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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	Gregg A. Galecki	Phone Number	+1 (435) 448-2636
Mailing Address	HC 35 Box 380	Email	ggalecki@archcoal.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 4/17/12, 8/10/12, 10/26/12, and 1/13/13, respectively.
Impoundments	☒ Required ☐ Not Required	Submitted quarterly in electronic format - same dates as Refuse Pile reports.
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

Samples WR2012-1 through WR2012-17 were collected and analyzed. Analysis is included with the electronic submittal; a .pdf document titled WasteRockSamples.pdf. All samples were considered non-toxic and are placed in an area with a minimum of 4 feet of cover.

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: Annual report
Citation: MRP, Chapter 4, Section 4.18, page 4-103

Operator Comments

A report is included with the electronic submittal; an adobe file document titled 2012Subsidence Memo_raptor.pdf.

Reviewer Comments ☐ Met Requirements ☐ Did Not Meet Requirements

Title: MACROINVERTEBRATE SURVEYS
Objective: To determine if mining and mining related activities are impacting the perennial streams located in Woods, Eccles, Burnout and James Canyons.
Frequency: Fall and Spring every three years beginning in 2007.
Status: Next surveys due in fall 2011/ Spring 2012. These reports have not yet been submitted to the Division.
Reports: Annual
Citation: MRP, Appendix A-3, Volume 2, Volume 1A, Section 2.8, pages 2-71, 71A, B,C. Section 2.8, table 2.8-1a

Operator Comments

Sample collection frequency was modified in January 2011, collecting samples in Spring and Fall 2011 to accommodate available Lab personnel scheduling at BYU. To date, the 2011 Spring report for Woods and Winter Quarters Creeks is being submitted electronically with this form titled, 'Canyon13.WQ11.Jul.macro.final.pdf'. On May 15, 2013, the Eccles Creek July 2011 and September 2011 report was submitted electronically with this modified form titled, 'Canyon13.Eccles11.Jul.macro.final'. The Woods and Winter Quarters Fall 2011 reports will be submitted as they become available.

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

Submitted electronically with this report, the file titled, 'canyon13.WQ12.rip.rpt.complete.final.veg.pdf.

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: FISH SURVEY
Objective: To determine if mining and mining related activities are impacting the perennial streams located in Eccles, and Winter Quarters. Woods, Burnout and James Canyon Surveys are complete.
Frequency: In the fall every three years beginning in 2007.
Status: 2010 surveys complete. Next survey due in 2013.
Reports: Annual
Citation: MRP, Volume 1A, Section 2.8, page 2-71.

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: 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.

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.

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).

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)

No Waste Rock was stored more than three (3) months in a temporary stockpile during 2012. All material was hauled, placed, and sampled at the Waste Rock site.

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

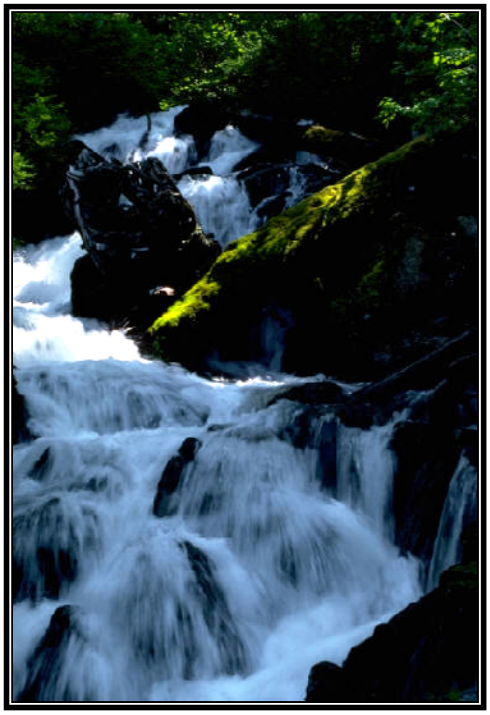
Copies of mine maps, current and up-to-date, are to be provided to the Division as an attachment to this report in accordance with the requirements of R645-301-525.240. The map copies shall be made in accordance with 30 CFR 75.1200 as required by MSHA. Mine maps are not considered confidential.

Map Name	Map Number	Included		Confidential	
		Yes	No	Yes	No
Cumulative Subsidence 1982-2012		☐	☐	☐	☒
Skyline Mine...Projected Mining 2013-2017		☐	☐	☐	☒
Skyline Mine, Mine 3, As Mined 2012		☐	☐	☐	☒
		☐	☐	☐	☐
		☐	☐	☐	☐

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. One (1) set of the above-listed maps were hand-delivered to the UDOGM-PIC located in Salt Lake City, Utah on March 27, 2013. The cited maps have the required original certification.

An Assessment of the Macroinvertebrates of Eccles Creek in July 2011 & September 2011



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for

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March 2013

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INTRODUCTION

In August, 2001, an aquifer tapped by Skyline Mine, near Scofield, UT, significantly increased the discharge of water from the mine into Eccles Creek. The discharge maintained the stream at approximately bank-full levels. This report summarizes results of monitoring of the benthic invertebrate community in Eccles Creek through the summer of 2011. It includes summaries of previous data to maintain the context for comparative purposes and a multivariate analysis of all available benthic data for Eccles Creek collected through 2011. The samples taken in fall, 2011, represent the eleventh series taken from the stream following the increased discharge. This project was undertaken for Canyon Fuel Company with the objective of determining the impact of the increased flows on the stream community.

METHODS

Quantitative samples were taken from Eccles Creek in July 2011 and September 2011. The three stations sampled were Eccles Creek above South Fork (EC2: N 39^0 40.970', W 111.11.579', 8,406 feet elevation), Eccles Creek at Whisky Canyon (EC-4: N 39^0 40.908', W 111.10.747', 8,234 feet elevation), and Lower Eccles Creek (EC-5: N 39^0 41.001', W 111.10.031', 8,074 feet elevation). These three stations have been sampled intermittently since 1979 (Shiozawa 2003). The samples were taken from the same locations sampled in July and October, 2002, June and October, 2003, October and June 2004, September 2007 and July 2008. Five replicate samples were taken per station. All samples were taken from locations in the stream where rubble or cobble substrates were present. A box sampler with a net mesh of 250 microns was used to collect the samples. The substrate was stirred to a depth of approximately 5 cm whenever possible. In some cases, the streambed could only be brushed. All rocks within the area of the sampler were removed and individually washed to insure quantitative collection of the invertebrates. The samples were concentrated on a screen with a mesh of 64 microns and field preserved in ethyl alcohol. A GPS unit was used to locate the sample stations.

In the laboratory, the samples were sorted in illuminated pans. All invertebrates were removed and identified to the lowest possible taxonomic level using the keys of Merritt and Cummins (1996) and Merritt et al. (2008). The visually sorted samples were then subsampled by suspending the residual sample in a volume of 200 ml of water. Five 2 ml subsamples were removed and processed under magnification with a dissecting scope. The mean density per subsample was used to project the total density of organisms remaining in the sample after visual sorting. These projections were added to the total count from the visual sorting. The data were then used to determine the density of taxa per square meter. Mean biomass estimates, based on wet weights of invertebrates, were also generated so that trends in standing crop could be documented.

Analyses included comparisons of the number of taxa and mean densities in the July and September 2011 samples with those generated from samples taken July 2008 , September 2007 (Shiozawa and Fordham 2011), October, 2004 (Shiozawa 2007), June 2004 (Shiozawa and Kauwe 2006), October, 2003, June 2003, October, 2002, November, 2001 (Shiozawa 2002a),

and July, 2002 (Shiozawa 2002c) and with baseline samples taken in 1979 (Winget 1980) and 1992 (Ecosystems Research Institute 1992). These comparisons allow a general evaluation of changes that have occurred since the increased discharge of water into the stream channel from the mine and help place the results in perspective relative to other perturbations as well as baseline conditions.

The community tolerance quotient (CTQ; Winget and Mangum 1979) was used to gain insight into the condition of the stream relative to that predicted for an idealized system from slope, water chemistry, and substrate. Water chemistry for Eccles Creek was provided by EarthFax Engineering (2001). The following estimates were used for alkalinity and sulfate levels: Eccles Creek alkalinity recorded levels at 264 mg/l and sulfate estimated at 49 mg/l. The gradient in Eccles Creek is approximately 3.3%. This combination of physical properties, gives a predicted community tolerance quotient (CTQp) of 80 (Winget and Mangum 1979). The Biotic Condition Index was used to further interpret the data generated with this procedure.

Diversity was calculated for the stations using the Shannon-Weiner index (Pieliou 1977). This allows a general comparison among sample stations and dates. Diversity indices take the number of taxa and their individual relative densities into account, generating a single value for each station. The greater the number of species or taxa and/or generally the more even the distribution of densities among taxa, the higher the diversity index value.

The data were clustered with the UPGMA algorithm using the Bray-Curtis measure of dissimilarity (Poole 1974, Krebs 1989). The NTSYSpc package was utilized to generate the cluster dendrograms (Rolf 2000). As a final analysis, the entire data set was examined with an ordination technique, correspondence analysis (Braak and Smilauer 2002). This was applied to the full data set. This was an exploratory procedure to graphically visualize general trends among the sampling stations.

RESULTS AND DISCUSSION

Number of Taxa

Twenty-nine taxa were collected from Eccles Creek in July of 2011 and thirty-two taxa were collected in September 2011. The total number of taxa is the highest collected from Eccles Creek since the recent sampling series began in 2001. After combining adults, pupae and larvae of the same taxon, chironomid pupae), 20 taxa were collected in station EC2 in July 2011 and 14 in September 2011. Station EC5 on both sampling periods had 23 taxa, the highest number collected at any single station. This is about half to a third of the baseline number of taxa collected in 1979 (Winget 1980). Station EC4 had 23 to 24 taxa collected in 2011and station EC5 had 22 to 23. The higher numbers of taxa in both EC4 and EC5 indicate that the stream is gaining more species as time passes. This gain implies a directional shift of the community towards the number of taxa present in the pre-perturbation conditions.

Table 1. Number of taxa collected from Eccles Creek.

	Winget 1980		Ecosystems Research Institute 1992			Shiozawa 2002a	Shiozawa 2002c	Shiozawa 2003	Shiozawa & Hansen 2004	Shiozawa 2005	Shiozawa 2005	Shiozawa 2007	Shiozawa & Fordham 2010	Shiozawa & Fordham 2010	This Report	This Report
Sampling date	May-June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002	June 2003	Oct 2003	June 2004	Oct 2004	Sept 2007	July 2008	Jul 2011	Sept 2011
South Fork tributary above mine, upper site (USF2)			20	11												
South Fork tributary above mine (USF)	30		12	9	21											
Middle Fork tributary above mine (UMF)	29		14	18												
Eccles Creek below mine (EC1)			4	2												
Eccles Creek above south Fork (EC2)	35	42	6		6		6	11	11	5	10	7	7	7	20	14
South Fork Eccles Creek (SF)	36	35	12													
Eccles Creek below South Fork (EC3)	27	30														
Eccles Creek at Whisky Canyon (EC4)	35	37	7	17	15	6	14	7	9	13	14	16	24	15	23	24
Lower Eccles Creek (EC5)	38	21	12	13/11	14		6	11	9	11	21	24	17	11	22	23

Only the August 1979 sample for station EC5 had fewer taxa collected. The other baseline sampling dates are still above the number of taxa collected in 2011. In 2004, station EC5 could also have been considered to have recovered to pre-mining conditions, based on the total taxa count alone, but in both 2007 and 2008 the number of taxa had again decreased. The taxa count for the other two stations, EC2 and EC4, were below the base-line counts of 1979 for their respective locations. Total taxa counts give one measure of the state of the community but, by themselves, such counts are relatively uninformative except for giving a rough estimate of diversity. Species composition needs to be considered.

Total Density Comparisons

The July 2011 samples for EC2 and EC4 had a greater total density than recorded in the baseline stream collections made in 1979 (Table 2), and EC5 was close enough in numbers to be considered essentially at the 1979 level. Both EC4 and EC5 in September 2011 exceeded the 1979 baseline densities. EC2, however was lower than the baseline estimates, even though its total density estimate in for July of 2011 was the highest recorded for that station since the increase in discharge in 2001. In June of 2004 very similar increases in density occurred, but with much greater numbers occurring in EC4 and EC5.

The total densities in the three stations in both sampling periods were higher than the densities recorded for the three stations from 2001 through June of 2003. They also exceeded the densities estimated in 2007-2008. The 2007 samples in EC2 and EC4 were indicative of no change, but the 2008 data suggested that the system may have recovered to baseline levels in total numbers, despite contrasting evidence from the number of taxa. However, with the 2011 sample series, both the number of taxa and the total densities were near or exceeded the ranges of number of taxa and densities in 1979 (Table 2).

As noted in previous reports, our protocol of sorting samples under dissecting scopes after general sorting is much more accurate than open-pan sorting. While we do not know how the processing was completed in the previous studies, we do know that our approach will give a more accurate count of individuals when compared to open-pan sorting alone. This would result in our density estimates being higher than estimates generated by other laboratories. Another factor that seems to be important is the failure of several beaver dams above these sites. These released significant amounts of sediment into the stream channel and the increased sediment would be favorable to the benthic invertebrates.

If density alone was evidence of recovery, and if higher numbers denote greater recovery, then stations EC4 and EC5 could be considered to have recovered. Likewise, EC2 would have more than recovered in July of 2011, but then fell below those levels in September 2011. But, as noted previously (Shiozawa 2007), in stressed systems a few taxa often dominate the community with high numbers of individuals and these can easily mask the state of the community.

Table 2. Total invertebrate densities per square meter for selected studies on Eccles Creek

	Winget 1980		Ecosystems Research Institute 1992			Shiozawa 2002a	Shiozawa 2002c	Shiozawa 2003	Shiozawa & Hansen 2004	Shiozawa 2005	Shiozawa 2005	Shiozawa 2007	Shiozawa 2009	Shiozawa & Fordham 2010	This Report	This Report
Sampling date	May-June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002	June 2003	Oct 2003	June 2004	Oct 2004	Sep 2007	Jul 2008	Jul 2011	Sept 2011
South Fork tributary above mine, upper site (USF2)			1,089	528												
South Fork tributary above mine (USF)	10,179		1,144	216	2,455											
Middle Fork tributary above mine (UMF)	7,447		1,503	3,812												
Eccles Creek below mine (EC1)			164	16												
Eccles Creek above South Fork (EC2)	12,341	73,181	267		89		3,703	1,260	6,265	1,267	10,865	4,339	2,436	15,772	55,421	9,873
South Fork Eccles Creek (SF)	9,321	17,773	1,356													
Eccles Creek below South Fork (EC3)	18,093	23,247														
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
Lower Eccles Creek (EC5)	18,661	2,526	2,212	4,104/ 2,863	1,468		4,927	2,879	3,387	16,919	97,614	65,206	10,878	12,743	16,427	48,847

Taxa Specific Densities

While total densities give a quick picture of the state of the stream system, the component taxa should be considered. High densities of relatively few taxa are common in stressed or polluted systems because a few tolerant taxa are able to monopolize resources. This is especially enhanced in an environment with reduced predation and competition.

In stationEC2 three taxa made up 94% of the July 2011 density estimates (Table 3); 43% were chironomids, 18% were copepods, and 33% were oligochaetes, The next most abundant taxon, *Baetis* made up less than 3% of the total density. The September 2011 samples from that location (Table 4) was comprised of 59% chironomids, 18% oligochaetes, 10% *Baetis* and 5% early instar mayflies. The next most abundant taxon was the empid, *Chelifera* at 2.5%. Collectively these taxa make up almost 95% of the total invertebrate density recorded.

Station EC4 in July 2011 had 92% of the organisms made up of three taxa. These consisted of chironomids (40%), oligochaetes (33%) and copepods (18%). The September 2011 EC4 sample had six taxa in the samples that comprised 92% of the total density. Chironomids made up 45% and oligochaetes 19% of the individuals. The caddisfly, *Hydropsyche*, accounted for 15% and early instar plecopterans 7% of the numbers. The remaining 6% were mayflies: *Baetis* (3%) and early instar mayflies (3%).

In July 2011 91% of the total density in Station EC5 was due to five taxa. Chironomids made up 41% of the numbers and copepods 26%. Oligochaetes were the third most abundant taxon, comprising 14% of the total density followed by the empid *Chelifera* with 3% and ostracods with 2%. Just three taxa dominated the September 2011 samples from this station. They contributed to 92% of the station's total density estimate. These were chironomids with 41%, oligochaetes with 44%, and early instar mayflies with 7%. This station had a reverse pattern compare to the other two stations in that the number of dominant taxa decreased in the fall samples, while in EC2 and EC4 the numbers of taxa increased in that same sampling period.

The individual density data illustrate the limitations of examining only the total density of invertebrates. In Eccles Creek, the 2011 total density estimates appeared to reflect the 1979 base-line numbers and the total number of taxa appeared to also be climbing. But inspection of individual density estimates indicates that many of the taxa were very uncommon. Instead only a portion of the taxa dominated the total numbers recorded at a station. The individual density estimates thus suggest that the system is still under considerable stress with the high sustained flows and associated water chemistry that are present.

Table 3. July 2011, sample data and invertebrates per square meter.

	Upper Eccles						Middle Eccles					
Taxa	1	2	3	4	5	**#/m^2**	1	2	3	4	5	**#/m^2**
Ephemeroptera: *Baetis*	108	17	37	9	84	**1546**	8	7	4	5	5	**176**
Ephemeroptera: Epeorus	1	0	0	0	0	**7**	0	0	0	0	0	**0**
Ephemeroptera: Ephemerella	0	0	0	0	0	**0**	0	0	2	0	0	**13**
Ephemeropter: *Cinygmula*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ephemeroptera: early instar*	0	0	0	7	86	**564**	0	20	0	0	0	**122**
Plecoptera: early instar*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Plecoptera: Isoperla	1	0	0	0	1	**13**	4	1	7	3	3	**110**
Plecoptera: *Paraperla frontalis*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Plecoptera: *Malenka californica*	0	0	0	0	2	**13**	0	0	0	0	0	**0**
Trichoptera: early instar*	10	0	0	1	16	**164**	0	0	0	0	0	**0**
Trichoptera: *Brachycentrus*	0	1	0	0	0	**7**	0	1	0	0	0	**7**
Trichoptera: *Hesperophylax*	0	0	1	0	0	**7**	0	0	0	0	1	**7**
Trichoptera: *Hydropsyche*	0	0	0	0	0	**0**	4	2	7	22	22	**346**
Trichoptera: *Hydroptila*	11	0	1	0	14	**158**	0	1	0	0	0	**7**
Trichoptera: Dicosmoecua	0	0	0	0	0	**0**	0	3	0	1	0	**26**
Trichoptera: Limnephilidae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: Ochrotrichia	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: *Polycentropus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: *Rhycophila*	1	1	0	0	4	**37**	0	1	0	0	1	**13**
Trichoptera: pupae*	0	0	0	0	1	**7**	0	3	11	1	4	**116**
Coleoptera: Dytiscidae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (adult)	0	0	0	0	0	**0**	1	0	0	1	0	**13**
Coleoptera: *Heterlimnius* (larvae)	0	0	0	16	0	**97**	1	0	0	4	1	**37**

Coleoptera: *Optioservus* (adult)	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Coleoptera: *Optioservus* (larvae)	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Antocha*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Caloparyphus	0	0	0	0	0	**0**	0	0	0	1	0	**7**
Diptera: Ceratopogonidae	0	1	0	0	0	**7**	1	1	0	2	1	**31**
Diptera: Chironomidae larva	497	784	389	1180	874	**22568**	147	330	480	320	182	**8842**
Diptera: Chironomidae pupae	20	65	27	22	63	**1194**	2	2	33	5	12	**328**
Diptera: *Chelifera*	4	2	1	8	6	**128**	5	4	13	1	5	**170**
Diptera: *Dicranota*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Euparyphus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Dolichopodidae	0	0	0	0	0	**0**	0	1	0	0	0	**7**
Diptera: *Limnophora*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Limnophila*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Hemerodromia*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Neoplasta	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Rhabdomastix*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Phoridae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Simulium*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Tipula*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Crustacea: Copepoda	837	248	429	16	151	**10187**	59	301	8	61	260	**4176**
Crustacea: Ostracoda	0	0	3	0	14	**104**	2	21	8	1	2	**207**
Arachnida: Hydracarina	0	0	0	1	16	**104**	0	20	1	5	0	**158**
Mollusca: *Gyrulus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Mollusca: *Sphaerium*	0	0	1	0	0	**0**	2	20	0	6	2	**182**
Annelida: Oligochaeta	194	1847	109	314	589	**18502**	18	372	404	58	390	**7527**
Collembola	0	0	0	0	0	**0**	1	0	0	0	0	**7**
Nematoda	1	0	0	0	0	**7**	2	40	1	3	40	**522**
Totals:	1685	2966	998	1574	1921	**55421**	257	1151	979	500	931	**23157**

Table 3 (cont.). July 2011, sample data and invertebrates per square meter.

	Lower Eccles Creek (EC5)					
Taxa	1	2	3	4	5	**#/m^2**
Ephemeroptera: *Baetis*	0	1	7	21	2	**188**
Ephemeroptera: Ephemerlla	0	0	0	0	1	**7**
Ephemeropter: *Cinygmula*	0	0	0	0	0	**0**
Ephemeroptera: early instar*	0	2	1	0	32	**213**
Plecoptera: early instar*	0	1	3	0	0	**25**
Plecoptera: *Paraperla frontalis*	0	0	0	0	0	**0**
Plecoptera: Isoperla	0	0	3	7	3	**79**
Plecoptera: *Malenka californica*	0	0	0	0	0	**0**
Trichoptera: early instar*	17	0	2	0	16	**213**
Trichoptera: *Brachycentrus*	0	0	1	3	2	**37**
Trichoptera: *Dicosmoecus*	0	0	0	1	0	**7**
Trichoptera: *Hydropsyche*	0	0	1	3	0	**25**
Trichoptera: *Hydroptila*	0	0	0	0	0	**0**
Trichoptera: Limnephilidae	0	0	2	0	0	**13**
Trichoptera: Ochrotrichia	0	0	0	0	0	**0**
Trichoptera: *Polycentropus*	0	0	0	0	0	**0**
Trichoptera: *Rhycophila*	0	0	0	0	0	**0**
Trichoptera: pupae*	0	0	0	4	2	**37**
Coleoptera: Narpus (larvae)	0	0	0	0	1	**7**
Coleoptera: Dytiscidae	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (adult)	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (larvae)	0	0	0	1	1	**13**

Coleoptera: *Optioservus* (adult)	0	0	0	0	0	**0**
Coleoptera: *Optioservus* (larvae)	0	0	0	0	0	**0**
Diptera: *Antocha*	0	0	0	0	0	**0**
Diptera: Caloparyphus	0	0	0	0	0	**0**
Diptera: Ceratopogonidae	0	1	1	1	0	**19**
Diptera: Chironomidae larva	98	42	193	750	174	**7618**
Diptera: Chironomidae pupae	3	1	6	12	4	**158**
Diptera: *Chelifera*	15	11	10	20	14	**425**
Diptera: *Dicranota*	0	0	0	0	0	**0**
Diptera: *Euparyphus*	0	0	0	0	0	**0**
Diptera: *Limnophora*	0	0	0	0	0	**0**
Diptera: *Limnophila*	0	0	0	0	0	**0**
Diptera: *Hemerodromia*	0	0	0	0	0	**0**
Diptera: Neoplasta	0	0	0	0	0	**0**
Diptera: *Rhabdomastix*	0	0	0	0	0	**0**
Diptera: Phoridae	0	0	0	0	0	**0**
Diptera: *Simulium*	0	0	0	0	0	**0**
Diptera: *Tipula*	0	0	0	0	0	**0**
Crustacea: Copepoda	33	14	151	300	215	**4321**
Crustacea: Ostracoda	17	0	1	0	48	**400**
Arachnida: Hydracarina	17	1	6	0	1	**152**
Mollusca: *Gyrulus*	0	0	0	0	0	**0**
Mollusca: *Sphaerium*	0	1	1	0	0	**13**
Gastropoda	0	1	0	0	0	**7**
Annelida: Oligochaeta	53	1	12	208	106	**2303**
Collembola	0	0	2	0	16	**110**
Nematoda	1	0	5	0	0	**37**
Totals:	**254**	**77**	**408**	**1330**	**638**	**16427**

Table 4. September 2011, sample data and invertebrates per square meter.

