poecile gambeli*), ruby-crowned kinglet (*Regulus calendula)*, Rocky Mountain elk (*Cervus elaphus*), mule deer (*Odocoileus hemionus*), and black bear (*Urus americanus*). Information such as species, call station observed, and type of observation (e.g., aural (A) or visual (V)) were documented for species of concern; other species listed were observed and listed herein for reference only.

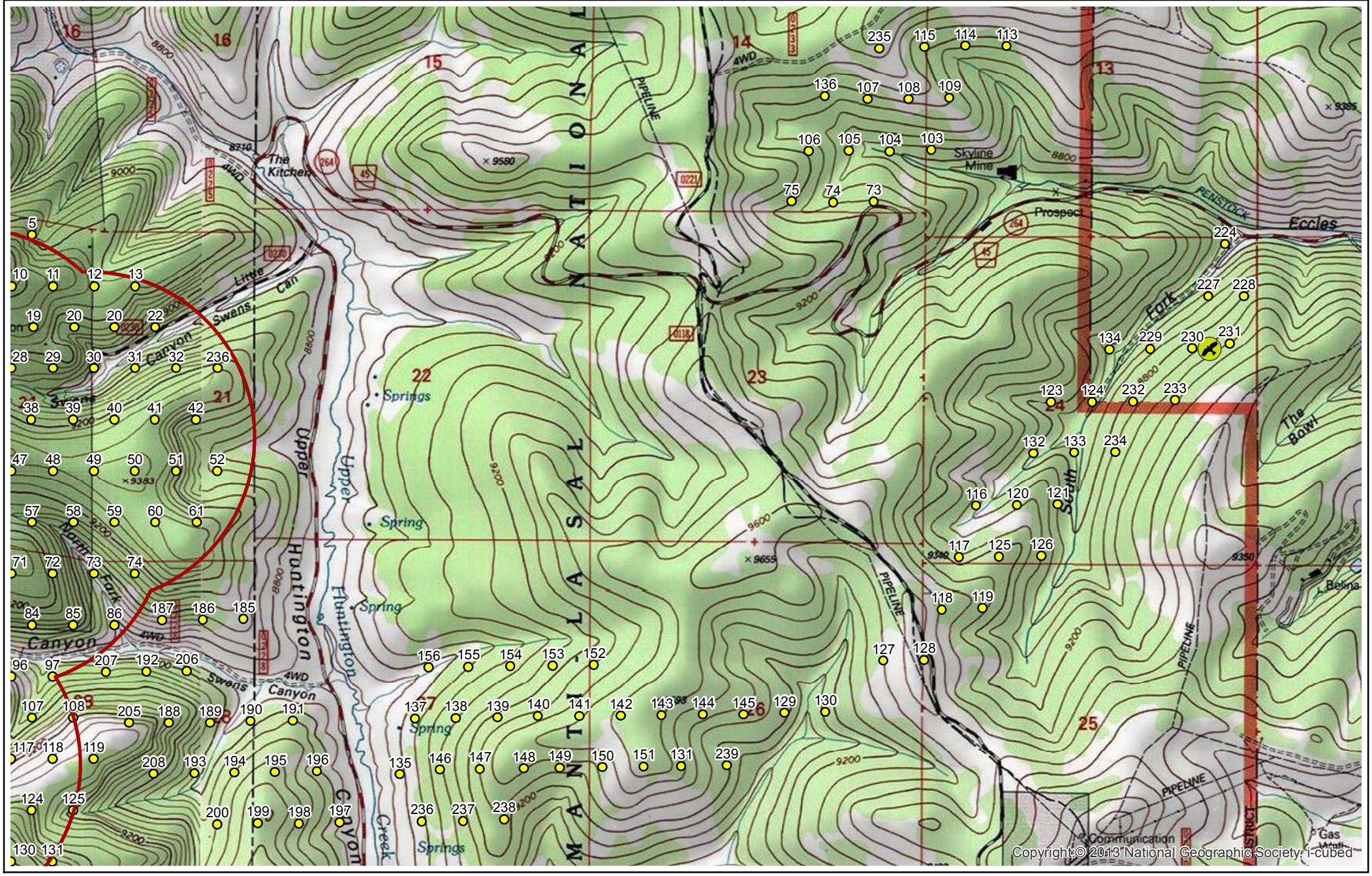
Table 1 summarizes the results of the survey by call station, raptor species, and type of observation.

Station#	Survey	Aural	Visual	Species	Notes
125	1	X		CORA	CORA heard to the N.
133	1	X		CORA	CORA heard to the N.
124	1		X	AMKE	AMKE observed near drainage bottom.
232	1		X	REHA	REHA seen soaring to the NE across Eccles Canyon Road.
231	1	X	X	NOGO	NOGO response elicited, nest located between call station 230 and 231.
106	1	X	X	REHA	REHA observed soaring in basin
136	1	X	X	REHA	REHA observed soaring in basin
107	1	X	X	REHA	REHA observed soaring in basin
136	2	X	X	REHA	REHA observed soaring above 106
107	2	X	X	REHA	REHA soaring above 106 and 75
106	2	X	X	REHA	REHA observed soaring at ridge top.
Nest Monitoring	2	X	X	NOGO	3 fledglings were observed in trees around the nest. Nest has had significant construction since the first observation. Nest tree is extremely small, dbh <12 in., persistence is unlikely.

The vegetative communities within the Project Area are classified by the Utah Division of Wildlife Resources as crucial summer mule deer fawning habitat and crucial summer elk calving habitat. This was confirmed by biologists throughout each project area as individual mule deer fawns and elk calves were observed on numerous occasions throughout the project areas during both surveys.

During the first round of inventories, an active northern goshawk nest was documented between call stations 230 and 231 (See Figure 1). A response was elicited between the second and third calling sequence. The nest was located in a small aspen tree; height approximately 25 feet; nest size was small; nest appeared to be made of entirely new material. Likelihood of nest site persistence on the landscape is low. Productivity monitoring was conducted during the second round of surveys. Biologists were able to identify three individual fledglings during the monitoring period.

Other raptors documented include red-tailed hawk, and American kestrel. One red-tailed hawk was observed soaring across the road on the north side of Eccles Canyon outside of the project area; another red-tailed hawk was observed soaring in the basin and ridge top above the Mine site; and an American kestrel observed flying near the drainage bottom in the south fork of Eccles Canyon. There were no audio or visual observations of American three-toed woodpecker during the course of the 2015 surveys.



Skyline Mine 2015
Powerline and Vent Shaft Project

FIGURE 1

08/02/2015

1:24,000

RAPTOR SURVEY FORM

Division of Oil Gas and Mining
Coal Regulatory Program

Instructions:

Complete the following form including as much information as possible. This form is to be used for hand entry if direct electronic data entry is not possible. All data collected with this form must be submitted to the Division in an electronic format suitable for uploading into ArcGIS. Only nest status information should be collected aerially. All other data can be collected in a subsequent ground visit. Additional reporting requirements are located in the Raptor Survey Procedures provided by the Division of Oil, Gas and Mining.

1. Qualified Biologist: M.Crane

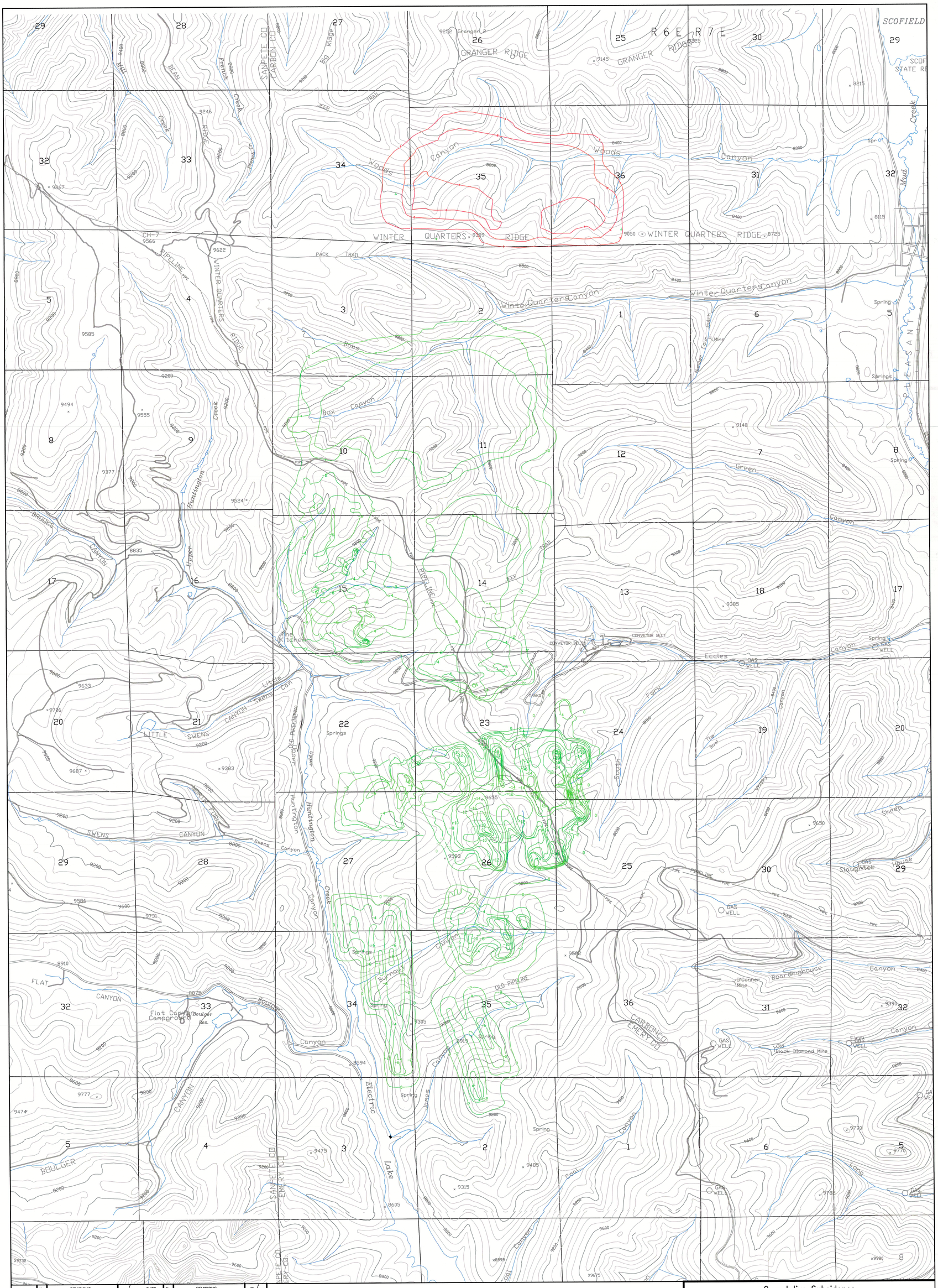
2. Mine: Skyline MIne

3. Survey Date: June and July 2015

4. Survey Type: (Check One)

- [ ] Aerial
- [x] Ground (for tree or cliff nesting species)
- [ ] Ground (for ground nesting species)
- [ ] Calling

Nest Number or "NEW"	Species	Nest Status *(See Back)	Nest Condition *(See Back)	Number of Eggs in the nest:	Number of Young in nest	Age of young in nest (days)	Substrate *(See Back)	Productivity (# fledged)	Elevation/ Exposure of nest (optional)	Comments
New	NOGO	Active-2	Excellent	Unk	2	<7	BLT	3	NE	Observed 3 Fledglings during monitoring



DATE	No.	REVISIONS	BY/CHKD.	DATE	No.	REVISIONS	BY/CHKD.
MARCH 06	1	2005 SUBSIDENCE	GAG/GAG	MARCH 13	8	2012 SUBSIDENCE	GAG/GAG
MARCH 07	2	2006 SUBSIDENCE	GAG/GAG	MARCH 14	9	2013 SUBSIDENCE	JCA/GAG
JUNE 08	3	2007 SUBSIDENCE	KMC/GAG	MARCH 15	10	2014 SUBSIDENCE	JCA/GAG
MAY 09	4	2008 SUBSIDENCE	ARB/GAG	MARCH 16	11	2015 Prelim. SUBSIDENCE	GAG/GAG
MARCH 10	5	2009 SUBSIDENCE	ARB/GAG		12		/
MARCH 11	6	2010 SUBSIDENCE	GAG/GAG		13		/
MARCH 12	7	2011 SUBSIDENCE	GAG/GAG				

-2 SUBSIDENCE CONTOUR

-2 Preliminary SUBSIDENCE CONTOUR 2015

NOTES:
1. COORDINATE BASE ON MINE GRID DATA.
2. MAP DIGITIZED FROM 1:24000 USGS QUADRANGLE MAPS, SCOFIELD, UTAH AND FAIRVIEW LAKES, UTAH.
3. MINE FACILITY, CONVEYOR, AND NEW ECCLES CANYON ROAD LOCATIONS FROM EXISTING RECORD DATA AND INCORPORATED TO MAP IN BEST FIT LOCATIONS.
4. UTM GRID TICK VALUES SHOWN ARE IN METERS.
5. SUBSIDENCE SURVEY CONDUCTED IN SEPTEMBER 2003

BASE PREPARED BY INTERMOUNTAIN AERIAL SURVEYS, SALT LAKE CITY, UTAH - M96147

LICENSED PROFESSIONAL GEOLOGIST GREGG GALECKI 5248584 3-30-16 STATE OF UTAH

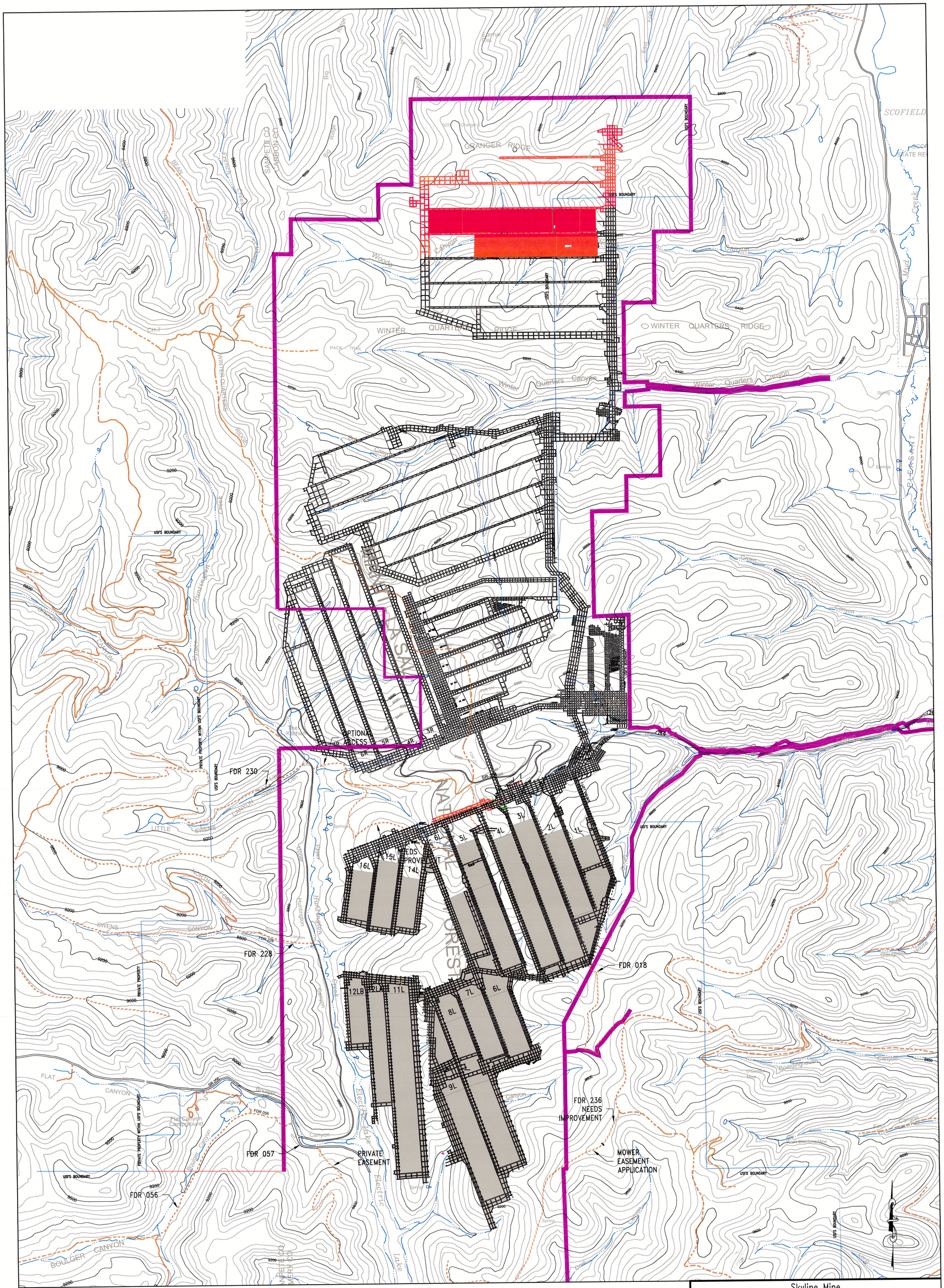
Cumulative Subsidence
1982-2015
2015 Preliminary Data

Canyon Fuel Company, LLC
Skyline Mines

HCR 35 BOX380, HELPER, UT, 84526
435-448-2632

CAD FILE: 2015 Subsidence Prelim	DATE: 3/30/2016	CK.BY:GAG
	SCALE: 1"/1500'	DR.BY:GAG
DWG. NO.: Cumulative Subsidence 2015		REVISION: 11 3/30/16

Skyline Mine
2016
5-year Mine Plan
Canyon Fuel Company, LLC
Skyline Mines
HCR 35 BOX380, HELPER, UT, 84526
435-448-2632
DATE: 3/23/2016
CK.BY:GGalecki
SCALE: 1"=1500'
DR.BY:GGalecki
CAD FILE:
REVISION:
DWG. NO.:
LICENSED PROFESSIONAL GEOLOGIST
GREGG GALECKI
5248584
3-23-16
STATE OF UTAH
LEGEND
1st QUARTER 2016
2nd QUARTER 2016
3rd QUARTER 2016
4th QUARTER 2016
2017
2018
2019
2020
MANTI-LA SAL NATIONAL FOREST
USFS BOUNDARY
PRIVATE PROPERTY WITHIN USFS BOUNDARY
PRIVATE PROPERTY
FDR 018
FDR 236 NEEDS IMPROVEMENT
MOWER EASEMENT APPLICATION
NEEDS IMPROVEMENT
OPTIONAL ACCESS
PRIVATE EASEMENT
FDR 057
FDR 056
SKYLINE MINE SITE
SR-264
SR-96
WINTER QUARTERS RIDGE
QUARTERS RIDGE
Winter Quarters Canyon
SANPETE CO
CARBON CO
BEAN RIDGE
French Creek
Mill Creek
Electric Lake
Huntington Creek
Boulger Reservoir
Flat Canyon Campground
Gooseberry Campground
Gooseberry Reservoir
Beaver Dam Reservoir
BEAVER DAM RIDGE
BOULGER CANYON
FLAT CANYON
SWENS CANYON
LITTLE SWENS CANYON
CH-7
PACK TRAIL



LEGEND

Area Approved for Mining Activities

2015 As Mined

LICENSED PROFESSIONAL GEOLOGIST
GREGG GALECKI
5248584
3-23-16
STATE OF UTAH

0 2000' 4000'

Skyline Mine
2015 As Mined

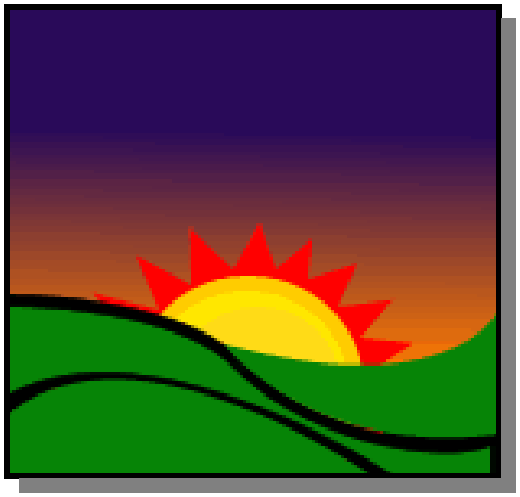
Canyon Fuel Company, LLC
Skyline Mines

HCR 35 BOX380, HELPER, UT, 84526 435-448-2632	DATE: 3/123/16	CK.BY:GGalecki	REVISION:
CAD FILE: P:/Reports/...Asmined 2015	SCALE: 1"=1500'	DR.BY:GGalecki	

RIPARIAN PLANT COMMUNITY MONITORING IN SELECTED REACHES WOODS CANYON

2015

AT THE
SKYLINE MINE
CARBON COUNTY, UTAH



Prepared by

MT. NEBO SCIENTIFIC, INC.
330 East 400 South, Suite 6
Springville, Utah 84663
(801) 489-6937

by

Patrick D. Collins, Ph.D.

for

CANYON FUEL COMPANY, LLC.
Skyline Mines
HC 35 Box 380
Helper, Utah 84526

February 2016

Table of Contents

INTRODUCTION 1
History & Study Objectives 1
The Study Areas 2

METHODS 2
Sample Design, Transect Placement & Frequency 2
Qualitative Data 3
Quantitative Data 3

RESULTS 5

MAP A: Mining Map 6

MAP B: Riparian Sample Stations 7

RIPARIAN COMPLEX DATA SHEETS
WD-01 8
WD-02 12
WD-03 16
WD-04 20
WD-05 24
WD-06 28
WD-07 32
WD-08 36
WD-09 40
WD-10 44
WD-11 48
WD-12 52

Introduction

History & Study Objectives

As described in the preceding reports regarding the riparian communities in the area, coal mining activities are currently being conducted at the Skyline Mine in Carbon County, Utah. Some of the mining occurs underneath Winter Quarters Canyon, Woods Canyon and their tributaries. As a means to monitor impacts from mining to the riparian plant communities supported along the stream-sides in the area, baseline and yearly studies have been and will continue to be conducted. This report describes the results of the field study conducted in 2015 to monitoring in the riparian communities in the study area.

Vegetation monitoring studies have been conducted *before*, *during* and *after* the mining operations occur. The first such study began in 2005 with the objective to provide a comprehensive baseline dataset of representative stream reaches for the *entire* area in Winter Quarters Canyon and Woods Canyon, or those areas that could potentially be impacted by the proposed underground mining activities. The 2005 monitoring year has been called the *Initial Baseline Year* for the riparian studies of the area.

Regular vegetation monitoring in the riparian zones should provide data to determine long-term trends, natural variability and benchmark information including the possible impacts to the riparian plant communities caused by mining under the creeks and streams of the canyons. The studies have been designed so that the sample frequency is intensified in the areas where: 1) underground mining is planned for the near future (for more baseline data), 2) where mining is currently occurring, and 3) where mining has occurred in the recent past.

The methodologies used in the studies have been consistent for all monitoring periods. They were not designed to provide data that could show *subtle* changes to community structure and species composition as a result of minor changes to the riparian habitat (which can occur as a result of several factors i.e. precipitation changes, grazing impacts, etc.). Rather, the studies were designed to be compared with future monitoring studies in an attempt to document *major* impacts to the plant communities along the stream due to catastrophic events, such as

loss of water and habitat from the effects of subsidence caused from underground mining.

The Study Area

Only Woods Canyon was included in the study area in 2015 due to the mining progress. This canyon is located within the Wasatch Plateau, a high plateau that lies between the Colorado Plateau and Great Basin regions of the western United States. The canyon is located approximately 2.5 miles west of the town of Scofield, Utah and are located within the Manti-La Sal National Forest.

The dominant plant communities of the canyon were riparian, spruce-fir, aspen/grass, sagebrush/grass and mountain herblands.

Methods

Sample Design, Transect Placement & Frequency

The riparian vegetation of specific reaches in Woods Canyon were sampled in August 2015. Selection of the sample locations of the reaches was based on the underground coal mining schedule for the Skyline Mines. The methods for 2015 follow the *Initial Baseline Year* (2005) described above. As mentioned, the riparian vegetation surveys have been designed to concentrate on recently mined areas, current mining, and areas to be mined in the near future. More specifically, the surveys have been conducted where mining activities are planned under the streams according to the following schedule: 1) two years prior to mining specific areas, 2) the year of the mining activities, and 3) two years after mining has occurred in the areas. During these study periods, sampling is intensified by placing sample stations at regular intervals every 400 ft., rather than the 800 ft. spacing that was used in the *Baseline Year* (2005).

[***NOTE***: *In the Initial Baseline Year (2005) sample locations were placed every 800 ft with the exception of those areas that were scheduled to be mined in late-2005, where the 400 ft spacing was used. Because of the spacing differences and because the underground mining progress determines where transects will be placed each year, sometimes the site numbers in each sample*

area are not in sequential order].

Line transects were placed at each sample station. Locations and extent of the transects were semi-permanently marked using numbered and flagged wooden stakes and 12-inch metal rods. The vegetation monitoring methods of the studies have been primarily based on those described by the USDA Forest Service manual for a "*Level III Riparian Area Evaluation*" (Integrated Riparian Evaluation Guide, March 1992). Qualitative and quantitative data were recorded at the sample stations established in the field. In the first year of the studies, the overall objective of the study plan was to begin monitoring years with one complete baseline dataset for all riparian areas near the perennial streams located in the mine permit area prior to any mining. As mentioned in the previous monitoring reports, all sample station locations have been determined and mapped based on the timing and schedule of the underground mining activities (see Map A).

Geomorphological stream channel data outlined in the Forest Service protocol were not recorded as part of this study because Canyon Fuel Company has conducted other studies that will suffice for this information. Additionally, soils information through the Natural Resources Conservation Service (NRCS) were not available for the study areas.

Qualitative Data

The "Riparian Complex Data Sheet" shown on Table 1 lists all of the qualitative (and quantitative) data that has been, and will continue to be, collected in the future at each sample station.

Photographic stations for documentation and future comparisons have also been established at each sample location. A sample location map has been included in this report (Map B).

Quantitative Data

USDA Forest Service protocol was employed as a model to drive the study plan for quantitative data. *Community Type Cover* is one method to record cover in the Forest Service Level III

protocol. At the sample locations, transect lines have been placed across (or perpendicular to) the stream channel. By design, the line transects vary in lengths and are based on several factors. Although sometimes limited by topographical features, the intent was to make the transects long enough to cover the entire stream, its riparian communities, plus an additional 10 ft on each side of the stream to record the adjacent upland communities. Monitoring the total extent of the riparian plant communities including some upland community data should provide information about possible increases or decreases in the riparian communities relative to the adjacent upland communities.

TABLE 1: RIPARIAN COMPLEX DATA SHEET

CLIENT:
COMPLEX: Riverine - Number
WATERBODY NAME:
LOCATION:
DATE:
OBSERVER(S):
QUAD NAME:
GEOLOGIC PARENT MATERIAL:
ASPECT:
STREAM GRADIENT:
ELEVATION: .
ADJACENT UPLAND VEGETATION (looking downstream)
Left: Right:
VEGETATIVE DESCRIPTION (Dominance by Community Types)
SUCCESSIONAL STATUS:
APPARENT FORAGE TREND:
ESTIMATED FORAGE PRODUCTION:
BEAVER ACTIVITY:
PHOTOGRAPH TAKEN:
LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA:
SPECIES OBSERVED:
POOL ATTRIBUTES
- % area in pools:
- % pool area made up of pools > 2' deep:

AQUATIC VEGETATION
- % streambed with filamentous algae:
- % stream margin with rooted aquatic:

BANK TYPE & VEGETATION OVERHANG
- % bank length undercut (<90°):
- % bank length gently sloping (>135°):
- % bank length with overhanging vegetation:

BANK CONDITION (bankfull area only)
- % bank length vegetated, stable:
- % bank length unvegetated, stable:
- % bank length vegetated, unstable:
- % bank length unvegetated, unstable:

NOTES:
QUANTITATIVE DATA SUMMARY:
PHOTOGRAPHIC DOCUMENTATION:

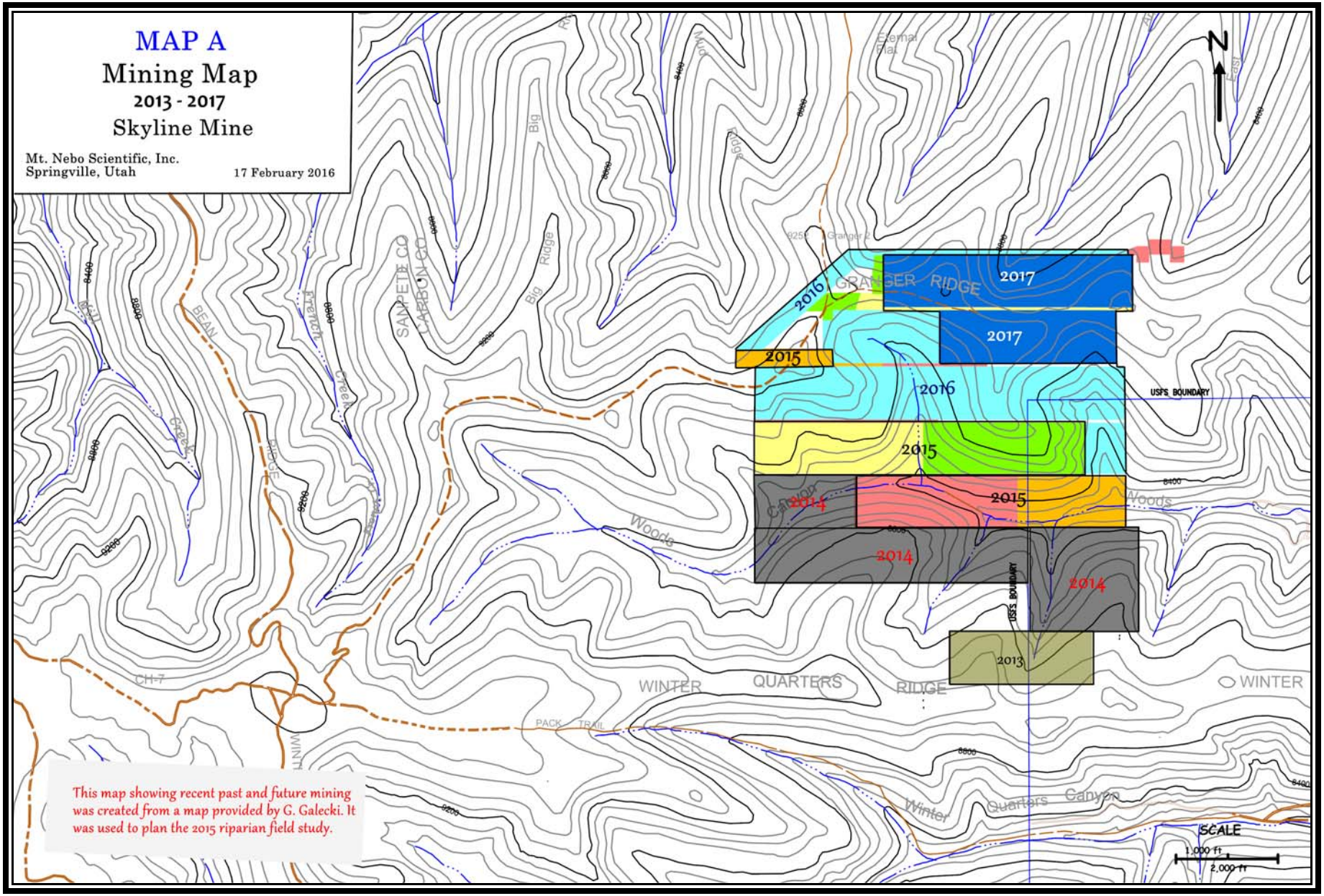
Once the transects were placed, the line-intercept method was employed to measure the extent of each major riparian plant community. The communities have been named by the dominant two plant species. If only one species dominated the community by a wide margin, the plant community was named by this single species. In this report, when reference is made to the left or right side of the drainage, this means "river left" or "river right", *as characterized by looking downstream*.

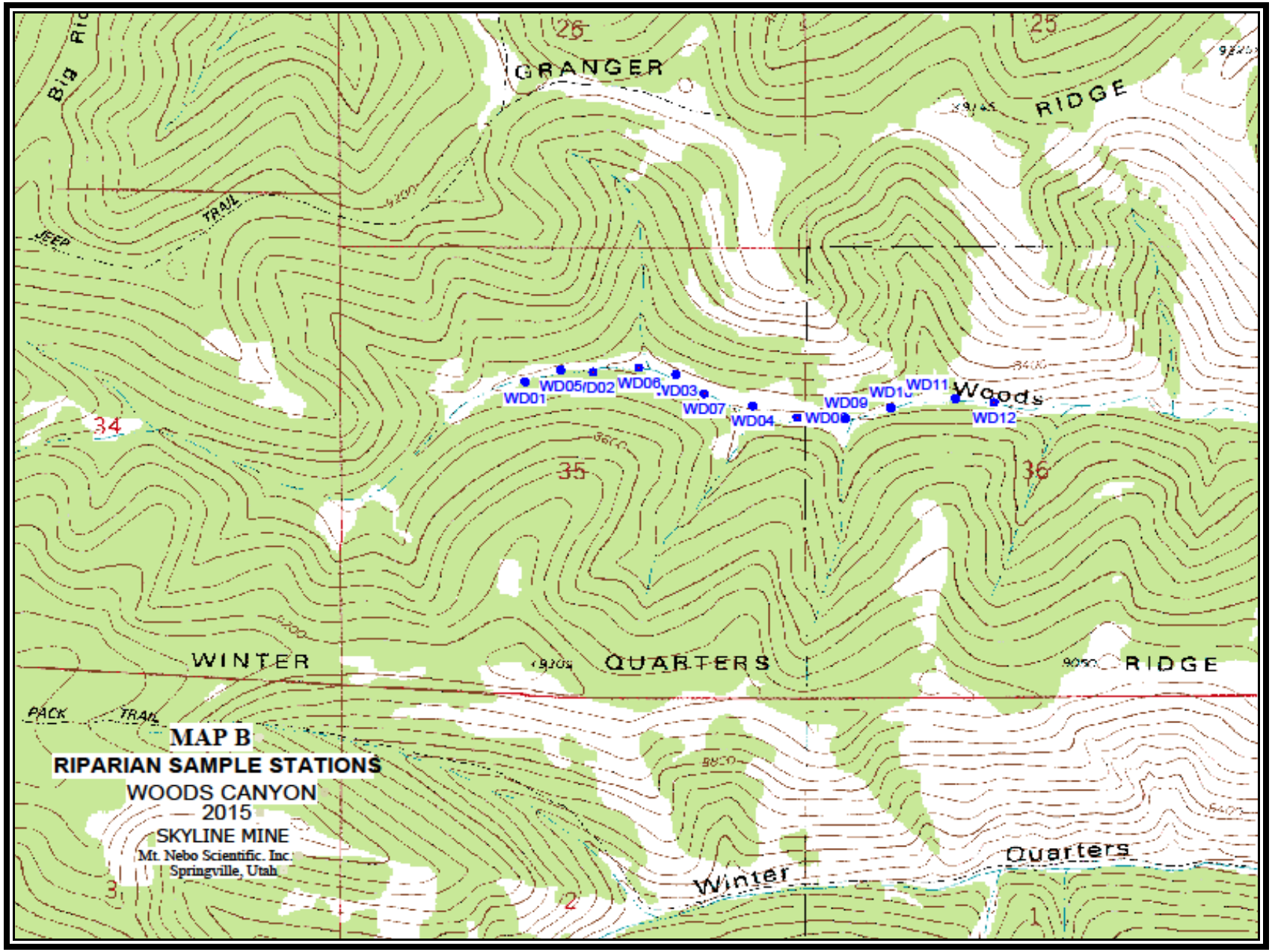
Results

Listed below is a summary of the sample stations for the study areas for 2015 (Table 2). For a map of the potential subsidence areas for the applicable mining years, refer to Map A. This map was used to determine the sample sites for 2015. For a map of the sample locations, refer to Map B in this report. Both of these maps are provided below.

TABLE 2: Riparian Sample Stations in Winter Quarters & Woods Canyons: 2015

WOODS CANYON CREEK	BOB'S CANYON CREEK	NO-NAME DRAINAGE CREEK	BOX CANYON CREEK	WINTER QUARTERS CREEK
WD-01				
WD-02				
WD-03				
WD-04				
WD-05				
WD-06				
WD-07				
WD-08				
WD-09				
WD-10				
WD-11				
WD-12				


MAP A
Mining Map
2013 - 2017
Skyline Mine
Mt. Nebo Scientific, Inc.
Springville, Utah
17 February 2016
N
GRANGER RIDGE
2017
2017
2016
2016
2015
2015
2015
2014
2014
2014
2013
USFS BOUNDARY
USFS BOUNDARY
Woods
Canyon
WINTER
QUARTERS
RIDGE
WINTER
PACK TRAIL
Winter
Quarters
Canyon
SAMPETE CO
CARBON CO
BEAN
RIDGE
French
Creek
Big
Ridge
CH-7
SCALE
1,000 ft
2,000 ft
This map showing recent past and future mining was created from a map provided by G. Galecki. It was used to plan the 2015 riparian field study.


GRANGER
RIDGE
TRAIL
JEEP
WD01
WD05/D02
WD06
WD03
WD07
WD04
WD08
WD09
WD10
WD11
WD12
Woods
WINTER
QUARTERS
RIDGE
PACK
TRAIL
Winter
Quarters
MAP B
RIPARIAN SAMPLE STATIONS
WOODS CANYON
2015
SKYLINE MINE
Mt. Nebo Scientific, Inc.
Springville, Utah

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *WD-01*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *ENE*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,475 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Herbland* Right: *Blue Spruce*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,200 lbs/acre*

BEAVER ACTIVITY: *No*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Picea pungens		*Achillea millefolium*	*Agrostis stolonifera*
		Geranium richardsonii	*Carex hoodii*
		Ranunculus cymbalaria	*Elymus canadensis*
		Senecio serra	*Hordeum brachyantherum*
		Urtica dioica	

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *30*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º): *100 of riparian community*

% bank length with overhanging vegetation: *0 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *95*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

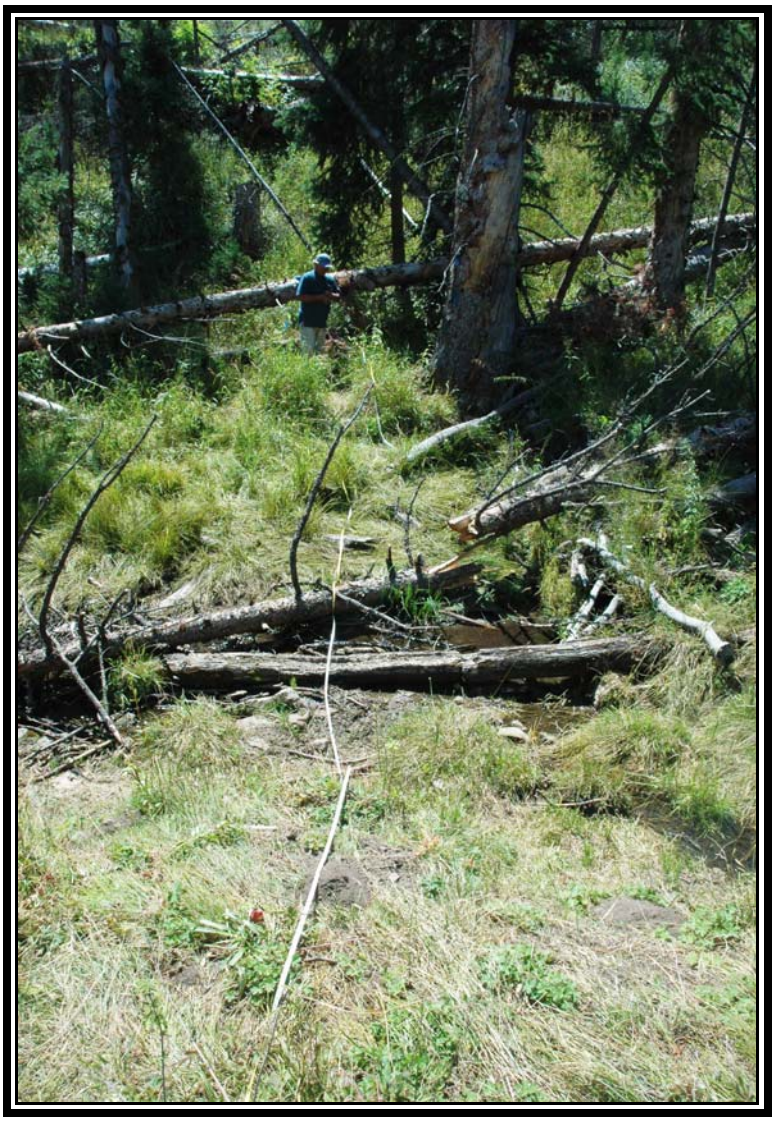
1) *In 2013 we found the original 2005 stakes. Also found them in 2014 and 2015.*

DATA SUMMARY

WD-01: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	9.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	4.00
Agrostis stolonifera/Elymus canadensis	12.00
TOTAL COVER (Upland Species)	19.00
TOTAL COVER (Riparian Species)	16.00
ROCK (channel)	2.00
WATER (channel)	3.50
BAREGROUND/MUD (channel)	1.00
LITTER (channel)	0.50
MOSS (channel)	0.00
TOTAL COVER	40.00

PHOTOGRAPHIC DOCUMENTATION



WD-01

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *WD-02*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,444 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Blue Spruce/Grass* Right: *Blue Spruce/Grass*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: Climax

APPARENT FORAGE TREND: *Seral now due to debris and fallen trees*

ESTIMATED FORAGE PRODUCTION: *900 lbs/acre*

BEAVER ACTIVITY: *No*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	**Shrubs**	**Forbs**	**Grasses (or grasslike)**
		Achillea millefolium	*Agrostis stolonifera*
		Geranium richardsonii	*Elymus canadensis*
		Lathyrus sp.	*Juncus longistylis*
		Ranunculus cymbalaria	
		Senecio serra	
		Urtica dioica	
		Viguiera multiflora	

POOL ATTRIBUTES

% area in pools: *50 (debris in creek)*
% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*
% stream margin with rooted aquatic: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0 left; 0 right*
% bank length gently sloping (>135º): *50 (right side)*
% bank length with overhanging vegetation: *50 (herb)*

BANK CONDITION

% bank length vegetated, stable: *95*
% bank length unvegetated, stable: *2·5*
% bank length vegetated, unstable: *0*
% bank length unvegetated, unstable: *2·5*

NOTES:

1) The location of this site was just down from red ($1000 fine) sign.
2) A well-defined channel delineated the riparian comm.
3) Bank elevation went up ~ 3·5 ft above the stream.
4) We found the original 2005 stakes.
5) Some trees had fallen in the creek since 2005.
6) There was one big tree that had fallen in the creek that made it difficult to sample. We did however find the original marker stakes.

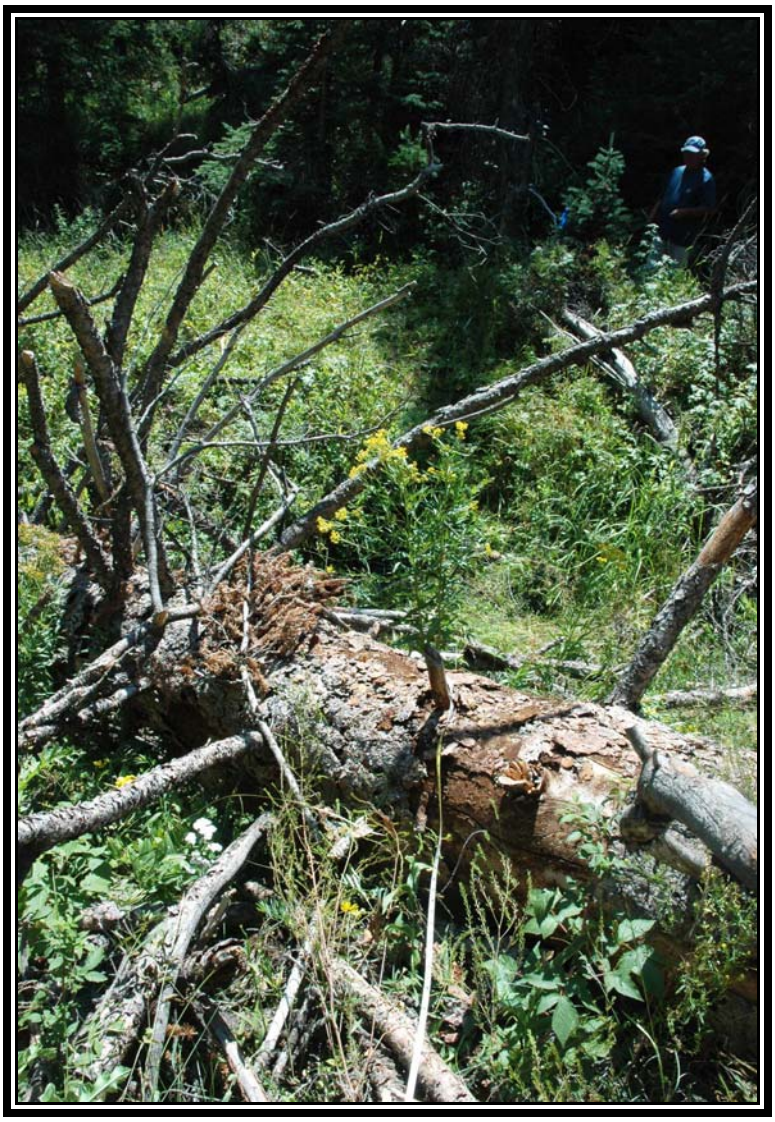
DATA SUMMARY

WD-02: Cover by community types in Woods Canyon (2015).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	8.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis/Agrostis stolonifera	7.00
TOTAL COVER (Upland Species)	18.00
TOTAL COVER (Riparian Species)	7.00
ROCK (channel)	0.00
WATER (channel)	3.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
ROOTED VEGETATION (channel)	0.00
TOTAL COVER	28.00

PHOTOGRAPHIC DOCUMENTATION



WD-02

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-03*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *ESE*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,392 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Nettle/Grass* *Right: Spruce/Fir*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Increasing*

ESTIMATED FORAGE PRODUCTION: *1,000 lbs/acre*

BEAVER ACTIVITY: *No*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Abies concolor	*Fragaria vesca*	*Epilobium angustifolium*	*Agrostis stolonifera*
Picea pungens	*Rosa woodsii*	*Taraxacum officinale*	*Carex nebrascensis*
		Vicia americana	*Elymus canadensis*
		Viguiera multiflora	*Hordeum brachyantherum*
		Urtica dioica	*Juncus longistylis*
			Carex hoodii

POOL ATTRIBUTES

% area in pools: *50+*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º): *100 right and 50 left*

% bank length with overhanging vegetation: *0*

BANK CONDITION

% bank length vegetated, stable: *95*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) This sample site was located 0.18 mile downstream (instead of 0.15 mi) because of the complexity of measuring the communities at 0.15 mile (it was near a drainage confluence).
2) In 2013, we found the 2005 right stake so we marked the last distance recorded from that stake to place the position of the left side stake (33 ft).
3) We had to adjust the transect tape line due to slough-age, so it measured 34 ft in 2014 and 2015, not 33 ft like 2013.

DATA SUMMARY

WD-03: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	7.00
	9.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	8.50
Carex hoodii/Elymus canadensis	7.00
TOTAL COVER (Upland Species)	16.00
TOTAL COVER (Riparian Species)	15.50
ROCK (channel)	0.00
WATER (channel)	2.50
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	34.00

PHOTOGRAPHIC DOCUMENTATION

WD-03

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-04*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,321 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Woods Rose/Grass* Right: *Spruce/Fir*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,100 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Abies concolor	*Ribes sp.*	*Artemisia dracunculus*	*Agrostis stolonifera*
Picea pungens		*Equisetum arvense*	*Elymus canadensis*
		Fragaria vesca	*Juncus longistylis*
		Geranium richardsonii	

POOL ATTRIBUTES

% area in pools: *25*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *10 (½ of water channel)*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0, filled in now.*

% bank length gently sloping (>135º): *40*

% bank length with overhanging vegetation: *35*

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *10*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) We put this sample site 0.18 mi (not 0.15) from last site because of the spring at 0.15 mi on the left side would have made it difficult to measure accurately.

2) Both upland sides seemed to have hillside water influence.

3) In 2005, this was the final sample site in Woods Canyon. Therefore, there was a buffer at the top and bottom ends. It was located < 0.15 mile from the FS boundary.

4) In 2013, 2014 and 2015, we found all 2005 stakes, but remarked it with the GPS.

5) What was called "upland" in 2005 was redtop (Agst) in 2013, so I gave 0 ft to upland on left.

6) In 2014, it changed again to mostly Canada wildrye (Elca), so I put it back to more upland. There was a great deal of hillside influenced water (seeps), so it is a confusing site to monitor. In 2015 if was mostly dominated by redtop.