	Upper Eccles						Middle Eccles					
Taxa	1	2	3	4	5	**#/m^2**	1	2	3	4	5	**#/m^2**
Ephemeroptera: *Baetis*	37	10	89	16	9	**976**	44	15	42	53	26	**1091**
Ephemeroptera: Epeorus	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ephemeroptera: Ephemerella	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ephemeroptera: Drunella grandis	0	0	0	0	0	**0**	0	40	0	0	0	**243**
Ephemeropter: *Cinygmula*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Ephemeroptera: early instar*	21	0	0	61	0	**497**	180	0	19	22	0	**1340**
Plecoptera: early instar*	0	0	0	20	0	**122**	60	31	68	100	183	**2679**
Plecoptera: Isoperla	0	0	0	0	0	**0**	1	0	0	2	2	**31**
Plecoptera: *Paraperla frontalis*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Plecoptera: *Malenka californica*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: early instar*	0	1	0	0	0	**7**	0	0	0	0	3	**19**
Trichoptera: *Brachycentrus*	0	0	0	0	0	**0**	1	11	0	0	0	**73**
Trichoptera: *Hesperophylax*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: *Hydropsyche*	0	2	2	4	0	**49**	126	0	333	139	345	**5715**
Trichoptera: *Hydroptila*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: Dicosmoecua	0	0	0	0	0	**0**	0	0	0	0	0	**7**
Trichoptera: Limnephilidae	0	0	0	0	0	**0**	1	0	0	0	0	**0**
Trichoptera: Ochrotrichia	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: *Polycentropus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Trichoptera: *Rhycophila*	0	0	0	1	0	**7**	0	0	36	0	0	**219**
Trichoptera: pupae*	0	0	0	0	0	**0**	0	0	0	0	0	**0**

Coleoptera: Dytiscidae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (adult)	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (larvae)	0	0	1	0	0	**7**	0	2	3	62	2	**419**
Coleoptera: *Optioservus* (adult)	0	0	0	0	0	**0**	0	0	0	4	0	**25**
Coleoptera: *Optioservus* (larvae)	0	0	0	0	0	**0**	3	0	0	0	1	**25**
Diptera: *Antocha*	21	0	0	0	0	**128**	1	11	10	0	1	**140**
Diptera: Caloparyphus	0	0	0	0	0	**0**	0	0	34	0	1	**213**
Diptera: Ceratopogonidae	0	0	0	0	0	**0**	30	21	3	0	0	**328**
Diptera: Chironomidae larva	237	45	502	45	128	**5780**	277	63	1494	100	915	**17265**
Diptera: Chironomidae pupae	0	1	0	0	10	**67**	0	0	0	0	0	**0**
Diptera: *Chelifera*	0	0	0	0	41	**249**	0	0	0	0	0	**0**
Diptera: *Dicranota*	0	0	0	0	0	**0**	1	0	0	0	0	**7**
Diptera: *Euparyphus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Dolichopodidae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Limnophora*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Limnophila*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Hemerodromia*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Neoplasta	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Rhabdomastix*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: Phoridae	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Diptera: *Simulium*	0	1	0	0	0	**7**	0	0	4	0	0	**25**
Diptera: *Tipula*	0	0	20	0	0	**122**	0	0	0	0	0	**0**
Diptera: Small Tipulid	0	0	0	0	0	**0**	1	0	0	0	0	**7**
Crustacea: Copepoda	0	0	0	0	0	**0**	30	0	0	0	0	**182**
Crustacea: Ostracoda	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Arachnida: Hydracarina	0	0	0	0	0	**0**	30	0	35	0	0	**340**

Mollusca: *Gyrulus*	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Mollusca: *Sphaerium*	0	0	0	0	0	**0**	0	0	0	20	0	**122**
Annelida: Oligochaeta	0	35	81	60	123	**1812**	362	123	105	201	413	**7297**
Collembola	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hemiptera	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Planaria	0	7	0	0	0	**43**	0	0	0	0	0	**0**
Nematoda	0	0	0	0	0	**0**	60	0	0	0	0	**364**
Totals:	316	102	695	207	314	**9873**	1308	317	2186	703	1892	**38176**

Table 4 (cont.). September 2011, sample data and invertebrates per square meter.

	Lower Eccles Creek (EC5)					
Taxa	1	2	3	4	5	**#/m^2**
Ephemeroptera: *Baetis*	38	9	37	10	8	**619**
Ephemeroptera: Ephemerlla	2	0	0	0	0	**13**
Ephemeropter: *Cinygmula*	0	0	0	0	0	**0**
Ephemeroptera: early instar*	91	69	3	221	230	**3721**
Plecoptera: early instar*	68	32	0	0	0	**606**
Plecoptera: *Paraperla frontalis*	0	0	0	0	0	**0**
Plecoptera: Isoperla	0	4	0	0	0	**25**

Plecoptera: Sweltza	4	0	0	0	0	**25**
Plecoptera: *Malenka californica*	0	0	0	0	0	**0**
Trichoptera: early instar*	0	20	0	0	0	**122**
Trichoptera: *Brachycentrus*	35	3	0	0	0	**231**
Trichoptera: *Hesperophylax*	0	0	0	0	0	**0**
Trichoptera: *Hydropsyche*	34	6	30	53	2	**758**
Trichoptera: *Hydroptila*	0	0	0	0	0	**0**
Trichoptera: Limnephilidae	0	0	0	0	0	**0**
Trichoptera: Parapsyche	0	0	0	0	1	**7**
Trichoptera: Ochrotrichia	0	0	0	0	0	**0**
Trichoptera: *Polycentropus*	0	0	0	0	0	**0**
Trichoptera: *Rhycophila*	1	0	1	0	0	**13**
Trichoptera: pupae*	0	0	0	0	0	**0**
Coleoptera: Narpus (larvae)	0	0	0	0	0	**0**
Coleoptera: Dytiscidae	0	0	0	0	0	**0**
Coleoptera: *Heterlimnius* (adult)	1	0	0	0	0	**7**
Coleoptera: *Heterlimnius* (larvae)	0	0	0	0	0	**0**
Coleoptera: *Optioservus* (adult)	0	0	0	0	0	**0**
Coleoptera: *Optioservus* (larvae)	0	0	0	0	0	**0**
Diptera: *Antocha*	1	0	3	2	3	**55**
Diptera: Caloparyphus	0	1	0	0	0	**7**
Diptera: Ceratopogonidae	1	2	0	0	0	**19**
Diptera: Chironomidae larva	642	264	340	713	1301	**19756**
Diptera: Chironomidae pupae	31	2	0	0	0	**194**
Diptera: *Chelifera*	60	60	0	0	0	**728**
Diptera: *Dicranota*	0	0	0	0	0	**0**
Diptera: *Euparyphus*	0	0	0	0	0	**0**
Diptera: *Limnophora*	0	0	0	0	0	**0**
Diptera: *Limnophila*	0	0	0	0	0	**0**
Diptera: *Hemerodromia*	15	0	0	0	0	**91**
Diptera: Neoplasta	0	0	0	0	0	**0**
Diptera: *Rhabdomastix*	0	0	0	0	0	**0**
Diptera: Phoridae	0	0	0	0	0	**0**
Diptera: *Simulium*	1	0	0	0	27	**170**
Diptera: Syrphidae	0	1	0	0	0	**7**

Diptera: *Tipula*	0	0	0	0	0	**0**
Crustacea: Copepoda	0	0	0	0	0	**0**
Crustacea: Ostracoda	0	0	0	0	0	**0**
Arachnida: Hydracarina	0	0	0	0	0	**0**
Mollusca: *Gyrulus*	0	0	0	0	0	**0**
Mollusca: *Sphaerium*	0	0	0	0	0	**0**
Gastropoda	0	0	0	0	0	**0**
Annelida: Oligochaeta	1764	1317	61	10	403	**21544**
Collembola	0	0	0	0	0	**0**
Hemiptera	1	0	0	0	0	**7**
Nematoda	0	20	0	0	0	**122**
Totals:	**2790**	**1810**	**475**	**1009**	**1975**	**48847**

Biomass

Total biomass estimates were generated for each station for both the July 2011 and September 2011 sampling periods (Table 5). These biomass estimates can be compared with biomass estimates from previous collections (Table 6) to gain insight into the standing stock of energy in the system at different time periods. We do not have biomass estimates for Eccles Creek prior to the increased discharge in 2001, but we can use biomass estimates from Woods and Winter Quarters canyons (Shiozawa 2004, Shiozawa and Fordham 2010; Table 7) for comparison since those two streams parallel Eccles Creek and should be similar to the pre-impact Eccles Creek system.

The overall mean biomass for Woods and Winter Quarters canyons is just over 43 g/m^2. In contrast, the mean biomass for Eccles Creek for the two sampling periods in 2011 was 5.15 g/m$^{2.}$. This biomass estimate is down from 2002 when the estimate was 12.8 g/m^2. The biomass estimates in Woods-Winter Quarters range from 17.6 g/m^2 to 86.6 g/m^2 while the range in Eccles Creek is from 1.82 g/m^2 to 36.7 g/m^2. Thus the estimate for 2011 is within the expected range of the post-2001 Eccles Creek stations. The high estimate for Eccles Creek came from EC4 in June of 2004 and is almost double the biomass of the next highest estimate, which is from the October 2004 series from Eccles Creek. Both the September 2007 and July 2008 overall biomass estimates for Eccles Creek are a fifth to a seventh of the respective Woods-Winter Quarters estimates. The July 2011stations are between half to 6% of the July 2008 data, but when compared to the July 2011 Woods/Winter Quarters data the Eccles Creek biomass estimates are slightly below or equal. The Woods/Winter Quarters system was subject to intense spring flooding in 2011. The September 2011 Eccles Creek stations ranged from 2% to 15% of the September 2008 samples biomass for the Woods/Winter Quarters system.

Table 5. Biomass estimates, July, 2011 and September 2011.

	Upper Eccles (EC2)		Middle Eccles (EC4)		Lower Eccles (EC5)	
Sample	Jul-11	Sep-11	Jul-11	Sep-11	Jul-11	Sep-11
1	0.026 g	0.252 g	0.201 g	0.121 g	0.433 g	0.049 g
2	0.068 g	0.072 g	0.460 g	0.032 g	0.312 g	0.015 g
3	0.131 g	0.098 g	2.430 g	0.147 g	0.146 g	0.052 g
4	0.857 g	0.039 g	0.839 g	0.253 g	0.276 g	0.058 g
5	0.188 g	0.076 g	1.456 g	0.295 g	0.767 g	0.049 g
Total	1.27 g	0.537 g	5.386. g	0.848 g	1.934 g	0.223 g
g/ m^2	3.848 g/m^2	1.627 g/m^2	16.32 g/m^2	2.569 g/m^2	5.860 g/m^2	0.676 g/m^2

Table 6. Biomass averages (g/m^2) for Eccles Creek 2002-2008.

Eccles Cr,	October 2002	June 2003	June 2004	October 2004	September 2007	July 2008	July 2011	September 2011	Average
Upper (EC2)	16.06	6.46	3.21	2.36	1.82	5.73	3.85	1.63	5.14
Middle (EC4)	10.40	6.67	36.66	10.75	8.75	6.91	16.32	2.57	12.38
Lower (EC5)	11.92	3.74	16.28	19.68	5.25	5.33	5.86	0.68	8.59
Average	12.79	5.62	18.72	6.12	5.27	5.99	8.68	1.63	**8.10**

Table 7. Biomass in g/m^2 for Woods and Winter Quarter Canyons based on Shiozawa (2004) and Shiozawa and Fordham (2010), Shiozawa (2013).

	Jun-03	Oct-03	Jun-04	Sep-07	Jul-08	Jul-11	Average
Upper Woods Canyon	36.57	31.64	30.78	32.98	35.49	5.88	28.89
Lower Woods Canyon	54.58	49.43	57.19	22.52	31.45	10.72	37.65
Upper Winter Quarters Canyon	39.77	51.82	47.07	17.56	42.03	13.21	35.24
Middle Winter Quarters Canyon	37.62	67.18	52.43	22.75	67.06	14.38	43.57
Lower Winter Quarters Canyon	57.23	37.72	86.60	30.88	42.31	19.04	45.63
Average	45.15	47.56	54.81	25.34	43.67	12.65	**38.20**

A general trend I biomass is not clearly established, but it does appear to be slightly downward. Fluctuations are still apparent, but the trend indicates that change may still be taking place in the streambed. Armoring and marl deposition should progressively move downstream as easily

eroded materials are cemented in or flushed out of upstream locations. Such processes will eliminate interstitial spaces and thus the surface area available for benthic invertebrates will become more restricted.

Biotic Condition Index

Community tolerance quotients are a part of the biotic condition index developed by Winget and Mangum (1979). The community tolerance quotients are of two types, the actual community tolerance quotient, CTQa, and the predicted community tolerance quotient, CTQp. The predicted community tolerance quotient is based on water chemistry, substrate, and gradient. This was determined to be 80 using the criteria in Winget and Mangum (1979). CTQa values are a simple arithmetic mean of pre-assigned index values for the taxa present at a given station. The CTQa indices for an idealized stream, based on a combination of taxa collected from Boardinghouse Creek in November 2001, and all taxa collected in Eccles Creek from 2001-2011, are given in Tables 8 and 9.

Generally lower average CTQa values represent high quality waters, while those between 65 and 80 represent situations with moderate to high quality water. CTQa values greater than 80 represent low water quality or stressed systems. The July 2011 stations EC2, EC4, and EC5 had CTQa values of 84.7, 85.9, 92.7 respectively and all would be rated as stressed stations. In September 2011 the same three stations had CTQa values of 84.8, 77.6, and 80.1, suggesting that the fall samples had slightly improved from the July samples.

Table 8. Actual Community Tolerance quotients July 2011.

Taxa	above South Fork (EC2)	at Whisky Canyon (EC4)	Lower Eccles (EC5)	Ideal stream (species list, including Boarding-house Creek)
Ephemeroptera: Baetidae: Baetis	72	72	72	72
Ephemeroptera: early instar	72	72	72	72
Ephemeroptera: Ephemerellidae: *Drunella* grandis				48
Ephemeroptera: Ephemerellidae: *Drunella doddsi*				4
Ephemeroptera: Ephemerellidae: *Serratella*				48
Ephemeroptera: Ephemerellidae: *Ephemerella*		48	48	48
Ephemeroptera: Heptageniidae: *Cinygmula*				21
Ephemeroptera: Heptageniidae: *Epeorus*	21			21
Ephemeroptera: Leptophlebidae: *Paraleptophlebia*				24
Plecoptera early instar	36			36

Plecoptera: Chloroperlidae: *Paraperla frontalis*		24		24
Plecoptera: Leuctridae: *Perlomyia utahensis*				18
Plecoptera: Nemouridae: *Malenka californica*	36			36
Plecoptera: Nemouridae: *Zapada*				16
Plecoptera: Perlididae: *Hesperoperla pacifica*				18
Plecoptera: Perlodidae: *Diura knowltoni*				24
Plecoptera: Perlodidae: *Skwalla parallela*				18
Plecoptera: Perlodidae: *Isoperla*	48	48	48	48
Plecoptera: Chloroperlidae: Sweltsa				24
Trichoptera: pupae	108	108		108
Trichoptera: Brachycentridae: *Brachycentrus*	24	24	24	24
Trichoptera: Brachycentridae**:** *Micrasema*				24
Trichoptera: early instar	108		108	108
Trichoptera: Hydropsychidae: *Arctopsyche*				18
Trichoptera: Hydropsychidae: *Hydropsyche*	108	108		108
Trichoptera: Hydroptilidae: *Hydroptila*	108			108
Trichoptera: Hydroptilidae: *Ochrotrichia*	108	108		108
Trichoptera: Limnephilidae: *Dicosmecus*		24		24
Trichoptera: Limnephilidae: *Hesperophylax*	108	108	108	108
Trichoptera: Polycentropidae: Polycentropus		108		108
Trichoptera: Psychomyiidae: *Tinodes*				108
Trichoptera: Rhyacophilidae: *Rhyacophila*	18	18		18
Trichoptera: Uenoidae: *Neothremma alica*				8
Trichoptera: Uenoidae: *Oligoplebodes*				24
Coleoptera: Dytiscidae				72
Coleoptera: *Heterlimnius*	108	108	108	108
Coleoptera: Elmidae: *Optioservus*				108
Coleoptera: Haliplidae: *Peltodytes*				54
Coleoptera: Narpus				108
Diptera: Ceratopogonidae	108	108	108	108
Diptera: Chironomidae	108	108	108	108
Diptera: Dolichopodia		108		108
Diptera: Empididae: *Chelifera*	108	108	108	108
Diptera: Empididae: *Hemerodromia*				108
Diptera: Empididae: *Neoplasta*				108
Diptera: Ephydridae: ***Scatella***				108
Diptera: Limoniidae: *Nr. Rhabdomastix*				108

Diptera: Muscidae: *Limnophora*				108
Diptera: Simuliidae: *Simulium*				108
Diptera: Stratiomyidae: *Allognasa*				108
Diptera: Stratiomyidae: *Caloparyphus*		108		108
Diptera: Stratiomyidae: *Euparyphus*				108
Diptera: Syrphidae				108
Diptera: Tipulidae *Dicranota*				24
Diptera: Tipulidae *Limnophila*				72
Diptera: Tipulidae *Tipula*				36
Diptera: Tipulidae *Pedicea*				72
Diptera: Tipulidae *Antocha*				24
Diptera: Phoridae				108
Collembola		108	108	108
Hemiptera: Saldidae				108
Acari: Hydracarnia	108		108	108
Ostracoda	108		108	108
Copepoda	108		108	108
Cladocera				108
Mollusca: Gastropoda: *Gyraulus*				108
Mollusca: Spharidae: *Sphaerium*			108	108
Oligochaeta	108	108	108	108
Tricladida: Planariidae				108
Nematoda	108	108	108	108
total	1947	1890	1668	
n	23	22	18	
CTQa	84.65	85.91	92.67	

Table 9. Tolerance quotients September 2011.

Taxa	above South Fork (EC2)	at Whisky Canyon (EC4)	Lower Eccles (EC5)	Ideal stream (species list, including Boarding-house Creek)
Ephemeroptera: Baetidae: Baetis	72	72	72	72
Ephemeroptera: early instar	72	72	72	72
Ephemeroptera: Ephemerellidae: *Drunella sp.*				48
Ephemeroptera: Ephemerellidae: *Drunella dodsei*		4		4
Ephemeroptera: Ephemerellidae: *Serratella*				48
Ephemeroptera: Ephemerellidae: *Ephemerella*	48			48
Ephemeroptera: Heptageniidae: *Cinygmula*				21
Ephemeroptera: Heptageniidae: *Epeorus*				21
Ephemeroptera: Leptophlebidae: *Paraleptophlebia*				24
Plecoptera early instar	36	36	36	36
Plecoptera: Chloroperlidae: *Paraperla frontalis*				24
Plecoptera: Leuctridae: *Perlomyia utahensis*				18
Plecoptera: Nemouridae: *Malenka californica*				36
Plecoptera: Nemouridae: *Zapada*				16
Plecoptera: Perlididae: *Hesperoperla pacifica*				18
Plecoptera: Perlodidae: *Diura knowltoni*				24
Plecoptera: Perlodidae: *Skwalla parallela*				18
Plecoptera: Perlodidae: *Isoperla*	48	48		48
Plecoptera: Chloroperlidae: Sweltsa		24		24
Trichoptera: pupae				108
Trichoptera: Brachycentridae: *Brachycentrus*	24	24		24
Trichoptera: Brachycentridae**:** *Micrasema*				24
Trichoptera: early instar	108	108	108	108
Trichoptera: Hydropsychidae: *Arctopsyche*				18
Trichoptera: Hydropsychidae: *Hydropsyche*	108			108
Trichoptera: Hydroptilidae: *Hydroptila*				108
Trichoptera: Hydroptilidae: *Ochrotrichia*				108
Trichoptera: Limnephilidae: *Dicosmecus*				24
Trichoptera: Limnephilidae: *Hesperophylax*				108
Trichoptera: Polycentropidae: Polycentropus				108

Trichoptera: Psychomyiidae: *Tinodes*				108
Trichoptera: Rhyacophilidae: *Rhyacophila*	18	18	18	18
Trichoptera: Uenoidae: *Neothremma alica*				8
Trichoptera: Uenoidae: *Oligoplebodes*				24
Coleoptera: Dytiscidae				72
Coleoptera: *Heterlimnius*	108		108	108
Coleoptera: Elmidae: *Optioservus*		108		108
Coleoptera: Haliplidae: *Peltodytes*				54
Coleoptera: Narpus				108
Diptera: Ceratopogonidae	108	108		108
Diptera: Chironomidae	108	108	108	108
Diptera: Dolichopodia				108
Diptera: Empididae: *Chelifera*	108		108	108
Diptera: Empididae: *Hemerodromia*	108			108
Diptera: Empididae: *Neoplasta*				108
Diptera: Dixidae: *Dixa*				108
Diptera: Limoniidae: *Nr. Rhabdomastix*				108
Diptera: Muscidae: *Limnophora*				108
Diptera: Ptychopteridae: *Ptychoptera*				108
Diptera: Simuliidae: *Simulium*	108	108	108	108
Diptera: Stratiomyidae: *Allognasa*				108
Diptera: Stratiomyidae: *Caloparyphus*	108	108		108
Diptera: Stratiomyidae: *Euparyphus*				108
Diptera: Syrphidae			108	108
Diptera: Tipulidae *Dicranota*		24		24
Diptera: Tipulidae *Limnophila*				72
Diptera: Tipulidae *Tipula*			36	36
Diptera: Tipulidae *Pedicea*				72
Diptera: Tipulidae *Antocha*	24	24	24	24
Diptera: Phoridae				108
Diptera: *Scatella*				108
Collembola				108
Hemiptera: Saldidae				108
Acari: Hydracarnia	108	108		108
Ostracoda	108			108
Copepoda	108	108		108
Cladocera				108

Mollusca: Gastropoda: *Gyraulus*				108
Mollusca: Spharidae: *Sphaerium*	108	108		108
Oligochaeta	108	108	108	108
Tricladida: Planariidae			108	108
Nematoda	108	108		108
Total	1950	1552	1122	
N	23	20	14	
CTQa	84.78	77.60	80.14	

In September 2007 stations EC2, EC4, and EC5 had CTQa values of 92, 89.9, and 90 respectively. This contrasts with the fall 2004 CTQa readings of 64.5, 77, and 86.3 which would have placed station EC2 as a high quality system. In the July 2008 stations EC2, EC4, and EC5 had CTQa values of 54.9, 89.3 and 87. Both of the lower stations again showed impact or stress, but the upper station, as in 2004, showed high quality water. These results for EC2 in both the fall of 2004 and in July 2007 do not reflect other data being presented in this report. In addition, the CTQa for the July 2011 and September 2011 sample periods are higher for EC2, indicating that as the number of taxa increase the CTQa may be more accurately reflecting the stream condition. Of most importance here is the caution made in previous reports, that the CTQa values are based on the average index from just those taxa that are present, and taxa are not weighted for differences in abundance. A site could conceivably have a single individual, and nothing else, but if that organism has a low tolerance quotient assigned, one would conclude that the water was high quality. In station EC2 the organisms are on rock/marl surfaces, tend to be taxa with low tolerance to siltation, and by default, have a lower tolerance value. These include the mayflies *Cinygmula* and *Drunella doddsei*, the caddisfly *Rhyacophila*, and immature plecopterans.

CTQa values for Eccles Creek from the 1979, 1990, and 2000 sample periods can be examined for additional insights into the stream changes. In the 1979 series station EC2 has CTQa values in the mid-60s, EC4 had values in the low 60s and EC5 values were from the high 50s to mid 70s. The impact in the 1990s chemical spill in three stations below the mine (EC1, EC2, and EC4; Table 10), but the impact did not reach the lowest station, EC5. EC2 CTQa values before the chemical spill in the 1990s ranged in the 70s to 80. After the spill EC2 jumped to 86 and a year and a half later it fell to 73. EC4 during that same time period increased to 69-70, but by a year and half later it had essentially returned to the base levels. Beginning in 2001, with the high stream discharge, the average CTQa for the stream was 94. The next year EC2 was showing signs of heavy impacts (CTQa of 99) but both EC4 and EC5 had good CTQa values (52 and 66 respectively. By June of 2004, the CTQa also climbed into the 90s at these stations and has tended to remain in the 80s since then. The CTQa may show a seasonal signal, usually with lower CTQa values in the fall. With the 2011 samples it is still not possible to determine if the CTQa has peaked with the impact of the increased flow and may begin to decline, or if the stream will remain with an inflated CTQa as long as the high flows persist. It is apparent that the additional inflow has had a more intense, chronic impact on the stream than did the 1990 detergent spill.