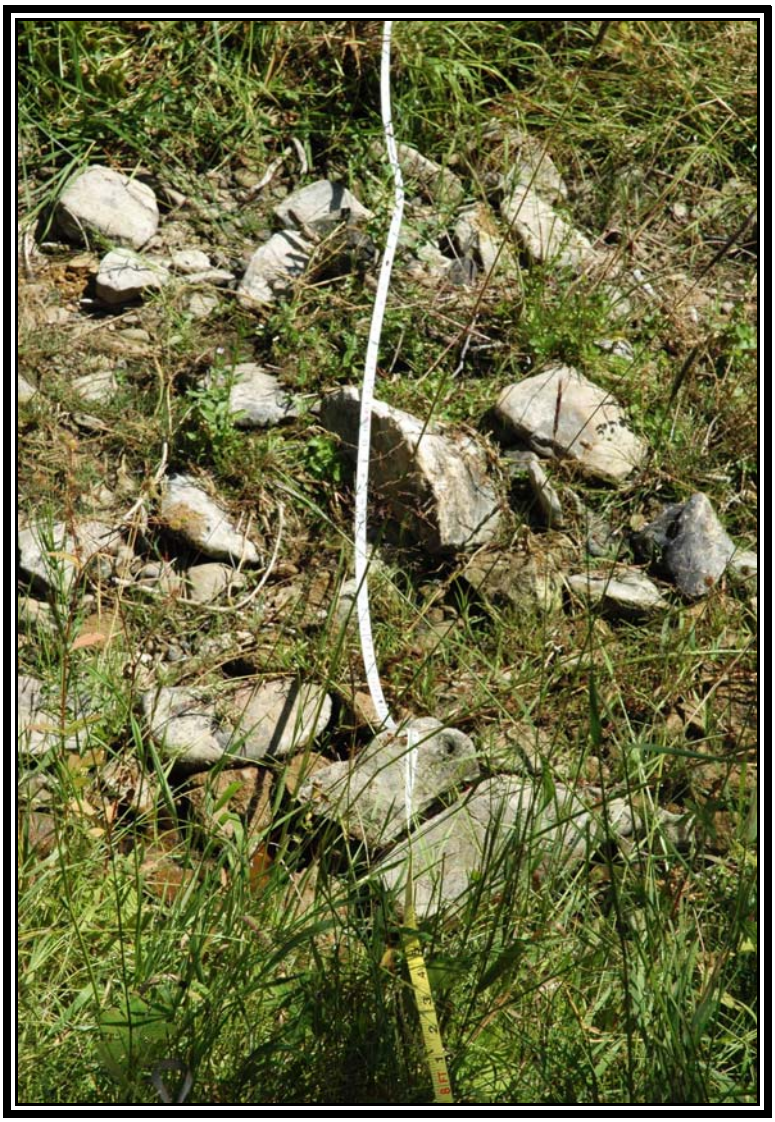
7) The channel had a wide rock area (less water).

DATA SUMMARY

WD-04: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	6.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	9.00
TOTAL COVER (Upland Species)	16.00
TOTAL COVER (Riparian Species)	9.00
ROCK (channel)	5.00
WATER (channel)	1.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
ROOTED VEGETATION (channel)	0.00
TOTAL COVER	31.00

PHOTOGRAPHIC DOCUMENTATION



WD-04

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-05*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,460 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Herbland* Right: *Conifer*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,100 lbs/acre*

BEAVER ACTIVITY: *There was an old beaver dam 80-100 ft upstream.*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Picea pungens		*Geranium richardsonii*	*Agrostis stolonifera*
		Senecio serra	*Carex nebrascensis*
			Carex hoodii
			Elymus canadensis
			Juncus longistylis

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *70 (see notes & photo)*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º): *100 on left*

% bank length with overhanging vegetation: *50 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *96*

% bank length unvegetated, stable: *4*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) In 2013, we did not find the stakes here. The GPS took us 100 ft adjacent the stream in the upland community, so we put the stake at that point but across the riparian community. I'm not sure when I recorded those coordinates.
2) In 2014 and 2015, we re-recorded the GPS coordinates.
3) In 2015 the tape went 36 ft not 39 ft.

DATA SUMMARY

WD-05: Cover by community types in Woods Canyon (2015).

USDA Forest Service Protocol (1992)	
UPLAND VEGETATION	
	14.00
	13.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Carex nebrascensis	6.00
TOTAL COVER (Upland Species)	27.00
TOTAL COVER (Riparian Species)	6.00
ROCK (channel)	0.50
WATER (channel)	2.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.50
ROOTED VEGETATION (channel)	0.00
TOTAL COVER	36.00

PHOTOGRAPHIC DOCUMENTATION

WD-05

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-06*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,420 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Herbland* Right: *Spruce/Fir*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,200 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Picea pungens		*Geranium richardsonii*	*Agrostis stolonifera*
			Carex hoodii
			Carex nebrascensis
			Elymus canadensis

POOL ATTRIBUTES

% area in pools: *10*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *3 ft and I put in riparian cover.*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º):

% bank length with overhanging vegetation: *100 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *80*

% bank length unvegetated, stable: *20*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) In 2014, we did not find old stakes, but found them in 2015.
2) We staked the location exactly where GPS put the site. This was in a well-defined channel.
3) It appeared that the right hillside moisture was augmenting the riparian community.
4) 3 ft length of water had rooted vegetation; unlike 2014 we did count it as a riparian vegetation measurement length on the data sheet in 2015.

DATA SUMMARY

WD-06: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	7.00
	15.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	5.00
Carex hoodii/Elymus canadensis	6.00
Carex nebrascensis	3.00
TOTAL COVER (Upland Species)	22.00
TOTAL COVER (Riparian Species)	14.00
ROCK (channel)	0.00
WATER (channel)	2.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
ROOTED VEGETATION (channel)	0.00
TOTAL COVER	38.00

PHOTOGRAPHIC DOCUMENTATION

WD-06

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-07*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,356 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Blue Spruce/Herbland* Right: *Aspen/Fir*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *500 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Abies concolor		*Achillea millefolium*	*Agrostis stolonifera*
Picea pungens		*Epilobium angustifolium*	*Elymus canadensis*
Populus tremuloides		*Ranunculus cymbalaria*	
		Rudbeckia occidentalis	

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0 (right side was close to being undercut)*

% bank length gently sloping (>135º): *50 (right and left sides)*

% bank length with overhanging vegetation: *35*

BANK CONDITION

% bank length vegetated, stable: *95*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) Like WD-06, in 2014 we did not find old stakes but found them in 2015.
2) This was in a well-defined channel.
3) In 2014 and 2015, the left side where we had called "upland" before seems more mesic, but we left it upland to be consistent.
4) There is probably a lot of hillside moisture influence at this site.

DATA SUMMARY

WD-07: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	8.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera/Carex hoodii	7.00
TOTAL COVER (Upland Species)	18.00
TOTAL COVER (Riparian Species)	7.00
ROCK (channel)	3.00
WATER (channel)	5.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	33.00

PHOTOGRAPHIC DOCUMENTATION

WD-07

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-08 (new site in 2014)*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,312 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Grass/Snowberry/Sagebrush* Right: *Conifer/Aspen*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *900 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	**Shrubs**	**Forbs**	**Grasses (or grasslike)**
Picea pungens	*Artemisia tridentata*	*Achillea millefolium*	*Agrostis stolonifera*
Populus tremuloides	*Chrysothamnus nauseosus*	*Geranium richardsonii*	*Carex hoodii*
	Symphoricarpos oreophilus	*Osmorhiza depauperata*	*Elymus canadensis*
		Ranunculus cymbalaria	
		Rudbeckia occidentalis	

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *100 (left)*

% bank length gently sloping (>135º): *100 (right)*

% bank length with overhanging vegetation:

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *10*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) On the left side, the riparian community goes up to the slope.
2) The flat bottom is a good place to monitor.

DATA SUMMARY

WD-08: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera/Carex hoodii	22.00
Agrostis stolonifera/Geranium richardsonii	13.50
TOTAL COVER (Upland Species)	20.00
TOTAL COVER (Riparian Species)	35.50
ROCK (channel)	1.00
WATER (channel)	2.50
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	59.00

PHOTOGRAPHIC DOCUMENTATION

WD-08

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-09 (new site in 2014)*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,280 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Sagebrush/Grass* Right: *Aspen/Conifer*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Decreasing do to grazing pressure*

ESTIMATED FORAGE PRODUCTION: *800 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: Yes

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: Mining, grazing, hunting, recreation.

SPECIES OBSERVED:

Trees	**Shrubs**	**Forbs**	**Grasses (or grasslike)**
Pinus edulis	*Artemisia tridentata*	*Taraxacum officinale*	*Agrostis stolonifera*
Populus tremuloides	*Chrysothamnus nauseosus*		*Carex nebrascensis*
			Juncus ensifolius
			Poa pratensis

POOL ATTRIBUTES

% area in pools: 50

% pool area made up of pools > 2' deep: 0

AQUATIC VEGETATION

% streambed with filamentous algae: 0

% stream margin with rooted aquatic: 0 (1 ft of Cane rooted on left side)

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): 0

% bank length gently sloping (>135º): 0

% bank length with overhanging vegetation: 3 ft on left side; herbaceous on right

BANK CONDITION

% bank length vegetated, stable: 85

% bank length unvegetated, stable: 15

% bank length vegetated, unstable: 0

% bank length unvegetated, unstable: 0

NOTES:

1) Good, well-defined channel of riparian zone to monitor.
2) There was a lot of grazing pressure due to topography,

DATA SUMMARY

WD-09: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	7.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	9.00
Carex nebrascensis	6.50
TOTAL COVER (Upland Species)	17.00
TOTAL COVER (Riparian Species)	15.50
ROCK (channel)	0.50
WATER (channel)	1.00
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	34.00

PHOTOGRAPHIC DOCUMENTATION

WD-09

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-10 (new site in 2014)*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,252 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Grass to Sagebrush* Right: *Conifer*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Left bank was unstable due to grazing pressure*

ESTIMATED FORAGE PRODUCTION: *1,100 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: *Yes*

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: *Mining, grazing, hunting, recreation.*

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Pinus edulis		*Geranium richardsonii*	*Agrostis stolonifera*
Populus tremuloides		*Osmorhiza depauperata*	*Elymus canadensis*
		Ranunculus cymbalaria	*Juncus ensifolius*
		Rudbeckia occidentalis	
		Urtica dioica	
		Mimulus guttatus	

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *0*

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *Right margin with rooted vegetation (added to riparian vegetation data cover)*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º): *00*

% bank length with overhanging vegetation:

BANK CONDITION

% bank length vegetated, stable: *95*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) The right side has 2 levels of riparian zones; the upper may have hillside moisture influence, but I doubt it's much.
2) The channel bottom had lots of dry bareground and rock cover.

DATA SUMMARY

WD-10: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	11.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera/Carex hoodii	19.00
Agrostis stolonifera	4.00
Carex hoodii	1.00
TOTAL COVER (Upland Species)	21.00
TOTAL COVER (Riparian Species)	24.00
ROCK (channel)	2.00
WATER (channel)	1.00
BAREGROUND (channel)	2.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	50.00

PHOTOGRAPHIC DOCUMENTATION

WD-10

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-11 (new site in 2014)*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,223 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Grass to Rabbitbrush* Right: *Conifer*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,100 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: Yes

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: Mining, grazing, hunting, recreation.

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Picea pungens	*Chrysothamnus nauseosus*	*Geranium richardsonii*	*Agrostis stolonifera*
		Mimulus guttatus	*Carex hoodii*
		Urtica dioica	*Elymus canadensis*

POOL ATTRIBUTES

% area in pools: 30

% pool area made up of pools > 2' deep: 0

AQUATIC VEGETATION

% streambed with filamentous algae: 0

% stream margin with rooted aquatic: 0

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): 100 on left side

% bank length gently sloping (>135º): 100 on right side

% bank length with overhanging vegetation: 0

BANK CONDITION

% bank length vegetated, stable: 97

% bank length unvegetated, stable: 3

% bank length vegetated, unstable: 0

% bank length unvegetated, unstable: 0

NOTES:

1) A well-defined riparian zone on the right side to monitor.
2) The left upland bank was unstable due to grazing pressure.

DATA SUMMARY

WD-11: Cover by community types in Woods Canyon (2015).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	18.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Carex hoodii/Agrostis stolonifera	11.00
Agrostis stolonifera	1.50
TOTAL COVER (Upland Species)	18.00
TOTAL COVER (Riparian Species)	12.50
ROCK (channel)	1.00
WATER (channel)	2.50
BAREGROUND (channel)	0.00
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	34.00

PHOTOGRAPHIC DOCUMENTATION

WD-11

RIPARIAN COMPLEX DATA SHEET
2015

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WD-12 (new site in 2014)*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 18-20, 2015*

OBSERVER(S): *P. Collins, G. McMillan*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,194 ft*

SIZE OF COMPLEX: (see quantitative data)

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Grass to Conifer* Right: *Grass to Snowberry*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex
(refer to quantitative data results for this information)	

SUCCESSIONAL STATUS: *Climax*

APPARENT FORAGE TREND: *Stable*

ESTIMATED FORAGE PRODUCTION: *1,100 lbs/acre*

BEAVER ACTIVITY: *no*

PHOTOGRAPH TAKEN: Yes

LAND USE ACTIVITIES THAT COULD INFLUENCE RIPARIAN AREA: Mining, grazing, hunting, recreation.

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)
Pinus ponderosa	*Chrysothamnus nauseosus*	*Urtica dioica*	*Agrostis stolonifera*
Picea pungens	*Chrysothamnus viscidiflorus*		*Carex nebrascensis*
	Rosa woodsii		*Poa pratensis*
	Symphoricarpos oreophilus		

POOL ATTRIBUTES

% area in pools: 0

% pool area made up of pools > 2' deep: 0

AQUATIC VEGETATION

% streambed with filamentous algae: 0

% stream margin with rooted aquatic: 0

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): 100 left side

% bank length gently sloping (>135º): 100 right side

% bank length with overhanging vegetation:

BANK CONDITION

% bank length vegetated, stable: 95

% bank length unvegetated, stable: 5

% bank length vegetated, unstable: 0

% bank length unvegetated, unstable: 0

NOTES:

1) A good well-defined riparian zone for monitoring.
2) Could have driven the ATV to site on bottom trail. We used the upper new logging road.

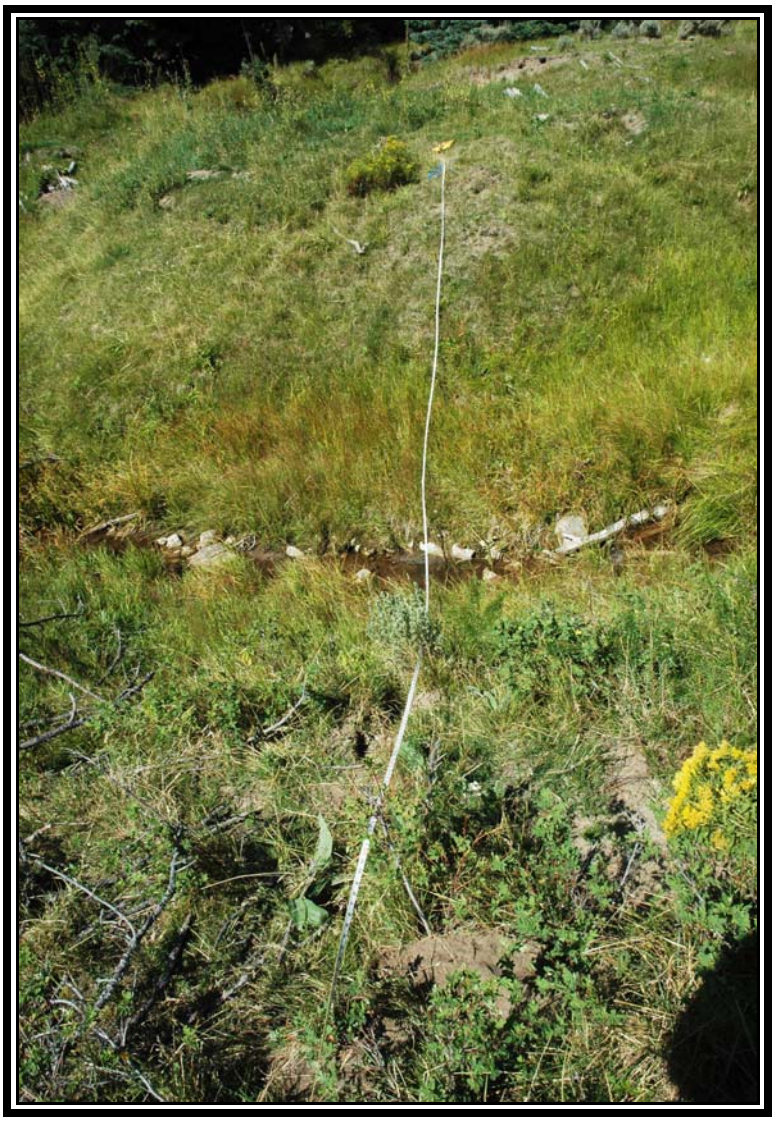
DATA SUMMARY

WD-12: Baseline plant community cover types in Woods Canyon riparian areas (2015).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	12.00
Carex nebrascensis	3.50
TOTAL COVER (Upland Species)	20.00
TOTAL COVER (Riparian Species)	15.50
ROCK (channel)	0.50
WATER (channel)	2.00
BAREGROUND/MUD (channel)	0.50
LITTER (channel)	0.00
MOSS (channel)	0.00
TOTAL COVER	38.00

PHOTOGRAPHIC DOCUMENTATION



WD-12

Macroinvertebrate Assessment on Eccles Creek, 2015

FINAL REPORT

PN 1926-01 March 2016

Prepared for:
Canyon Fuel Company
Skyline Mine
HC 35 Box 380
Helper, UT 84526

Prepared by:
BIO-WEST, Inc.
Ron Kegerries
Harrison Mohn
1063 W. 1400 N.
Logan, UT 84321

TABLE OF CONTENTS

INTRODUCTION 1

METHODS 1
Data Analysis 4
Metrics 5
Taxa Richness 5
Total Density 5
Shannon-Wiener Diversity 5
U.S. Forest Service (USFS) Community Tolerance Quotient (CTQ) 5
Hilsenhoff Biotic Index (HBI) 6
Functional Feeding Groups 6

RESULTS 7
Discharge and Water Quality 7
Macroinvertebrate Community 7
Taxa Richness 7
Total Density 9
Shannon-Wiener Diversity 9
U.S. Forest Service (USFS) Community Tolerance Quotient (CTQ) 11
Hilsenhoff Biotic Index (HBI) 12
Functional Feeding Groups 12

DISCUSSION AND RECOMMENDATIONS 13

LITERATURE CITED 15

APPENDIX A: ECCLES CREEK MACROINVERTEBRATE SAMPLING RESULTS INCLUDING TAXA COLLECTED AND CALCULATED METRICS FROM THE NATIONAL AQUATIC MONITORING CENTER IN 2015

Figures

Figure 1. Macroinvertebrate sampling stations along Eccles Creek, Carbon County, Utah, on October 1, 2015 2

Figure 2. Historic and current data for (A) taxa richness, (B) total density, (C) Shannon diversity, and (D) community tolerance quotient (CTQ) for Eccles Creek, Carbon County, Utah 8

Figure 3. Functional feeding group taxa composition in 2015 at each sampling station on Eccles Creek, Carbon County, Utah 12

Tables

Table 1. Station names and locations sampled for macroinvertebrates on October 1, 2015, in Eccles Creek, Carbon County, Utah 3

Table 2. Discharge and water-quality data collected at each station prior to macroinvertebrate sampling on Eccles Creek, October 1, 2015 7

Table 3. Number of macroinvertebrate taxa collected from sampling locations on Eccles Creek, Carbon County, Utah 9

Table 4. Total density (number/m^2) of macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah 10

Table 5. Calculated Shannon-Wiener diversity from macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah 10

Table 6. Calculated community tolerance quotient (CTQ) of macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah 11

INTRODUCTION

Eccles Creek is a first-order stream flowing west to east into Pleasant Valley Creek, which flows north into Scofield Reservoir in Carbon County, Utah (G. Galecki, 2015 memorandum to the Utah Division of Oil, Gas, and Mining, on macroinvertebrate and fish monitoring). In early August 2001, the advancing face of the Skyline Mine encountered fractured sandstone, resulting in a significant inflow of water to the mine. From early September 2001 through July 2003, this water was discharged from the mine into Eccles Creek at mean monthly rates ranging from approximately 15.6–21.9 cubic feet per second (ft^3/sec or cfs), compared to the mean monthly discharge of about 4.0 ft^3/sec for the previous 2 years (Earthfax 2007; G. Galecki, Canyon Fuels Company, personal communication). Except for a period of lower discharge (mean monthly discharge of 4.0 ft^3/sec) for most of 2004, the mean monthly discharge from the mine since July 2003 ranged from 2.3–21.9 ft^3/sec (Earthfax 2007; G. Galecki, personal communication). The 2015 mean monthly discharge (4.0 ft^3/sec) (G. Galeki, personal communication) maintains the stream at near bankfull level (Shiozawa 2013; personal observation). The effects of increased base flows (or increased minimum instream flows) during nonpeak seasons on the macroinvertebrate community are poorly understood, and most studies focus on depleted base flows or increases in peak flows (Carlisle et al. 2012). Thus, it becomes important to understand the effects of increased base flows on the macroinvertebrate community in Eccles Creek.

Benthic macroinvertebrate monitoring has been conducted on Eccles Creek from 1979–1985, 2001–2004, and in 2007 and 2011 (Galecki, memorandum). During that time, the relatively undisturbed canyon experienced the opening of the Skyline Mine and widening of SR-264 in 1981, along with increased flow to the channel in 2001. Disturbances and increased flow have likely modified the morphology of the stream bed through deposition, as well as calcification and hardening resulting from introduced calcium-bicarbonate-rich water. Thus, changes in the benthic macroinvertebrate community, such as decreased taxa richness and densities, have been documented (Shiozawa 2013; Galecki, memorandum).

This report summarizes results of macroinvertebrate community sampling in Eccles Creek during 2015 as a means to determine the impact of increased discharge among the stream biota and assess stream health. Where applicable, summaries of previous data are presented for comparative purposes.

METHODS

Quantitative and qualitative sampling for benthic macroinvertebrates was conducted at three sampling stations along Eccles Creek on October 1, 2015 (Figure 1 and Table 1). The sampling stations are consistent with previous sampling events and monitoring efforts conducted intermittently since 1979 (Shiozawa 2013). The station codes used within this report correspond with previous reports for comparative purposes (Table 1).

Before macroinvertebrate sampling began, discharge was determined from Lower Eccles (EC-5) using a Marsh-McBirney, Inc. Flow-Mate Model 2000 velocity meter. The velocity-area procedure was conducted once at a cross-section determined to be typical of the reaches to be sampled in a glide area free of obstructions. A tape measure was stretched perpendicular to the

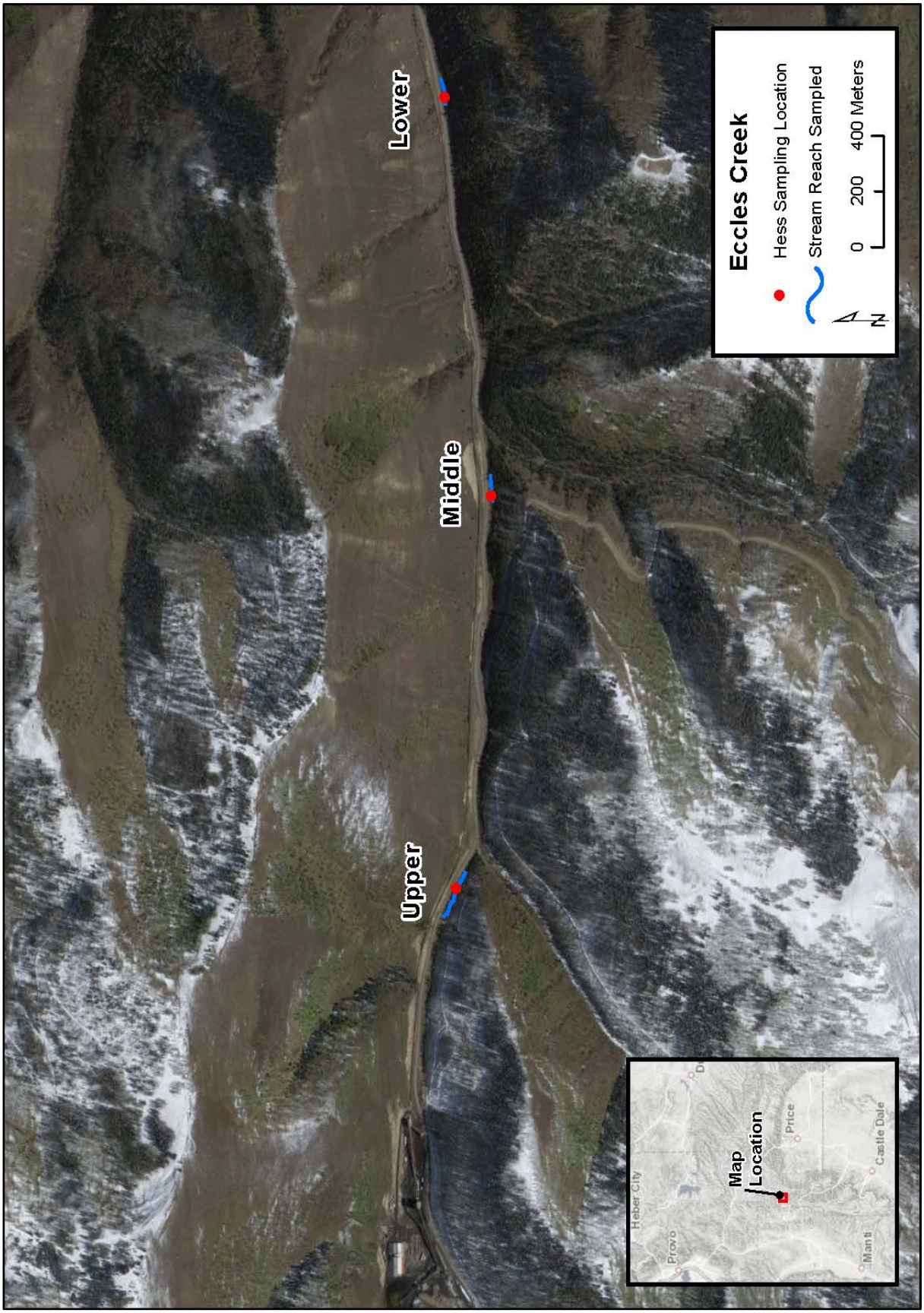


Figure 1. Macroinvertebrate sampling stations along Eccles Creek, Carbon County, Utah, on October 1, 2015.