Comparisons of Community Tolerance Quotient and Biotic Comparison Indices

The biotic condition index (BCI) is CTQp/CTQa X 100. This measure (Winget and Mangum 1979) can be used in conjunction with CTQa to generate a broader interpretation of the state of stream systems. Ideally, if all predictors are accurate, a pristine system will have a BCI of 100 (CTQp = CTQa). BCI values below 100 represent a condition where fewer clean water taxa than predicted are present and thus indicate a reduction in the quality of the habitat. Any BCI value above 100 represents communities whose clean water taxa are in greater abundance than predicted. In 37 of the 58 sample stations presented in this report (Table 10), the BCI was 100 or higher. All of the stations sampled in 1979 had BCI values above 100, averaging over 120.

Table 10. CTQa and BCI values for selected studies on Eccles Creek.

	Winget 1980		Ecosystems Research Institute 1992			Shiozawa 2002a	Shiozawa 2002c	Shiozawa 2003	Shiozawa & Hansen 2004	Shiozawa 2005	Shiozawa 2005
Sampling date	May-June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002	June 2003	Oct 2003	June 2004
	CTQa/BCI	CTQa/ BCI	CTQa/BCI	CTQa/BCI	CTQa/BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI
South Fk. trib. abv. mine (USF2)			59/133	53/151							
South Fork trib. abv. mine (USF)	66/121		49/163	59/136	45/178						
Middle Fork trib. abv. mine (UMF)	69/117		54/148	49/163							
Eccles Creek below mine (EC1)			67/119	108/74							
Eccles Creek abv. S. Fk. (EC2)	64/125	65/123	86/93		73/110		99/81	86/93	87/92	88/91	83/97
South Fork Eccles Creek (SF)	59/136	64/125	55/145								
Eccles Cr. below S. Fk. (EC3)	65/123	55/145									
Eccles Creek at Whisky Can. (EC4)	62/127	61/131	69/116	70/114	63/127	94/85	52/154	69/116	94 /79	76/105	91/88
Lower Eccles Creek (EC5)	59/136	74/108	53/151	55/145 57/140	58/138		66/121	69/116	97/82	71/112	88/91
Average	62/131	64/126	59/140	64/132	60/138	94/85	72/119	75/108	93/86	78/102	87/92

Table 10. continued CTQa and BCI values for selected studies on Eccles Creek.

	Shiozawa & Fordham 2010	Shiozawa & Fordham 2010	This report	This report
Sampling date	Sept 2007	July 2008	June 2011	Oct 2011
	CTQa/BCI	CTQa/ BCI	CTQa/ BCI	CTQa/ BCI
South Fk. trib. abv. mine (USF2)				
South Fork trib. abv. mine (USF)				
Middle Fork trib. abv. mine (UMF)				
Eccles Creek below mine (EC1)				
Eccles Creek abv. S. Fk. (EC2)	92/87	55/145	85/94	85/94
South Fork Eccles Creek (SF)				
Eccles Cr. below S. Fk. (EC3)				
Eccles Creek at Whisky Can. (EC4)	90/89	89/90	86/93	78/103
Lower Eccles Creek (EC5)	90/89	87/92	93/86	80/100
Average	90/88	77/109	88/91	81/99

Likewise, all but one station, which was directly below the mine, in the 1990-1991 spill had BCI values above 100. Of the 28 stations sampled since 2001, nine were above 100. The majority of these were fall samples from stations EC4 and EC5. However it is not certain that the samples with high BCIs (over 100) are detecting high habitat quality in the stream. Other data, especially the individual densities and biomass, suggest otherwise.

Four of the stations examined in 2011 had BCI values less than 100. The two stations sampled in 2011 that had BCI values at 100 or above were Station EC4 in September, 2011 and Station EC5 in September, 2011. However given the relationships assigned by Winget and Mangum (1979) all six stations are rated as having high to moderate quality and are in need of water quality improvement.

Diversity

Diversity indices are a way of combining both the number of taxa and their relative densities into a single metric. High diversity index values indicate that the taxa have relatively evenly distributed densities in a community. It also generally reflects higher numbers of taxa in a community. Low diversity values generally result from a depauperate fauna in the number of species and populations where just a portion of the taxa dominate in number. The baseline stations (1979 samples; Table 11) had diversity values ranging between 1.96 and 3.51. The areas impacted by the chemical spill in 1990-1991 had diversities values between 0.4 and 1.6.

Diversity values for all sampled stations were below 1.0 from 2001-2002. In June 2003 station EC2 was 1.3, while stations EC4 and EC5 were slightly below their July 2002 levels but above their October 2002 readings. By October 2003, station EC4 had increased in diversity from 0.96 in June 2003 to 1.43. Station EC2 dropped in diversity to 1.19. Station EC5 was still below 1.0, with a diversity index value of 0.75 which was slightly lower than its June 2003 level. The June 2004 diversity readings showed station EC2 decreasing slightly to 1.17, and station EC4 also fell to a diversity value of 0.98. In contrast, station EC5 increased significantly in diversity to 1.47. The fall 2004 samples indicated that station EC2 was continuing to have a decline in diversity dropping to an index value of 0.94. EC4 increased its diversity reading to 1.17, but EC5 declined to 1.05.

In September 2007 EC2 and EC5 diversity values were 1.10 and 1.14 respectively. However station EC4 had a diversity value of 2.15, close to the base-line sites in 1979. The high diversity readings from EC4 in 2007 stems in part from the high number of taxa recorded and in part from the relatively low overall density at that site. In July 2008 the diversity values at all three stations were between 0.95 and 1.2, not much different from the previous sample series for EC2 and EC5, but it represents a significant diversity drop in station EC4. The July 2011 diversity values ranged from 1.29 to 1.53 and the September 2011 ranged from 1.28 and 1.74. Overall the three stations appear to have a slowly rising trend in the diversity values. This could be due to 1) a recovery of the community towards pre-flooding conditions (e.g. The stream is developing a new riffle-pool equilibrium with the new flow regime), 2) established taxa beginning to increase their individual densities so that the increased evenness is resulting in higher diversity values, or

Table 11. Diversity indices based on natural logs for selected studies on Eccles Creek.

Eccles stations	Winget 1980		Ecosystems Research Institute 1992			Shiozawa 2002a	Shiozawa 2002c	Shiozawa 2003	Shiozawa & Hansen 2004	Shiozawa 2005	Shiozawa 2005	Shiozawa 2007	Shiozawa & Fordham 2010		This Report	
Sampling date	May-June 1979	Aug 1979	June 1990	Oct 1990	Sept 1991	Nov 2001	July 2002	Oct 2002	June 2003	Oct 2003	June 2004	Oct 2004	Sept 2007	July 2008	July 2011	Sept 2011
South Fork tributary above mine, upper site (USF2)			1.63	1.9												
South Fork tributary above mine (USF)	2.63		1.72	1.9	0.702											
Middle Fork tributary above mine (UMF)	2.11		1.66	1.9												
Eccles Creek below mine (EC1)			1.06	0.7												
Eccles Creek above south Fork (EC2)	2.44	1.964	1.58		0.400		0.398	0.836	1.314	1.190	1.165	0.939	1.100	0.956	1.285	1.329
South Fork Eccles Creek (SF)	3.510	3.322	1.62													
Eccles Creek below South Fork (EC3)	2.450	2.743														
Eccles Creek at Whisky Canyon (EC4)	2.450	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
Lower Eccles Creek (EC5)	2.280	2.590	1.24	1.8/ 1.4	0.416		0.829	0.341	0.789	0.750	1.474	1.052	1.141	1.149	1.528	1.276

3) gradual dispersal into and successful colonization of the stream by taxa more tolerant of the present ambient conditions in the stream is gradually occurring.

Unfortunately the diversity indices do not help answer this question. Diversity index values can be similar whether obtained with high numbers of taxa or with low numbers of taxa, depending on how the evenness is distributed among the taxa. A high number of taxa with low evenness can generate a diversity index value similar to a low number of taxa with higher evenness. Other techniques need to be explored to determine whether or not the community is returning to a pre-impact state.

Cluster Analysis

Cluster analysis generates a visual representation of relationships among samples or stations. The Bray-Curtis dissimilarity index utilized in this study considers both quantitative counts of individuals within each taxon and the relative densities of those organisms (Poole 1974). A total of 56 station-date combinations were included in the cluster dendrogram (Figure 1). Each station-date combination is a composite of the individual samples taken at each station. The degree of dissimilarity is high in the resulting cluster so the associations should be interpreted as generalized relationships that give a pattern of relationships but are not statistically rigorous. These should be considered exploratory data analyses.

Cluster 1 – high impact response

With the 2011 stations added to the database, three highly dissimilar (98%, 93%) clusters were generated. The cluster with the fewest stations is cluster 1 (the lowest cluster on Figure 1). It consists of stations E1, E2, and E4 from 1990-91. These were stations nearest the mine and they would be expected to have suffered the greatest impact from the chemical spill in the 1990s. This cluster also includes the sample taken at station EC4 shortly after the increase in stream discharge in November, 2001. This suggests that in 2001 station EC4 responded to the increase in discharge with drastic changes in taxa composition in a manner similar to the 1990 perturbation. No other samples fell into this cluster. This same grouping was found in previous cluster analyses. This cluster reflects an immediate deleterious physical /chemical change in the stream. Thus immediately after the increase in discharge into Eccles Creek the stream community responded in a fashion similar to what happened in the chemical spill. In both cases drastic losses of taxa occurred.

Cluster 2, Subcluster 1 – transitional impact response

The remaining stations fell into the second cluster and within that, one of two sub-clusters, separating at 93% dissimilarity. The lower of these sub-clusters (Figure 1; Subcluster 1) contains the remainder of the 1990 sampling series as well as a number of fall samples taken from the upper (E2) and middle (E4) sampling stations between 2002 and 2003. This sub-cluster

Figure 1. UPGMA cluster dendrogram of relationships among invertebrate communities from Eccles Creek.

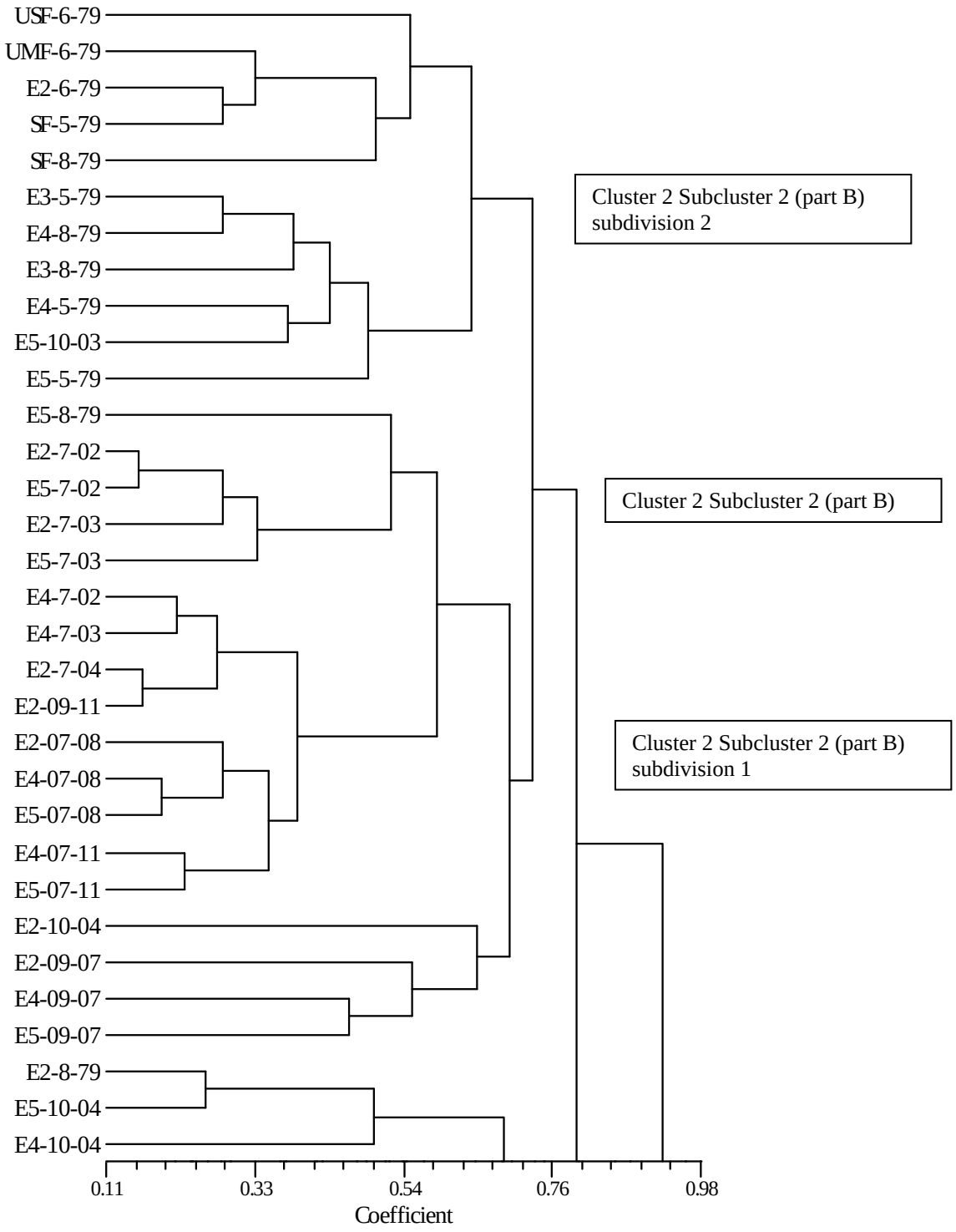
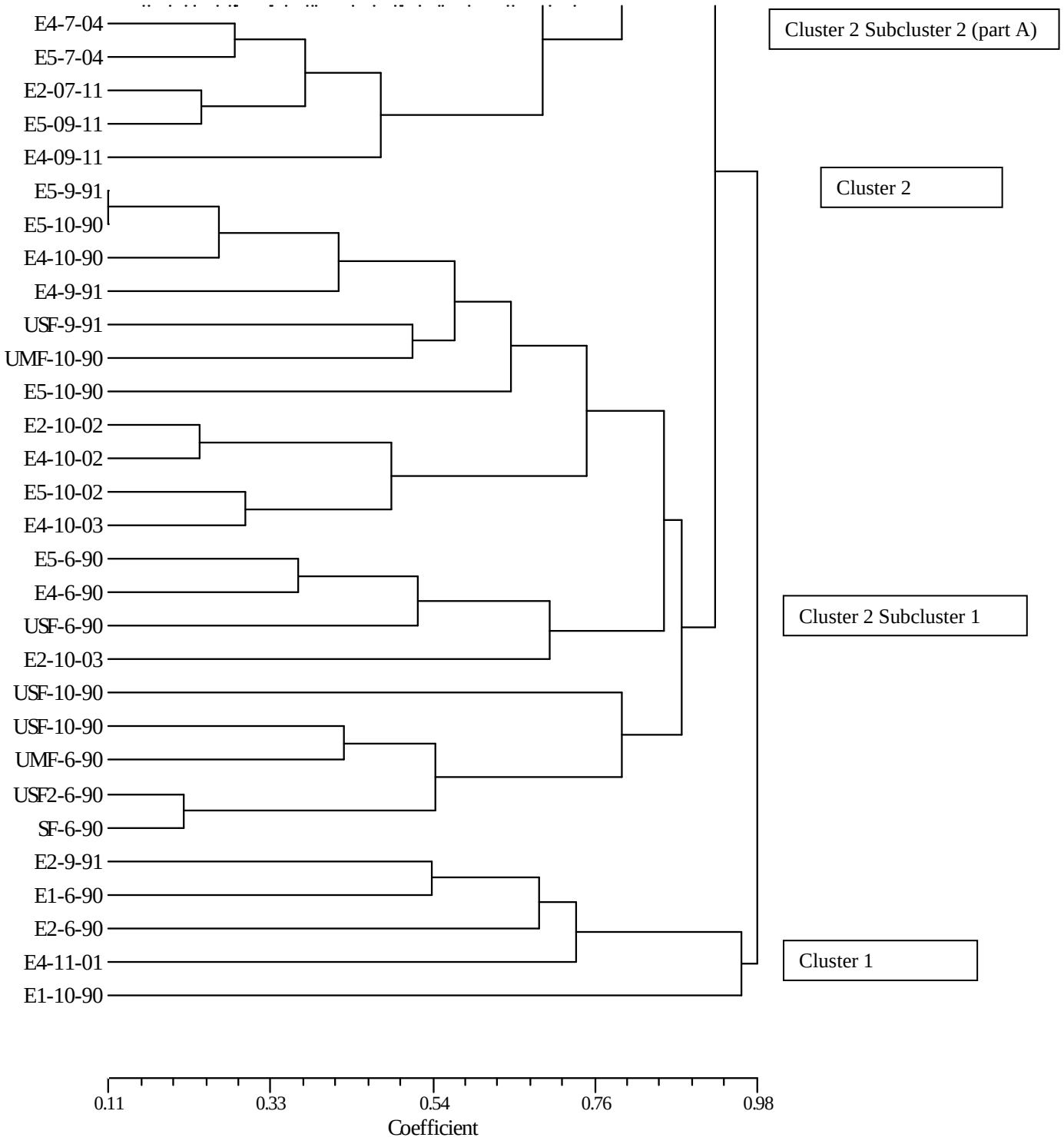


Figure 1 Continued. UPGMA cluster dendrogram of relationships among invertebrate communities from Eccles Creek.



is comprised of stations that have had a significant impact to their invertebrate community but appear to be biologically responding/adapting to the impact. Unfortunately we do not know the trajectory of the 1990 spill beyond this subcluster since sampling was not extended to recovery following the spill. It may be that recovery from both the chemical spill and the increased discharge are following the same path, but our lack of additional data does not allow us to evaluate the entire time series of changes.

Cluster 2 Subcluster 2 part A

The remaining stations are in subcluster 2 This subcluster is separated into two parts; part A and part B (Figure 1). Part A includes three of the 2011 stations along with four 2004 stations (spring and fall EC4 and EC5) and one 1979 reference station. While these do form a discrete cluster, it is defined at about 79% dissimilarity.

Cluster 2 Subcluster 2 part B

This group contains most of the samples and it has two clear subdivisions, one containing most of the stations impacted by high flows after 2002 (Subcluster 2 part B subdivision 1) and one with the majority of the reference stations (Subcluster 2 part B subdivision 2). These two subdivisions separate at about 75% dissimilarity, but the fact that the reference sites mostly fall into Subcluster 2 part B subdivision 2 indicates that the clustering separates the communities based on shared taxa.

The clustering gives a slightly different picture of what may be happening in the system as opposed to the more static images generated by the previous data sets. Cluster 2 Subcluster 2 part B subdivision 2 represents the reference stream community structure. Cluster 1 represents the immediate stream community response to a strong impact, whether it is a sustained increase in discharge or a point-source chemical spill. After this perturbation either stops (as in a chemical spill) or becomes a fixed part of the environment, the community responds by moving to a state more similar to the original community. Cluster 2 Subcluster 1 represents a transitional phase in that adjustment likely associated with species recolonizing from nearby sources and refuges. As time progresses and the community continues to become more similar to the original baseline composition, it should be clustering more closely with the reference clusters (Cluster 2 Subcluster 2 Part B subdivision 2). This trend should explain the sequence of clusters and subclusters becoming more similar to the reference stations.

The fact that no post-2001 stations fall into Cluster 2 Subcluster 2 Part B subdivision 2 (the reference community) indicates that the system has not yet recovered. Further, the shifting of some 2011 samples into Cluster 2 Subcluster 2 Part A, more dissimilar than the reference station, may reflect either a local perturbation (high spring runoff) causing a temporary change in community structure, or a broader process such as the development of a community more adapted to the new ambient conditions of the stream. If this includes new taxa that must disperse from distant sources, colonization could be a slow process.

The cluster analysis provides some evidence of the communities converging towards a common type, but whether that convergence is progressing to the original reference state is not clear with this analysis. However alternative techniques may enhance that understanding. To do that, canonical correspondence analyses was applied to the data set.

Correspondence Analysis

Correspondence analysis, an ordination technique (Braak and Smilauer 2002), was run on the data set in order to generate a graphical view of the relationships among the stations sampled in Eccles Creek. This includes the baseline data collected in 1979. A plot of the station ordinations (Figure 2) was generated to show the 2011 associations in the analyses. The corresponding invertebrate taxa ordination (Figure 3) was nearly identical to the plot in the 2010 report. Therefore the invertebrate plot from Shiozawa and Fordham (2010) without the 2011 data was included here for general illustrative purposes. For simplicity only the first two canonical axes were plotted. These two axes only carry a portion of the total variation being explained by the procedure, but they are sufficient for illustrating the associations.

The results (Figure 2) show a clear separation of the samples taken in 1979 (black triangles) from those taken in the 1990s (circles) and those taken in the 2001-2011 series (green, purple, red, and blue symbols). Some of the 1990-1991 samples were taken from locations (tributaries) that were not directly affected by the spill. Ellipses were drawn to help delineate the samples. The red ellipse (lower left) thus includes both the 1979 baseline samples and unimpacted tributary streams sampled in the 1990s. The 1990 tributary series have separated to the right on the first ordination axis and up on the second ordination axis (Figure 2).

The impacted stations for the 1990 sample period fall mainly in the upper center of the figure (denoted with a blue ellipse). Stations EC1 and EC2 (E1-6-90 and E2-6-90, Figure 2), which were the most heavily impacted by the spill, are central on the plot. Sampling associated with the chemical spill did not continue to recovery, so the trajectory of the stations between 1992 and 2000 are not known. The 2001-2011 sample series forms a discrete grouping in the lower right of the ordination plot (green ellipse in Figure 2). It appears to have a larger scatter in the second ordinal axis.

Of note with this plot is that the 2001 sample station (Figure 1; black square) falls clearly in the center of the green ellipse. This indicates that the cluster analysis could not identify associations as accurately as the canonical correspondence ordination. This is not surprising given the degree of dissimilarity in separating the basal clusters (Figure 1). Another important point is that the 2011 samples (Figure 2; blue circles) fall in the center of the green ellipse. This suggests that the communities in Eccles Creek are not tending to move back towards the reference state. Instead they seem to be staying in a fixed region of the canonical space. That conclusion was already alluded to with the individual density data and the biomass data evaluations.

Figure 2. Ordination of stations by date using Correspondence Analysis with log X+1 transformed data.

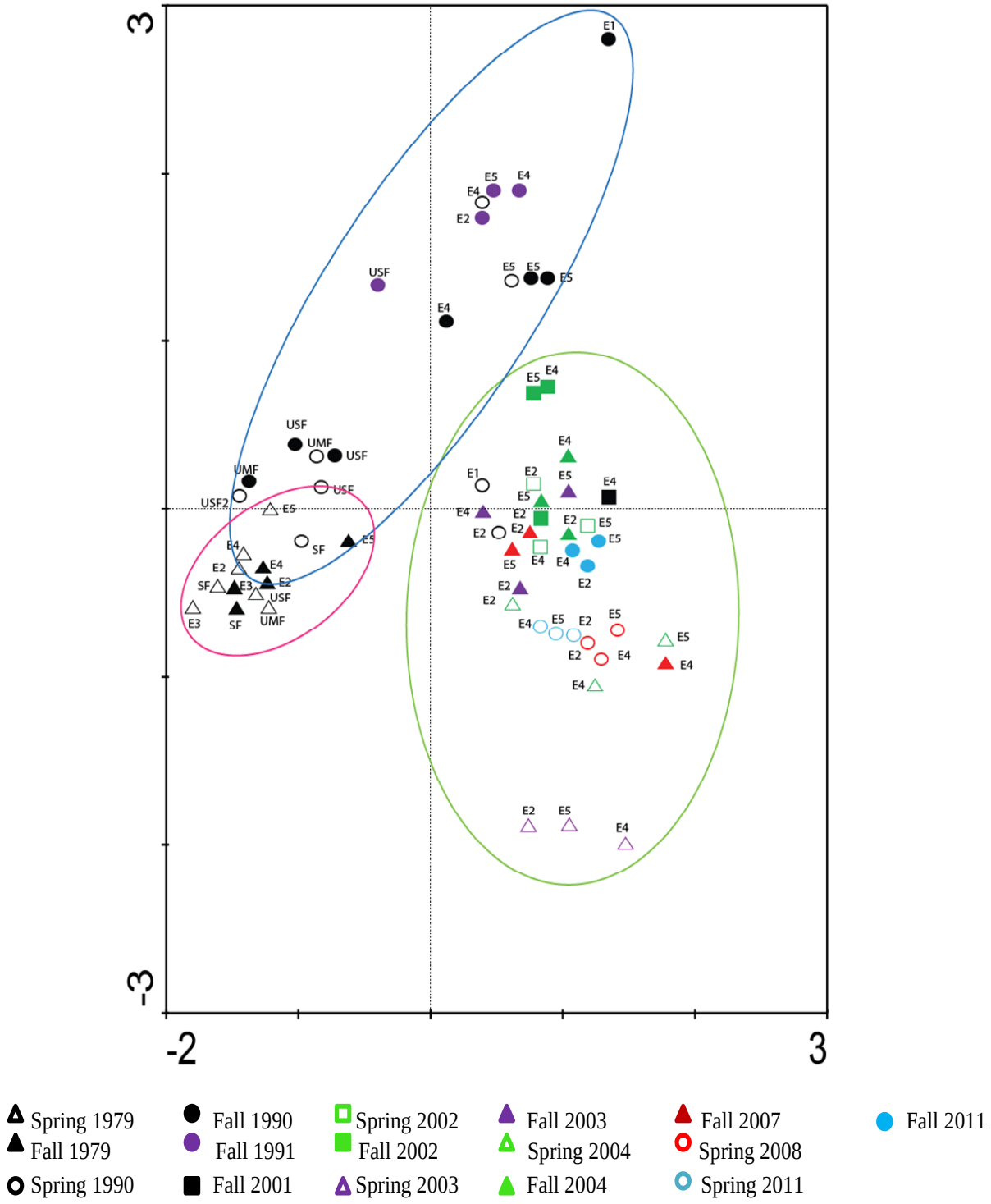
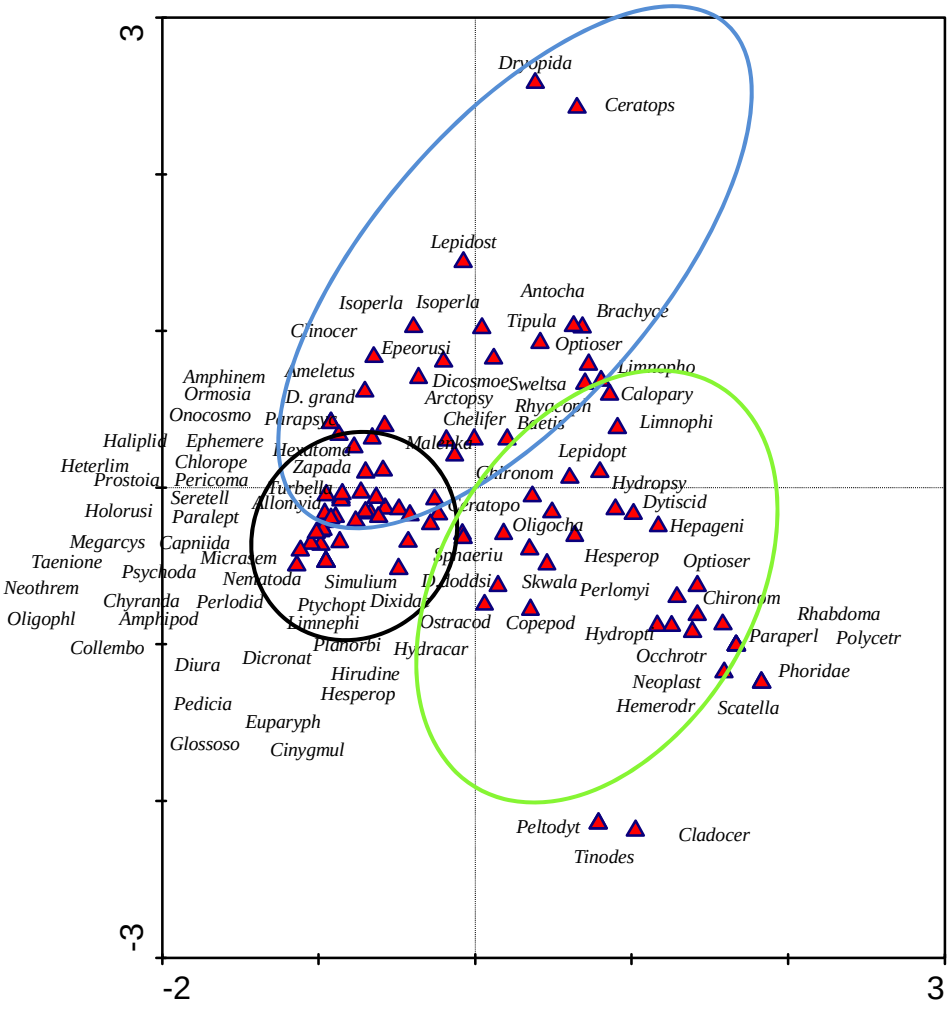


Figure 3. Taxa ordination corresponding to the stations in Figure 2, based on Correspondence Analysis with a log X+1 transformed data. Black circle = 1979 control conditions, blue = 1990 impact conditions, and green = 2001-2008 conditions.



The plot of the taxa utilized in the analysis (Figure 3) shows which taxa were important in the ordination of samples in Figure 2. Stoneflies (chloroperlids, capniids, perlodids: *Diura*, *Megarcys*) caddisflies (Glossomatidae, *Neothremma*, *Oligophlebodes*, *Onocosmoecus*) and mayflies (*Seretella*, *Cinygmula*, *Paraleptophlebia*) are important groups in establishing the position of the baseline stations from 1979 (Figure 2). The 1990 impact is especially noted in the densities of dryopids and *Ceratopsyche* and to a lesser extent *Brachycentrus*, *Antocha*, and *Tipula* The high discharge communities of 2001 through 2011 are most notable by *Hemerodromia*, *Paraperla*, *Optioservus*, and the caddisfly *Hydroptilla*.

These two ordinations (figures 2 and 3) give a distinct separation of the types of communities under normal, chemical, and high discharge impacts. The 2001-2011 samples have not shown a shift back towards the baseline state.

SUMMARY

Number of taxa

The number of taxa in 2011 increased, being one half to essentially 100% of the 1979 reference site collections. Alone, this would suggest that the system is recovering from the impacts associated with the high flows. However the increase in number of taxa needs to be monitored to determine if that number is relatively constant, or if it is just part of natural variation about a lower mean number of taxa. The data do suggest a trend of gradually increasing numbers of taxa being present in the stations.

Total densities

Based on total densities recorded in 2011, all stations either equaled or exceeded the 1979 reference community total density estimates. However concerns exist with potential differences in sorting protocols by different laboratories. Our quantitative approach may result in higher than average recovery of organisms from the samples. Never-the-less, total densities indicate that the stream is near the 1979 baseline levels.

Individual densities

In 2011, over 90% of the total density at a station was due to just 3 to 6 taxa. Chironomids made up between 40% and 60% of the total number with oligochaetes also being very abundant. These highly skewed abundances are more typical of stressed environments. This suggests that the communities are not trending towards the 1979 reference state and recovery.

Biomass

The overall mean biomass in Eccles Creek was 5.2 g/m^2 in 2011. In contrast Woods and Winter Quarters canyons had a mean biomass of 43 g/m^2. While the biomass estimates in Eccles Creek ranges from 7 g/m^2 to 36.7 g/m^2, the mean biomass indicates that the invertebrate standing stock is seldom near the upper end of the range and a slow trend of decreasing biomass may be underway. The 2011 overall biomass estimates for Eccles Creek are a tenth of the respective Woods-Winter Quarters estimates. One exception needs to be noted. The July 2011 Woods and Winter Quarters Canyon biomass estimates were similar to those of the 2011 Eccles Creek stations. The July 2011 samples in Woods and Winter Quarters Canyons followed significant rearrangements of the stream channel by high spring runoff. Thus these reference streams had been impacted by flooding. Eccles Creek did not show a similar catastrophic biomass decrease, the sites were generally consistent with or slightly lower than previous biomass estimates. This could be related to a benthic community that is adapted to high flows and thus is less impacted by spring flooding.

CTQa/BCI

The July 2011 CTQa values were 84.6 for EC2, 85.9 for EC4, and 92.7 for EC5. In September 2011 CTQa values were 84.8 for EC2, 77.6 for EC4, and 80.1 for EC5. These are high enough to indicate stressed waters with lower water quality. The BCI – CTQa relationships placed all three stations for the two sampling periods as in need of water quality improvement. Overall the CTQa increased in the stream, indicating poorer habitat quality. The increase was first detected in the upstream station, but within a year similar shifts occurred in the downstream stations. The CTQa fel from the high 90s to the 80s and has ended to remain in the high 70s to low 90s range since 2003. At this point no clear shift to an improved (lower) CTQa is apparent in the data.

Diversity

Diversity values do not indicate recovery of the stations. However with the addition of the 2011 data a slow trend of increasing diversity may be underway. It is not clear what is causing this, but it is unlikely that it is through the addition of taxa that were originally found in the reference conditions. It is more likely the either newly established taxa are increasing in numbers or, with time, new colonizers that can survive in the new conditions of the stream are able to disperse into the system.

Cluster analysis

Cluster analysis shows a shift in the 2001-2011 communities from initially very divergent states, likely induced by the initial impact of a perturbation, whether an acute chemical spill or the initiation of a chronic impact such as the increased discharge into Eccles Creek in 2001. After

the initial impact the community begins to respond by the reinvasion of eliminated taxa. These immediate recolonizers may or may not become re-established, depending on the state of the stream. One would expect that following an acute impact, recolonization will progress back to the original community structure. However with a chronic impact, the community should develop towards a set of taxa able to survive under the new prevailing conditions. The speed at which a new equilibrial community develops depends in part on the pool of potential colonizers in the region. The more dissimilar the stream is from adjacent streams, the longer it will take for a new community to develop and stabilize.

Correspondence analysis

Correspondence analysis also indicates that the stations in 2011 have not converged towards the original 1979 baseline conditions. This reinforces the differences between the sustained high flow Eccles Creek and the unimpacted reference stream community structure. This analysis indicates that Eccles Creek has shifted to a new region in the ordination space and the stations over almost the last decade have consistently stayed in the same general position in the station plot.

LITERATURE CITED

Braak, C. J. F. and P. Smilauer. 2002. CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (Version 4.5). Microcomputer Power. Icatha, NY. 500 pp.

EarthFax Engineering. 2001. Memo to Chris Hansen of Canyon Fuel Company, Skyline Mine. October 24, 2001.

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

Krebs, C. J. 1989. Ecological Methodology. Harper and Row Pub., Inc. NY, NY. 654 pp.

Merritt, R. W. and K. W. Cummins. (eds.) 1996. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Co. Dubuque, IA. 862 pp.

Merritt, R. W., K. W. Cummins, and M. B. Berg. (eds.) 2008. An Introduction to the Aquatic Insects of North America. 4th Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa. 1158 pp

Pielou, E. C. 1977. Mathematical Ecology. John Wiley and Sons. NY, NY. 385 pp.

Poole, R. W. 1974. An Introduction to Quantitative Ecology. McGraw-Hill, Inc. 532 pp.

Rolf, F. J. 2000. NTSpc: Numerical Taxonomy and Multivariate Analysis System. Version 2.1. Exeter Software. Setauket, NY.

Shiozawa, D. K. l983. Density independence versus density dependence in streams. pp. 55-72, in Stream Ecology: Application and Testing of General Ecological Theory. eds., J. R. Barnes and G. W. Minshall. Plenum Press, NY.

Shiozawa, D. K. 2002a. The Benthos of Bordinghouse & Eccles Creeks and the Impact of Increased Water Discharge into Eccles Creek in 2001. Report to Canyon Fuel Co, LLC. Skyline Mines. February, 2002.

Shiozawa, D. K. 2002b. A compilation and comparison of the Eccles Creek macro-invertebrate data for the period of 1979-2002. Report to Canyon Fuel Co, LLC. Skyline Mines. Sept., 2002.

Shiozawa, D. K. 2002c. The benthos Eccles Creek and the impact of increased water discharge in 2002. Report to Canyon Fuel Co, LLC. Skyline Mines. October, 2002.

Shiozawa, D. K. 2003. Eccles Creek benthic invertebrate monitoring, October, 2002. Report to Canyon Fuel Co, LLC. Skyline Mines. June, 2003.

Shiozawa 2004. Baseline monitoring of the benthos of Winter Quarters Canyon and Woods

Canyon creeks, October, 2002 and June of 2003. Report to Canyon Fuel Co, LLC. Skyline Mines. June, 2004.

Shiozawa, D. K. and A. Fordham. 2010. An Assesment of the macroinvertebrates of Eccles Creek in September 2007 and July 2008. Report to Canyon Fuel Co, LLC. Skyline Mines. March, 2010.

Shiozawa, D. K. 2007. Assessment of the macrobenthos of Eccles Creek. October 2004. Report to Canyon Fuel Co, LLC. Skyline Mines. March, 2007.
Shiozawa and Fordham 2010 An assessment of the macroinvertebrates of Woods Canyon Creek and Winter Quarters Creek, Sevier County Utah in October 2007 and July 2008.

Shiozawa, D. K. and K. Kauwe 2006. Eccles Creek benthic monitoring, June 2004. Report to Canyon Fuel Co, LLC. Skyline Mines. November, 2006.

Shiozawa D. K. and A. Fordham 2010 An assessment of the macroinvertebrates of Woods Canyon Creek and Winter Quarters Creek, Sevier County Utah in October 2007 and July 2008. Report to Canyon Fuel Co, LLC. Skyline Mines. March, 2010.

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.

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

AN ASSESSMENT OF THE MACROINVERTEBRATES OF WOODS CANYON CREEK & WINTER QUARTERS CREEK CARBON COUNTY, UTAH

in

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Introduction

The coal underlying both Woods Canyon and Winter Quarters Canyon is being mined. This report gives the results of benthic invertebrate monitoring of the stream systems in July of 2011. These data help establish baseline conditions against which any impacts due to the mining and subsequent subsidence can be compared. The 2011 samples were extended downstream in Woods Canyon because mining has shifted further East (these streams drain to the East).

Methods

Sample placement was determined by examination of the stream systems on USGS 7.5 minute quadrangles. Three reaches were examined on each stream, with each reach being defined by the inflow of a side stream and the general distance from the previous reach. The lowest reach in Winter Quarters Canyon was established on U. S. Forest Service land above the boundary with private grazing lands. The lowest station in Woods Canyon was new, beginning with this sampling series, and was designated the Base reach to avoid confusion between it and the original Lower Station which was established when sampling was first initiated on Woods Canyon. The location of each reach is given in Table 1. Four riffles were sampled within each reach in the fall of 2002, but this was increased to 8 riffles in the spring of 2004. Two samples were taken at each riffle and were bulked together in the field.

Table 1. Sampling station locations

Canyon	Reach	GPS coordinates	Elevation
Woods	Upper	N 39° 44.340' W 111° 13.471' UTM4398045 12S0480808	2609 m (8560 ft)
Woods	Lower	N 39° 44.071' W 111° 12.592'	2552 m (8374 ft)
Woods	Base	N 39° 44.091' W 111° 12.024'	2486 m (8156 ft)
Winter Quarters	Upper	N 39° 42.763' W 111° 13.907'	2587 m (8488 ft)
Winter Quarters	Middle	N 39° 42.933' W 111° 13.378'	2571 m (8434 ft)
Winter Quarters	Lower	N 39° 43.126' W 111° 12.807'	2519 m (8265 ft)

Physical characteristics for each reach were recorded (Table 2, 3). These included pH, conductivity, in micro-Siemens/cm (uS/cm), alkalinity, and hardness. Alkalinity and hardness were measured with a Hach water chemistry kit. The spring runoff in 2011 was very high and the sampling stations were significantly rearranged by the high flows. Thus the channel morphology, which had remained constant since sampling was initiated, was quite different, becoming more shallow in most stations. Those data are provided in Tables 2 and 3. Slope was recorded with an inclinometer, across a 100 meter length of stream, beginning at the first (starting downstream) riffle. The stream channel within each reach was characterized by measuring the width, depth, and velocity of the stream every five meters, beginning with the first

riffle. Three depth and velocity measures were taken at each five meter interval, these being at the center and approximately 10% of the width from either shore.

Quantitative invertebrate samples were taken with a modified box sampler (Shiozawa 1986) using a capture net with a net mesh of 253 microns. Samples were taken from each of the three reaches in Winter Quarters and Woods Canyon. Samples were concentrated in the field in sieves with 63 micron mesh netting and were preserved with ethyl alcohol. In the laboratory the samples were sorted in an illuminated pan and organisms were removed. After the visual sorting, the sample was subsampled and the subsamples were examined under magnification. The density estimates from the subsamples were calculated and the projected numbers of organisms missed in the visual sorting were added to the total for the sample. Organisms were identified to the lowest taxonomic unit possible. Small specimens and those of questionable identity were further examined under magnification. Identification was based on the keys of Merritt and Cummins (1996) and Merritt, Cummins, and Berg (2008). The mean values for each taxon were used to determine the density of invertebrates per square meter. Standing crop was estimated from wet weights of total invertebrates collected at the station.

Table 2. Physical Characterization of Woods Canyon Creek

Date	Site	Alkalinity mg/L $CaCO_3$ equivalents	Hardness mg/L $CaCO_3$ equivalents	Conductivity (uS/cm)	slope	depth (cm)	width (m)	velocity (m/s)	pH
10/19/02	1 2	136.8 188.1	273.6 324.9	415 452	4.0^o 3.5^o	3.6 4.333	1.213 1.157	0.268 0.327	8.30 8.23
6/27/03	1 2	119.7 136.8	222.3 239.4	351 393	4.0^o 3.5^o	5.267 6.250	1.645 1.345	0.187 0.276	8.18 8.42
10/13/03	1 2	220 260	320 320	380 440	4.0^o 3.5^o	2.650 3.66	1.048 1.038	0.140 0.118	8.63 7.73
6/28/04	1 2	220 240	240 240	340 405	4.0^o 3.5^o	5.56 4.76	1.919 1.580	0.174 0.244	8.52 8.36
9/25/07	1 2	160 160	180 180	377 446	4.0^o 3.5^o	7.53 5.00	1.296 1.591	0.181 0.175	8.43 8.40
7/17/08	1 2	120 120	200 240	313 396	4.0^o 3.5^o	6.42 8.73	2.304 1.793	0.454 0.493	8.41 8.33
7//11	1 2 3	16 35 35	140 100 110	237 393 399	2.6^o 2.1^o 3.5^o	16.03 15.76 17.20	1.835 1.971 2.218	0.2624 0.7916 0.6211	7.70 7.71 8.10

1 - Upper Site 2 - Lower Site 3 – Base Site

Table 3. Physical Characterization of Winter Quarters Creek

Date	Site	Alkalinity mg/L $CaCO_3$ equivalents	Hardness mg/L $CaCO_3$ equivalents	Conductivity (uS/cm)	slope	depth (cm)	width (m)	velocity (m/s)	pH
10/18/02	1 2 3	119.7 136.8 136.8	188.1 273.6 256.5	343 371 390	4.0° 3.0° 2.5°	5.8 6.367 6.983	1.028 1.252 2.129	0.199 0.240 0.222	8.26 8.34 8.32
6/20/03	1 2 3	51.3 85.5 119.7	136.8 153.9 205.2	239 275 352	4.0° 3.0° 2.5°	8.633 8.3 11.433	1.215 1.799 2.07	0.224 0.333 0.399	8.39 8.60 8.62
10/15/03	1 2 3	140 200 180	240 260 260	280 310 280	4.0° 3.0° 2.5°	4.817 6.433 5.266	0.978 1.945 1.680	0.210 0.275 0.240	8.57 8.55 8.58
6/30/04	1 2 3	160 180 180	160 200 240	260 294 353	4.0° 3.0° 2.5°	6.066 7.133 8.833	1.10 1.45 1.83	0.254 0.348 0.345	8.60 8.48 8.52
10/4/07	1 2 3	140 140 140	200 200 220	317 363 390	4.0° 3.0° 2.5°	5.917 7.233 9.600	1.059 1.853 2.183	0.168 0.242 0.2999	8.49 8.54 8.66
7/19/08	1 2 3	160 140 140	100 220 200	247 308 355	4.0° 3.0° 2.5°	8.700 10.47 13.867	1.398 2.19 2.631	0.4638 0.5086 0.6348	8.43 8.56 8.68
7/17/11	1 2 3	20 20 20	140 140 120	232 329 357	3.2° 2.5° 2.6°	11.833 14.000 16.333	2.597 2.048 2.682	0.3148 0.5282 0.4560	8.60 8.78 9.10

1 - Upper site 2 - Middle site 3 - Lower Site

The USFS Biotic Condition Index (Winget and Mangum 1979) was calculated with the community tolerance quotient (CTQa). The predicted community tolerance quotient (CTQp), based on water chemistry data provided in Winget (1972) for the Huntington Creek drainage, has been consistently 80. But in the spring 2011 samples water hardness and alkalinity dropped considerably, likely associate with a higher proportion of shallow surface runoff rather than groundwater input and, as noted above, slope also changed. Since we did not have a measure of sulfate concentration, we assume it also fell with the high flows as is typical for chemical concentrations under such situations (Hem 1971). This changed the CTQp to 50 for all sites.

Diversity was calculated for each reach using the Shannon-Weiner index (Pielou 1977). Diversity indices take the number of taxa and their individual proportional densities into account, generating a single value for each station. The greater the number of species or taxa and generally the more even the distribution of densities between taxa, the higher the diversity index value.

Cluster analysis was run with NTSYS-pc (Rolf 2000), using the Bray-Curtis dissimilarity index

with the UPGM clustering algorithm. Data from all reaches for the previous sampling periods from both Woods Canyon Creek and Winter Quarters Canyon Creek were included in the cluster analysis.

Since these samples are to be used to establish pre-mining base-line information, the most important information for future assessment will be the actual densities and taxa lists. The CTQa, diversity indices, and cluster analysis will serve to help understand relative associations between the two streams, seasonality effects, and within stream trends. As with all field collected data, annual variations in weather patterns (e.g. drought, high runoff) will need to be taken into account in interpreting the data.

Results and Discussion

Physical Characterization

The pre 2011 stream channel slopes became shallower as the streams proceeded down the canyons, a typical geomorphological profile for stream systems draining mountainous areas (Horton 1945). However following the high runoff in 2011, Upper and Lower Woods Canyon were more shallow than before. This is likely a transitional phase which should return towards an equilibrium profile over time. However since equilibrium dynamics are a function of watershed –level processes, not site specific changes, this may not happen if the site specific channel rearrangements included movement of large woody debris and boulders to new locations. Channel depth increased downstream for Winter Quarters Canyon and channel width increased downstream in Woods Canyon, but the width in Winter Quarters and depth in Woods Canyon varied. Velocity generally increased downstream.

The chemical characteristics of the streams changed in July 2011. Usually the water chemistry is typical for high desert systems draining exposed sedimentary bedrock. As a general rule, alkalinity, hardness, and conductivity increase in the downstream reaches as the water in the channel accumulates salts from streams, springs, and seeps that enter the main channel. In 2011 alkalinity was either constant (Winter Quarters Canyon) or increased slightly in the downstream reaches (Woods Canyon). Hardness was highest in the upstream sites. In addition, both measures were significantly below those made in previous sample periods. Alkalinity is generally a measure of carbonate concentration, while hardness is a measure of divalent cations (mainly Ca and Mg). In these two streams the total hardness is almost always greater than alkalinity and that was still the case in the anomalous 2011 spring sampling series. The higher hardness readings indicate that the remaining anions in the system are chlorides, sulfates, silicates, or nitrates (Boyd 1990). Given the origin of the bedrock it is likely that the major anions are sulfates and chlorides.