Table 1. Station names and locations sampled for macroinvertebrates on October 1, 2015, in Eccles Creek, Carbon County, Utah.

STATION	STATION CODE	LOCATION	LAT/LONG	SAMPLE SIZE
Upper Eccles	EC-2	Upstream Hess Downstream	N39.68347, W111.19403 N39.68302, W111.19312 N39.68272, W111.19253	8 kicks into 1 composite sample; 3 Hess samples
Middle Eccles	EC-4	Upstream Hess Downstream	N39.68198, W111.18064 N39.68179, W111.18041 N39.68183, W111.17972	8 kicks into 1 composite sample; 3 Hess samples
Lower Eccles	EC-5	Upstream Hess Downstream	N39.68339, W111.16778 N39.68340, W111.16753 N39.68359, W111.16694	8 kicks into 1 composite sample; 3 Hess samples

stream channel and the velocity meter was attached to a calibrated wading rod. The total wetted stream width (ft) was divided into 10 equal segments or interval points of water-velocity measurements.

For each water-velocity measurement, the distance from the initial point was recorded along with the segment width and depth (all in ft). While pointing the velocity meter upstream at a right angle and standing downstream, the velocity meter was adjusted using the calibrated wading rod so that velocity was determined at 60% of the total depth. The velocity (ft/s) was then recorded, and the procedure was repeated at each of the 10 interval points across the transect.

To calculate discharge, the depth and interval widths were multiplied to determine each interval area in ft^2. The area was then multiplied by the velocity to calculate interval discharge in ft^3/sec or CFS. Total discharge was then calculated by adding each of the interval discharges.

Also prior to sampling, data were obtained at each station using a Hydrolab Quanta Multi-Probe to determine the current water quality parameters important to general aquatic ecosystem health. Water quality parameters measured included temperature (°C), conductivity (mS/cm), dissolved oxygen (mg/L), percent dissolved oxygen (%), total dissolved solids (TDS, g/L), pH, and turbidity (nephelometric turbidity units [NTU]).

At each sampling site, riffles were chosen for collection of three replicate benthic macroinvertebrate samples within a reach ranging from 76–158 m in length. Each of the individual samples was collected with a Hess-type cylindrical (0.086 square m [m^2]) bottom sampler with a 250-micron mesh window and 250-micron collecting net and dolphin bucket. The requirements for sampling with this device include substrate sizes ranging from gravel to cobble, water depth of less than 2 feet, and water velocity that was not too great to prevent holding the sampling gear in place and on the bottom of the streambed. Once the sampler was secured, all rock surfaces confined within the sampler were cleaned of all algae and macroinvertebrates. The substrate was then disturbed vigorously to a depth of approximately 10 cm (Cuffney et al. 1993; Metzeling et al. 2003). All detritus and macroinvertebrates dislodged during this process were washed downstream into the net and ultimately into the attached dolphin bucket. All contents of the dolphin bucket were then rinsed into a 500-milliliter (mL) or 1-L Nalgene bottle. The contents were then preserved with 95% ethanol to obtain a final concentration of at least 70%

(Barbour et al. 1999). Hess samplers provide a quantitative estimate of both the density (number per area) and composition of the macroinvertebrate community in riffle type habitats within each monitoring station. Since similar habitat types were sampled in each station using the Hess sampler, estimates of richness and abundance are directly comparable among stations. The replicates within these quantitative samples will also allow for statistical comparison among subsequent sampling efforts to mathematically compare metrics to better determine the significance of change through time.

In addition to the three samples collected with the Hess-type sampler, one composite, kick-net sample collected from eight riffles (riffle-kick method, Peck et al. 2006) was collected within each reach. These composite samples were collected using a 500-micron mesh, D-frame kick-net (Cuffney et al. 1993; Barbour et al. 1999). In each of the eight kick sample locations, a 0.5-m area of substrate was disturbed in front of the D-frame kick-net by hand agitating and scraping rocks clean or kicking into the substrate. Stream current then carried the invertebrates and periphyton from the disturbed area into the D-frame kick-net below (Cuffney et al. 1993; Barbour et al. 1999).

Sample processing and preservation in the field included rinsing large debris over a 250-micron mesh sieve, thereby removing it from the sample. Samples were then rinsed and placed into a 1-L or 500-mL wide-mouth Nalgene container and preserved in 95% ethanol to achieve at least a 70% final concentration (Cuffney et al. 1993; Barbour et al. 1999). Both Hess and kick-net samples were taken to the U.S. Bureau of Land Management/Utah State University National Aquatic Monitoring Center (NAMC) in Logan, Utah, for further processing, identification, and analysis.

The NAMC processed and identified organisms in the benthic macroinvertebrate samples. Samples were randomly split to achieve approximately 600 organisms or more per split sample. All organisms were removed from the split sample, counted, and separated by family. These individuals were then identified to the lowest taxonomic level possible by qualified taxonomists. A synoptic reference collection was created, which was checked by a second taxonomist to ensure taxonomic accuracy. The number of each taxa collected was then entered into a spreadsheet, which was used to generate a list of 55 metrics that can be used as an index of the quality and health of the macroinvertebrate community. The NAMC provided the raw data and metrics to BIO WEST and retained a reference collection within their lab. For additional information regarding the sample processing and metric calculations, please refer to NAMC (2016).

Data Analysis

Several commonly used metrics were selected to examine differences between stations and compare results from previous sampling events dating back to 1979. The calculated metrics used were obtained from the NAMC for each Hess replicate and the qualitative kick net samples (Appendix A). For all quantitative analysis, mean values (± one SE) for the three Hess-sample replicates were used. Data from previous sampling events were summarized from tables presented in Shiozawa (2013).

Metrics

The metrics used for assessing and comparing macroinvertebrate communities included taxa richness, total density of all macroinvertebrates, the Shannon-Wiener diversity index, the U.S. Forest Service Community Tolerance Quotient (CTQ), the Hilsenhoff Biotic Index (HBI), and functional feeding groups. The relevance and calculated values for each of these metrics from all monitoring efforts during 2015 are described in Vinson (2006) and Miller and Judson (2011).

Taxa Richness

Taxa richness is the number of taxa observed in each sample (Hess or kick-net) at the lowest possible taxonomic resolution (Miller and Judson 2011). It provides an index for evaluating community diversity, but similar to total density it does not discriminate against taxa by tolerance to altered conditions. Because degraded conditions often lead to a high abundance of just a few tolerant species, higher taxa richness usually indicates greater habitat diversity and/or more suitable water quality and indicates conditions suitable to a wider range of macroinvertebrates (Vinson 2006). For this report, taxa richness was determined for each station by the total number of unique taxa collected in all three Hess samples. Additionally, unique taxa collected from the qualitative kick-net samples were reported as ancillary data.

Total Density

An estimate of the total density of macroinvertebrates provides one means of comparing biological conditions across stations. However, a high overall density may not indicate good habitat conditions and a healthy macroinvertebrate community if it results from an abundance of tolerant species. Very low total density indicates oligotrophic or toxic conditions, while very high total densities of macroinvertebrates are often associated with nutrient enrichment, higher flows, or increases in fine sediments and a degraded condition (Vinson 2006). Density is reported in number of individuals/m^2 for all historic collections and mean number of individuals/m^2 for collections from 2015.

Shannon-Wiener Diversity

The Shannon-Wiener diversity index is a measure of macroinvertebrate heterogeneity and community structure ($-\Sigma(\text{Relative Abundance}]_{taxa}*\ln([\text{Relative Abundance}]_{taxa}))$) (Ludwig and Reynolds 1988; Miller and Judson 2011). This index takes into account the number of taxa in relation to their relative abundance results in a single value calculated per sample. Typically, Shannon-Weiner diversity is weighted toward rare taxa: the greater number of taxa, the more even the distribution, and the higher the index value (Miller and Judson 2011). For 2015 macroinvertebrate data, the Shannon-Wiener index is reported as the mean index value from the three Hess samples per station.

U.S. Forest Service (USFS) Community Tolerance Quotient (CTQ)

The USFS community tolerance quotient has been widely used in the western United States where taxa are assigned a tolerant quotient from 2 to 108 (Winget and Mangum 1979; Vinson 2006; Miller and Judson 2011). A dominance weighted CTQ was calculated ($\Sigma([\text{Tolerance Quotient}] * \log([\text{Abundance}]_{taxa}))/\Sigma\log([\text{Abundance}]_{taxa})$) and values can range from 20–100, with lower values generally indicating better water quality (Miller and Judson 2011). Any community with values less than 65 represents high-quality habitats, values of 65–80 are moderate-quality

habitats, and values greater than 80 are considered poor-quality habitats (Winget and Mangum 1979). The CTQ is reported as the mean value from the three Hess samples per station.

Hilsenhoff Biotic Index (HBI)

The HBI provides an indication of the overall pollution tolerances of the macroinvertebrate community in a site from the taxa collected (Hilsenhoff 1987 and 1988). This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It was originally developed to detect organic pollution (Hilsenhoff 1988). Individual families were assigned an index value from 0 to 10 based on Hilsenhoff (1987; 1988) and the HBI calculated ($\Sigma([\text{Abundance}]_{taxa}*[\text{Tolerance}]_{taxa})/[\text{Abundance}]_{Total}$)(Miller and Judson 2011). Taxa with HBI values of 0–2 are considered intolerant, clean-water taxa. Taxa with HBI values of 9–10 are considered pollution-tolerant taxa. A family level HBI was calculated for each sample. Stations with HBI values of 0–2 are considered clean, 2–4 slightly enriched, 4–7 enriched, and 7–10 polluted (Vinson 2006). In an effort to more fully assess the current condition of the macroinvertebrate community, the HBI is introduced in this report and presented as the mean HBI by sampling station. Continued HBI comparisons should allow for future tracking of nutrient enrichment, thermal changes, and perhaps changes in sediment loads through time.

Functional Feeding Groups

Macroinvertebrates can be classified based on their primary feeding behavior and mechanics; recognizing that all macroinvertebrates exhibit some omnivory (Vinson 2006; Miller and Judson 2011). Such groups are shredders, scrapers, collector-filterers, collector-gatherers, and predators (Merritt et al. 2008). These feeding mechanisms are primarily based on the location (i.e., water column or stream bed) and the particle size and type (i.e., leaf litter, fine particulate organic matter, or live prey) of food they eat (Vinson 2006). These feeding groups may also help characterize the source of the food resource and whether the habitats sampled are erosional or depositional (Vinson 2006).

Shredders typically feed on living or decomposing aquatic vascular plants and can be sensitive to changes in vegetation. In turn, they can be good indicators of toxins that may be assimilated in organic matter (Vinson 2006). Scrapers primarily feed on periphyton and attached algae. As sedimentation and nutrient enrichment occur, scraper abundance typically will decline as more filamentous algae and vascular plants become dominant in areas with increased sedimentation and organic pollution (Vinson 2006). Both collector-filterers and -gatherers feed on particulate organic matter either within the water column (filterer) or deposited on sediment (gatherer) and are sensitive to toxicants (Vinson 2006). Predators, as their name implies, feed on living animal (primarily insect) tissue.

For this report, a brief analysis of relative abundance for macroinvertebrates by each feeding group was performed. This was calculated by taking the mean number of organisms by feeding group for each site and reporting that number as a percentage of the total.

RESULTS

Discharge and Water Quality

Discharge was calculated at 6.11 ft^3/sec (Table 1) at Lower Eccles (EC5) during the time of sampling and conducive for macroinvertebrate collection. Discharge at that rate created what appeared to be near or exceeding bankfull conditions within Eccles Creek. Temperature, dissolved oxygen, pH, and turbidity at all stations were within ranges identified for biologically healthy and productive systems (Wetzel 1983; Sigler and Sigler 1996; UDAR 2012) (Table 2). The only notable variation in water-quality parameters among stations was temperature. Sampling began downstream with a water temperature of 11.34°C and warmed as sampling progressed upstream (14.03°C) (Table 2). It is likely that the water temperature warmed as the air temperature increased, or the discharge water from the mine was cooled as it traveled downstream through the sampling reaches.

Table 2. Discharge and water-quality data collected at each station prior to macroinvertebrate sampling on Eccles Creek, October 1, 2015.

STATION	DISCHARGE (ft^3/sec)	TEMP (°C)	COND (millisiemens [mS]/cm)	DO (mg/L)	PH	TDS (g/L)	DO (%)	TURBIDITY (NTU)
EC2	-	14.03	0.841	9.10	8.48	0.5	88.8	-
EC4	-	12.17	0.796	9.80	8.52	0.5	90.9	-
EC5	6.11[a]	11.34	0.784	9.58	8.52	0.5	88.3	7.47[b]

[a] Only measured once as stations were close with little input or diversion throughout.
[b] Only collected at downstream location due to equipment malfunction.

Macroinvertebrate Community

Taxa Richness

From all of the Eccles Creek sampling stations combined, 34 total taxa were collected (Appendix A), marking the highest taxa richness recorded since sampling began in 2001 (Shiozawa 2013). Middle Eccles (EC4) exhibited the single highest richness for the stations sampled since 1979, with a total of 25 taxa in 2015 (Table 3). Stations EC5 and Upper Eccles (EC2) followed with 24 and 20 taxa, respectively (Table 3). The decline in taxa richness after the construction of the mine and highway (post 1979) is evident (Figure 2 and Table 3). Since then, the number of species present in Eccles Creek has remained fairly stable or perhaps even increased through time (Figure 2).

These richness values do not indicate high taxonomic order diversity, as nearly all sampled species were either dipterans or trichopterans. An additional two species were found at EC2 and EC4, and an additional three species at were found at EC5 via kick net sampling (Appendix A). These were also species of filter-feeding dipterans and trichopterans.

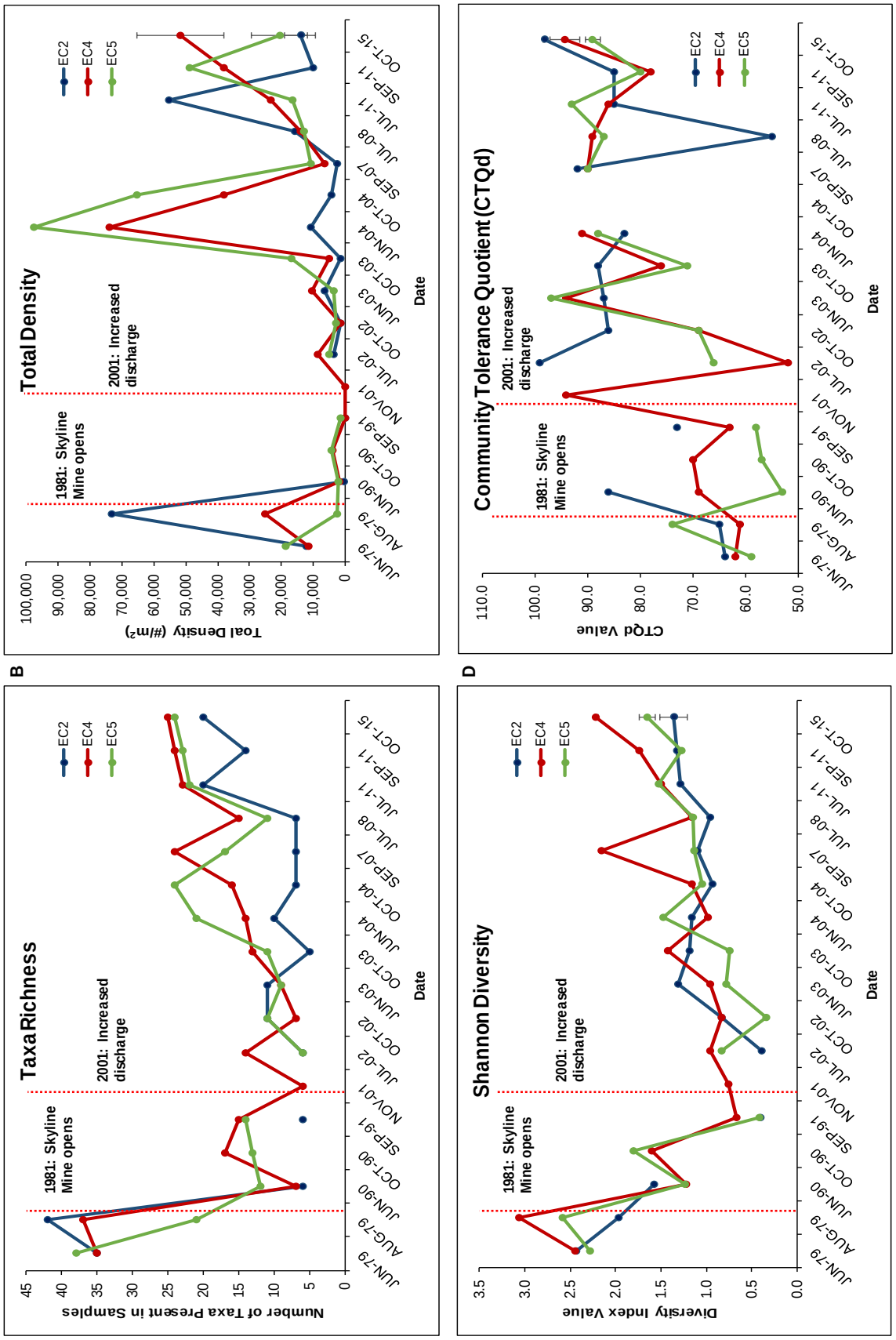


Figure 2. Historic and current data for (A) taxa richness, (B) total density, (C) Shannon diversity, and (D) community tolerance quotient (CTQ) for Eccles Creek, Carbon County, Utah.

Table 3. Number of macroinvertebrate taxa collected from sampling locations on Eccles Creek, Carbon County, Utah. (Modified from Shiozawa [2013]).

SAMPLING STATION/ DATE	JUN 1979[a]	AUG 1979[a]	JUN 1990[b]	OCT 1990[b]	SEP 1991[b]	NOV 2001[c]	JUL 2002[d]	OCT 2002[e]	JUN 2003[f]	OCT 2003[g]	JUN 2004[h]	OCT 2004[i]	SEP 2007[j]	JUL 2008[j]	JUL 2011[k]	SEP 2011[k]	OCT 2015
Eccles Creek above south Fork (EC2)	35	42	6	NS	6	NS	6	11	11	5	10	7	7	7	20	14	20
Eccles Creek at Whisky Canyon (EC4)	35	37	7	17	15	6	14	7	9	13	14	16	24	15	23	24	25
Lower Eccles Creek (EC5)	38	21	12	13	14	NS	6	11	9	11	21	24	17	11	22	23	24

[a] Winget 1980
[b] Ecosystems Research Institute 1992
[c] Shiozawa 2002a
[d] Shiozawa 2002b
[e] Shiozowa 2003
[f] Shiozowa and Hansen 2003
[g] Shiozowa 2005a
[h] Shiozowa 2005b
[i] Shiozowa 2007
[j] Shiozowa and Fordham 2010
[k] Shiozowa 2013
NS= not sampled

Total Density

Macroinvertebrate densities varied by sampling station in 2015, with EC4 having the highest mean density (51,608 individuals/m^2) followed by EC5 and EC2 (20,605 and 14,043 individuals/m^2, respectively (Table 4). Comparisons with conditions before mine operation are difficult because of the seasonal differences in sampling (summer 1979 vs. fall 2015). However, densities in 2015 for all sampling stations were higher than May–June 1979, and EC4 and EC5 densities were higher in 2015 than in August 1979 (Table 4). Macroinvertebrate densities appeared to decline throughout the 1990s and early 2000s (Figure 2); however, variations in densities could be seasonally driven due to the presence (or absence) of certain taxa found within the stream at different life cycles. The last decade has shown a near-steady increase in density at all stations (Figure 2).

For EC2, four taxa made up 87% of the mean macroinvertebrate density (Appendix A); 71% was from two taxa in the Chironomidae family, 8% was from the Baetidae family, and 8% was from the class Oligochaeta. At EC4, four taxa made up 69% of the mean macroinvertebrate density (Appendix A): 26% from the Elmidae family, 18% from the Chironomidae family, 13% from the Baetidae family, and 12% from the Planorbidae family. Three taxa made up 78% of the mean macroinvertebrate density at EC5 (Appendix A), 46% from two taxa in the Chironomidae family and 32% from the Baetidae family. In total, over 69% of the mean macroinvertebrate density at the three Eccles Creek sampling stations was derived from chironomids and baetids.

Shannon-Wiener Diversity

The calculated mean of the Shannon-Wiener diversity index for each station indicates that current values are lower for all stations compared to pre-mine sampling values (Table 5 and Figure 2). Diversity decreased throughout the 1990s before leveling off in the early 2000s, around the time when discharge increased within the channel (Figure 2). The diversity value of

Table 4. Total density (number/m^2) of macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah. (Modified from Shiozawa [2013]).

SAMPLING STATION/ DATE	JUN 1979[a]	AUG 1979[a]	JUN 1990[b]	OCT 1990[b]	SEP 1991[b]	NOV 2001[c]	JUL 2002[d]	OCT 2002[e]	JUN 2003[f]	OCT 2003[g]	JUN 2004[h]	OCT 2004[i]	SEP 2007[j]	JUL 2008[j]	JUL 2011[k]	SEP 2011[k]	OCT 2015
Eccles Creek above south Fork (EC2)	12,341	73,181	267	NS	89	NS	3,703	1,260	6,265	1,267	10,865	4,339	2,436	15,772	55,421	9,873	14,043
Eccles Creek at Whisky Canyon (EC4)	11,634	25,273	1,719	3,928	1,419	61	8,757	1,491	10,351	5,004	73,950	38,093	6,332	13,926	23,157	38,176	51,608
Lower Eccles Creek (EC5)	18,661	2,526	2,212	4,104	1,468	NS	4,927	2,879	3,387	16,919	97,614	65,206	10,878	12,743	16,427	48,847	20,605

[a] Winget 1980
[b] Ecosystems Research Institute 1992
[c] Shiozawa 2002a
[d] Shiozawa 2002b
[e] Shiozowa 2003
[f] Shiozowa and Hansen 2003
[g] Shiozowa 2005a
[h] Shiozowa 2005b
[i] Shiozowa 2007
[j] Shiozowa and Fordham 2010
[k] Shiozowa 2013
NS= not sampled

Table 5. Calculated Shannon-Wiener diversity from macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah. (Modified from Shiozawa [2013]).

SAMPLING STATION/ DATE	JUN 1979[a]	AUG 1979[a]	JUN 1990[b]	OCT 1990[b]	SEP 1991[b]	NOV 2001[c]	JUL 2002[d]	OCT 2002[e]	JUN 2003[f]	OCT 2003[g]	JUN 2004[h]	OCT 2004[i]	SEP 2007[j]	JUL 2008[j]	JUL 2011[k]	SEP 2011[k]	OCT 2015
Eccles Creek above south Fork (EC2)	2.44	1.964	1.58	NS	0.400	NS	0.398	0.836	1.314	1.190	1.165	0.939	1.100	0.956	1.285	1.329	1.362
Eccles Creek at Whisky Canyon (EC4)	2.45	3.060	1.22	1.6	0.666	0.757	0.957	0.835	0.955	1.432	0.982	1.165	2.152	1.162	1.506	1.737	2.214
Lower Eccles Creek (EC5)	2.28	2.590	1.24	1.8	0.416	NS	0.829	0.341	0.789	0.750	1.474	1.052	1.141	1.149	1.528	1.276	1.654

[a] Winget 1980
[b] Ecosystems Research Institute 1992
[c] Shiozawa 2002a
[d] Shiozawa 2002b
[e] Shiozowa 2003
[f] Shiozowa and Hansen 2003
[g] Shiozowa 2005a
[h] Shiozowa 2005b
[i] Shiozowa 2007
[j] Shiozowa and Fordham 2010
[k] Shiozowa 2013
NS= not sampled

EC2 is relatively unchanged from 2011; its current value of 1.362 is very close to 2011's values of 1.285 and 1.329. The EC4 value of 2.214 is higher than diversity values observed in 2011; however, observations made in 2007 (Shiozowa and Fordham 2010) indicate that 2.214 is within the range of values to be expected. The EC5 station's values are also similar to those found in 2011. Although lower than 1979 values, diversity appears to be increasing and may be approaching values observed before mining operations commenced. Qualitative kick net sampling produced results and diversity values very similar to those obtained with Hess samplers (Appendix A).