The pH shows a general trend of increasing downstream. The pH, while at the high end of the normal scale for natural waters (about 8.5; Hem 1971) may be partially confounded with time of day, since our standard sampling protocol starts with sample collection in the upstream reach first and then we progressively sample the downstream reaches. Such an approach could lead to bias in the pH measures because of the amount of photosynthetic activity in the stream channel. Photosynthesis takes place during the day, increasing as the light intensity increases. Thus in the

afternoon, photosynthesis would be maximum and that is the same time that we tend to be sampling the downstream reaches of the two streams. Algae utilizes bicarbonate ions for the carbon source in photosynthesis, and in the process increases the pH. This also facilitates the precipitation of calcium carbonate.

Biological Characterization

Number of Taxa

The Upper Woods Canyon sample site for the spring of 2011 had 41 taxa, just above the running mean of 39.4 for the five sampling periods (Table 4). Lower Woods Canyon had 38 taxa, the lowest number collected since sampling began. The running mean for this station is 40.4. However this change in number of taxa alone is likely not significant, despite the recorded changes in the physical environment. The base station had 34 taxa collected.

The Upper Winter Quarters Canyon sample site for July 2008 had 34 taxa identified, slightly above the running mean of 37.8. In 2011 39 taxa were collected at that station. Middle Winter Quarters recorded 33 different taxa in July 2008, below the average of 38.2 collected from that site. In July 2011, 40 taxa were recorded. The Lower Winter Quarters Canyon sample sites for the spring of 2011 recorded 38 different taxa, just one short of the running average from this location (Table 4). Based on the total number of tax this stream shows no change.

Table 4. Number of Taxa collected from Woods and Winter Quarter Canyons

	Shiozawa 2006	Shiozawa 2006	Shiozawa and Fordham 2010	Shiozawa and Fordham 2010	This Report
Sampling date	October 2003	June 2004	Sept/Oct 2007	July 2008	July 2011
Upper Woods Canyon	42	37	37	40	41
Lower Woods Canyon	42	39	42	41	38
Base Woods Canyon	-	-	-	-	34
Upper Winter Quarters Canyon	35	42	39	34	39
Middle Winter Quarters Canyon	34	45	39	33	40
Lower Winter Quarters Canyon	37	44	41	35	38

Total Densities

For July 2011, all previously sampled stations on both streams showed a dramatic decline in density in July of 2011 (Table 5), averaging about 10% of the previously measured sample densities. These density estimates ranged from 6% of earlier estimates in Woods Canyon to a

maximum of about 20% in Winter Quarters Canyon. This decrease is extreme but corresponds to the high runoff which occurred in the spring of 2011. As noted above, the spring channel was significantly rearranged by the high flows associated with the winter of 2010-2011 and that in turn would have both mechanically scoured invertebrates from the system as well as reduced the availability of detritus in the stream bed. Woods Canyon in July 2011 averaged 9689 organisms per square meter, while in previous years the average was 97,231. Winter Quarters Canyon in July 2011 averaged 14,330 while in previous years the average density in this stream was 91,629

Table 5. Total invertebrate densities per square meter for Woods and Winter Quarter Canyons

	Shiozawa 2006	Shiozawa 2006	Shiozawa and Fordham 2010	Shiozawa and Fordham 2010	This Report
Sampling date	October 2003	June 2004	Sept/Oct 2007	July 2008	July 2011
Upper Woods Canyon	58804	32949	181813	59267	5131
Lower Woods Canyon	62655	41852	212752	127756	7916
Base Woods Canyon	-	-	-	-	16021
Upper Winter Quarters Canyon	60471	42464	119136	99763	12085
Middle Winter Quarters Canyon	49713	40272	217796	107936	13205
Lower Winter Quarters Canyon	46179	54894	136740	124181	17881

Taxa Specific Densities

In Upper Woods Canyon, eight taxa for the July 2011 samples comprised 5% or more of the total density. These were Diptera: Chironomidae (20.4%; 1053/m^2), Ephemeroptera: Baetis (9.3%; 480/m^2), Cinygmula (5.2%; 271/m^2), early instar Ephemeroptera (12.8%; 660/m^2), Coleoptera - Heterolimnus (9.0%; 467/m^2), Crustacea: *Ostracoda* (5.6%; 292/m^2), Hydracariina (7.4%; 383/m^2), and Oligochaeta (6.2%; 319/m^2) .

In Lower Woods Canyon six taxa for the July 2011 samples comprised 5% or more of the total density. These were Diptera: Chironomidae (43.2%; 3415/m^2), Ephemeroptera: Baetis (11.2%; 887/m^2), early instar Ephemeroptera (8.9%; 703/m^2), Coleoptera - Heterolimnus (8.8%; 696/m^2), Hydracariina (6.6%; 519/m^2), and Oligochaeta (5.1%; 400/m^2) .

In Base Woods Canyon four taxa for the July 2011 samples comprised 5% or more of the total density. These were Diptera: Chironomidae (50.9%; 7933/m^2), Ephemeroptera: Baetis (17.5%; 2727/m^2), early instar Ephemeroptera (7.6%; 1186/m^2), and Oligochaeta (7.4%; 1148/m^2) .

In Upper Winter Quarters Canyon, seven taxa for the July 2011 samples comprised 5% or more

of the total density. These were Diptera: Chironomidae (16.5%; 1898/m^2), Ephemeroptera: Baetis (10.8%; 1247/m^2), Cinygmula (5.5%; 633/m^2), early instar Ephemeroptera (28.3%; 3250/m^2), Coleoptera - Heterolimnus (9.2%; 1055/m^2), Crustacea: Ostracoda (12.1%; 1389/m^2), and Hydracariina (5.0%; 578/m^2).

In Middle Winter Quarters Canyon, two taxa for the July 2011 samples comprised 5% or more of the total density. These were Diptera: Chironomidae (42.2%; 5485/m^2) and early instar Ephemeroptera (34.2%; 4438/m^2).

In Lower Winter Quarters Canyon, three taxa for the July 2011 samples comprised 5% or more of the total density. These were Diptera: Chironomidae (58.6%; 10371/m^2), Ephemeroptera: Baetis (6.7%; 1194/m^2), and early instar Ephemeroptera (20.1%; 3551/m^2

Several observations can be made about the July, 2011stations. First oligochaetes were about twice as abundant percentage-wise in Woods Canyon than in Winter Quarters and their actual densities in Woods Canyon were significantly higher in the lower two stations compared to the lower two stations in Winter Quarters Canyon. In addition the upper most stations in both streams tended to have invertebrate densities more evenly distributed than the lower stations, suggesting that the upper reaches had been less impacted from the 2011 spring flooding. The stonefly, Hesperoperla pacifica appears to be best established in Woods Canyon Creek, and in Winter Quarters Canyon the Chloroperlid stoneflies, Sweltza and Suwallia are abundant. The reason for this difference is not clear, although Hesperoperla is known to be a top invertebrate predator in streams.

Table 6. Summary of invertebrate densities by taxa for Woods and Winter Quarter Canyons

	Upper Woods Canyon				Lower Woods Canyon				Base Woods Canyon	Upper Winter Quarters Canyon				Middle Winter Quarters Canyon				Lower Winter Quarters Canyon			
Taxa	Jun-04	Sep-07	Jul 08	Jul-11	Jun-04	Sep-07	Jul-08	Jul-11	Jul-11	Jun-04	Oct-07	Jul-08	Jul-11	Jun-04	Oct-07	Jul-08	Jul-11	Jun-04	Oct-07	Jul-08	Jul-11
Ephemeroptera: *Ameletus*		284	38	14		8	4	2			170		6		1049		2		83		
Ephemeroptera: *Baetis*	2422	6090	928	480	9016	45	3075	887	2727	4526	939	11287	1247	13514	3757	5602	605	8643	9798	21017	1194
Ephemeroptera: *Cinygmula*	1049	16945	2110	271	1148	2409	7579	190	214	3087	4814	1988	633	1127	11541	1905	398	2267	15067	2390	430
Ephemeroptera: *Drunella doddsi*	23	1916	4		21	947	8	14	46	21	2238	167	10	45	682	129	29	4	686	30	21
Ephemroptera: Drunella coloradensis				29				114	146				319				230				135
Ephemeroptera: *Drunella grandis*			432	23		4	398			210		901		218	83	549		17	235	515	
Ephemeroptera: *Epeorus iron*	32			6	102			23	40	356		220	71	161		64	192	508		57	59
Ephemeroptera: early instar *	7316	26433	23551	660	2187	7317	18979	703	1186	1261	24463	18510	3250	4189	56699	36864	4438	20661	18153	28020	3551
Ephemeroptera: *Ephemerella*					4	8				4	1401			2				2			2
Ephemeroptera: *Heptagenia*			23				15							4				8			
Ephemeroptera: *Nixe criddlei*																		4			
Ephemeroptera: *Paraleptophlebia*	78	1795	76	6	72	526	231	4		4	269	38		186	242	27		13	458	4	6
Ephemeroptera: *Rithrogena*											8										
Ephemeroptera: *Seratella tibialis*	53				15					1244	364	462		568	4174	970	6	364	3492		31
Plecoptera: *Alloperla severa*										2				15				15			
Plecoptera: *Classenia sabulosa*														34							
Plecoptera: *Diura knowltoni*																					
Plecoptera: early instar *	1358	4060	515	143	3098	1924	534	25	152	1596	1951	644	340	737	2102	852	137	1034	3424	564	83
Plecoptera: early instar perlodidae				6													4				12
Plecoptera: *Hesperoperla pacifica*	250	258	76	27	191	401	91	29	14	6	102	27	4	17			6	11			
Plecoptera: *Isocapina*																					
Plecoptera: *Isogenodea*																					
Plecoptera: Chlorperlidae				2									6				19				42
Plecoptera: Eccoptura													2								
Plecoptera: Paraleuctra				8																	
Plecoptera: *Isoperla*								2		6							4	2			2

Plecoptera: *Malenka californica*			34		2		473			148		23		379		42				38	
Plecoptera: *Megarcys signata*		8									19										
Plecoptera: *Paraperla frontalis*			11					2						195						261	
Plecoptera:Paragnetina															4						
Plecoptera: Chloperlidae								2													
Plecoptera: *Pteronuarcella badia*						8												2	11	4	
Plecoptera: *Skwalla parallela*		27									80			23	114				364		
Plecoptera: *Suwallia*	2												2				12	8			2
Plecoptera: *Sweltza*		341				72	4		2	30	526	189	10		1216	640	16	157	973		54
Plecoptera: Nemuaridae													2								
Plecoptera: *Zapada*	91	3761	49	27	686	1409	34	8	12	2	235	34	6	133	2617	110	33	314	568	27	23
Trichoptera: Early instar*				48				8	139				23								4
Trichoptera: pupae *	8		140	10	9		30	8		19		167	31	36		133	21	28		19	42
Trichoptera: *Asynarchus*					2																
Trichoptera: *Arctopsyche grandis*			61									4						4			
Trichoptera: Amphicosmoecus																				4	
Trichoptera: Brachycentrus	2										140				455			13	53		
Trichoptera: Chyranda																					
Trichoptera: Dicosmoecus	17	49	95		42	38	49			40	30	23	16	61	38	136	19	47	68	322	31
Trichoptera: Dolophilodes gabriella																		4			
Trichoptera: Hesperophylax				2	2			8	8									2			
Trichoptera: Hydropsyche		30				379	19		4	2					11				439		
Trichoptera: Hydorptila											30										
Trichoptera: Lepidostoma			4	2			4		6				2								
Trichoptera: Limnephilidae								4	4												
Trichoptera: Limnephilus										2									8		
Trichoptera: Micrasema					2	102	258				186	4			871	38			4		
Trichoptera: Neothremma alicia	6	314	140	72	11		163		2	57		114		2		4					
Trichoptera: Ocetis			4																		
Trichoptera: Ochrotrichia					2																
Trichoptera: Oligophlebodes	4	481	4	59	8	193	8	29	16	244	38		4	462	148		6	17		11	

Trichoptera: Parapsyche elsis	30	265	15	14		4					80		2								
Trichoptera: Pshychomyia flavida																					
Trichoptera: Rhyacophila (larvae)	307	1326	436	63	324		212	36	93	34	216	239	54	131	1254	227	124	85	398	170	228
Trichoptera: Rhyacophila (pupae)						856															
Trichoptera: Tinodes																					
Coleoptera: Agabus (adult)																					
Coleoptera: Ampumixis	4																				
Coleoptera: Cleptelmis				2				6	10	4				21				2			
Coleoptera: Dryopidae																					
Coleoptera: Dytiscidae	2		68									8						2		4	
Coleoptera: Helichus (adult)																					
Coleoptera: Heterlimnius (larvae)	1297	3242	1651	461	591	3549	1121	684	338	4229	5007	3121	1036	3310	4962	1329	328	858	3553	508	305
Coleoptera: Heterlimnius (adult)	68	174	11	6	11	87	11	12	10	288	533	72	19	34	212	53	4	53	61		6
Coleoptera: Hydrobius										2				2			2				
Coleoptera: Optioservus (larvae)	932	4			1483	167	27	4	8	1216	11	34	57	407	19	4	38	237	95	8	31
Coleoptera: Optioservus (adult)	6	11	4		23	19	38			15		61			11	38	2	8	53	8	
Coleoptera: Tropisternus				2																	
Coleoptera: Microcylleopus										13				4							
Coleoptera: Narpus			4		4	4	30														
Coleoptera: Peltodytes callosus																					
Coleoptera: Hydophilidae					11							4									
Coleoptera: Staphylinidae																4					
Diptera: pupae																					
Diptera: Allognasta					2																
Diptera: Antocha														27	23			362	1204	345	16
Diptera: Antocha (pupae)																				49	
Diptera: Atherix											27				4			4			
Diptera: Caloparyphus				4	25	19	27	2			8		2	17	182	133		28	49	30	10
Diptera: Canace macateei																					
Diptera: Ceratopogonidae	595	928	269	127	250	2420	1420	129	137	882	1595	1125	86	371	1375	1045	31	76	667	246	84
Diptera: Chelifera	4	572				621	8	2	16		15		25		557			2	1276		2

Diptera: Chironomidae (larvae)	4259	52222	15177	1053	5568	119545	66891	3415	7933	8999	26797	44018	1898	4075	74519	41295	5485	8440	53620	62206	10371
Diptera: Chironomidae (pupae)	6	182	265	143	186	754	712	59	61	2	87	455		2	818	818	19	64	390	1458	158
Diptera: Chyrsops	2																				
Diptera: Clinocera		34				879	11								8	4	4				
Diptera: Dicranota	4	602	19	10		61	8	4	8	8	242	45	59	2	87	49	23	104	674	34	12
Diptera: Empididae Clinecera								2	22												
Diptera: Stratiomyidae								2					2								
Diptera: Dixa	8				9				4										114		
Diptera: Euparyphus	2				2	4	4			8					27				45	8	
Diptera: Hemerodromia (larvae)					2						15			2							
Diptera: Hemerodromia (pupae)	6				2									2							
Diptera: Hexatoma				8					2										8		2
Diptera: Limnophila		292	53			15	11				4	4			4	8				4	
Diptera: Limnophora		5				19									8				11		
Diptera: Molophilus																					
Diptera: Neoplasta						553	405					4				27				587	
Nr. Rhabdomstix			15																4		
Pedica							30														
Diptera: Pericoma		1326	4	2		1939			2		477				1507				739		
Diptera: Ptychoptera		383	4			15										4			30	4	
Rhyamphomyia																					
Scleroptrocta tetonica		4	8			4	11													4	
Diptera: Syrphidae				2																	
Diptera: Simulium (larvae)	62	492	27	4		1898	477	4	2	142	30	216	4	763	455	3507	14	5183	155	860	18
Diptera: Simulium (pupae)			4											4			2	184		4	4
Diptera: Oreogeton (Empididae)									4				2								
Diptera: Dolichopodidae				4					2								2				
Diptera: Tipula	80	64	8		21	53	19			6	4	27		4	23		4	8	8		6
Diptera: Tipulidae													4				4				2
Diptera: Too Small*				2				2	4												
Crustacea: Cladocera					114	4								57							

Crustacea: Copepoda	5056	20358	4821	148	3352	16146	5825	40	78	3189	23986	4352		1988	18786	2511		114	3689	348	
Crustacea: Isopoda														68							
Crustacea: Ostracoda	3642	25251	5026	292	9168	33531	9302	273	720	4401	12438	4280	1389	3653	19831	4859	288	1197	6208	2030	205
Arachnida: Hydracarina	2163	9310	1985	383	2333	10745	5291	519	321	2449	4787	4753	578	1375	6605	2352	451	1663	4412	1432	589
Mollusca: Sphaerium	102	144		23	125	27		65	23	833	148		250	184	473	4	80		242	227	4
Mollusca: Gyraulus	6				2													246			
Molusaca: Gastropoda				2					2				2								
Columella																					
Mollusca: Lymai														2							
Collembola		466					348		33	76		117	175	174		8	4	2	114		
Haplotaxidae (Oligochaeta)																					
Annelida: Oligochaeta	865	1117	845	319	1415	2867	2901	400	1148	1507	3935	1136	355	970	1273	1223	40	1763	4954	311	48
Annelida: Hirudinea				2																	
Lepidoptera			4				15			2		11		4						8	
Turbellaria: Planariidae	106	530	292	35	208	129	648			1309	398	882	88	68	19	193	12	108	167		2
Nematoda *	625			125					40					515			42				2
Hemiptera:													2				25				52

Biomass

Because of the drastic decrease in density of invertebrates in the two streams, the biomass estimates also decreased significantly (Table 7). The Upper Woods Canyon July 2011 sample biomass decreased to about one sixth of the July 2007 estimate and Lower Woods Canyon in July of 2011 had less than a third of the July 2011 biomass estimate. The July 2011 Winter Quarters sites ranged from almost a fifth to a third of the corresponding biomass in 2008.

Table 7. Biomass in grams for Woods and Winter Quarters Canyons

	Woods Canyon			Winter Quarters Canyon		
Sample period	Upper	Lower	Base	Upper	Middle	Lower
Oct-03	31.64 g/m^2	49.43 g/m2	---	51.82 g/m^2	67.18 g/m^2	37.72 g/m^2
Jun-04	30.78 g/m^2	57.19 g/m^2	---	47.07 g/m^2	52.43 g/m^2	86.60 g/m^2
Sep-07	32.98 g/m2	22.52 g/m2	---	17.56 g/m2	22.75 g/m2	30.88 g/m2
Jul-08	35.49 g/m2	31.45 g/m2	---	42.03 g/m2	67.06 g/m2	42.31 g/m2
Jul-11	5.88 g/m2	10.72 g/m2	11.48 g/m2	13.21 g/m2	14.38 g/m2	19.04 g/m2

The Biotic Condition Index

The actual Community Tolerance Quotient (CTQa; Winget and Mangum 1979) was determined from the taxa present at each station (Table 8). These represent an overall average generated from a list provided by Winget and Mangum (1979) and are based on the presence-absence of taxa. Relative abundance is not considered in this index. Thus a single individual per square meter is given equal weighting to another taxa represented by thousands of individuals in the same area. The CTQa values for the six stations ranged from 62.1 to 74.5. Lower values represent higher habitat quality. In the July 2011 sample series, the Winter Quarters station have low CTQa values, indicating that, under these metrics, the stream in Winter Quarters Canyon was in better condition than the stream in Woods Canyon.

Community Tolerance Quotient and Biotic Condition Indices

The CTQp values are estimated from a combination of gradient, substrate, and water chemistry in accordance with a key provided by Winget and Mangum (1979). The shift in water chemistry detected in the July 2011 samples changed the CTQp value from the 70 used in previous years to 50. The Biotic Condition Index, the ratio of CTQp/CTQa, is expressed as a percent. This ratio effectively reverses the reading of the relationships so that instead of low values being indicative of higher quality waters (as is the case with the CTQa measure), high BCI values indicate better water quality. The ideal is a BCI of 100 or higher, meaning that the station meets or exceeds the predicted level.

In 2011 Woods Canyon recorded CTQa values in the range of 70 to 75 for all three sites. This is classified as high to moderate habitat quality which, according to Winget and Mangum (1979), may require habitat improvement. Previously Woods Canyon has tended to have high habitat

Table 8. Tolerance quotients for Woods and Winter Quarter Canyons

Taxa	Upper Woods July 2011	Lower Woods July 2011	Base Woods July 2011	Upper WQ July 2011	Middle WQ July 2011	Lower WQ July 2011	Ideal stream
Ephemeroptera: Ameletus							48
Ephemeroptera: Baetidae: Baetis sp.	72	72	72	72	72	72	72
Ephemeroptera: early instar *	72	72		72	72	72	72
Ephemeroptera: Ephemerellidae: Drunella coloradensis	18	18	18	18	18	18	18
Ephemeroptera: Ephemerellidae: Drunella doddsi		4	4	4	4	4	4
Ephemeroptera: Ephemerellidae: Drunella grandis	24						24
Ephemeroptera: Ephemerellidae: Ephemerella						48	48
Ephemeroptera: Ephemerellidae: Seratella tibialis					24	24	24
Ephemeroptera: Heptageniidae: Cinygmula	21	21	21	21	21	21	21
Ephemeroptera: Heptageniidae: Epeorus iron	21	21	21	21	21	21	21
Ephemeroptera: Heptageniidae: Heptagenia							48
Ephemeroptera: Heptageniidae: Nixe criddlei							48
Ephemeroptera: Heptageniidae: Rithrogena							21
Ephemeroptera: Leptophlebiidae: Paraleptophlebia	24	24				24	24
Plecoptera: Capniidae: Isocapina							24
Plecoptera: Chloroperlidae: Alloperla severa							24
Plecoptera: Chloroperlidae: Paraperla frontalis		24					24
Plecoptera: Paragnetina							24
Plecoptera: Chloroperlidae: Suwallia				24	24	24	24
Plecoptera: Chloroperlidae: Sweltza			24	24	24	24	24
Plecoptera: early instar *	36	36	36	36	36	36	36
Plecoptera: Nemouridae: Malenka californica							36
Plecoptera: Nemouridae: Zapada	16	16	16	16	16	16	16
Plecoptera: Perlidae: Classenia sabulosa							6
Plecoptera: Perlidae: Hesperoperla pacifica	18	18	18	18	18		18
Plecoptera: Perlodidae: Diura knowltoni							24
Plecoptera: Perlodidae: Isogenoides							24
Plecoptera: Perlodidae: Isoperla		48			48	48	48
Plecoptera: Perlodidae: Megarcys signata							24
Plecoptera: Perlodidae: Skwalla parallela							18
Plecoptera: Pteronarcyidae: Pteronarcella badia							24
Trichoptera: pupae *	108	108	108	108	108	108	108
Trichoptera: Amphicomoecus							18
Trichoptera: Brachycentridae: Brachycentrus							24
Trichoptera: Brachycentridae: Micrasema							24
Trichoptera: Hydroptilidae: Hydroptila							108
Trichoptera: Hydroptilidae: Ochrotrichia							108
Trichoptera: Hydropsychidae: Arctopsyche grandis							18
Trichoptera: Hydropsychidae: Hydropsyche			108				108
Trichoptera: Hydropsychidae: Parapsyche elsis	6			6			6
Trichoptera: Lepidostomatidae: Lepidostoma	18		18	18			18
Trichoptera: Leptoceridae: Ocetis							54
Trichoptera: Limnephilidae: Asynarchus							108
Trichoptera: Limnephilidae: Chyranda							18
Trichoptera: Limnephilidae: Dicosmoecus				24	24	24	24
Trichoptera: Limnephilidae: Hesperophylax	108	108	108				108
Trichoptera: Limnephilidae: Limnephilus			108				108
Trichoptera: Philopotamidae: Dolophilodes gabriella							24
Trichoptera: Psychomyidae: Tinodes							108
Trichoptera: Rhyacophilidae: Rhyacophila	18	18	18	18	18	18	18
Trichoptera: Uenoidae: Neothremma alicia	8		8				8
Trichoptera: Uenoidae: Oligophlebodes	24	24	24	24	24		24
Coleoptera: Dryopidae: Helichus							54
Coleoptera: Dytiscidae							72
Coleoptera: Dytiscidae: Agabus							72
Coleoptera: Elmidae: Ampumixis							108

Coleoptera: Elmidae: Cleptelmis	108	108	108				108
Coleoptera: Elmidae: Heterlimnius	108	108	108	108	108	108	108
Coleoptera: Elmidae: Microcylleopus							108
Coleoptera: Elmidae: Narpus							108
Coleoptera: Elmidae: Optioservus	108	108	108	108	108	108	108
Coleoptera: Haliplidae: Peltodytes callosus							54
Coleoptera: Hydrophilidae: Hydrobius					72		72
Coleoptera: Hydrophilidae: Tropisternis	72						72
Coleoptera: Staphylinidae							108
Diptera: pupae *							108
Diptera: Athericidae: Atherix							24
Diptera: Canacidae: Canace macateei							108
Diptera: Ceratopogonidae	108	108	108	108	108	108	108
Diptera: Chironomidae	108	108	108	108	108	108	108
Diptera: Dixidae: Dixa			108				108
Diptera: Dolichopodie	108		108		108		108
Diptera: Empididae: Chelifera		108	108	108		108	108
Diptera: Empididae: Clinocrea		108	108		108		108
Diptera: Empididae: Hemerodromia							108
Diptera: Empididae: Neoplasta							108
Diptera: Empididae: Oreogeton			108				108
Diptera: Muscidae: Limnophora							108
Diptera: Pedica							24
Diptera: Psychodidae: Pericoma	36		36				36
Diptera: Ptychopteridae: Ptychoptera							108
Diptera: Simuliidae: Simulium	108	108	108	108	108	108	108
Diptera: Stratomyidae: Allognasta							108
Diptera: Stratiomyidae: Caloparyphus	108	108	108	108		108	108
Diptera: Stratiomyidae: Euparyphus							108
Diptera: Syrphidae	108						108
Diptera: Tabanidae: Chyrsops		108					108
Diptera: Tipulidae: Antocha						24	24
Diptera: Tipulidae: Dicranota	24	24	24	24	24	24	24
Diptera: Tipulidae: Hexatoma	36		36			36	36
Diptera: Tipulidae: Limnophila							72
Diptera: Tipulidae:Scleroprocta tetonica							72
Diptera: Tipulidae: Tipula					36	36	36
Diptera: Limoniidae: Nr. Rhabdomastix							108
Crustacea: Cladocera							108
Crustacea: Copepoda	108	108	108	108	108	108	108
Crustacea: Isopoda							108
Crustacea: Ostracoda	108	108	108	108	108	108	108
Arachnida: Hydracarina	108	108	108	108	108	108	108
Mollusca: Lymnaidae: Lymai	108		108	108			108
Mollusca: Planoribidae: Gyraulus							108
Mollusca: Sphaeriidae: Sphaerium	108	108	108	108	108	108	108
Annelida: Oligochaeta	108	108	108	108	108	108	108
Annelida: Hirudinea	108						108
Tricladida: Planariidae	108	108	108				108
Collembola		108		108	108		108
Hemiptera: Corixidae							108
Lepidoptera							72
Nematoda *	108	108	108		108	108	108
Total	2719	2600	2982	1988	2216	2126	
N	39	35	40	32	34	34	
CTQa	69.718	74.286	74.550	62.125	65.177	62.529	

Quality. It is likely that the high spring runoff in 2011 is the factor inducing this shift. In contrast, Winter Quarters Canyon ranged from 62 to 65, which is classified as high habitat quality and no stream improvement is recommended beyond maintaining the habitat. This is a continuation of the trend noted in previous years (Table 9).

The July 2011 BCI values for the stations fell substantially. Previously they had all been characterized by BCIs well over 100, indicating better than expected condition. The July 2011 BCI values fell to between 66.6 to 80.6 percent of ideal. This change is induced in part by water chemistry, which is a component of calculating the BCI. If water chemistry changes quickly but the stream community does not have time for new dispersal into the system, the result will be a community that is being evaluated on physical-chemical parameters that only recently developed. In this case the change is likely ephemeral because of the unique weather conditions in the spring of 2011. In future sampling it is likely that the chemical conditions in the stream will trend back to previous states. According to Winget and Mangum (1979), the CTQa-BCI values for Upper Woods Canyon (a CTQa greater than 65 but a BCI less than 80) gives this station a low habitat quality rating. The other two Woods Canyon stations maintained their classification of having high to moderate habitat quality. Middle Winter Quarters received a high to moderate habitat quality rating (CTQa between 65 and 80 and BCI between 70 and 85). But the Upper and Lower Winter Quarters sites received low habitat quality ratings (CTQa less than 80 and BCI greater than 70). Again these contrasting results are likely due to transient changes in water chemistry associated with the high spring runoff.

Table 9. CTQa and BCI values for Woods and Winter Quarter Canyons

	Shiozawa 2004	Shiozawa 2004	Shiozawa and Fordham 2010	Shiozawa and Fordham 2010	This report
Sampling date	Oct 2003	June 2004	Sept/Oct 2007	June July 2008	July 2011
	CTQa / BCI	CTQa / BCI	CTQa / BCI	CTQa / BCI	CTQa / BCI
Upper Woods Canyon	61/131	68/ 117	64/125	60/ 117	70/ 71.4
Lower Woods Canyon	60/134	73/ 110	67/119	66/ 110	74/ 67.6
Base Woods Canyon	---	---	---	---	75/ 66.6
Upper Winter Quarters Canyon	58/ 139	67/ 121	59/ 137	60/ 121	62/ 80.6
Middle Winter Quarters Canyon	58/139	66/ 122	61/130	69/ 116	65/ 76.9
Lower Winter Quarters Canyon	55/ 145	61/ 133	68/118	65/ 133	63/ 79.4
Average	58/ 138	67/ 121	64/ 126	64/ 121	68/ 73.3

Diversity Indices

Diversity indices combine both number of taxa and relative densities into a single measurement. High diversity index values indicate more taxa and an even number of individuals per taxon. Low diversity values generally reflect a depauperate fauna in species and a very skewed distribution in numbers per taxon. Usually a low diversity community will be dominated by just a few taxa with other taxa being rare and in low density.

The spring 2011 Upper Woods Canyon sample diversity index was 2.716 (Table 10), a significant increase from the July 2008 sample which had a diversity value 1.957. The July 2011 Lower Woods Canyon diversity index was 2.054, again significantly greater than the July 2008 value of 1.648. Since sampling at the base station of Woods Canyon was initiated in 2011 no comparisons can be made with it, other than to note that it did have a much lower diversity that the two upstream stations.

The Upper Winter Quarters July 2011 diversity index was 2.234, higher than the July 2008 value of 1.718. The Middle Winter Quarters July 2011 diversity index was 1.666, close to the July 2008 sample which was 1.703. Lower Winter Quarters July 2011 diversity index was 1.464, slightly higher than the 1.208 recorded for July 2008.

These diversity values seem somewhat counterintuitive given the impact of the spring floods on both biomass and densities (Tables 6 and 7). However the total number of taxa remained about the same (Table 5) and that is the key factor. Since overall densities were reduced, but the number of taxa remained about the same, the proportional difference between the high density taxa and the low density taxa were reduced (see the Taxa Specific Densities section above). The computation of diversity indices includes these differences and when the differences are lower, the diversity index is higher.

Table 10. Diversity indices, based on natural logs, for Woods and Winter Quarter Canyons

	Shiozawa 2004	Shiozawa 2004	Shiozawa and Fordham 2010	Shiozawa and Fordham2010	This report
Sampling date	Oct 2003	June 2004	Sept/Oct 2007	July 2008	July 2011
Upper Woods Canyon	2.041	2.327	2.153	1.957	2.7161
Lower Woods Canyon	1.930	2.153	1.532	1.648	2.0541
Base Woods Canyon	----	----	----	----	1.7564
Upper Winter Quarters Canyon	2.518	2.447	2.135	1.718	2.2337
Middle Winter Quarters Canyon	2.250	2.240	1.983	1.703	1.6658
Lower Winter Quarters Canyon	2.125	2.139	2.057	1.208	1.4640

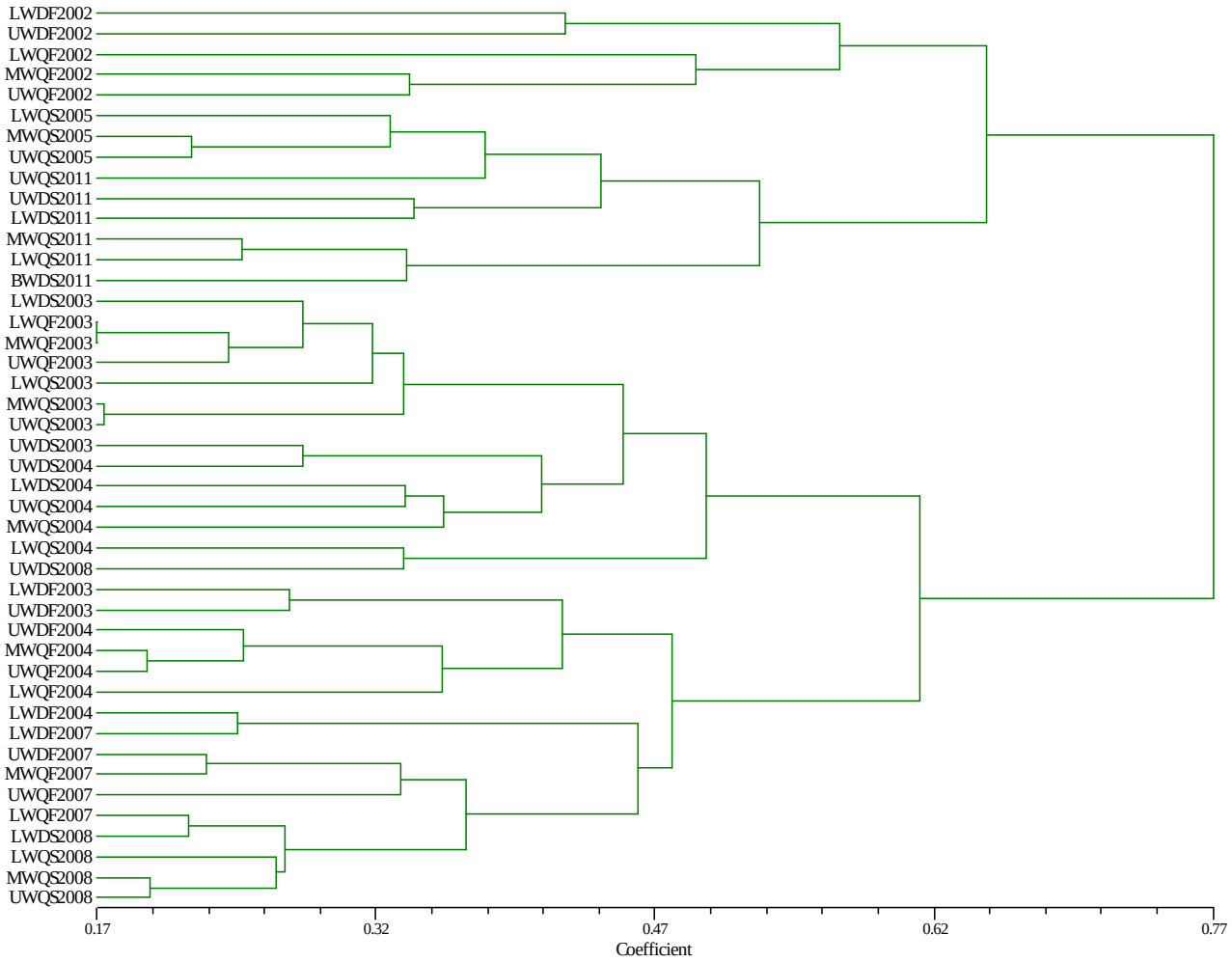
Cluster Analysis

The species density data were examined with cluster analysis using the Bray-Curtis dissimilarity index (Poole 1974, Krebs 1989) with the unweighted pairs group mean averaging algorithm (UPGMA) (NTSYS; Rolf 2000). The analysis resulted in two principle clusters separating at a

dissimilarity value of 77. The top cluster, cluster 1 (Figure 1), contained all of the fall 2002 sites for both Woods Canyon Creek and Winter Quarters Creek as well as three Winter Quarters Canyon sample stations from the spring of 2005 and all July 2011 samples. A subcluster in cluster 1, separating at 65% dissimilarity, included all of the July 2011 samples from both streams and the three Winter Quarters Canyon sample stations from the spring of 2005. The latter samples separated from the 2011 samples at a dissimilarity of about 50%.

The lower cluster, cluster 2, contained all of the 2003, 2004, 2007 and 2008 sites. Within cluster 2, two subclades exist, separating at about 60% dissimilarity. The upper one is mostly comprised of fall 2003 and spring 2004 samples. The second includes the fall 2004 and the majority of both fall 2007 and spring 2008 samples. The sites show tendencies to be grouped by site and sampling date. These trends are likely reflecting both seasonal changes in the community structure and annual variations in weather conditions (e.g. wet years and dry years). These data are beginning to develop a picture of the range of variation in the two streams systems.

Figure 1. UPGMA Cluster dendrogram of relationships among communities from Woods and Winter Quarters Canyons.



Conclusions

The July 2011samples were strongly influenced by the flooding that took place in the spring of that year. Invertebrate densities in the five established station were significantly down from previous sampling periods as was the standing crop of invertebrates. These changes were not detected in the stations with the CTQa or with diversity indices. These two measures are standardized either for presence/absence or proportional abundance so that actual density differences are lost. However the BCI did note a change, although it appears that the change reflects the shift in CTQp because of changes in water chemistry, which in turn are likely a transient effect of the high runoff. The most well defined changes in the system were seen in individual taxon densities and in overall biomass estimates. The cluster analysis, based on dissimilarity of taxon densities, placed the July 2011samples into a single group imbedded in one of two general clusters of stations sampled over the past decade. This indicates that the shifts in community structure over time at the six sites may follow a reasonably predictable pattern, especially once physical data are considered.

These samples are still documenting the pre-mining subsidence conditions of the two streams, but as more data are compiled a fuller interpretation of background variation is becoming possible.

Literature Cited

Boyd, C. E. 1990. Water quality in ponds for aquaculture. Birmingham Publishing Co. Birmingham, AL. 482 pp.

Elliott, J, M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association Scientific Publication No. 25. Ambleside.

Hem, J. D. 1971. Study and interpretation of the chemical characteristics of natural water. U. S. Geological Survey Water-Supply Paper No. 1473. 363 pp.

Horton, R. E. 1945. Erosional development of streams and their drainage basins: a hydrophysical approach to quantitative geomorphology. Bulletin of the Geological Society of America 56:275-370.

Hynes, H. B. N. 1972. The ecology of running waters. University of Toronto Press. Toronto, Canada. 555 pp.

Merritt, R. W. and K. W. Cummins. (eds.) 1996. An Introduction to the Aquatic Insects of North America. 3rd Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa. 862 pp.

Merritt, R. W., K. W. Cummins, and M. B. Berg. (eds.) 2008. An Introduction to the Aquatic Insects of North America. 4th Edition. Kendall/Hunt Publishing Co. Dubuque, Iowa. 1158 pp

Pielou, E. C. 1977. Mathematical Ecology. John Wiley and Sons. NY, NY. 385 pp.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, Inc. 532pp.

Rolf, F. J. 2000. NTSpc: Numerical taxonomy and multivariate analysis system. Version 2.1. Exeter Software. Setauket, NY.

Resh, V. H. and E. P. McElravy. 1993. Contemporary quantitative approaches to biomonitoring using benthic macroinvertebrates. In D. M. Rosenberg and V. H. Resh (eds). Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall. NY, NY. pp.159-194.

Shiozawa, D. K. 1986. The seasonal community structure and drift of microcrustaceans in Valley Creek, Minnesota. Canadian Journal of Zoology 64: 1655-1664.

Winget, R. N. 1972. Aquatic environmental impact study of Huntington Canyon generating station and Electric lake. Annual Report No. 2. Center for Environmental Studies. Brigham Young University.

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

Appendix A. July 2011 Sample Data for Woods Canyon

	Upper Woods Canyon									Lower Woods Canyon									Base Woods Canyon								
Taxa	1	2	3	4	5	6	7	8	**#/m²**	1	2	3	4	5	6	7	8	**#/m²**	1	2	3	4	5	6	7	8	**#/m²**
Ephemeroptera: Baetis	15	78	1	38	10	62	35	14	**480**	29	105	58	56	37	39	107	37	**887**	304	123	142	90	179	221	84	297	**2727**
Ephemeroptera: Cinygmula	23	19	16	15	19	25	17	9	**271**	9	17	12	17	6	17	7	15	**190**	24	12	14	4	12	16	18	13	**214**
Ephemeroptera:Drunella coloradensis	0	1	0	7	0	5	0	2	**29**	5	5	10	6	7	3	3	21	**114**	9	16	10	7	14	7	6	8	**146**
Ephemeroptera: Drunella doddsi	0	0	0	0	0	0	0	0	**0**	0	3	2	0	0	0	0	2	**14**	6	6	8	1	3	0	0	0	**46**
Ephemeroptera: Drunella grandis	4	8	0	0	0	0	0	0	**23**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Epeorus iron	0	2	0	0	0	1	0	0	**6**	0	2	3	2	2	0	0	3	**23**	6	1	2	4	3	4	0	1	**40**
Ephemeroptera: Ephemerella	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Heptagenia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Nixe criddlei	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: early instar *	42	100	0	48	60	60	38	0	**660**	13	13	22	180	24	63	23	33	**703**	103	10	170	23	128	69	1	122	**1186**
Ephemeroptera: Ameletus	0	0	0	0	4	0	0	3	**14**	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera:Paraleptophlebia	0	0	0	0	0	2	0	1	**6**	0	0	0	0	0	0	0	2	**4**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Serratella tibialis	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Alloperla	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Classenia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: early instar *	10	9	0	4	2	43	1	6	**143**	1	2	3	0	0	2	3	2	**25**	0	1	60	0	10	0	9	0	**152**
Plecoptera: early instar perlodidae	0	3	0	0	0	0	0	0	**6**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera:Hesperoperla pacifica	1	1	0	0	5	6	1	0	**27**	4	1	2	1	3	1	2	1	**29**	2	1	2	0	1	1	0	0	**14**
Plecoptera: Isoperla	0	0	0	0	0	0	0	0	**0**	0	1	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Malenka californica	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Paraperla	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Chlorperlidae	0	0	0	0	0	1	0	0	**2**	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Pteronuarcella badia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Paraleuctra	0	4	0	0	0	0	0	0	**8**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Skwalla parallela	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**

Plecoptera: Suwallia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Sweltza	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	1	0	0	0	**2**
Plecoptera: Zapada	2	2	0	2	0	7	1	0	**27**	0	0	3	0	0	0	0	1	**8**	1	0	0	0	2	2	1	0	**12**
Trichopterea: Early instar*	0	1	0	0	0	22	1	1	**48**	1	1	0	0	0	0	0	2	**8**	2	11	60	0	0	0	0	0	**139**
Trichoptera: pupae *	2	0	0	1	0	1	0	1	**10**	0	2	1	0	0	0	0	1	**8**	1	4	0	0	1	2	0	0	**16**
Trichoptera: Arctopsyche grandis	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Brachycentrus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Dicosmoecus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Dolophilodes	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Hesperophylax	0	1	0	0	0	0	0	0	**2**	0	0	0	0	1	0	1	2	**8**	0	0	0	0	0	3	0	1	**8**
Trichoptera: Hydropsyche	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	2	0	0	0	0	0	**4**
Trichoptera: Limnephilidae	0	0	0	0	0	0	0	0	**0**	0	0	2	0	0	0	0	0	**4**	1	0	1	0	0	0	0	0	**4**
Trichoptera: Limniphilus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Lepidostoma	1	0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	1	1	0	1	**6**
Trichoptera: Neothremma alicia	9	4	0	2	0	17	1	5	**72**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	1	0	0	**2**
Trichoptera: Oligophlebodes	5	13	0	2	0	10	0	1	**59**	3	1	7	0	0	0	2	2	**29**	4	0	0	0	2	2	0	0	**16**
Trichoptera: Parapsyche elsis	3	2	0	1	0	1	0	0	**14**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Rhyacophila	9	8	2	3	0	6	4	1	**63**	2	1	2	4	1	3	0	6	**36**	23	8	2	5	4	3	2	2	**93**
Coleoptera: Cleptelmis	0	0	0	0	0	0	1	0	**2**	0	0	3	0	0	0	0	0	**6**	0	0	0	3	2	0	0	0	**10**
Coleoptera: Dytiscidae	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Heterlimnius (larvae)	34	36	33	95	22	6	11	6	**461**	12	35	75	74	37	44	40	44	**684**	5	16	62	1	4	46	14	30	**338**
Coleoptera: Heterlimnius (adult)	0	0	1	0	0	1	0	1	**6**	2	3	0	0	0	0	0	1	**12**	2	2	1	0	0	0	0	0	**10**
Coleoptera: Hydrobius	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Tropisternus (Hydrophilidae)	0	1	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Micorcylleopus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Optioservus (larvae)	0	0	0	0	0	0	0	0	**0**	0	0	1	1	0	0	0	0	**4**	0	0	0	0	0	4	0	0	**8**
Coleoptera: Optioservus (adult)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Antocha	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**

Diptera: Atherix	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Caloparyphus	1	0	0	0	1	0	0	0	**4**	0	0	1	0	0	0	0	0	**2**	0	1	1	0	0	0	2	0	**8**
Diptera: Ceratopogonidae	14	29	0	12	0	0	10	2	**127**	36	9	0	1	1	15	6	0	**129**	10	9	0	0	13	9	6	25	**137**
Diptera: Chelifera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	1	0	**2**	1	1	0	0	0	1	4	1	**16**
Diptera: Chironomidae (larvae)	111	121	36	86	52	82	31	37	**1053**	237	214	129	230	94	232	162	505	**3415**	727	660	684	333	470	424	507	384	**7933**
Diptera: Chironomidae (pupae)	9	9	0	9	2	24	15	7	**143**	1	6	11	0	1	3	6	3	**59**	6	2	1	5	10	3	3	2	**61**
Diptera: Dicranota	0	1	0	0	2	1	1	0	**10**	0	0	0	0	0	1	0	1	**4**	2	0	0	0	2	0	0	0	**8**
Diptera: Dixa (Dixidae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	1	0	0	0	0	0	0	1	**4**
Diptera: Euparyphus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Empididae Clinocera	0	0	0	0	0	0	0	0	**0**	0	1	0	0	0	0	0	0	**2**	0	0	0	0	1	0	1	0	**4**
Diptera: Hemerodromia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Dolichopodidae	0	0	1	0	0	0	1	0	**4**	0	0	0	0	0	0	0	0	**0**	1	0	0	0	0	0	0	0	**2**
Diptera: Tabanidae Chrysops	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	1	0	**2**	0	0	0	0	0	0	0	0	**0**
Diptera: Stratiomyidae (Stratiomys)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	1	0	**2**	0	0	0	0	0	0	0	0	**0**
Diptera: Hexatoma (Tipulidae)	0	0	1	2	0	0	1	0	**8**	0	0	0	0	0	0	0	0	**0**	0	1	0	0	0	0	0	0	**2**
Diptera: Simulium (larvae)	0	0	0	0	0	1	1	0	**4**	1	0	0	0	0	0	0	1	**4**	0	0	0	0	0	0	0	1	**2**
Diptera: Simulium (pupae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Pericoma (Psychodidae)	0	0	0	1	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	1	0	0	0	0	0	0	0	**2**
Diptera: Oreogeton (Empididae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	1	0	0	1	**4**
Diptera: Tipula	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Syrphidae	0	1	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Too small*	0	0	0	0	0	0	0	1	**2**	0	0	0	0	0	0	1	0	**2**	0	0	0	0	1	0	1	0	**4**
Crustacea: Cladocera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Crustacea: Copepoda	0	0	0	72	0	0	5	1	**148**	0	0	9	0	0	0	12	0	**40**	0	0	0	0	16	17	8	0	**78**
Crustacea: Ostracoda	30	25	0	49	0	40	10	0	**292**	1	21	25	0	12	4	50	31	**273**	19	53	60	20	26	35	44	123	**720**
Arachnida: Hydracarina	44	39	0	72	0	21	21	5	**383**	1	12	33	0	1	35	130	62	**519**	0	20	61	10	1	35	18	24	**321**
Mollusca: Sphaerium	0	6	0	3	0	1	1	1	**23**	0	1	1	30	0	0	2	0	**65**	1	0	0	0	0	1	8	2	**23**
Mollusca: Gastropoda	0	0	0	0	0	0	1	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	1	0	**2**