U.S. Forest Service (USFS) Community Tolerance Quotient (CTQ)

Mean CTQ values for 2015 were very similar across all stations, which is indicative of similar water quality (Table 6). The highest values were found at the farthest upstream station (EC2, 98.3), while the lowest value was at the farthest downstream station (EC5, 89) (Table 6). Qualitative kick net samples had nearly identical values at all stations, with a CTQ value of 90–91 (Appendix A). These CTQ values suggest poor-quality habitat. Although variable through time, CTQ values have increased since 1979 (pre-mine) (Figure 2). Such an increase likely indicates a change in water quality or habitat that creates an environment more suitable to tolerant organisms.

Table 6. Calculated community tolerance quotient (CTQ) of macroinvertebrates collected from sampling locations on Eccles Creek, Carbon County, Utah. (Modified from Shiozawa [2013])

SAMPLING STATION/ DATE	JUN 1979[a]	AUG 1979[a]	JUN 1990[b]	OCT 1990[b]	SEP 1991[b]	NOV 2001[c]	JUL 2002[d]	OCT 2002[e]	JUN 2003[f]	OCT 2003[g]	JUN 2004[h]	OCT 2004[i]	SEP 2007[j]	JUL 2008[j]	JUL 2011[k]	SEP 2011[k]	OCT 2015
Eccles Creek above south Fork (EC2)	64	65	86	NS	73	NS	99	86	87	88	83	NS	92	55	85	85	98.3
Eccles Creek at Whisky Canyon (EC4)	62	61	69	70	63	94	52	69	94	76	91	NS	90	89	86	78	94.3
Lower Eccles Creek (EC5)	59	74	53	57	58	NS	66	69	97	71	88	NS	90	87	93	80	89.0

[a] Winget 1980
[b] Ecosystems Research Institute 1992
[c] Shiozawa 2002a
[d] Shiozawa 2002b
[e] Shiozowa 2003
[f] Shiozowa and Hansen 2003
[g] Shiozowa 2005a
[h] Shiozowa 2005b
[i] Shiozowa 2007
[j] Shiozowa and Fordham 2010
[k] Shiozowa 2013
NS= not sampled

Finding high numbers of intolerant organisms indicates that the stream is healthy (low CTQ score). All three stations have low numbers of intolerant organisms; however, the lower two stations did contain more intolerant species. No intolerant species were captured in Hess samplings at EC2, though one was captured in supplementary kick net sampling (Appendix A). Up to four intolerant species were found at station EC4, most of which were caddisflies (Trichoptera spp.). Within EC5, two to three intolerant species were found at all stations (Appendix A).

Hilsenhoff Biotic Index (HBI)

The HBI was used to provide an indication of overall pollution tolerances of macroinvertebrates within a single station. Mean HBI values were highest at the uppermost station (EC2, 5.18), similar to the CTQ values. Stations EC4 and EC5 had very similar HBI values of 3.87 and 4.66, respectively. Values between four and seven would be considered "enriched" and indicate that only relatively tolerant taxa would be able to inhabit these waters. Areas with values above seven would be considered polluted, while areas with values less than two would be considered to have clean water. The HBI scores for kick net samples were very similar and showed a pattern similar to Hess sampler-obtained values. Tracking this metric through time is another means of determining the overall health of the macroinvertebrate community and whether or not change is occurring.

Functional Feeding Groups

Functional feeding groups provide a primary indication of change in stream communities. The current feeding group primarily consists of collector-gatherers and secondarily collector-filterers (Figure 3). Again, Diptera and Trichoptera orders, which are largely gatherers and filter feeders, dominate the aquatic community in this stream. The Baetis (Ephemeroptera) found, as well as some caddisflies (Trichoptera), are considered collectors and scrapers, while the one Plecoptera species found is a predator of these aquatic insects. No shredders, which require higher amounts of plant detritus and are common in higher-order, healthy streams, were found within any samples.

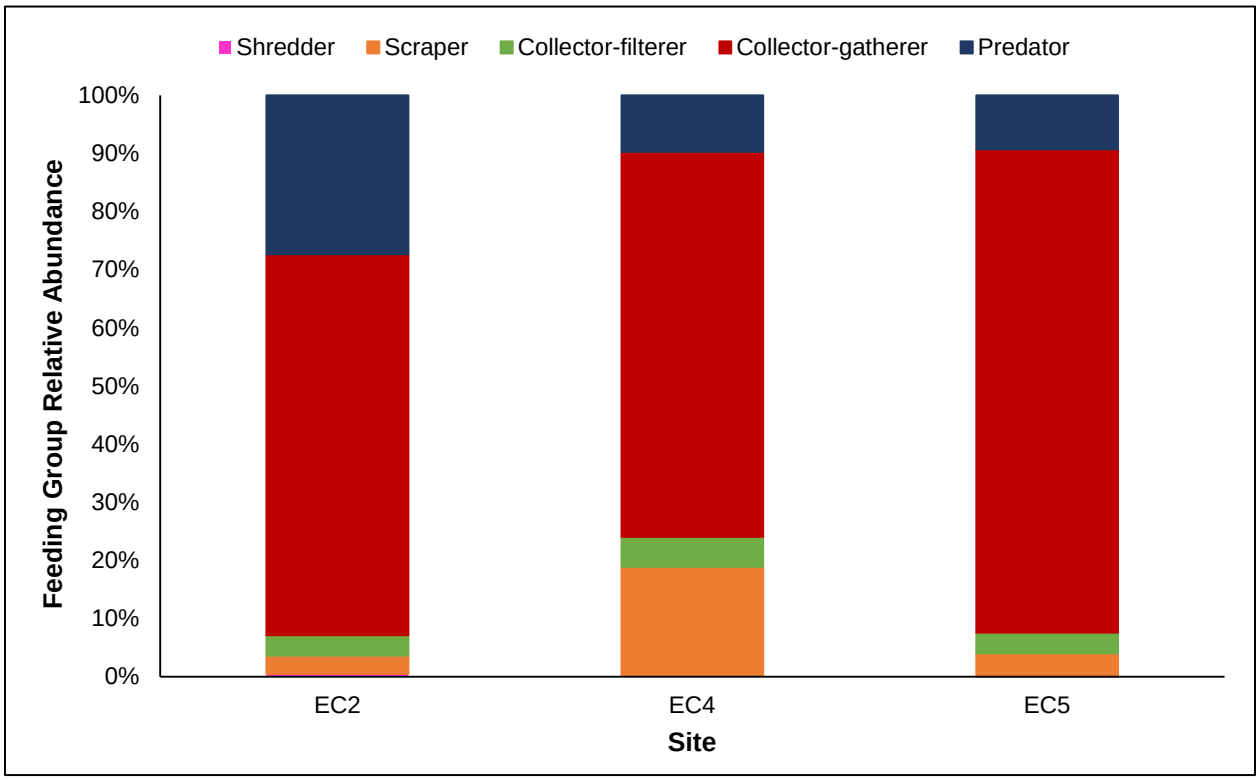


Figure 3. Functional feeding group taxa composition in 2015 at each sampling station on Eccles Creek, Carbon County, Utah.

DISCUSSION AND RECOMMENDATIONS

The apparent increase of taxa richness since 1990 is positive, especially considering that richness values in 2015 were nearing or exceeding the baseline observations made in 1979 (Winget 1980). These data show that impacts to the stream community, which occurred sometime after 1979 and before 1990, are likely due to the initiation of mining and road-widening activities. Although the exact impacts under mining operations or road-widening activities are unknown, the addition of impervious surfaces (i.e., pavement) can increase runoff rates (Trombulak and Frissell 2000), thus increasing sedimentation and perhaps effecting the macroinvertebrate species composition as the substrate composition changes. Increasing taxa richness may indicate system health, but taxa diversity should also be considered in this determination. For example, of the taxa currently present, there is little diversity in taxonomic order. Even though the number of taxa seems to be increasing, most of the taxa are filter-feeding dipterans and trichopterans. Increased calcification and hardening of the channel from calcium-rich water (post 2001) is likely responsible for the more recent community shift to new filter-feeding species from other areas colonizing the stream and, thus, increasing taxa richness. Filterers and gatherers dominate this macroinvertebrate community, which is somewhat void of detritus and plant debris under the current flow conditions. Consequently, shredders are essentially gone from the stream.

Like taxa richness, mean densities of macroinvertebrates were near or exceeded 1979 baseline densities. Density comparisons of different seasonal samples should be cautioned due to seasonal life-cycle variation; however, densities exceeded those of fall 2011 at EC2 and EC4. The increase in density through time is likely related to the increase in taxa richness, at least for the dipterans that make up 50% of the total density for all three Eccles Creek stations. Ephemeropterans (mostly baetids) make up an additional 20%; therefore, 70% of the total macroinvertebrate density is derived from two taxonomic orders. The skewed abundance is likely due to stressors within the system that have altered macroinvertebrate habitat through time. Those stressors could be related to landscape disturbances and modified flow regimes.

Although diversity appears to be increasing, it is still below the baseline diversity measured in 1979 (Winget 1980). The gradual increase in diversity through time is positive, but based on the current taxa there are likely new colonizers of filter feeders that can tolerate the impacted system. Additionally, there seems to be an increase in community tolerance, which indicates habitat quality has degraded since earlier sampling events. The CTQ values over time have increased and remain high (indicating habitat degradation). This metric will be important to monitor, as it may be a better gauge of system health compared to taxa richness or density. Currently, all stations score poorly and are near the upper limit of the CTQ values (108).

To better assess macroinvertebrate health, the HBI was calculated for each station. The HBI is another method for assessing pollution, sedimentation, and nutrient enrichment. Much like the CTQ values, HBI scores indicate that stream reaches have been degraded and more tolerant species are present. Like the CTQ, this metric is another way to track macroinvertebrate health and provide an indication of increased stress or recovery of the system moving forward.
It is apparent that anthropogenic activities have impacted the Eccles Creek macroinvertebrate community through time. More apparent, but not well understood, is the impact after mining began and the road was widened (1981). Less apparent, based on the macroinvertebrate data, is

the impact of increased discharge since 2001. It is likely that the stream is eroding along cut banks and causing increased sedimentation in pools formed by what appear to be former beaver dams, combined with calcification and hardening. Although geomorphic surveys conducted in 2006 (Earthfax 2007) found little difference in comparison with cross-sectional and longitudinal profiles from 2002, down-cutting was observed at EC1. That report also documented water levels at or near bankfull during those surveys. Bankfull flows are channel-forming flows with the highest rate of sediment transport and erosion (Rosgen 1996). Erosion and deposition can combine to create unfavorable habitat for invertebrates that require interstitial space (space between substrate particles) to thrive, as that space becomes filled in with fine sediments. Although taxa richness, density, and even diversity appear to be increasing, community composition must be taken into account. Based on the CTQ values and HBI scores, it appears that the system remains under stress.

Continued monitoring within these three Eccles Creek stations is recommended to track changes though time and identify potential avenues for remediation. Using the current methodology for future monitoring will enable statistical comparisons of metrics and quantitative assessments to determine whether changes within the system are mathematically significant. The sampling methods, reporting, and analysis of means as contained in this report will allow for statistical analysis with calculations of error and significance. Maintaining sampling during the same season each year will also allow for unbiased sampling and analysis that can be attributed to seasonal differences within the macroinvertebrate community. Since the stream channel currently experiences unnatural flows, it may be informative to continue geomorphic survey efforts to periodically track change throughout the reaches. Additionally, and under a holistic approach, continuing fish sampling as part of the study may facilitate better assessment of stream health at all trophic levels.

LITERATURE CITED

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish, Second edition. EPA 841-B-99-002. Washington (D.C.): U.S. Environmental Protection Agency, Office of Water.

Carlisle, D.M., S.M. Nelson, and K. Eng. 2012. Macroinvertebrate community condition associated with the severity of streamflow alteration. River Research and Applications 30:29–39.

Cuffney, T.F., Gurtz, M.E. and Meador, M.R. 1993. Methods for collecting benthic invertebrate samples as part of the National Water Quality Assessment Program. United States Geological Survey Open File Report 93-406.

[Earthfax] Earthfax Engineering, Inc. 2007. Results of the 2006 annual geomorphic evaluation of Eccles and Mud Creeks. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Ecosystems Research Institute. 1992. Eccles Creek invertebrate studies and rock dissolution experiments. Report to Skyline Mines. Utah Fuel Company. Coastal States Energy Company.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist, 20(1):31–40.

Hilsenhoff, W.L. 1988. Rapid field assessment of organic pollution with a family-level biotic index. Journal of the North American Benthological Society, 7(1):65–68.

Ludwig, J.A. and J.F. Reynolds. 1988. Statistical ecology: a primer on methods and computing, John Wiley & Sons, Inc. New York, NY.

Merritt, R.W., K.W. Cummins, and M.B. Berg. 2008. An introduction to the aquatic insects of North America, 4th ed. Kendall Hunt Publishing, Dubuque, IA.

Metzeling, L., B. Chessman, R. Hardwick, and V. Wong. 2003. Rapid assessment of rivers using macroinvertebrates: the role of experience, and comparisons with quantitative methods. Hydrobiologia 510:39–52.

Miller, S. and S. Judson. 2011. Macroinvertebrate sample processing and reporting methodologies of the National Aquatic Monitoring Center. Bureau of Land Management/Utah State University National Aquatic Monitoring Center, Department of Watershed Sciences, Utah State University, Logan, UT.

[NAMC] BLM/USU National Aquatic Monitoring Center. 2016. Buglab-sample processing. Available: http://www.usu.edu/buglab/SampleProcessing/. (February 17, 2016).

Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J.M. Lazorchak, F.H. McCormick, S.A. Peterson, P.L. Ringold, T. Magee, and M. Cappaert. 2006. Environmental monitoring and assessment program-surface waters western pilot study: field operations manual for wadeable streams. EPA/620/R-06/003. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C.

Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, Colorado

Shiozawa, D. K. 2002a. The benthos of Bordinghouse & Eccles Creeks and the impact of increased water discharge into Eccles Creek in 2001. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D. K. 2002b. The benthos Eccles Creek and the impact of increased water discharge in 2002. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D. K. 2003. Eccles Creek benthic invertebrate monitoring, October, 2002. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D.K. 2005a. Eccles Creek benthic invertebrate monitoring October 2003. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D.K. 2005b. Eccles Creek benthic invertebrate monitoring June 2004. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D. K. 2007. Assessment of the macrobenthos of Eccles Creek October 2004. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D.K. 2013. An assessment of the macroinvertebrates of Eccles Creek in July 2011 & September 2011. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D. K. and A. Fordham. 2010. An assessment of the macroinvertebrates of Eccles Creek in September 2007 and July 2008. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Shiozawa, D.K. and J. Hansen. 2003. Eccles Creek benthic invertebrate monitoring June 2003. Prepared for Canyon Fuel Company, Skyline Mine, Helper, UT.

Sigler, W.F. and J.W. Sigler. 1996. Fishes of Utah: A natural history. University of Utah Press, Salt Lake City, UT.

Trombulak, S.C. and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

[UDAR] Utah Division of Administrative Rules. 2012. Standards of quality for waters of the state. Utah Administrative Code, Rule R317-2. Available: http://www.rules.utah.gov/publicat/code/r317/r317-002.htm (February 17, 2016).

Vinson, M. 2006. Aquatic invertebrate report for samples collected from the Six Rivers National Forest, 2006. Report prepared for United States Forest Service, Six Rivers National Forest, Eureka, CA by National Aquatic Monitoring Center, Utah State University, Logan, UT.

Wetzel, R.G. 1983. Limnology, second edition. Harcourt Brace College Publishing, San Diego, CA.

Winget, R.N. and F.A. Mangum. 1979. Biotic condition index: integrated biological, physical, and chemical stream parameters for management, US Department of Agriculture, Forest Service, Intermountain Region, Ogden, UT.

Winget, R. N. 1980. Aquatic ecology of surface waters associated with the Skyline Project, Coastal States Energy Company. General Aquatic Resource Description. Report to Coastal States Energy Company.

APPENDIX A: ECCLES CREEK MACROINVERTEBRATE SAMPLING RESULTS INCLUDING TAXA COLLECTED AND CALCULATED METRICS FROM THE NATIONAL AQUATIC MONITORING CENTER IN 2015

Table 1. Macroinvertebrate taxa collected for each stations on Eccles Creek in 2015.

					SAMPLEID	155492	155493	155494	155495	155496	155497	155498	155499	155500	155501	155502	155503
					STATION (NAMC)	4933070	4933070	4933070	4933070	Middle Eccles	Middle Eccles	Middle Eccles	Middle Eccles	LowerEccles	LowerEccles	LowerEccles	LowerEccles
					STATION (CUSTOMER)	Upper Eccles	Upper Eccles	Upper Eccles	Upper Eccles	Middle Eccles	Middle Eccles	Middle Eccles	Middle Eccles	Lower Eccles	Lower Eccles	Lower Eccles	Lower Eccles
					WATERBODY	S. Eccles Cree	S. Eccles Cree	S. Eccles Cree	S. Eccles Cree	Eccles Creek	Eccles Creek	Eccles Creek	Eccles Creek	Eccles Creek	Eccles Creek	Eccles Creek	Eccles Creek
					COUNTY	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon	Carbon
					STATE	UT	UT	UT	UT	UT	UT	UT	UT	UT	UT	UT	UT
					LATITUDE	39.68388	39.68388	39.68388	39.68388	39.681794	39.681794	39.681794	39.681794	39.683401	39.683401	39.683401	39.683401
					LONGITUDE	-111.1925	-111.1925	-111.1925	-111.1925	-111.180406	-111.180406	-111.180406	-111.180406	-111.167527	-111.167527	-111.167527	-111.167527
					COLLECTION DATE	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015	10/1/2015
					HABITAT SAMPLED	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle	Targeted Riffle
					COLLECTION METHOD	Hess net	Hess net	Hess net	Kick net	Hess net	Hess net	Hess net	Kick net	Hess net	Hess net	Hess net	Kick net
					FIELD NOTES	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
					LAB NOTES	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL
					AREA SAMPLED (M^2)	0.09	0.09	0.09	0.74	0.09	0.09	0.09	0.74	0.09	0.09	0.09	0.74
					FIELD SPLIT	100	100	100	100	100	100	100	100	100	100	100	100
					LAB SPLIT	100	31.25	37.5	10.94	12.5	9.38	25	6.25	65.625	18.75	55.5	9.38
					SPLIT COUNT	385	559	598	618	568	637	636	740	667	640	618	683
CLASS	**ORDER**	**FAMILY**	**GENUS**	**SPECIES**	**OTUNAME**												
					Nemata	0	35.55555556	0	0	0	0	0	0	0	0	0	0
					Other_Oligochaeta	22.22222222	35.55555556	3122.222222	86.46672266	0	118	0	26	0	59	0	0
					Acari	11.11111111	71.11111111	0	0	89	237	0	0	576	1007	360	43
Insecta	Coleoptera	Elmidae			Optioservus	322.2222222	888.8888889	59.25925926	61.76194476	7967	17583	3233	3222	327	1896	251	216
Insecta	Diptera				Muscidae	0	35.55555556	0	1.351351351	11	0	89	0	0	0	0	14
Insecta	Diptera				Simuliidae	0	0	0	0	444	829	356	259	0	474	20	1066
Insecta	Diptera	Ceratopogonidae			Ceratopogoninae	33.33333333	0	0	0	178	237	133	22	51	59	0	14
Insecta	Diptera	Chironomidae			Chironominae	0	0	125.9259259	0	1156	3554	711	173	237	1896	420	648
Insecta	Diptera	Chironomidae			Orthocladiinae	3055.555556	10382.22222	5600	3718.069075	4089	12556	2756	908	3471	16415	3483	2695
Insecta	Diptera	Chironomidae			Tanypodinae	288.8888889	3982.222222	5392.592593	864.6672266	2133	6041	2133	303	102	296	140	86
Insecta	Diptera	Empididae			Chelifera_Metachela_Neoplasta	22.22222222	248.8888889	207.4074074	347.218242	356	711	244	43	457	711	300	173
Insecta	Diptera	Psychodidae			Pericoma_Telmatoscopus	0	35.55555556	0	0	0	0	0	0	0	0	0	0
Insecta	Diptera	Stratiomyidae			Caloparyphus_Euparyphus	111.1111111	284.4444444	29.62962963	0	978	1788	722	86	34	178	0	58
Insecta	Diptera	Tipulidae			Antocha	0	0	0	0	89	118	0	0	586	1622	162	144
Insecta	Diptera	Tipulidae			Dicranota	33.33333333	71.11111111	0	24.7047779	0	259	0	22	0	0	0	45
Insecta	Diptera	Tipulidae			Hexatoma	0	0	0	0	0	0	0	0	0	11	0	0
Insecta	Diptera	Tipulidae			Limnophila	0	0	0	0	0	0	0	0	0	59	0	0
Insecta	Diptera	Tipulidae			Tipula	0	0	0	26.05612926	11	0	0	7	0	0	0	1
Insecta	Ephemeroptera	Baetidae			Baetis	188.8888889	853.3333333	2196.296296	1546.751322	4711	7463	2533	432	4317	9137	4865	995
Insecta	Ephemeroptera	Baetidae			Diphetor	0	177.7777778	0	0	1511	1066	44	1168	0	474	0	173
Insecta	Ephemeroptera	Ephemerellidae			Ephemerella	0	0	0	0	0	711	222	195	0	0	0	0
Insecta	Plecoptera	Perlodidae			Isoperla	0	177.7777778	0	0	0	118	0	65	34	178	80	115
Insecta	Trichoptera	Brachycentridae			Brachycentrus	0	0	0	0	800	485	0	173	34	367	0	115
Insecta	Trichoptera	Brachycentridae			Micrasema	0	0	0	0	0	118	0	0	0	0	0	0
Insecta	Trichoptera	Hydropsychidae			Hydropsyche	66.66666667	142.2222222	703.7037037	322.5134641	1511	1499	489	86	130	378	503	692
Insecta	Trichoptera	Hydroptilidae			Hydroptila	22.22222222	995.5555556	148.1481481	172.9334453	533	0	133	22	0	119	40	158
Insecta	Trichoptera	Hydroptilidae			Ochrotrichia	0	0	0	0	0	0	0	0	17	0	0	0
Insecta	Trichoptera	Limnephilidae			Hesperophylax	22.22222222	35.55555556	0	0	0	0	0	22	0	0	0	0
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		Rhyacophila_brunnea_\emna_groups	0	0	0	0	0	0	0	22	0	0	0	0
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		Rhyacophila_nevadensis_group	0	0	0	0	0	0	0	0	0	0	51	0
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		Rhyacophilla_rotunda_group	0	0	0	38.40851821	11	11	0	0	85	0	0	0
Insecta	Trichoptera	Rhyacophilidae	Rhyacophila		Rhyacophilla_\agrita_group	0	0	0	0	0	0	0	0	0	0	0	1
Bivalvia	Veneroida				Pisidiidae	0	462.2222222	0	61.76194476	89	118	44	0	34	119	0	29
Gastropoda	Basommatophora				Planorbidae	0	0	0	0	7822	3791	2089	2962	0	59	0	29

Table 2. Metrics calculated for macroinvertebrate community analysis of Eccles Creek in 2015.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	WATERBODY	COUNTY	STATE	LATITUDE	LONGITUDE	COLLECTION DATE	HABITAT SAMPLED	COLLECTION METHOD	FIELD NOTES	LAB NOTES	AREA SAMPLED (M^2)	FIELD SPLIT	LAB SPLIT	SPLIT COUNT	FIXED COUNT	BIG RARE COUNT
155492	4933070	Upper Eccles	S. Eccles Creek above confluence with Eccles Creek	Carbon	UT	39.68388	-111.1925	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	100	385	300	0
155493	4933070	Upper Eccles	S. Eccles Creek above confluence with Eccles Creek	Carbon	UT	39.68388	-111.1925	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	31.3	559	300	0
155494	4933070	Upper Eccles	S. Eccles Creek above confluence with Eccles Creek	Carbon	UT	39.68388	-111.1925	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	37.5	598	300	23
155495	4933070	Upper Eccles	S. Eccles Creek above confluence with Eccles Creek	Carbon	UT	39.68388	-111.1925	10/1/2015	Targeted Riffle	Kick net	NULL	NULL	0.74	100	10.9	618	300	7
155496	Middle Eccles	Middle Eccles	Eccles Creek	Carbon	UT	39.68179	-111.180406	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	12.5	568	300	8
155497	Middle Eccles	Middle Eccles	Eccles Creek	Carbon	UT	39.68179	-111.180406	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	9.38	637	300	41
155498	Middle Eccles	Middle Eccles	Eccles Creek	Carbon	UT	39.68179	-111.180406	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	25	636	300	6
155499	Middle Eccles	Middle Eccles	Eccles Creek	Carbon	UT	39.68179	-111.180406	10/1/2015	Targeted Riffle	Kick net	NULL	NULL	0.74	100	6.25	740	300	8
155500	Lower Eccles	Lower Eccles	Eccles Creek	Carbon	UT	39.6834	-111.167527	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	65.6	667	300	7
155501	Lower Eccles	Lower Eccles	Eccles Creek	Carbon	UT	39.6834	-111.167527	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	18.8	640	300	7
155502	Lower Eccles	Lower Eccles	Eccles Creek	Carbon	UT	39.6834	-111.167527	10/1/2015	Targeted Riffle	Hess net	NULL	NULL	0.09	100	55.5	618	300	6
155503	Lower Eccles	Lower Eccles	Eccles Creek	Carbon	UT	39.6834	-111.167527	10/1/2015	Targeted Riffle	Kick net	NULL	NULL	0.74	100	9.38	683	300	5