Mollusca: Gyraulus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Mollusca: Lymai	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Annelida: Oligochaeta	13	96	1	20	1	8	15	14	**319**	68	21	52	1	0	4	34	31	**400**	127	4	61	33	21	35	301	24	**1148**
Annelida: Hirudinea	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Collembola	6	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	17	0	0	0	0	0	0	0	**33**
Lepidoptera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Planaria (Turbellaria)	6	6	2	0	0	1	3	0	**35**	2	0	0	0	0	0	1	0	**6**	6	1	0	1	3	4	3	3	**40**
Nematoda	1	0	1	35	0	22	7	0	**125**	30	38	18	0	1	0	11	0	**186**	0	32	60	10	9	17	34	2	**311**
Totals	395	626	96	579	180	477	234	118		458	515	487	604	228	466	606	809		1412	995	1464	550	940	964	1075	1068	

Appendix B. July 2011 Sample Data for Winter Quarters Canyon

	Upper Winter Quarters Canyon									Middle Winter Quarters Canyon									Lower Winter Quarters Canyon								
Taxa	1	2	3	4	5	6	7	8	**#/m²**	1	2	3	4	5	6	7	8	**#/m²**	1	2	3	4	5	6	7	8	**#/m²**
Ephemeroptera: Baetis	359	22	85	30	31	64	19	48	**1247**	53	30	46	24	15	53	30	68	**605**	58	50	154	75	156	40	45	52	**1194**
Ephemeroptera: Cinygmula	31	22	55	9	48	92	22	55	**633**	34	47	43	11	6	14	13	42	**398**	7	16	49	44	34	44	9	24	**430**
Ephemeroptera: Drunella coloradensis	91	17	9	9	12	5	7	18	**319**	9	12	12	14	18	14	32	10	**230**	8	6	13	5	8	13	14	4	**135**
Ephemeroptera: Drunella doddsi	1	2	0	2	0	0	0	0	**10**	0	2	1	2	3	3	4	0	**29**	0	0	3	0	1	2	0	5	**21**
Ephemeroptera: Drunella grandis	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Epeorus iron	19	7	1	3	1	6	0	0	**71**	17	13	6	3	11	8	31	12	**192**	3	4	0	1	15	2	5	1	**59**
Ephemeroptera: Ephemerella	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	1	0	0	0	0	0	**2**
Ephemeroptera: Heptagenia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: Nixe criddlei	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera: early instar *	180	240	151	120	180	240	125	480	**3250**	425	225	263	142	100	317	480	391	**4438**	163	304	459	217	8	360	165	199	**3551**
Ephemeroptera: Ameletus	0	0	0	0	0	2	1	0	**6**	1	0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Ephemeroptera:Paraleptophlebia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	3	0	**6**
Ephemeroptera: Serratella tibialis	0	0	0	0	0	0	0	0	**0**	0	0	0	2	0	0	0	1	**6**	0	3	0	2	0	8	3	0	**31**
Plecoptera: Alloperla	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Classenia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: early instar *	91	30	30	49	1	2	3	2	**340**	5	15	2	4	1	0	30	15	**137**	4	0	10	30	0	0	0	1	**83**
Plecoptera: early instar perlodidae	0	0	0	0	0	0	0	0	**0**	0	2	0	0	0	0	0	0	**4**	0	0	0	4	0	0	0	2	**12**
Plecoptera:Hesperoperla pacifica	0	0	0	0	0	0	1	1	**4**	0	1	1	0	0	1	0	0	**6**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Isoperla	0	0	0	0	0	0	0	0	**0**	0	0	0	1	0	0	0	1	**4**	0	0	0	0	0	0	1	0	**2**
Plecoptera: Malenka californica	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Paraperla	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Chlorperlidae	0	0	0	0	3	0	0	0	**6**	0	6	0	0	0	4	0	0	**19**	0	5	0	0	12	0	0	5	**42**
Plecoptera: Pteronuarcella badia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Paraleuctra	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Eccoptura	0	0	0	0	0	0	0	1	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**

Plecoptera: Skwalla parallela	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Suwallia	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	6	0	**12**	0	0	0	0	0	0	0	1	**2**
Plecoptera: Sweltza	4	0	0	0	1	0	0	0	**10**	0	2	6	0	0	0	0	0	**16**	2	0	5	14	0	3	4	0	**54**
Plecoptera: Nemuaridae	0	0	0	0	1	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Plecoptera: Zapada	1	1	0	0	0	1	0	0	**6**	2	2	6	3	0	0	0	4	**33**	1	1	3	1	2	1	2	1	**23**
Trichopterea: Early instar*	0	0	0	12	0	0	0	0	**23**	0	0	0	0	0	0	0	0	**0**	0	0	2	0	0	0	0	0	**4**
Trichoptera: pupae *	5	5	1	4	0	1	0	0	**31**	0	6	0	0	2	0	2	1	**21**	2	1	2	0	0	1	16	0	**42**
Trichoptera: Arctopsyche grandis	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Brachycentrus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Dicosmoecus	0	2	0	0	0	6	0	0	**16**	0	4	0	2	1	0	3	0	**19**	1	1	3	1	1	1	6	2	**31**
Trichoptera: Dolophilodes	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Hesperophylax	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Hydropsyche	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Limnephilidae	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Limniphilus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Lepidostoma	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Neothremma alicia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Oligophlebodes	0	0	0	2	0	0	0	0	**4**	0	0	0	0	1	0	1	1	**6**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Parapsyche elsis	0	0	0	1	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Trichoptera: Rhyacophila	6	5	7	1	3	0	0	6	**54**	4	4	2	6	26	7	11	5	**124**	11	10	14	5	11	11	48	10	**228**
Coleoptera: Cleptelmis	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Hydrophilid (Larvae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	1	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Dytiscidae	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Heterlimnius (larvae)	5	20	86	41	46	132	151	66	**1036**	2	16	10	22	44	7	66	6	**328**	6	8	16	33	13	46	28	11	**305**
Coleoptera: Heterlimnius (adult)	0	1	0	0	0	2	2	5	**19**	0	1	0	0	0	1	0	0	**4**	0	0	0	0	0	1	2	0	**6**
Coleoptera: Hydrobius	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Tropisternus (Hydrophilidae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Coleoptera: Micorcylleopus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**

Coleoptera: Optioservus (larvae)	0	0	0	0	0	0	30	0	**57**	0	0	20	0	0	0	0	0	**38**	0	1	3	0	0	6	6	0	**31**
Coleoptera: Optioservus (adult)	0	0	0	0	0	0	0	0	**0**	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Diptera: Antocha	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	1	1	1	1	1	0	3	0	**16**
Diptera: Atherix	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Caloparyphus	0	0	0	0	0	0	0	1	**2**	0	0	0	0	0	0	0	0	**0**	0	0	1	1	0	2	1	0	**10**
Diptera: Ceratopogonidae	0	2	31	12	0	0	0	0	**86**	0	2	4	2	1	7	0	0	**31**	3	0	32	3	3	1	2	0	**84**
Diptera: Chelifera	0	1	0	12	0	0	0	0	**25**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	1	0	0	**2**
Diptera: Chironomidae (larvae)	240	195	229	127	50	52	54	55	**1898**	144	45	146	507	428	707	573	346	**5485**	630	727	778	284	494	664	1827	672	**10371**
Diptera: Chironomidae (pupae)	0	3	0	0	2	1	0	0	**12**	0	1	3	1	0	3	1	1	**19**	8	8	17	0	9	7	10	24	**158**
Diptera: Dicranota	0	2	2	0	6	6	5	10	**59**	0	0	0	0	0	1	2	9	**23**	0	0	1	3	1	0	1	0	**12**
Diptera: Dixa (Dixidae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Euparyphus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Empididae Clinocera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	2	0	0	**4**	0	0	0	0	0	0	0	0	**0**
Diptera: Hemerodromia	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Dolichopodidae	0	0	0	0	0	0	0	0	**0**	0	0	1	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**
Diptera: Tabanidae	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Stratiomyidae	0	0	0	1	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Hexatoma (Tipulidae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	1	0	0	0	0	0	**2**
Diptera: Simulium (larvae)	0	0	1	0	0	1	0	0	**4**	0	0	1	0	0	5	0	1	**14**	0	1	3	1	0	3	0	1	**18**
Diptera: Simulium (pupae)	0	0	0	0	0	0	0	0	**0**	0	1	0	0	0	0	0	0	**2**	0	0	0	0	0	0	1	1	**4**
Diptera: Pericoma (Psychodidae)	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Oreogeton (Empididae)	1	0	0	0	0	0	0	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Tipula	0	0	0	0	0	0	0	0	**0**	0	2	0	0	0	0	0	0	**4**	0	0	0	0	0	0	0	3	**6**
Diptera: Tipulidea	0	0	0	1	0	0	0	1	**4**	1	0	1	0	0	0	0	0	**4**	0	0	0	1	0	0	0	0	**2**
Diptera: Syrphidae	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Diptera: Too small*	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Crustacea: Cladocera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Crustacea: Copepoda	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Crustacea: Ostracoda	60	90	150	12	30	90	1	300	**1389**	30	31	41	20	0	0	0	30	**288**	0	0	1	16	0	0	90	1	**205**

Arachnida: Hydracarina	0	33	30	0	60	90	31	61	**578**	0	19	43	0	43	41	31	61	**451**	91	60	12	17	5	30	93	3	**589**
Mollusca: Sphaerium	30	0	30	12	0	0	60	0	**250**	0	1	0	0	20	21	0	0	**80**	0	0	0	2	0	0	0	0	**4**
Mollusca: Gastropoda	0	0	0	0	0	0	1	0	**2**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Mollusca: Gyraulus	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Mollusca: Lymai	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Annelida: Oligochaeta	38	2	42	66	3	5	0	31	**355**	1	7	0	2	6	3	0	2	**40**	0	2	0	3	2	4	13	1	**48**
Annelida: Hirudinea	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Collembola	60	31	0	0	1	0	0	0	**175**	1	0	0	0	0	1	0	0	**4**	0	0	0	0	0	0	0	0	**0**
Hemiptera	1	0	0	0	0	0	0	0	**2**	0	13	0	0	0	0	0	0	**25**	0	0	0	0	0	0	0	27	**52**
Lepidoptera	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**	0	0	0	0	0	0	0	0	**0**
Planaria (Turbellaria)	30	0	2	12	1	1	0	0	**88**	0	1	0	5	0	0	0	0	**12**	0	0	0	0	0	1	0	0	**2**
Nematoda	0	0	0	0	0	0	0	0	**0**	1	0	0	20	0	0	1	0	**42**	0	0	0	1	0	0	0	0	**2**
Totals	1253	733	944	538	480	799	513	1141		730	511	659	793	726	1221	1317	1007		999	1209	1584	765	776	1252	2398	1051	

RIPARIAN PLANT COMMUNITY MONITORING IN SELECTED REACHES IN WINTER QUARTERS & WOODS CANYONS

2012

AT THE
SKYLINE MINE
CARBON COUNTY, UTAH

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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 for the 2012 monitoring study in the riparian communities there.

The vegetation monitoring studies have been conducted before, during and after the mining operations. 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). 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 Areas

Winter Quarters and Woods Canyons are located within the Wasatch Plateau, a high plateau that lies between the Colorado Plateau and Great Basin regions of the western United States. The canyons are located approximately 3 miles west of the town of Scofield, Utah and are located within the Manti-La Sal National Forest.

Geologically, most of the area is Cretaceous in age with formations present that include the Price River, North Horn, and Blackhawk formations. The dominant plant communities of these canyons were riparian, spruce-fir, aspen/grass, sagebrush/grass and mountain herblands.

Methods

Sample Design, Transect Placement & Frequency

The riparian vegetation of specific reaches in Winter Quarters Canyon were sampled in August 2012. Selection of the sample locations of the reaches were based on the underground coal mining schedule of the Skyline Mines. Like 2006 - 2011, the methods for 2012 follow the *Initial Baseline Year* (2005) described above. 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 will be 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 subsequent monitoring years, sample station locations have been determined and mapped based on the time period schedule for the proposed underground mining activities.

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.

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:

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.

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 which 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.

Once the transects were placed, the line-intercept method was employed to measure the extent of each major riparian plant community. The plant communities have been named by the dominant two plant species. If only one species dominates 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*.

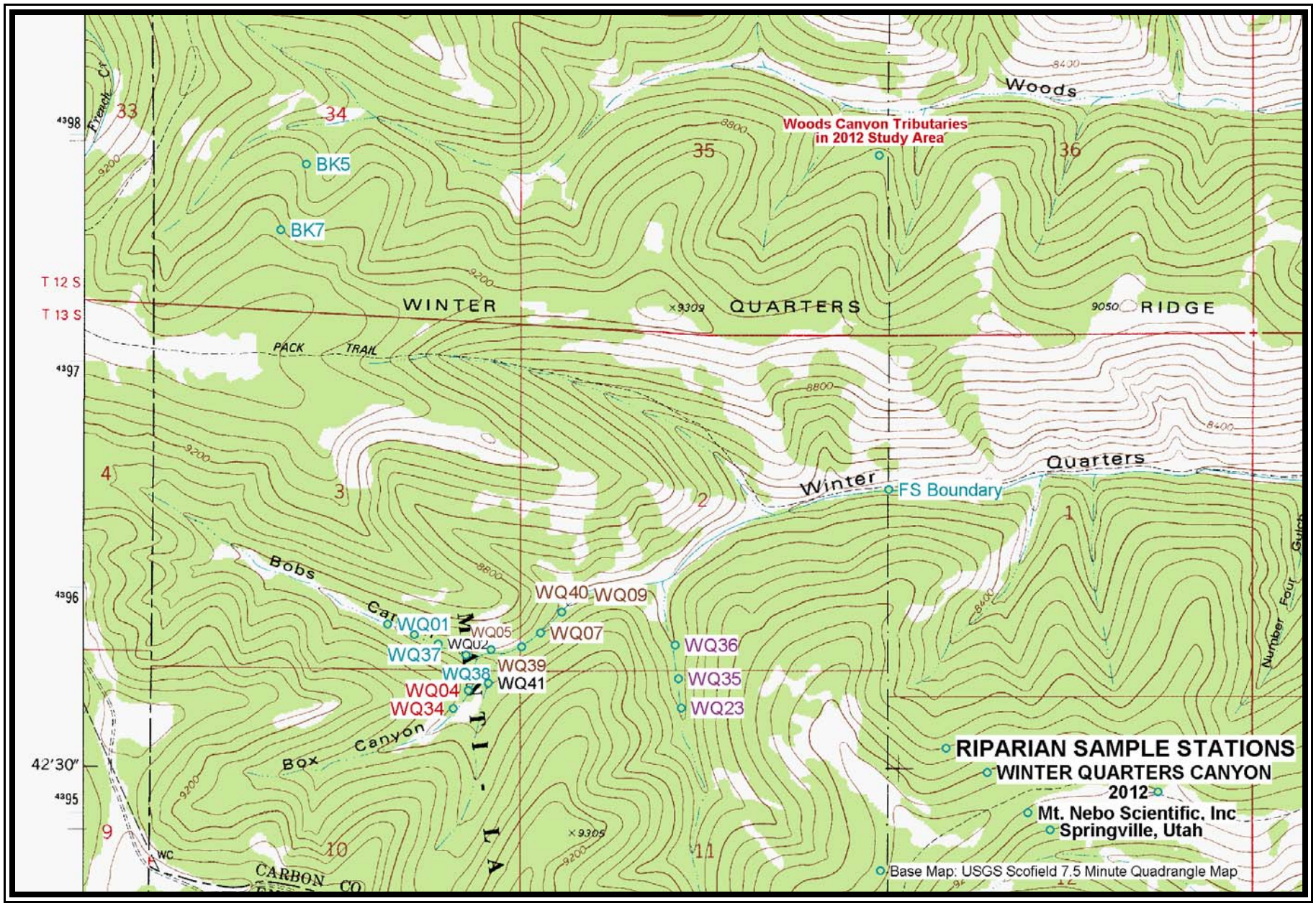
Results & Discussion

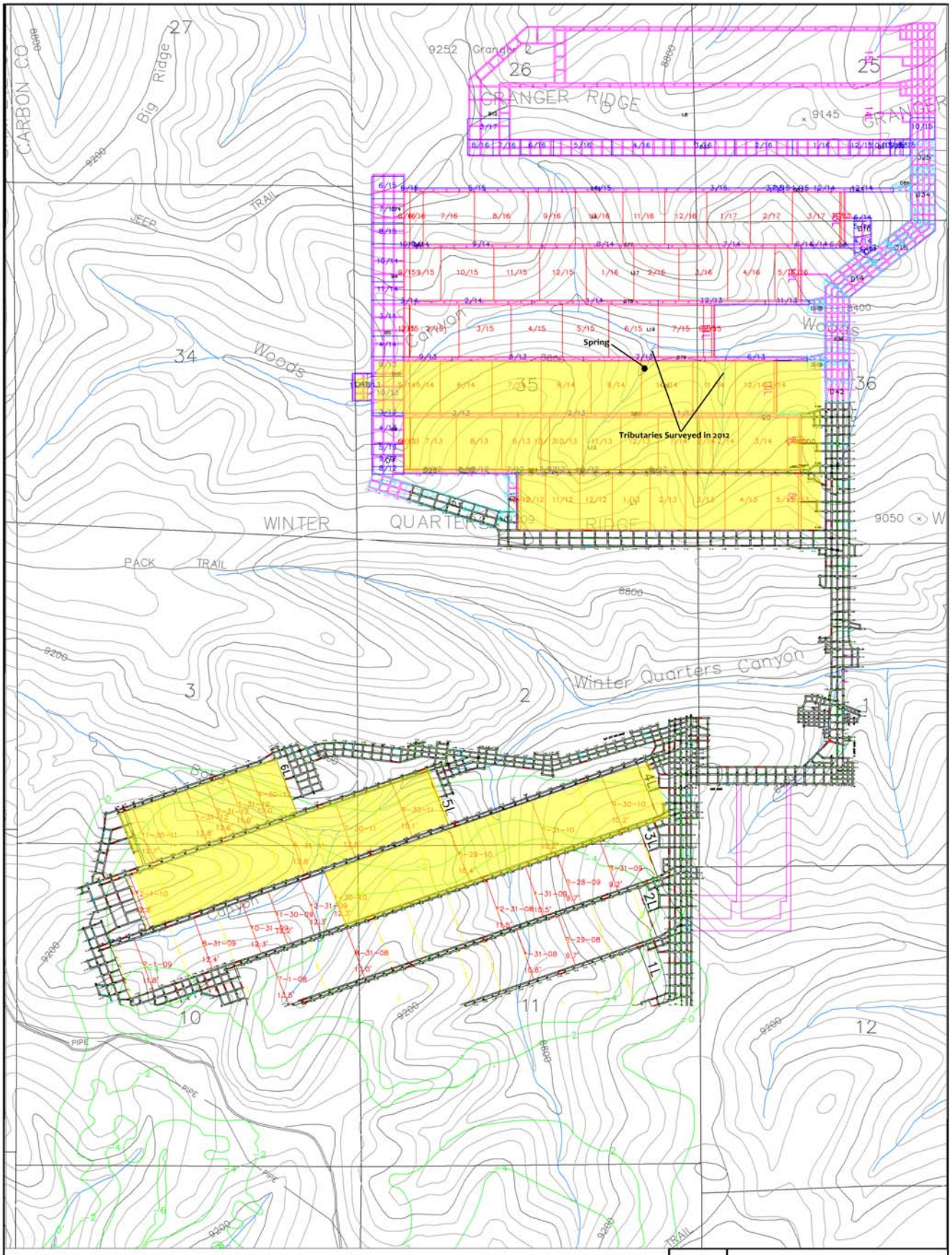
Listed below is a summary of the sample stations for the study areas in 2012 (Table 2). For a map of the locations, refer to the *Sample Station Locations for 2012 in Winter Quarters Canyon* in this report.

TABLE 2: Riparian Sample Stations in Winter Quarters Canyon: 2012

Section 11 Drainage	No-Name Drainage	Box Canyon	Bob's Canyon	WINTER QUARTERS CREEK	WOODS CANYON CREEK
WQ-23	WQ-41	WQ-34	WQ-01	WQ-05	"East" Tributary
WQ-35		WQ-04	WQ-37	WQ-39	"West" Tributary
WQ-36			WQ-02	WQ-07	
			WQ-38	WQ-40	
				WQ-09	

Sample results are shown for each site on the data sheets provided in this report. Each sheet shows all qualitative and quantitative data recorded as well as was photographic documentation.


Woods Canyon Tributaries
in 2012 Study Area
Woods
WINTER
QUARTERS
RIDGE
PACK
TRAIL
Winter
Quarters
FS Boundary
Bobs
Cat
Box
Canyon
MANTI
CARBON CO
BK5
BK7
WQ01
WQ02
WQ04
WQ05
WQ07
WQ09
WQ23
WQ34
WQ35
WQ36
WQ37
WQ38
WQ39
WQ40
WQ41
RIPARIAN SAMPLE STATIONS
WINTER QUARTERS CANYON
2012
Mt. Nebo Scientific, Inc
Springville, Utah
Base Map: USGS Scofield 7.5 Minute Quadrangle Map


CARBON CO
Big Ridge
9252 Granger
GRANGER RIDGE
9145
JEEP TRAIL
Woods
Spring
Tributaries Surveyed in 2012
WINTER QUARTERS RIDGE
PACK TRAIL
Winter Quarters Canyon
9050
PIPE
TRAIL
SUBSIDENCE CONTOUR
Subsidence Zones 2010-2014
Added by P.D. Collins, August 2012
2000' 0' 1000' 2000'
CUMULATIVE SUBSIDENCE
Canyon Fuel Company, LLC
Skyline Mines
DATE: 3/30/2012
SCALE: 1"=1000'
REVISION: 0

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-36*

WATERBODY NAME: *Winter Quarters Canyon Creek (Section 11 tributary)*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *north*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,475 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Conifer* 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: *900*

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*
		Delphinium barbeyi	*Elymus canadensis*
		Geranium richardsonii	
		Ranunculus cymbalaria	
		Senecio serra	

POOL ATTRIBUTES

% area in pools: *50 (dry, in 2011, not in 2012*)

% 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 (<90°): *0*

% bank length gently sloping (>135°): *75*

% bank length with overhanging vegetation: *75 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *5*

NOTES:

1) This was a new site for 2008 monitoring.
2) There was an especially good riparian community on the left side for monitoring.
3) This sample site was somewhat more than the prescribed distance from the last monitoring station because a spring would have made the appropriate distance difficult to accurately monitor. That said, even in this area there could have been some hillside water influence to the riparian community. I would guess it about a 70% chance that this influence existed.
4) 2008, 2009, 2011, 2012 there was water in the stream channel (it was dry in 2010, but water surfaced ~50 ft downstream that year).
5) In 2010, I was stung by a wasp on the way to this site at 75 ft downstream (marked as waypoint "WQBee" on GPS).