*Standardized to OTU and fixed count, see Metadata for details

Table 2. Continued.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	RICHNESS*	ABUNDANCE	SHANNON'S DIVERSITY*	SIMPSON'S DIVERSITY*	EVENNESS*	# OF EPT TAXA*	EPT TAXA ABUNDANCE	DOMINANT FAMILY	ABUNDANCE OF DOMINANT FAMILY	DOMINANT TAXA	ABUNDANCE OF DOMINANT TAXA	HILSENHOFF BIOTIC INDEX*
155492	4933070	Upper Eccles	12	4278	1.079492124	0.45340022	0.43441959	4	356	Chironomidae	3344	Orthocladiinae	3056	5.486666667
155493	4933070	Upper Eccles	12	19876	1.402179556	0.61404682	0.56427856	4	2702	Chironomidae	14436	Orthocladiinae	10382	5.43
155494	4933070	Upper Eccles	10	17974	1.603351692	0.76345596	0.69632679	3	3289	Chironomidae	11119	Orthocladiinae	5600	4.646666667
155495	4933070	Upper Eccles	12	7643	1.542697717	0.69188406	0.62082723	4	2254	Chironomidae	4706	Orthocladiinae	3718	5.26
155496	Middle Eccles	Middle Eccles	17	50578	2.259085001	0.86532887	0.79735789	5	21078	Elmidae	11433	Ephemerellidae	10311	3.41
155497	Middle Eccles	Middle Eccles	19	75912	2.183717385	0.84956522	0.74164124	7	24394	Chironomidae	23099	Optioservus	17583	4.2
155498	Middle Eccles	Middle Eccles	16	28333	2.199053377	0.86749164	0.79314085	5	10356	Elmidae	8078	Ephemerellidae	6178	4.006666667
155499	Middle Eccles	Middle Eccles	19	16011	1.975162799	0.79725753	0.67081125	9	7654	Ephemerellidae	5341	Ephemerellidae	5146	3.026666667
155500	Lower Eccles	Lower Eccles	15	11371	1.647646355	0.72178372	0.60842534	5	5294	Baetidae	4402	Baetis	4317	4.506666667
155501	Lower Eccles	Lower Eccles	16	38004	1.802606823	0.73792642	0.65015298	6	12548	Chironomidae	18607	Orthocladiinae	16415	4.863333333
155502	Lower Eccles	Lower Eccles	12	12439	1.511231639	0.68439242	0.60816435	4	6420	Baetidae	4865	Baetis	4865	4.6
155503	Lower Eccles	Lower Eccles	20	9847	2.222020752	0.83513935	0.74172875	6	3417	Chironomidae	3805	Orthocladiinae	2695	4.99

*Standardized to OTU and fixed count, see Metadata for details

Table 2. Continued.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	# OF INTOLERANT TAXA*	INTOLERANT TAXA ABUNDANCE	# OF TOLERANT TAXA*	TOLERANT TAXA ABUNDANCE	USFS COMMUNITY TOLERANCE QUOTIENT (D)*	# OF SHREDDER TAXA*	SHREDDER ABUNDANCE	# OF SCRAPER TAXA*	SCRAPER ABUNDANCE	# OF COLLECTOR-FILTERER TAXA*	COLLECTOR-FILTERER ABUNDANCE
155492	4933070	Upper Eccles	0	56	0	0	98	1	22	2	322	1	67
155493	4933070	Upper Eccles	0	356	0	0	96	1	178	2	889	1	604
155494	4933070	Upper Eccles	0	122	0	0	101	0	0	2	59	1	763
155495	4933070	Upper Eccles	1	150	0	0	91	1	38	2	62	2	434
155496	Middle Eccles	Middle Eccles	1	11567	0	0	95	0	11	2	7967	4	3378
155497	Middle Eccles	Middle Eccles	4	13537	0	0	89	1	118	1	17583	4	3169
155498	Middle Eccles	Middle Eccles	1	6933	0	0	99	0	44	2	3233	3	1333
155499	Middle Eccles	Middle Eccles	4	5622	0	0	90	1	50	2	3222	3	649
155500	Lower Eccles	Lower Eccles	3	745	0	0	88	0	0	1	327	3	197
155501	Lower Eccles	Lower Eccles	2	2263	0	0	90	0	0	2	1896	4	1396
155502	Lower Eccles	Lower Eccles	2	952	0	0	89	0	0	1	251	2	583
155503	Lower Eccles	Lower Eccles	2	1356	0	0	90	0	1	2	216	4	1902

*Standardized to OTU and fixed count, see Metadata for details

Table 2. Continued.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	# OF COLLECTOR-GATHERER TAXA*	COLLECTOR-GATHERER ABUNDANCE	# OF PREDATOR TAXA*	PREDATOR ABUNDANCE	# OF CLINGER TAXA*	LONG-LIVED TAXA*	# OF EPHEMEROPTERA TAXA*	EPHEMEROPTERA ABUNDANCE	# OF PLECOPTERA TAXA*	PLECOPTERA ABUNDANCE	# OF TRICHOPTERA TAXA*
155492	4933070	Upper Eccles	3	3400	5	444	2	1	1	200	0	33	3
155493	4933070	Upper Eccles	4	12053	3	4764	1	1	2	1173	0	178	2
155494	4933070	Upper Eccles	4	11074	3	5870	2	1	1	2196	0	59	2
155495	4933070	Upper Eccles	2	5537	5	1375	3	1	1	1559	0	86	3
155496	Middle Eccles	Middle Eccles	7	35022	3	3400	4	2	2	17333	0	89	3
155497	Middle Eccles	Middle Eccles	7	46231	5	8207	6	2	3	21215	1	355	3
155498	Middle Eccles	Middle Eccles	7	20011	4	3267	3	1	3	8978	0	89	2
155499	Middle Eccles	Middle Eccles	7	11355	6	497	6	2	3	7092	1	65	5
155500	Lower Eccles	Lower Eccles	5	9255	5	1490	6	2	1	4995	1	34	3
155501	Lower Eccles	Lower Eccles	5	31559	4	2915	5	2	2	11270	1	237	3
155502	Lower Eccles	Lower Eccles	4	10192	4	1292	5	1	1	5425	1	180	2
155503	Lower Eccles	Lower Eccles	7	6817	6	694	5	2	2	2206	1	144	3

*Standardized to OTU and fixed count, see Metadata for details

Table 2. Continued.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	TRICHOPTERA ABUNDANCE	# OF COLEOPTERA TAXA*	COLEOPTERA ABUNDANCE	# OF ELMIDAE TAXA*	ELMIDAE ABUNDANCE	# OF MEGALOPTERA TAXA*	MEGALOPTERA ABUNDANCE	# OF DIPTERA TAXA*	DIPTERA ABUNDANCE	# OF CHIRONOMIDAE TAXA*	CHIRONOMIDAE ABUNDANCE
155492	4933070	Upper Eccles	122	1	322	1	289	0	0	6	3567	2	3344
155493	4933070	Upper Eccles	1351	1	1244	1	604	0	0	5	15253	2	14436
155494	4933070	Upper Eccles	1033	1	59	1	59	0	0	5	11504	3	11119
155495	4933070	Upper Eccles	608	1	136	1	62	0	0	5	5106	2	4706
155496	Middle Eccles	Middle Eccles	3656	1	11433	1	5956	0	0	8	10067	3	7378
155497	Middle Eccles	Middle Eccles	2824	1	17594	1	9240	0	0	7	27397	3	23099
155498	Middle Eccles	Middle Eccles	1289	1	8078	1	2711	0	0	8	7767	3	5600
155499	Middle Eccles	Middle Eccles	497	1	3546	1	2054	0	0	7	1823	3	1384
155500	Lower Eccles	Lower Eccles	265	1	344	1	152	0	0	7	5107	3	3810
155501	Lower Eccles	Lower Eccles	1041	1	1896	1	711	0	0	7	22315	3	18607
155502	Lower Eccles	Lower Eccles	814	1	972	1	100	0	0	6	4567	3	4044
155503	Lower Eccles	Lower Eccles	1067	1	893	1	187	0	0	10	5407	3	3805

*Standardized to OTU and fixed count, see Metadata for details

Table 2. Continued.

SAMPLEID	STATION (NAMC)	STATION (CUSTOMER)	# OF CRUSTACEA TAXA*	CRUSTACEA ABUNDANCE	# OF OLIGOCHAETE TAXA*	OLIGOCHAETE ABUNDANCE	# OF MOLLUSCA TAXA*	MOLLUSCA ABUNDANCE	# OF INSECT TAXA*	INSECT ABUNDANCE	# OF NON-INSECT TAXA*	NON-INSECT ABUNDANCE
155492	4933070	Upper Eccles	0	0	0	22	0	0	11	4244	1	33
155493	4933070	Upper Eccles	0	0	0	36	1	462	10	19200	2	676
155494	4933070	Upper Eccles	0	0	0	3122	0	0	9	14852	1	3122
155495	4933070	Upper Eccles	0	0	0	86	1	62	10	7495	2	148
155496	Middle Eccles	Middle Eccles	0	0	0	0	2	7911	14	42578	3	8000
155497	Middle Eccles	Middle Eccles	0	0	0	118	2	6052	15	69385	4	6526
155498	Middle Eccles	Middle Eccles	0	0	0	0	2	2133	14	26200	2	2133
155499	Middle Eccles	Middle Eccles	0	0	0	26	1	2962	17	13023	2	2988
155500	Lower Eccles	Lower Eccles	0	0	0	0	1	34	13	10744	2	626
155501	Lower Eccles	Lower Eccles	0	0	0	59	1	178	14	36759	2	1244
155502	Lower Eccles	Lower Eccles	0	0	0	0	0	0	11	11959	1	480
155503	Lower Eccles	Lower Eccles	0	0	0	0	2	58	17	9717	3	130

*Standardized to OTU and fixed count, see Metadata for details

Inter-Mountain Labs
Your Environmental Monitoring Partner
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

Date: 3/30/2016

CLIENT: Canyon Fuel Company, LLC.
Project: Skyline Utah#6
Lab Order: S1603288

CASE NARRATIVE

Report ID: S1603288001

Samples WR2015-1, and WR2015-2 were received on March 22, 2016.

Samples were analyzed using the methods outlined in the following references:

U.S.E.P.A. 600/2-78-054 "Field and Laboratory Methods Applicable to Overburden and Mining Soils", 1978
American Society of Agronomy, Number 9, Part 2, 1982
USDA Handbook 60 "Diagnosis and Improvement of Saline and Alkali Soils", 1969
Wyoming Department of Environmental Quality, Land Quality Division, Guideline No. 1, 1984
New Mexico Overburden and Soils Inventory and Handling Guideline, March 1987
State of Utah, Division of Oil, Gas, and Mining: Guidelines for Management of Topsoil and Overburden for Underground and Surface Coal Mining, April 1988
Montana Department of State Lands, Reclamation Division: Soil, Overburden, and Regraded Spoil Guidelines, December 1994
State of Nevada Modified Sobek Procedure
Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW846, 3rd Edition

All Quality Control parameters met the acceptance criteria defined by EPA and Inter-Mountain Laboratories except as indicated in this case narrative.

Reviewed by:

Crystal Herman, Soil Analyst

Inter-Mountain Labs
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

Your Environmental Monitoring Partner

Soil Analysis Report

Canyon Fuel Company, LLC.
HCR 35, Box 380
Helper, UT 84526

Report ID: S1603288001

Project: Skyline Utah#6
Date Received: 3/22/2016

Date Reported: 3/30/2016
Work Order: S1603288

Lab ID	Sample ID	pH	Saturation	Electrical Conductivity	Field Capacity	Wilting Point	Calcium PE	Magnesium PE	Potassium PE	Sodium PE	SAR
		s.u.	%	dS/m	%	%	meq/L	meq/L	meq/L	meq/L	
S1603288-001	WR2015-1	7.8	33.0	1.80	26.3	5.3	6.64	3.76	0.42	5.17	2.27
S1603288-002	WR2015-2	7.7	30.0	2.42	26.0	5.4	10.8	5.30	0.45	6.28	2.22

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: _____
Crystal Herman, Soil Analyst

Inter-Mountain Labs
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

Your Environmental Monitoring Partner

Soil Analysis Report

Canyon Fuel Company, LLC.
HCR 35, Box 380
Helper, UT 84526

Report ID: S1603288001

Project: Skyline Utah#6
Date Received: 3/22/2016

Date Reported: 3/30/2016
Work Order: S1603288

Lab ID	Sample ID	Sand %	Silt %	Clay %	Texture	Coarse Fragment %	Boron ppm	Selenium ppm	Nitrate(as N) ppm	TKN %
S1603288-001	WR2015-1	89.0	7.0	4.0	Sand	0.42	0.47	<0.02	0.3	0.62
S1603288-002	WR2015-2	90.0	6.0	4.0	Sand	0.16	0.38	0.02	0.2	0.31

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate
Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential
Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: _____
Crystal Herman, Soil Analyst

Inter-Mountain Labs
1673 Terra Avenue, Sheridan, Wyoming 82801 ph: (307) 672-8945

Your Environmental Monitoring Partner

Soil Analysis Report

Canyon Fuel Company, LLC.

HCR 35, Box 380
Helper, UT 84526

Report ID: S1603288001

Project: Skyline Utah#6

Date Received: 3/22/2016

Date Reported: 3/30/2016

Work Order: S1603288

Lab ID	Sample ID	Available Sodium meq/100g	Exchangeable Sodium meq/100g	Total Carbon %	TOC %	Total Sulfur %	T.S. AB t/1000t	Neutral. Potential t/1000t	T.S. ABP t/1000t
S1603288-001	WR2015-1	0.35	0.18	21.0	20.7	0.29	9.17	23.8	14.7
S1603288-002	WR2015-2	0.34	0.15	19.5	19.2	0.34	10.6	19.5	8.93

These results apply only to the samples tested.

Abbreviations for extractants: PE= Saturated Paste Extract, H20Sol= water soluble,AB-DTPA= Ammonium Bicarbonate-DTPA, AAO= Acid Ammonium Oxalate

Abbreviations used in acid base accounting: T.S.= Total Sulfur, AB= Acid Base, ABP= Acid Base Potential, PyrS= Pyritic Sulfur, Pyr+Org= Pyritic Sulfur + Organic Sulfur, Neutral. Pot.= Neutralization Potential

Miscellaneous Abbreviations: SAR= Sodium Adsorption Ratio, CEC= Cation Exchange Capacity, ESP= Exchangeable Sodium Percentage

Reviewed by: _____

Crystal Herman, Soil Analyst

Canyon Fuel Company, LLC
A Subsidiary of Bowie Resource Holdings, LLC

Skyline Mine
Gregg A. Galecki, Environmental Engineer
HC35, Box 380
Helper, Utah 84526
(435) 448-2636
Fax (435) 448-2632

March 21, 2016

Ms. Karen Secor
Inter-Mountain Laboratories, Inc.
1633 Terra Avenue
Sheridan, Wyoming 82801

RE: Two (2) Samples for Analysis According to the Parameters Listed in Table 6 of the Utah Division of Oil, Gas and Mining Guidelines for Topsoil and Overburden

Dear Ms. Secor:

Please find enclosed in one (1) box a total of two (2) samples (WR2015-1 and WR2015-2) for analysis in accordance with the parameters listed in Table 6 of the Utah Division of Oil, Gas and Mining Guidelines for Topsoil and Overburden.

I'll forward a purchase order number ASAP.

If you have any questions regarding these samples, please give me a call at (435) 448-2636.

Sincerely,

Gregg A. Galecki

Gregg A. Galecki
Environmental Engineer – Skyline Mines
Canyon Fuel Company, LLC.
(435) 448-2636
ggalecki@archcoal.com

Rec'd 3/22/16
Karen A Secor
51603288

Results of the 2015 Geomorphic Evaluation of Eccles Creek

Canyon Fuel Company
Skyline Mine
Helper, Utah

October 2015

EarthFax Engineering Group, LLC

Engineers / Scientists
www.earthfax.com

TABLE OF CONTENTS

Section | Page

CHAPTER 1 – INTRODUCTION 1

CHAPTER 2 – FIELD DATA COLLECTION METHODS 2

CHAPTER 3 – RESULTS SUMMARY 3

CHAPTER 4 – REFERENCES 5

LIST OF FIGURES

Figure | Page

2-1. Location of Reference Sites 6

3-1. EC-1 Cross Section and Profiles 7

3-2. EC-2 Cross Section and Profiles 8

3-3. EC-3 Cross Section and Profiles 9

LIST OF APPENDICES

Appendix A – Reference Site Photographs

Appendix B – Copy of Filed Log Book

Appendix C –Survey Tabulations with Individual Cross Section and Profile Drawings

RESULTS OF THE 2015 GEOMORPHIC EVALUATION OF ECCLES CREEK

CHAPTER 1

INTRODUCTION

In early August 2001, the advancing face of the Skyline Mine encountered fractured sandstone, resulting in a significant inflow of water to the mine. From early September 2001 through July 2003, this water was discharged from the mine to Eccles Creek at rates ranging from about 7,000 and 10,000 gallons per minute ("gpm"), compared with an average discharge for the 30 months prior to August 2001 of about 1,500 gpm. Except for a period of lower discharge (less than about 1,000 gpm) in the first two-thirds of 2004, the discharge from the mine since July 2003 has typically ranged from about 3,000 to 5,000 gpm.

From 2001 through 2006, EarthFax Engineering conducted detailed evaluations of the impact of the mine-water discharge on geomorphic conditions in three reference reaches in Eccles Creek. The purpose of this document is to present the results of data collection from the same reference reaches in September 2015 and to compare the current results with prior data.

CHAPTER 2

FIELD DATA COLLECTION METHODS

The locations of reference sites previously established on Eccles Creek are shown on Figure 2-1. Monitoring of the reference sites was conducted on September 23 and 30, 2015 in general conformance with the recommendations of Harrelson et al. (1994) and included the following:

- Attempting to locate previously established benchmarks at each site. It having been 9 years since the last survey, soil and vegetation had accumulated over the benchmarks at each location, In spite of lengthy attempts, including the use of a metal detector, only one benchmark could be located (at cross section EC-1). However, end stakes were found at each cross section, and the bases of these end stakes were used for comparing prior elevation data collected from each reference reach.
- Photographing each site, as recommended by Harrelson et al. (1994), looking upstream, downstream, and across the channel at each cross section location (see Appendix A).
- Locating previously established cross sections. The endpoints of each cross section were previously marked with 4-foot long, 1/2-inch diameter steel reinforcing bars that were driven approximately 3.5 feet into the ground.
- Surveying the channel cross section at each site. A measuring tape was stretched between the cross section monuments and surveying was performed using a Sokkia survey level and rod. Elevations were shot at each change in elevation (e.g., slope breaks, channel banks, etc.). The readings were recorded in the field log book (see Appendix B).
- Surveying the longitudinal profile at each site. The profiles extended a distance of approximately 20 times the channel width (half upstream and half downstream from the cross section location). Data were collected to indicate the elevation of the channel bottom at the thalweg, the water surface, and indications of bankfull stage. Measurements were collected on intervals approximately equal to the channel width. Data were collected using a Leica Rugby 82 laser level with receiver and rod, with the location of the starting and endpoints being measured as noted above. Data readings were recorded in the field log book (see Appendix B).

CHAPTER 3
RESULTS SUMMARY

Cross section and selected profile spreadsheets and drawings are provided in Appendix C. These data were plotted for 2006 and 2015 to visually assess the effect of the mine discharge on geomorphic conditions within Eccles and Mud Creeks. These plots are presented in Figures 3-1 through 3-9.

In steep, cobble-bedded streams such as Eccles Creek, several of the survey measurements are subjective and difficult to replicate from year to year. If the survey rod is set on top of a cobble one year and to the side of that cobble the next year, the apparent channel bottom may vary by several inches, even though no appreciable change has occurred. Furthermore, although cross section locations are fixed, the profile points are re-established each year as recommended by Harrelson et al. (1994), resulting in some variation in location from year to year. Finally, some measurements (e.g., the location of bankfull stage) are highly subjective. In Eccles Creek, which is cut into a steep canyon, it is frequently difficult to discern between the bankfull stage and the adjacent hillside. All of these factors may contribute to reduced data quality within the survey area.

Notwithstanding the survey difficulties noted above, Figures 3-1 through 3-3 indicate that the following conclusions can be drawn with respect to changes in the reference site profiles and cross-sections between 2006 and 2015:

- All reaches were flowing at bankfull stage at the time of the September 2015 survey. Rosgen (1996) indicates that bankfull discharge is that discharge which is most effective in channel maintenance. Hence, the rate at which mine water was discharging should not adversely affect channel stability and maintenance.
- The channel has aggraded slightly since 2006 in portions of reaches EC-1 and EC-2, while aggradation was less evident in reach EC-3. Much of this aggradation appeared to be the result of the natural accumulation of sediment upstream from deadfall. Sediment has also naturally accumulated upstream from moss and other macrophytes that are growing on the deadfall, cobbles, and similar obstructions.
- No areas of substantial stream-channel degradation or bank instability were noted in any of the reaches.

Thus, the 2015 survey data and visual observations of the reference reaches indicate that mine-water discharges have not substantially impacted geomorphic conditions in Eccles Creek.

CHAPTER 4

REFERENCES

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, Colorado.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

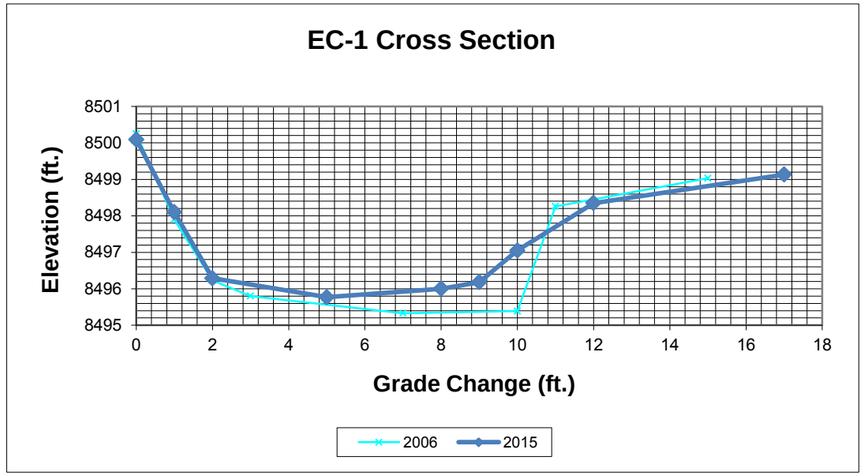
BASE MAP: USGS 7-1/2 MIN. QUADRANGLE
SCOFIELD, UTAH (1979)

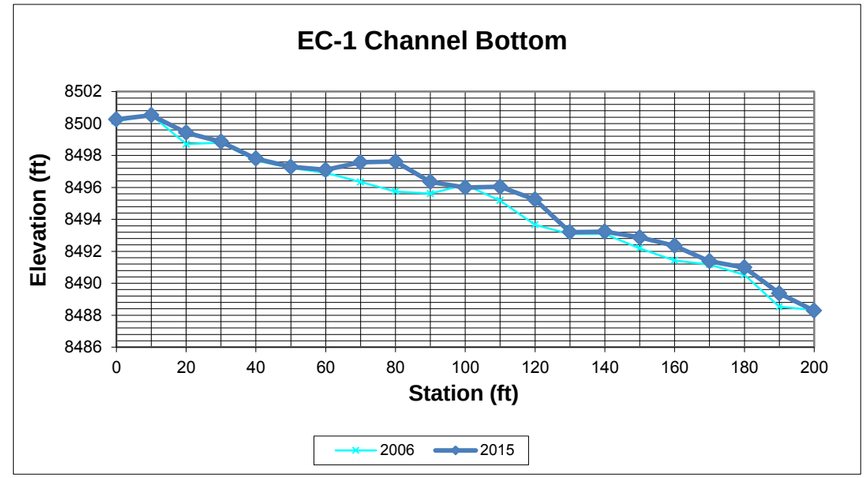
0' 3000'

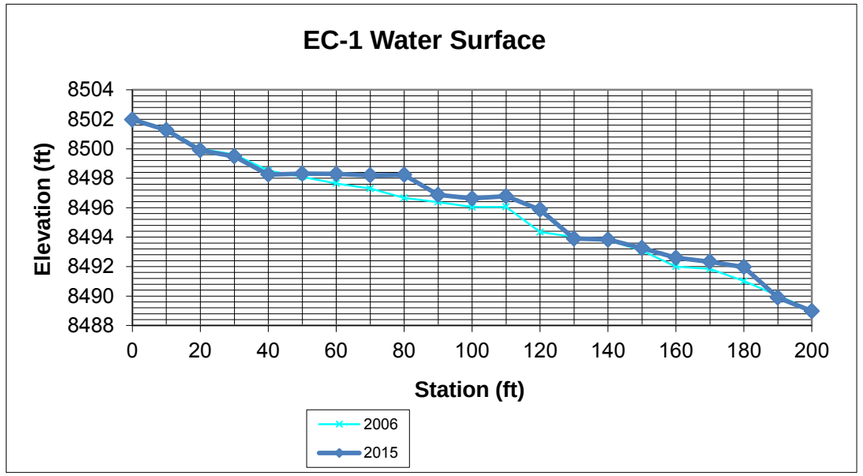
FIGURE 2-1. LOCATION OF REFERENCE SITES

EarthFax

G:\UC794\23 - 2015 Eccles Creek geomorph survey\FIG-2-1.dwg, 10/6/2015 2:35:38 PM







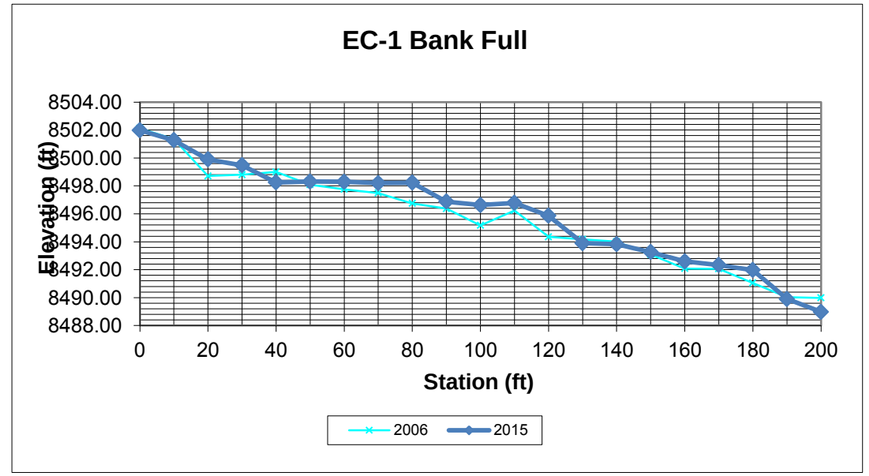
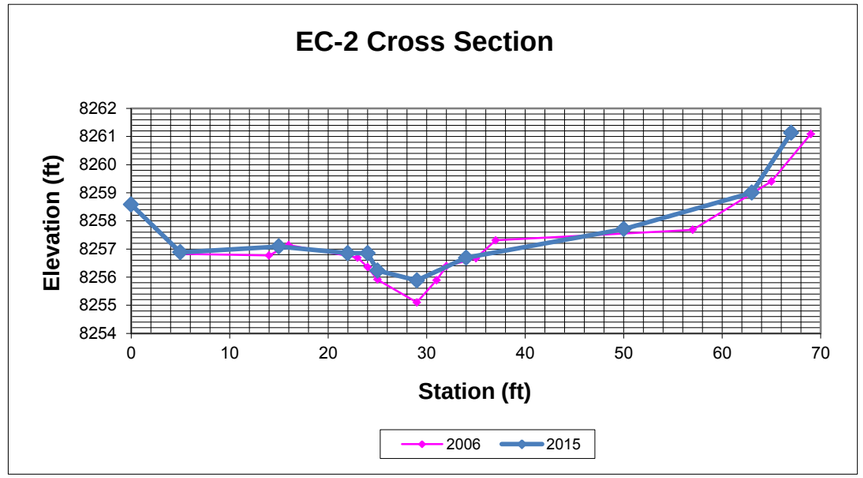
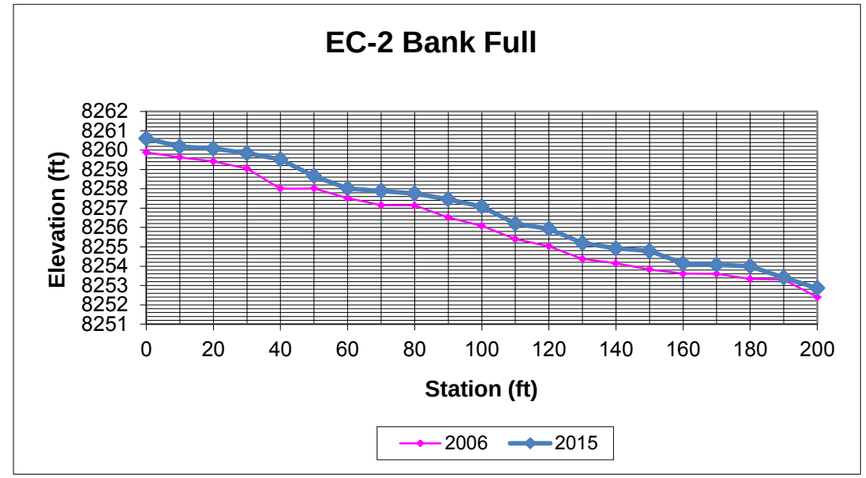
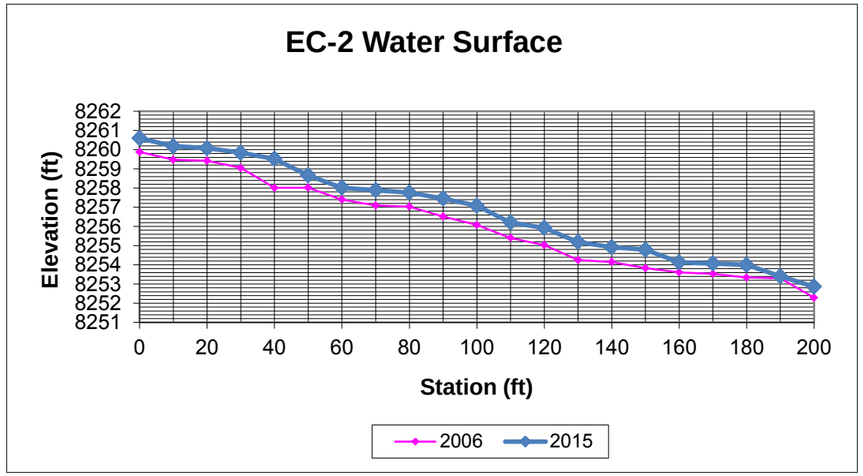


FIGURE 3-1. EC-1 CROSS-SECTION AND PROFILES

EarthFax







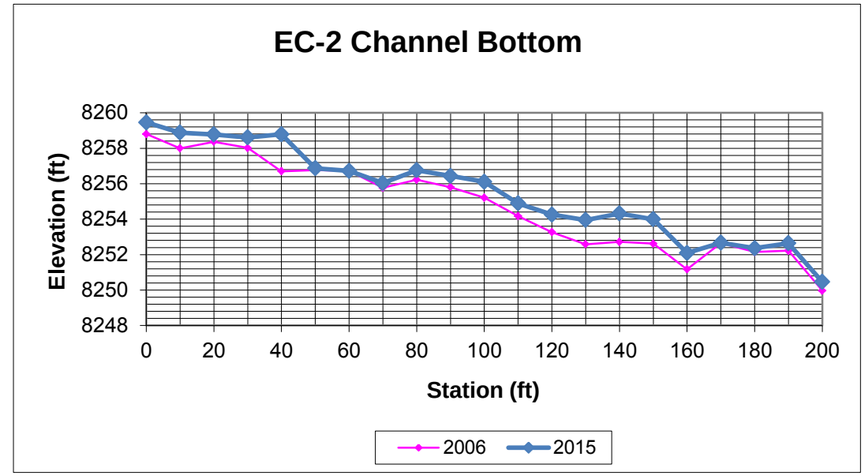
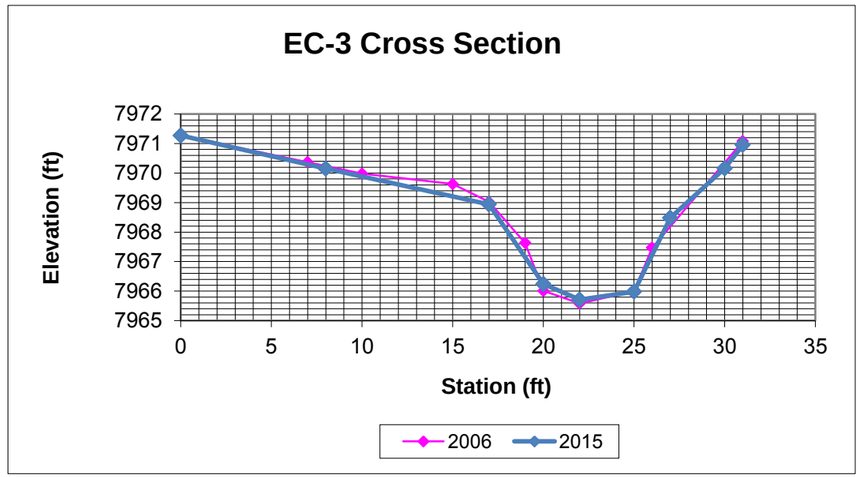
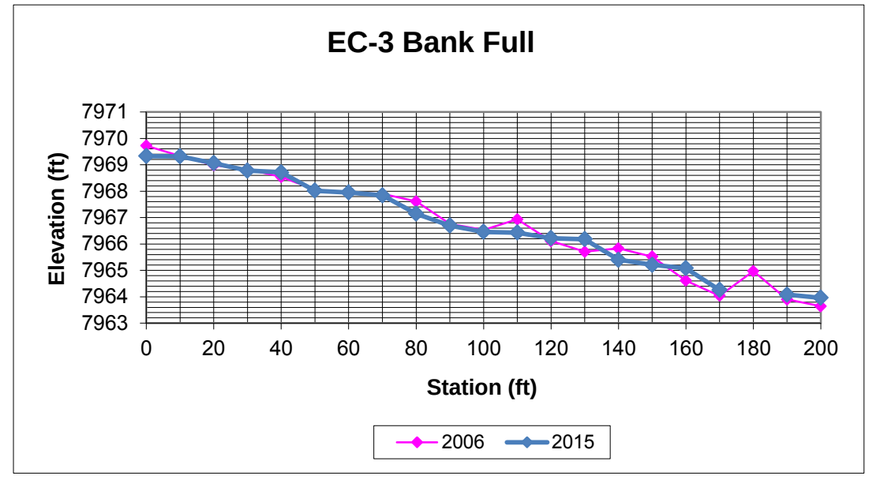
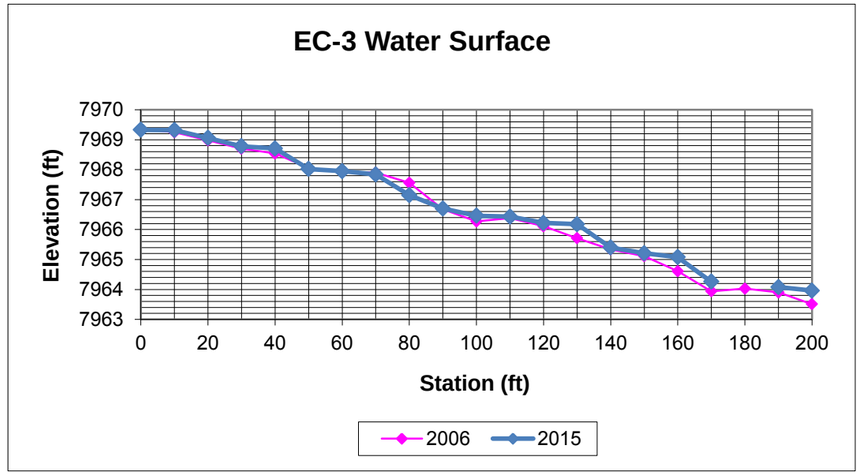


FIGURE 3-2. EC-2 CROSS-SECTION AND PROFILES

EarthFax







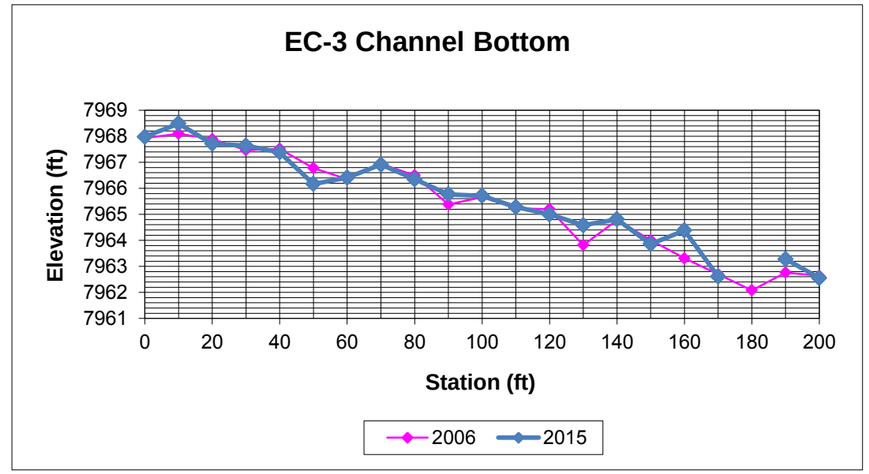


FIGURE 3-3. EC-3 CROSS-SECTION AND PROFILES

EarthFax

APPENDIX A

Reference Site Photographs

EC-1 cross section

EC-1 upstream view

EC-1 downstream view

EC-2 cross section

EC-2 lower upstream view

EC-2 upper upstream view

EC-2 upper downstream view

EC-2 lower downstream view

EC-3 cross section

EC-3 lower upstream view

EC-3 upper upstream view

EC-3 downstream view

APPENDIX B

Copy of Field Log Book

EC-1 Profile 23 Sep 2015

BM = 3.85

Sta	WS	Bottom	Bankfull
0+00	1.00	2.72	@ WS
0+10	1.71	2.46	"
0+20	3.09	3.55	"
0+30	3.50	4.12	"
0+40	4.73	5.18	"
0+50	4.67	5.69	"
0+60	4.69	5.88	
0+70	4.78	5.41	
0+80	4.75	5.36	
0+90	6.11	6.63	
1+00	6.35	6.99	
1+10	6.20	6.94	
1+20	7.12	7.74	
1+30	9.08	9.78	
1+40	9.15	9.75	
1+50	9.72	10.10	
1+60	10.38	10.63	
1+70	10.65	11.60	
1+80	11.01	11.99	
1+90	13.08	13.61	
2+00	14.00	14.70	

EC-1 Cross section

Sta	Elev.
0+00	1.51
0+01	3.50
0+02	5.31
0+05	5.83
0+08	5.60
0+09	5.42
0+10	4.55
0+12	3.25
0+17	2.47

BM = 2.47

Survey instrument → Leica Rugby 82 Laser level

Rite in the Rain

EC-2 Profile

23 Sep 2015

Sta	WS	Bottom	Bankfull
0+00	2.34	3.48	@ WS
0+10	2.76	4.06	
0+20	2.86	4.16	
0+30	3.10	4.33	
0+40	3.42	4.15	
0+50	4.28	6.07	
0+60	4.92	6.22	
0+70	5.05	6.90	
0+80	5.18	6.18	
0+90	5.49	6.50	
1+00	5.86	6.83	
1+10	6.74	8.05	
1+20	7.01	8.68	
1+30	7.75	8.79	
1+40	8.02	8.62	
1+50	8.15	8.95	
1+60	8.80	10.85	
1+70	8.87	10.27	
1+80	8.94	10.58	
1+90	9.53	10.30	
2+00	10.08	12.48	

EC-2 Cross Section

Sta	Elev	
0+00	4.36	Base of south stake
0+05	6.06	
0+15	5.85	
0+22	6.09	
0+24	6.09	
0+25	6.71	
0+29	7.06	
0+34	6.25	
0+60	5.23	
0+63	3.94	
0+67	1.81	Base of north stake

Bench mark not found. Used elev at base of stakes for BM.

Rite in the Rain

EC-3 Profile

30 Sep 2015

Sta	WS	Bottom	Backfill @ WS
0+00	6.55	7.90	
0+10	6.56	7.39	
0+20	6.82	8.17	
0+30	7.10	8.24	
0+40	7.17	8.50	
0+50	7.86	9.71	
0+60	7.93	9.47	
0+70	8.04	8.97	
0+80	8.73	9.53	
0+90	9.18	10.11	
1+00	9.42	10.17	
1+10	9.45	10.60	
1+20	9.66	10.88	
1+30	9.70	11.30	
1+40	10.48	11.07	
1+50	10.67	12.02	
1+60	10.80	11.50	
1+70	11.62	13.27	
1+80	Huge deadfall tree blocking sight		
1+90	11.80	12.60	
2+00	11.92	13.33	

EC-3 cross section

Sta	Elev.	
0+00	4.61	Base of south stake
0+08	5.73	
0+17	6.94	
0+20	9.64	
0+22	10.17	
0+25	9.90	
0+27	7.40	
0+30	5.72	
0+31	4.93	Base of north stake

Could not locate bench mark. Used base of cross section stakes for reference.

Rite in the Rain

APPENDIX C

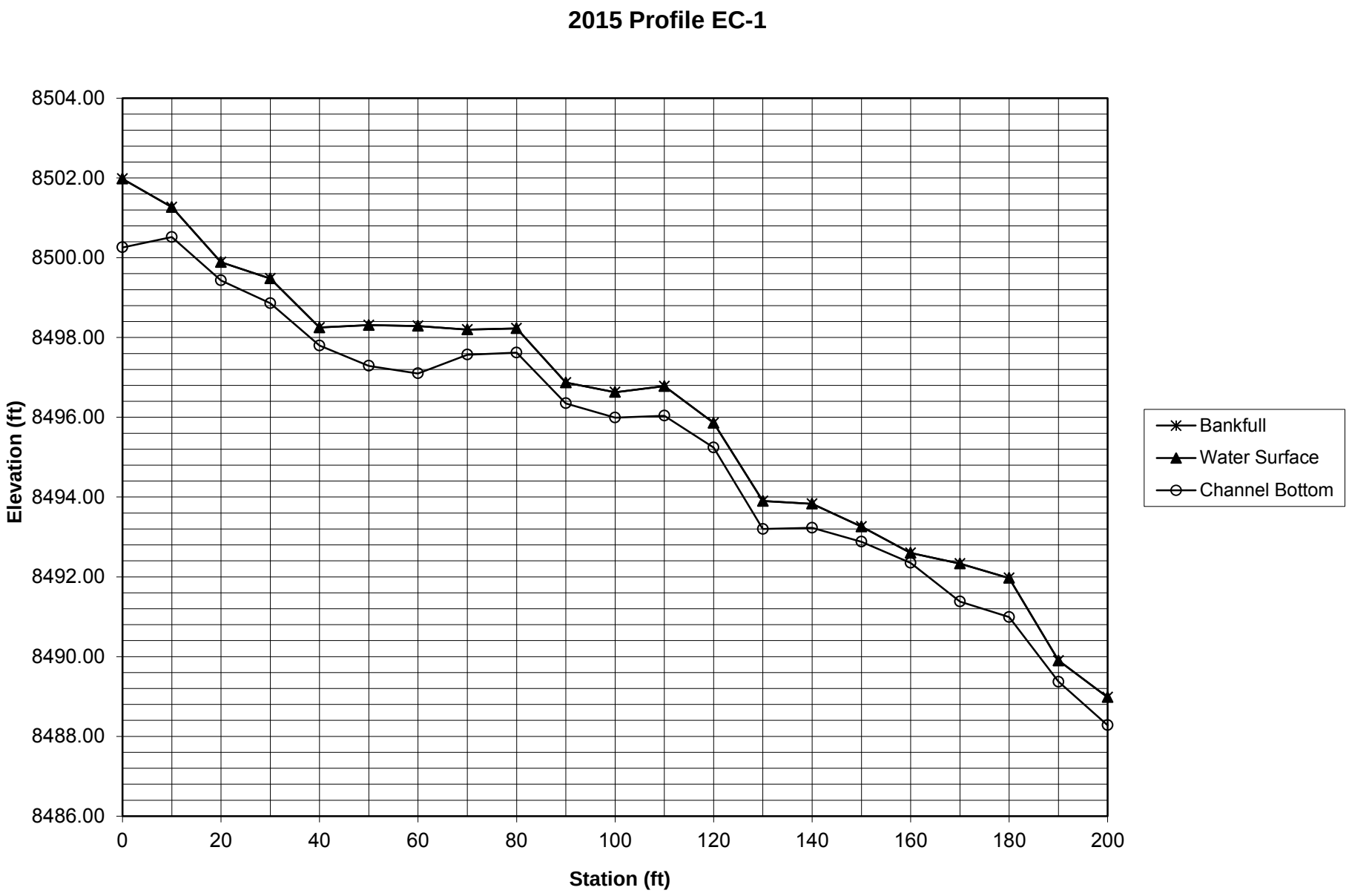
Survey Tabulations with
Individual Cross Section and Profile Drawings

Profile: EC-1

Benchmark elevation (ft): 8499.13 Survey date: 9/23/2015
Rod reading at benchmark (ft): 3.85

	Water Surface (ft)		Channel Bottom (ft)		Water Surface Calculations			Bankfull (ft)	
Station	Rod Reading	Elevation	Rod Reading	Elevation	Elev change	Distance	Slope (fraction)	Rod Reading	Elevation
0	1.00	8501.98	2.72	8500.26				1.00	8501.98
10	1.71	8501.27	2.46	8500.52	0.71	10.00	0.071	1.71	8501.27
20	3.09	8499.89	3.55	8499.43	1.38	10.00	0.138	3.09	8499.89
30	3.50	8499.48	4.12	8498.86	0.41	10.00	0.041	3.50	8499.48
40	4.73	8498.25	5.18	8497.80	1.23	10.00	0.123	4.73	8498.25
50	4.67	8498.31	5.69	8497.29	-0.06	10.00	-0.006	4.67	8498.31
60	4.69	8498.29	5.88	8497.10	0.02	10.00	0.002	4.69	8498.29
70	4.78	8498.20	5.41	8497.57	0.09	10.00	0.009	4.78	8498.20
80	4.75	8498.23	5.36	8497.62	-0.03	10.00	-0.003	4.75	8498.23
90	6.11	8496.87	6.63	8496.35	1.36	10.00	0.136	6.11	8496.87
100	6.35	8496.63	6.99	8495.99	0.24	10.00	0.024	6.35	8496.63
110	6.20	8496.78	6.94	8496.04	-0.15	10.00	-0.015	6.20	8496.78
120	7.12	8495.86	7.74	8495.24	0.92	10.00	0.092	7.12	8495.86
130	9.08	8493.90	9.78	8493.20	1.96	10.00	0.196	9.08	8493.90
140	9.15	8493.83	9.75	8493.23	0.07	10.00	0.007	9.15	8493.83
150	9.72	8493.26	10.10	8492.88	0.57	10.00	0.057	9.72	8493.26
160	10.38	8492.60	10.63	8492.35	0.66	10.00	0.066	10.38	8492.60
170	10.65	8492.33	11.60	8491.38	0.27	10.00	0.027	10.65	8492.33
180	11.01	8491.97	11.99	8490.99	0.36	10.00	0.036	11.01	8491.97
190	13.08	8489.90	13.61	8489.37	2.07	10.00	0.207	13.08	8489.90
200	14.00	8488.98	14.70	8488.28	0.92	10.00	0.092	14.00	8488.98

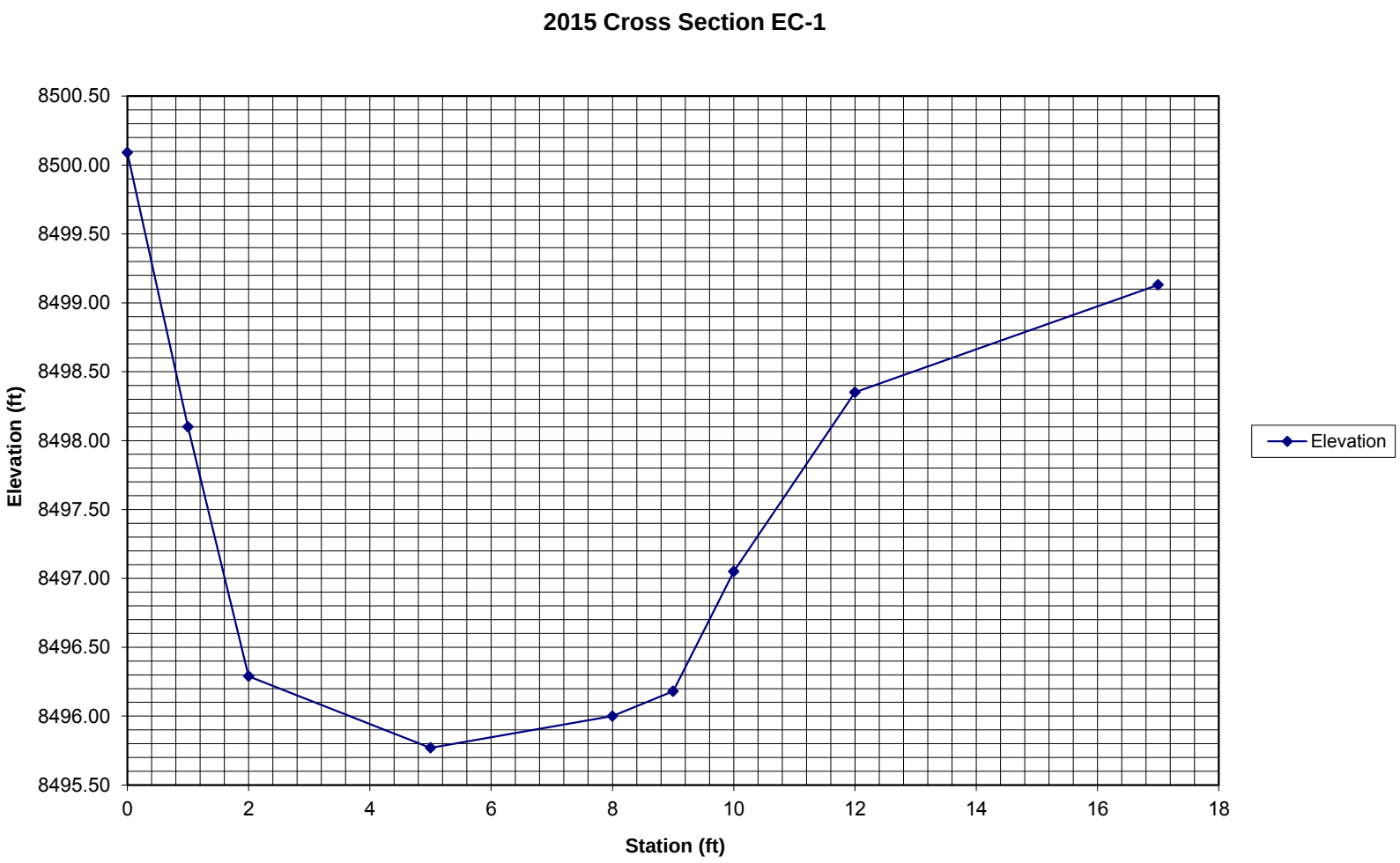
Max. Water Surface Slope (fraction): 0.207
Min. Water Surface Slope (fraction): -0.015
Avg. Water Surface Slope (fraction): 0.065


2015 Profile EC-1
8504.00
8502.00
8500.00
8498.00
8496.00
8494.00
8492.00
8490.00
8488.00
8486.00
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Bankfull
Water Surface
Channel Bottom

Cross Section: EC-1

Benchmark elevation: 8499.13 Survey Date: 9/23/2015
BenchMark Rod Reading: 2.47

Station	Rod Reading	Elevation
0	1.51	8500.09
1	3.50	8498.10
2	5.31	8496.29
5	5.83	8495.77
8	5.60	8496.00
9	5.42	8496.18
10	4.55	8497.05
12	3.25	8498.35
17	2.47	8499.13

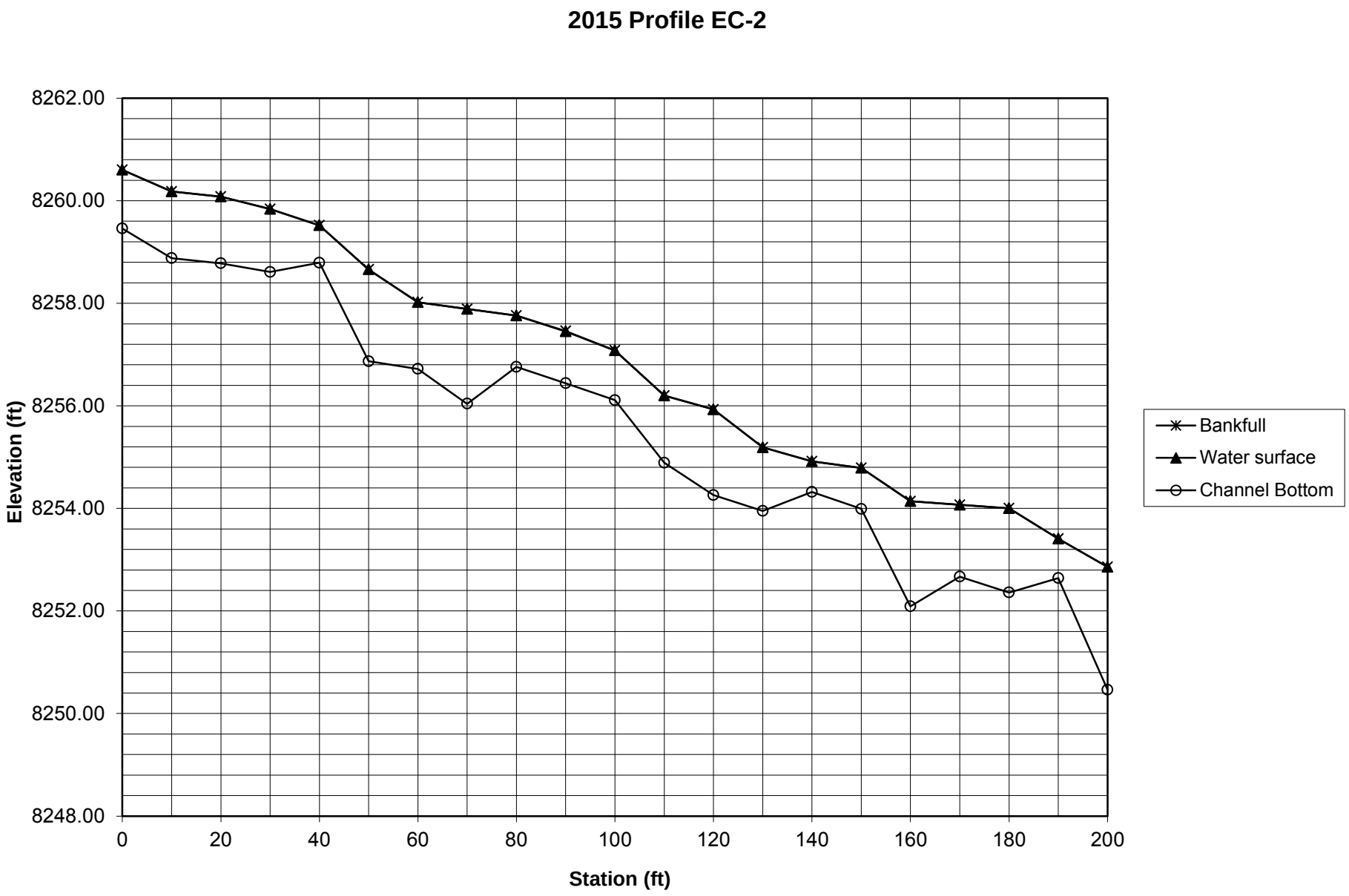

2015 Cross Section EC-1
8500.50
8500.00
8499.50
8499.00
8498.50
8498.00
8497.50
8497.00
8496.50
8496.00
8495.50
Elevation (ft)
0
2
4
6
8
10
12
14
16
18
Station (ft)
Elevation

Profile: EC-2

Benchmark elevation (ft): 8257.72 Survey date: 9/23/2015
Rod reading at benchmark (ft): 5.22 (Note: Benchmark not found. 2015 Rod reading at benchmark based on 2006 elevation difference between benchmark and cross section station 0+00)

	Water Surface (ft)		Channel Bottom (ft)		Water Surface Calculations			Bankfull (ft)	
Station	Rod Reading	Elevation	Rod Reading	Elevation	Elev change	Distance	Slope (fraction)	Rod Reading	Elevation
0	2.34	8260.60	3.48	8259.46				2.34	8260.60
10	2.76	8260.18	4.06	8258.88	0.42	10.00	0.042	2.76	8260.18
20	2.86	8260.08	4.16	8258.78	0.10	10.00	0.010	2.86	8260.08
30	3.10	8259.84	4.33	8258.61	0.24	10.00	0.024	3.10	8259.84
40	3.42	8259.52	4.15	8258.79	0.32	10.00	0.032	3.42	8259.52
50	4.28	8258.66	6.07	8256.87	0.86	10.00	0.086	4.28	8258.66
60	4.92	8258.02	6.22	8256.72	0.64	10.00	0.064	4.92	8258.02
70	5.05	8257.89	6.90	8256.04	0.13	10.00	0.013	5.05	8257.89
80	5.18	8257.76	6.18	8256.76	0.13	10.00	0.013	5.18	8257.76
90	5.49	8257.45	6.50	8256.44	0.31	10.00	0.031	5.48	8257.46
100	5.86	8257.08	6.83	8256.11	0.37	10.00	0.037	5.86	8257.08
110	6.74	8256.20	8.05	8254.89	0.88	10.00	0.088	6.74	8256.20
120	7.01	8255.93	8.68	8254.26	0.27	10.00	0.027	7.01	8255.93
130	7.75	8255.19	8.99	8253.95	0.74	10.00	0.074	7.75	8255.19
140	8.02	8254.92	8.62	8254.32	0.27	10.00	0.027	8.02	8254.92
150	8.15	8254.79	8.95	8253.99	0.13	10.00	0.013	8.15	8254.79
160	8.80	8254.14	10.85	8252.09	0.65	10.00	0.065	8.80	8254.14
170	8.87	8254.07	10.27	8252.67	0.07	10.00	0.007	8.87	8254.07
180	8.94	8254.00	10.58	8252.36	0.07	10.00	0.007	8.94	8254.00
190	9.53	8253.41	10.30	8252.64	0.59	10.00	0.059	9.53	8253.41
200	10.08	8252.86	12.48	8250.46	0.55	10.00	0.055	10.08	8252.86

Max. Water Surface Slope (fraction): 0.088
Min. Water Surface Slope (fraction): 0.007
Avg. Water Surface Slope (fraction): 0.039


2015 Profile EC-2
8262.00
8260.00
8258.00
8256.00
8254.00
8252.00
8250.00
8248.00
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Bankfull
Water surface
Channel Bottom

Cross Section: EC-2

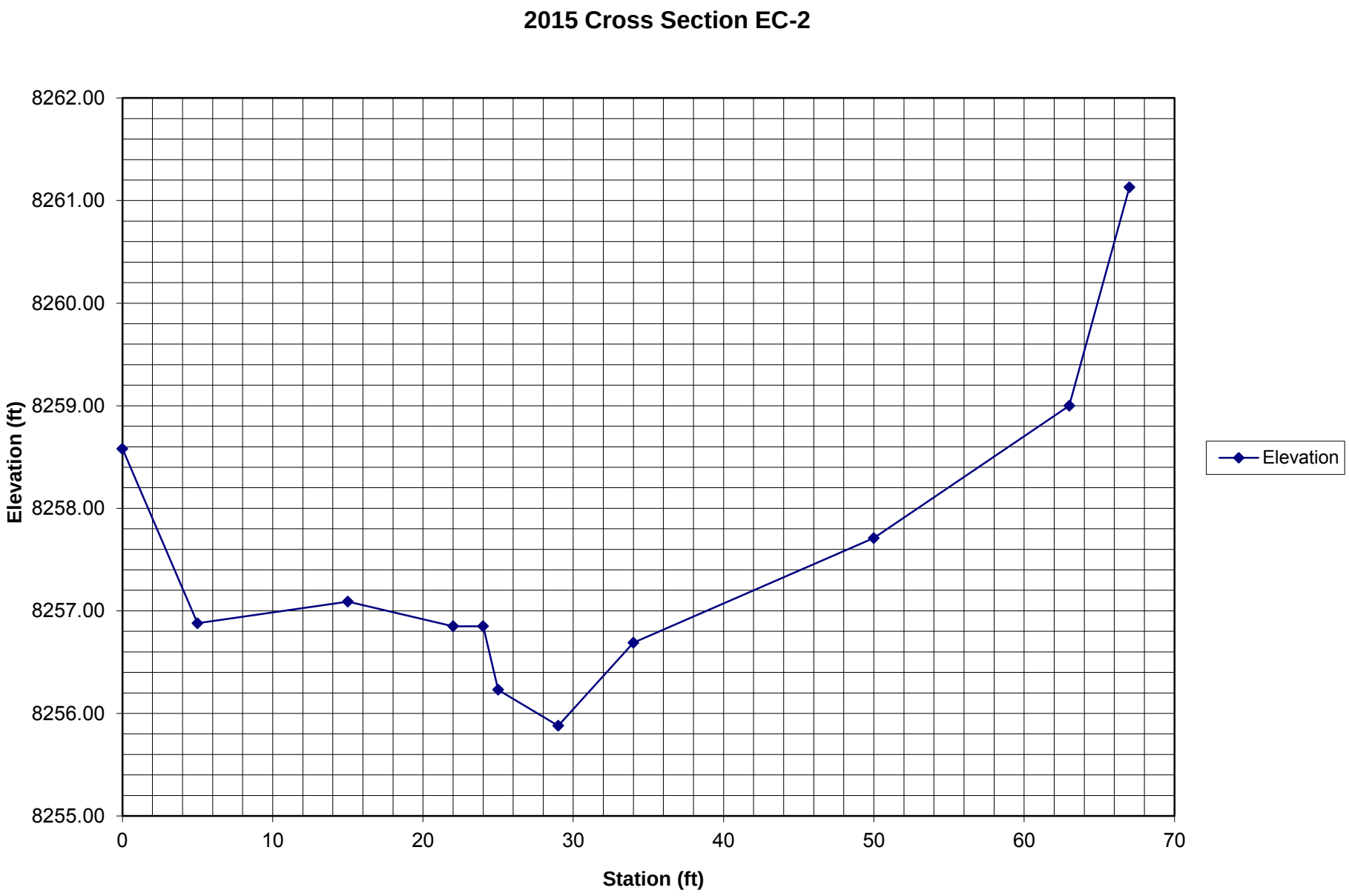
Benchmark elevation: 8257.72

BenchMark Rod Reading: 5.22

Survey Date: 9/23/2015

(Note: Benchmark not found. 2015 Rod reading at benchmark based on 2006 elevation difference between benchmark and cross section station 0+00)

Station	Rod Reading	Elevation
0	4.36	8258.58
5	6.06	8256.88
15	5.85	8257.09
22	6.09	8256.85
24	6.09	8256.85
25	6.71	8256.23
29	7.06	8255.88
34	6.25	8256.69
50	5.23	8257.71
63	3.94	8259.00
67	1.81	8261.13

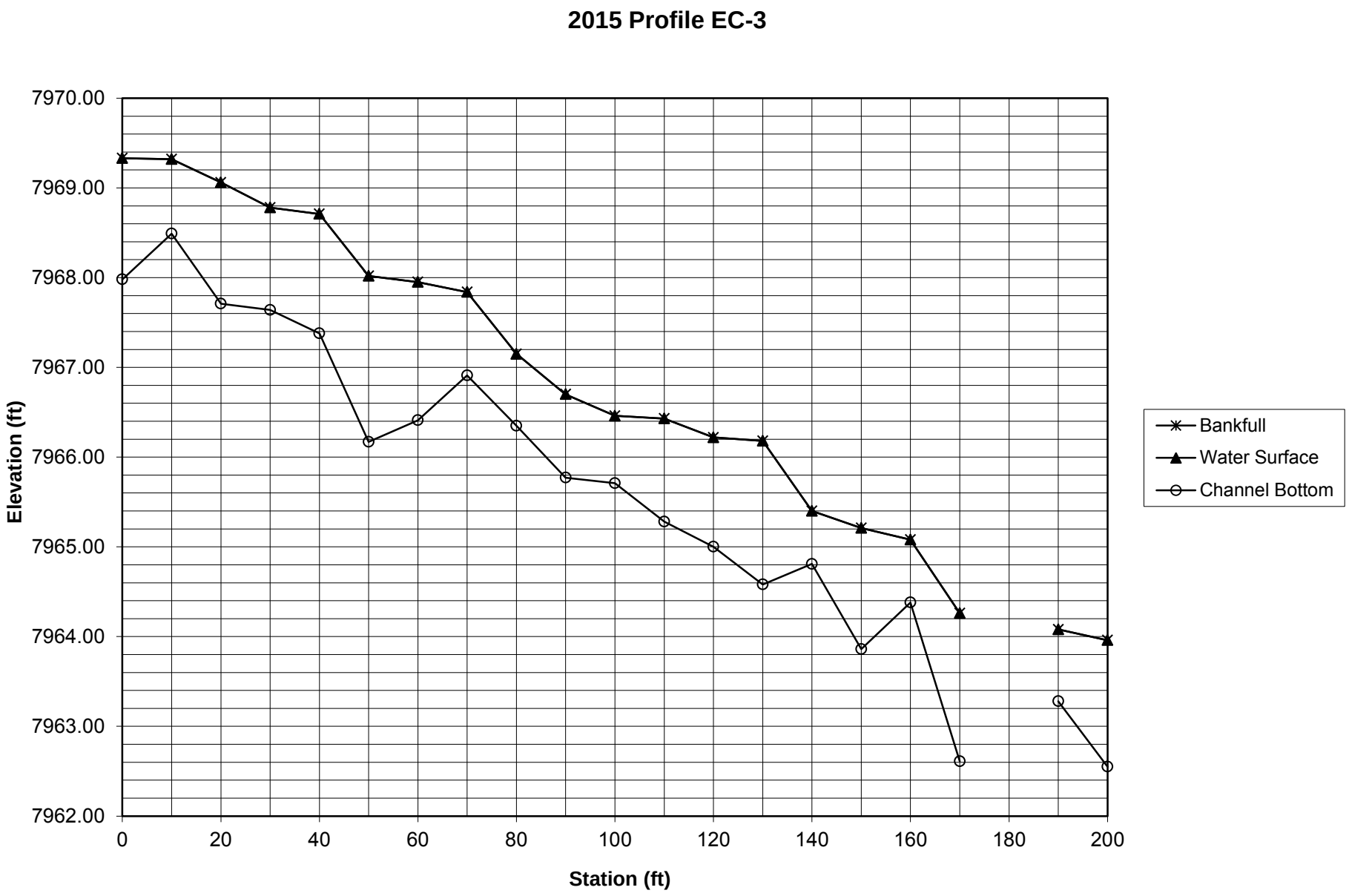

2015 Cross Section EC-2
8262.00
8261.00
8260.00
8259.00
8258.00
8257.00
8256.00
8255.00
Elevation (ft)
0
10
20
30
40
50
60
70
Station (ft)
Elevation

Profile: EC-3

Benchmark elevation (ft): 7971.59 Survey date: 9/30/2015
Rod reading at benchmark (ft): 4.29 (Note: Benchmark not found. 2015 Rod reading at benchmark based on 2006 elevation difference between benchmark and cross section station 0+00)

	Water Surface (ft)		Channel Bottom (ft)		Water Surface Calculations			Bankfull (ft)	
Station	Rod Reading	Elevation	Rod Reading	Elevation	Elev change	Distance	Slope (fraction)	Rod Reading	Elevation
0	6.55	7969.33	7.90	7967.98				6.55	7969.33
10	6.56	7969.32	7.39	7968.49	0.01	10.00	0.001	6.56	7969.32
20	6.82	7969.06	8.17	7967.71	0.26	10.00	0.026	6.82	7969.06
30	7.10	7968.78	8.24	7967.64	0.28	10.00	0.028	7.10	7968.78
40	7.17	7968.71	8.50	7967.38	0.07	10.00	0.007	7.17	7968.71
50	7.86	7968.02	9.71	7966.17	0.69	10.00	0.069	7.86	7968.02
60	7.93	7967.95	9.47	7966.41	0.07	10.00	0.007	7.93	7967.95
70	8.04	7967.84	8.97	7966.91	0.11	10.00	0.011	8.04	7967.84
80	8.73	7967.15	9.53	7966.35	0.69	10.00	0.069	8.73	7967.15
90	9.18	7966.70	10.11	7965.77	0.45	10.00	0.045	9.18	7966.70
100	9.42	7966.46	10.17	7965.71	0.24	10.00	0.024	9.42	7966.46
110	9.45	7966.43	10.60	7965.28	0.03	10.00	0.003	9.45	7966.43
120	9.66	7966.22	10.88	7965.00	0.21	10.00	0.021	9.66	7966.22
130	9.70	7966.18	11.30	7964.58	0.04	10.00	0.004	9.70	7966.18
140	10.48	7965.40	11.07	7964.81	0.78	10.00	0.078	10.48	7965.40
150	10.67	7965.21	12.02	7963.86	0.19	10.00	0.019	10.67	7965.21
160	10.80	7965.08	11.50	7964.38	0.13	10.00	0.013	10.80	7965.08
170	11.62	7964.26	13.27	7962.61	0.82	10.00	0.082	11.62	7964.26
180	No measurements taken at this station. Large deadfall tree is blocking sight across channel.								
190	11.80	7964.08	12.60	7963.28	0.18	20.00	0.009	11.80	7964.08
200	11.92	7963.96	13.33	7962.55	0.12	10.00	0.012	11.92	7963.96

Max. Water Surface Slope (fraction): 0.082
Min. Water Surface Slope (fraction): 0.001
Avg. Water Surface Slope (fraction): 0.028

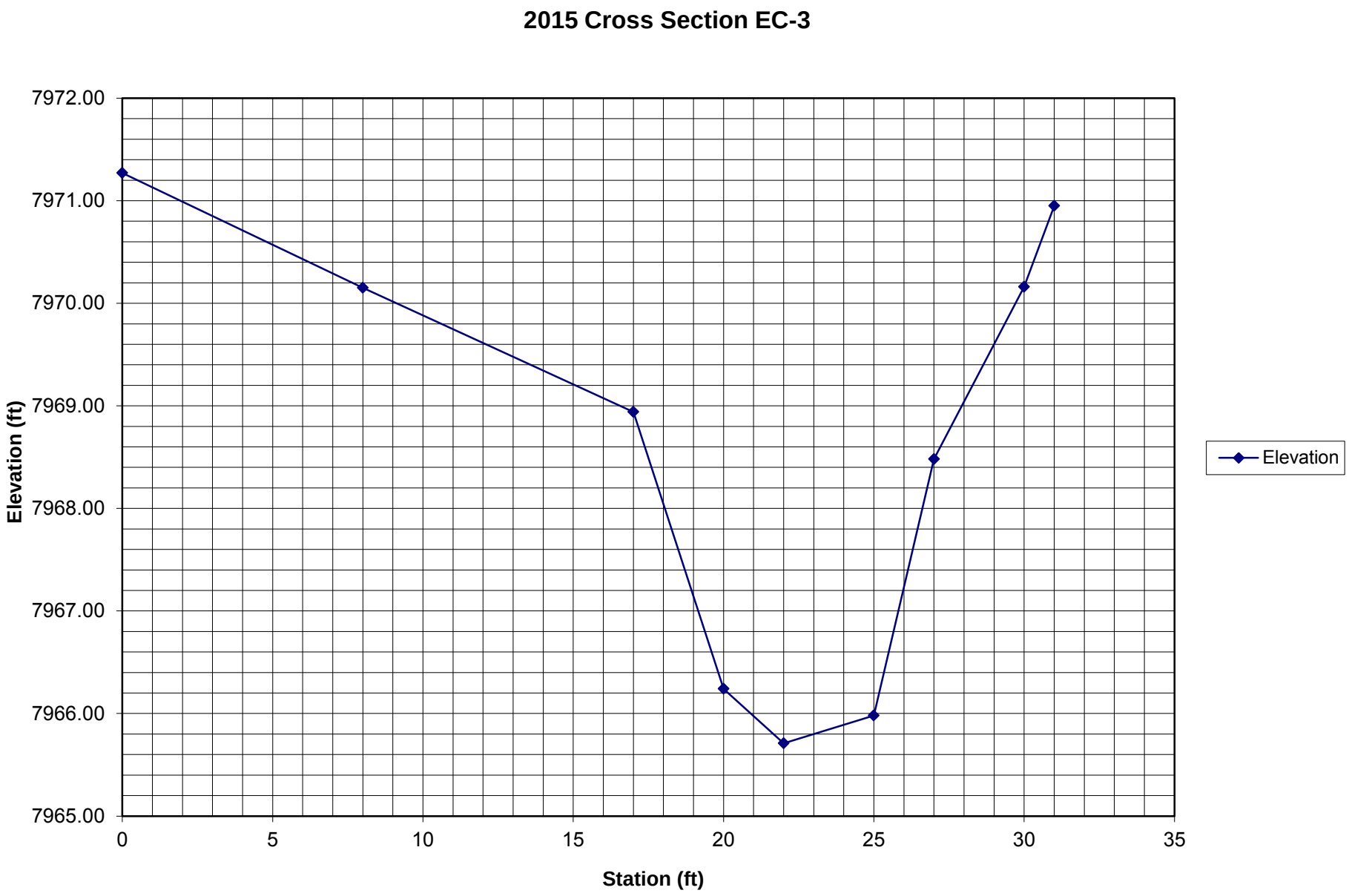

2015 Profile EC-3
7970.00
7969.00
7968.00
7967.00
7966.00
7965.00
7964.00
7963.00
7962.00
Elevation (ft)
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Bankfull
Water Surface
Channel Bottom

Cross Section: EC-3

Benchmark elevation: 7971.59
BenchMark Rod Reading: 4.29

Survey Date: 9/30/2015
(Note: Benchmark not found. 2015 Rod reading at benchmark based on 2006 elevation difference between benchmark and cross section station 0+00)

Station	Rod Reading	Elevation
0	4.61	7971.27
8	5.73	7970.15
17	6.94	7968.94
20	9.64	7966.24
22	10.17	7965.71
25	9.90	7965.98
27	7.40	7968.48
30	5.72	7970.16
31	4.93	7970.95


2015 Cross Section EC-3
7972.00
7971.00
7970.00
7969.00
7968.00
7967.00
7966.00
7965.00
Elevation (ft)
0
5
10
15
20
25
30
35
Station (ft)
Elevation