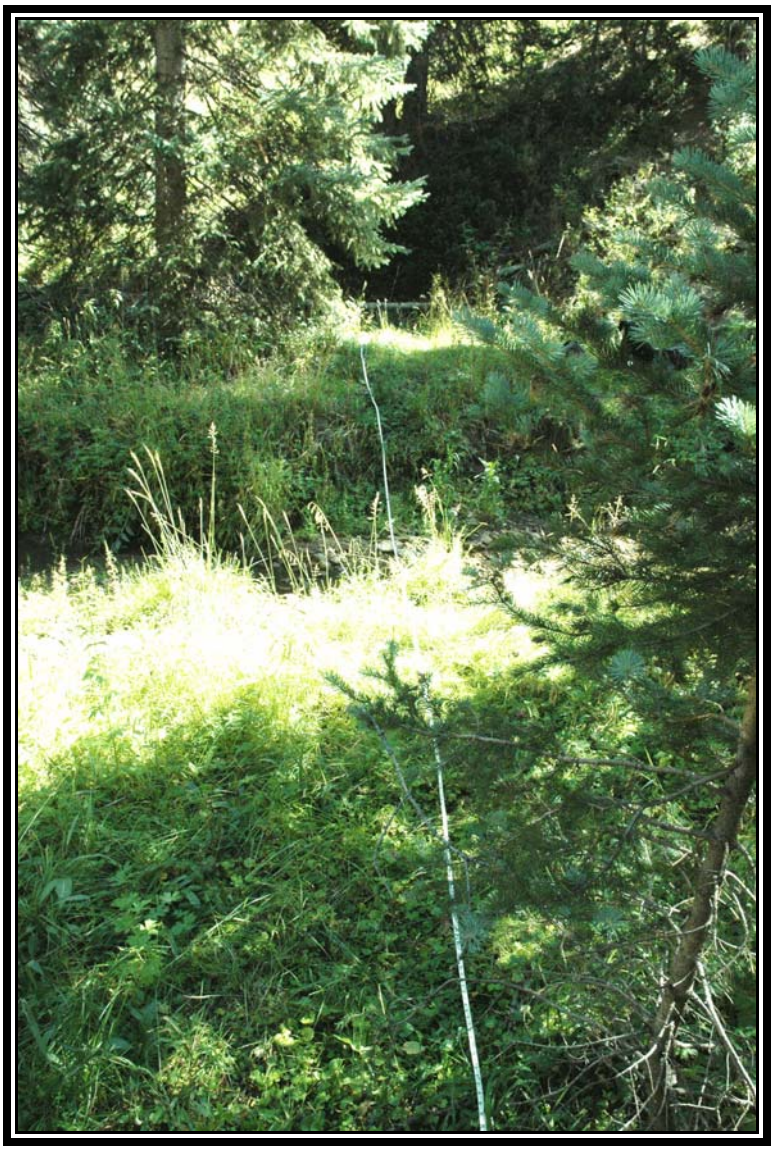
DATA SUMMARY

WQ-36: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	9.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera	17.00
Elymus canadensis/Geranium richardsonii	3.00
TOTAL COVER (Upland Species)	19.00
TOTAL COVER (Riparian Species)	20.00
ROCK (channel)	1.50
WATER (channel)	1.50
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	42.00

PHOTOGRAPHIC DOCUMENTATION



WQ-36

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-35*

WATERBODY NAME: *Winter Quarters Canyon Creek (Section 11 tributary)*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *north*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *~8478 ft.*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Conifer* 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: *1000*

BEAVER ACTIVITY: *None*

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	*Ribes sp.*	*Achillea millefolium*	*Agrostis stolonifera*
Populus tremuloides	*Symphoricarpos oreophilus*	*Delphinium barbeyi*	*Carex hoodii*
		Equisetum arvense	*Elymus canadensis*
		Geranium richardsonii	*Poa pratensis*
		Helianthella uniflora	
		Mimulus guttatus	
		Ranunculus cymbalaria	
		Rudbeckia occidentalis	
		Senecio serra	

POOL ATTRIBUTES

% area in pools: *0 (dry in 2010, but water in 2011, dry again in 2012)*
% 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 (<90°): *50*
% bank length gently sloping (>135°): *50*
% bank length with overhanging vegetation: *25*

BANK CONDITION

% bank length vegetated, stable: *85*
% bank length unvegetated, stable: *10*
% bank length vegetated, unstable: *0*
% bank length unvegetated, unstable: *5*

NOTES:

1) New sample site in 2008 year.
2) Good flat riparian community to monitor on the right site.
3) Channel was dry in 2010, but a good flow was present in 2011, dry again in 2012,
4) In 2011, two conifers had fallen across the stream channel and transect area, probably from flooding, and took out the stake. This did not seem to impact the riparian vegetation at this site.
5) Therefore, in 2010, the stake was reset at previous year distance (49 ft).
6) The fallen trees now make this site difficult to easily monitor.

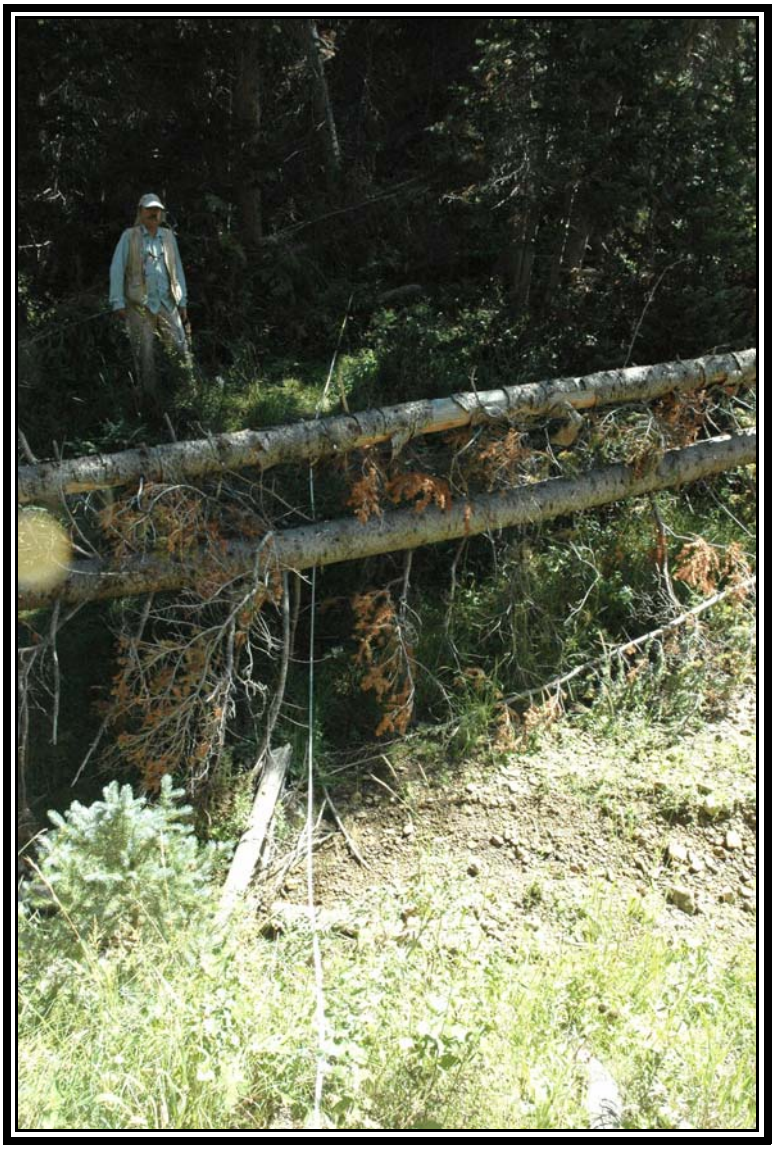
DATA SUMMARY

WQ-35: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	8.00
	17.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis	11.00
Agrostis stolonifera	7.00
Elymus canadensis/*Geranium richardsonii*	3.00
TOTAL COVER (Upland Species)	25.00
TOTAL COVER (Riparian Species)	21.00
ROCK (channel)	3.00
WATER (channel)	0.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	49.00

PHOTOGRAPHIC DOCUMENTATION



WQ-35

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-23*

WATERBODY NAME: *Winter Quarters Canyon Creek (Section 11 tributary)*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *N*

STREAM GRADIENT: *1-3* ^{o}

ELEVATION: *8,481 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Spruce/Fir* Right: *Open to 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: *700 lbs/acre*

BEAVER ACTIVITY: *Historical use lower in canyon*

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		*Delphinium nelsonii*	*Agrostis stolonifera*
Populus tremuloides		*Equisetum arvense*	*Carex hoodii*
		Geranium richardsonii	*Elymus canadensis*
		Mimulus guttatus	
		Ranunculus cymbalaria	
		Senecio serra	
		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: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90º): *0*

% bank length gently sloping (>135º): *10*

% bank length with overhanging vegetation: *10*

BANK CONDITION

% bank length vegetated, stable: *80*

% bank length unvegetated, stable: *15*

% bank length vegetated, unstable: *5*

% bank length unvegetated, unstable: *0*

NOTES:

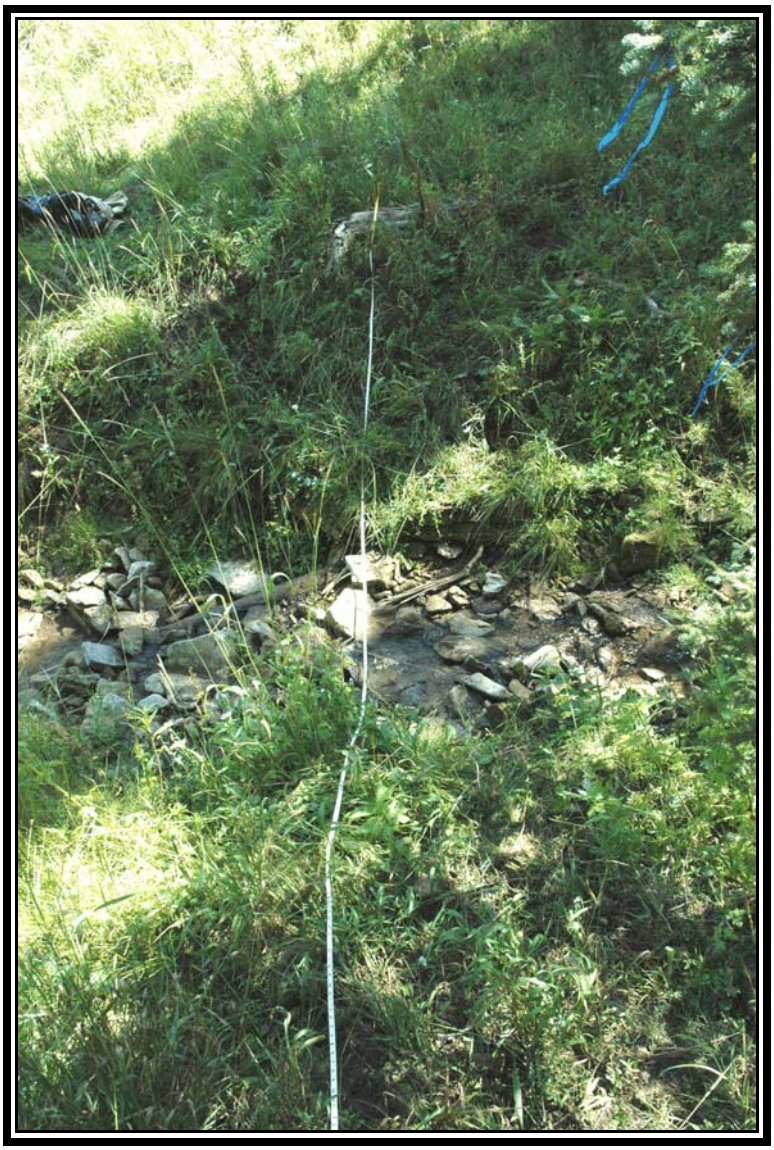
1) On the left side, the upper 3 ft of the riparian zone may be influenced by hillside and stream water.
2) Re-set coordinates with GPS in 2011 and again in 2012.

DATA SUMMARY

WQ-23: Cover by community types in Winter Quarters Canyon (2012).

UPLAND VEGETATION	Cover (ft)
	10.00
	5.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis/Geranium richardsonii	5.00
Carex hoodii	4.00
TOTAL COVER (Upland Species)	15.00
TOTAL COVER (Riparian Species)	9.00
ROCK (channel)	4.00
WATER (channel)	1.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	29.00

PHOTOGRAPHIC DOCUMENTATION



WQ-23

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-41 (New in 2011)*

WATERBODY NAME: *Winter Quarters Canyon Creek ("No-Name" Tributary)*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *N*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,625 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Herb* 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: *Increasing*

ESTIMATED FORAGE PRODUCTION: *1,100*

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.*	*Delphinium barbeyi*	*Carex hoodii*
Populus tremuloides		*Equisetum arvense*	*Elymus canadensis*
		Heracleum lanata	
		Mimulus guttatus	
		Ranunculus cymbalaria	
		Senecio serra	
		Swertia radiata	
		Urtica dioica	

POOL ATTRIBUTES

% area in pools: *70*

% 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 (<90°): *100 left side in 2011; but 0 in 2012 (filled in)*

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

% bank length with overhanging vegetation:

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *0*

% bank length vegetated, unstable: *5*

% bank length unvegetated, unstable: *5*

NOTES:

1) New site in 2011.

2) Although the right side 10 ft was called "upland", the Elymus canadensis and moisture here seemed to be coming from drainage from the side slope.

3) Use the left 1 ft and right 13 ft to monitor riparian vegetation.

DATA SUMMARY

WQ-41: Cover by community types in Winter Quarters Canyon (2012).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	10.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Ranunculus cymbalaria	1.00
Swertia radiata/Equisetum arvense	14.00
TOTAL COVER (Upland Species)	20.00
TOTAL COVER (Riparian Species)	15.00
ROCK (channel)	1.00
WATER (channel)	1.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	37.00

PHOTOGRAPHIC DOCUMENTATION

WQ-41

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-34*

WATERBODY NAME: *Winter Quarters Canyon Creek; upper Box Canyon*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *ENE*

STREAM GRADIENT: *2°*

ELEVATION: *8,729 ft.*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Mtn. Herbland/Conifer* Right: *Mtn. Herbland/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: *900 lbs./acre*

BEAVER ACTIVITY: *Historical activity near site.*

PHOTOGRAPH TAKEN: *Yes*

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

SPECIES OBSERVED:

Trees	**Shrubs**	**Forbs**	**Grasses (or grasslike)**
Abies lasiocarpa	*Ribes sp.*	*Equisetum arvense*	*Agrostis stolonifera*
		Geranium richardsonii	*Carex hoodii*
		Senecio serra	*Carex nebrascensis*
			Elymus canadensis
			Phleum pratensis

POOL ATTRIBUTES

% area in pools: *20*

% 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): *40 in 2011; 0 in 2012 (another site filled in)*

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

% bank length with overhanging vegetation: *90 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *85*

% bank length unvegetated, stable: *15*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) This site was a new sample station in 2008.

2) Like 2010, the left side riparian community was sloughing, and about 2 ft of the transect was lost (from 33 ft in 2010 to 31 ft in 2011 and 2012).

3) Quite a bit of Elymus canadensis here.

4) I'm not quite sure why more riparian community was measured in 2011 – perhaps in 2012 it was from the apparent sloughing due to a game trail.

DATA SUMMARY

WQ-34: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Carex hoodii	8.50
TOTAL COVER (Upland Species)	20.00
TOTAL COVER (Riparian Species)	8.50
ROCK (channel)	0.00
WATER (channel)	2.50
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	31.00

PHOTOGRAPHIC DOCUMENTATION

WQ-34

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-04*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *NE*

STREAM GRADIENT: *~2 °*

ELEVATION: *8,664 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream):

Left: *Aspen/Mtn. Herbland* Right: *Blue Spruce/Mtn. Herbland*

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: *800 lbs/acre*

BEAVER ACTIVITY: *Historical activity a few hundred feet 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		*Aster sp.*	*Agrostis stolonifera*
Populus tremuloides		*Geranium richardsonii*	*Carex hoodii*
		Lupinus sp.	*Elymus canadensis*
		Mimulus guttatus	
		Ranunculus cymbalaria	
		Urtica dioica	
		Viguiera multiflora	

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 (<90°): *10 in 2011; 50 in 2012*

% bank length gently sloping (>135°): *20*

% bank length with overhanging vegetation: *50 (herb.)*

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *10*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) This site is approx. midway between main channel and upper Box Canyon sample point.
2) In 2009, we were not sure why there was more riparian width here compared to 2005; the 2010 measurement was similar to 2009.
3) Left stake was displaced in 2009 and it was re-staked on this side using the 2008 measured transect distance (27 ft); in 2010 it was 27 ft; in 2011 26 ft (1 ft lost due to sloughing); same 26 ft in 2012.

DATA SUMMARY

WQ04: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	8.00
	8.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera/Ranunculus cymbalaria	2.00
Carex hoodii/Elymus canadensis	4.00
TOTAL COVER (Upland Species)	16.00
TOTAL COVER (Riparian Species)	6.00
ROCK (channel)	2.00
WATER (channel)	3.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	27.00

PHOTOGRAPHIC DOCUMENTATION

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-01*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,656ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Herb* 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: *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)**
Picea pungens	*Symphoricarpos oreophilus*	*Achillea millefolium*	*Agrostis stolonifera*
		Aster sp.	*Elymus canadensis*
		Polygonum sp.	*Carex hoodii*
		Ranunculus cymbalaria	
		Senecio serra	
		Urtica dioica	
		Veratrum californicum	

POOL ATTRIBUTES

% area in pools: *5*

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

AQUATIC VEGETATION

% streambed with filamentous algae: *0*

% stream margin with rooted aquatic: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°):

% bank length gently sloping (>135°): *50% on left side only*

% bank length with overhanging vegetation: *0*

BANK CONDITION

% bank length vegetated, stable: *75 (100 on lt; 50 on rt ave = 75)*

% bank length unvegetated, stable: *10*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *15*

NOTES:

1) All of left bar was considered riparian-influenced (22.5 ft in 2010; 19.0 ft in 2011).
2) New GPS coordinates were taken here in 2010.
3) Could not find the right stake in 2011, so I placed it at the 2010 distance (47 ft).
4) Total length decreased 3 ft to 44 ft in 2012.

DATA SUMMARY

WQ-01: Cover by community types in Winter Quarters Canyon (2012).

UPLAND VEGETATION	Cover (ft)
	9.00
	8.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis	3.00
Carex hoodii/Elymus canadensis	20.00
TOTAL COVER (Upland Species)	17.00
TOTAL COVER (Riparian Species)	23.00
ROCK (channel)	0.00
WATER (channel)	2.50
BAREGROUND (channel)	0.00
LITTER	1.50
MOSS	0.00
TOTAL COVER	44.00

PHOTOGRAPHIC DOCUMENTATION

WQ-01

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-37 (New in 2010)*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,622 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Snowberry* 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		*Helianthella uniflora*	*Agrostis stolonifera*
Populus angustifolia		*Mimulus guttatus*	*Carex hoodii*
		Ranunculus cymbalaria	*Elymus canadensis*
		Senecio serra	*Poa ampla*
		Urtica dioica	

POOL ATTRIBUTES

% area in pools: *75*

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

AQUATIC VEGETATION

% streambed with filamentous algae: *no*

% stream margin with rooted aquatic: *no*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°): *50% on left side in 2011; 0 in 2012*

% bank length gently sloping (>135°): *100% right side (2 ft)*

% bank length with overhanging vegetation:

BANK CONDITION

% bank length vegetated, stable: *85*

% bank length unvegetated, stable: *15*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *0*

NOTES:

1) A new site in 2010.
2) The left side was a point bar with a good, flat riparian zone.
3) The right side was considered a riparian zone only to the steep bank (~ 2 ft). After that the vegetation was influenced by side slope moisture.
4)The 2011 water year appeared greater; the left side (only) riparian area seemed to have expanded that year.
5) Flooding seemed to have done damage to the area in 2011 but was stabilized by 2012.
6)The transect length went from 42 ft (2010) to 39 ft (2011) ft and stayed at 39 ft (2012).

DATA SUMMARY

WQ-37: Cover by community types in Winter Quarters Canyon (2012).

UPLAND VEGETATION	Cover (ft)
	6.00
	9.50
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Carex hoodii/Agrostis stolonifera	19.50
TOTAL COVER (Upland Species)	15.50
TOTAL COVER (Riparian Species)	19.50
`ROCK (channel)	0.00
WATER (channel)	0.00
BAREGROUND (channel)	2.50
LITTER	1.50
MOSS	0.00
TOTAL COVER	39.00

PHOTOGRAPHIC DOCUMENTATION

WQ-37

Flooding Evidence (2011)

Flood Evidence (2011)

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-02*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah; Bob's Canyon*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: E

STREAM GRADIENT: *~2 °*

ELEVATION: *8,619 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Snowberry* 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: *Stabilizing*

ESTIMATED FORAGE PRODUCTION: *1000 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	*Rosa woodsii*	*Carduus nutans*	*Agrostis stolonifera*
Populus tremuloides		*Equisetum arvense*	*Bromus japonicus*
		Geranium richardsonii	*Carex hoodii*
		Helianthella uniflora	*Elymus canadensis*
		Lupinus argenteus	
		Rubus idaeus	
		Rudbeckia occidentalis	
		Urtica dioica	

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 (<90°): *average = 50%; 100% on right side*

% bank length gently sloping (>135°): *20*

% bank length with overhanging vegetation: *0*

BANK CONDITION

% bank length vegetated, stable: *95 right; 35 left*

% bank length unvegetated, stable: *5 right; 0 left*

% bank length vegetated, unstable: *0 right; 15 left*

% bank length unvegetated, unstable: *0 right; 50 left*

NOTES:

1) The right side had a bench that supported some riparian species, but it was probably due to hillside moisture, not the stream directly.
2) The riparian area measured was well defined below the right bench and left hillside.
3) In 2009, we found the right stake, but not the left. In 2010, it was re-staked at the previous measured length of (28 ft).
4) In 2011 we found the flags on the right side but no stake due to coverage by fallen trees from much sloughing that year. We put transect at 28 ft again.
5) Again in 2012, the left stake needed to be replaced at 2011 length or 28 ft.
6) On the left side there was not much living cover.

DATA SUMMARY

WQ-02: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	9.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Equisetum arvense	2.50
Elymus canadensis	2.00
TOTAL COVER (Upland Species)	19.00
TOTAL COVER (Riparian Species)	4.50
ROCK (channel)	1.00
WATER (channel)	3.50
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	28.00

PHOTOGRAPHIC DOCUMENTATION

WQ-02

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-38 (New in 2010)*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *N*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,566 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Snowberry* 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: *700*

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.*	*Equisetum arvense*	*Agrostis stolonifera*
Picea pungens	*Rubus idaeus*	*Geranium richardsonii*	*Elymus canadensis*
Populus tremuloides	*Symphoricarpos oreophilus*	*Helianthella uniflora*	*Poa secunda*
		Polygonum sp.	
		Ranunculus cymbalaria	

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: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°): *50 left; 50 right*

% bank length gently sloping (>135°): *0 left; 100 right (in riparian area)*

% bank length with overhanging vegetation: *20 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *90*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *0*

% bank length unvegetated, unstable: *5*

NOTES:

1) New site for 2010
2) Re-marked GPS coordinates in 2011.
3) In 2010 the transect length was 31 ft; 2011 and 2012 it was 30 ft.

DATA SUMMARY

WQ-38: Cover by community types in Winter Quarters Canyon (2012).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	9.00
	8.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis	3.00
Agrostis stolonifera/Elymus canadensis	6.00
TOTAL COVER (Upland Species)	17.00
TOTAL COVER (Riparian Species)	9.00
ROCK (channel)	0.00
WATER (channel)	1.50
BAREGROUND (channel)	2.50
LITTER	0.00
MOSS	0.00
TOTAL COVER	30.00

PHOTOGRAPHIC DOCUMENTATION

WQ-38

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-05*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,545ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Snowberry* 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: *Decreasing; unstable right bank*

ESTIMATED FORAGE PRODUCTION: *400*

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 lasiocarpa	*Ribes sp.*	*Geranium richardsonii*	*Agrostis stolonifera*
Picea pungens	*Salix sp.*	*Heracleum lanatum*	*Elymus canadensis*
Populus tremuloides	*Symphoricarpos oreophilus*	*Mimulus guttatus*	*Poa pratensis*
		Ranunculus cymbalaria	

POOL ATTRIBUTES

% area in pools: *50*

% pool area made up of pools > 2' deep: *no*

AQUATIC VEGETATION

% streambed with filamentous algae: *no*

% stream margin with rooted aquatic: *no*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°): *not on the transect line, but close upstream*

% bank length gently sloping (>135°): *0*

% bank length with overhanging vegetation*: 50 left; 100 right*

BANK CONDITION

% bank length vegetated, stable: *70*

% bank length unvegetated, stable: *5*

% bank length vegetated, unstable: *20*

% bank length unvegetated, unstable: *5*

NOTES:

1) Reset GPS in 2010 (previous coordinates put this site in an unlikely place).
2) In 2010, this site was relocated ~ 50 ft downstream from old waypoint.
3) Reset it again in 2011
4) This area was vulnerable to undercutting by high water.
5) This area is a less-than-desirable riparian monitoring station.
6) The site is now located just upstream from No-Name confluence.

DATA SUMMARY

WQ-05: Cover by community types in Winter Quarters Canyon (2012).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	8.00
	6.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Equisetum arvense/Elymus canadensis	10.50
TOTAL COVER (Upland Species)	14.00
TOTAL COVER (Riparian Species)	10.50
ROCK (channel)	1.00
WATER (channel)	5.50
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	31.00

PHOTOGRAPHIC DOCUMENTATION

WQ-05

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-39 (New in 2010)*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,507 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Snowberry* 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: *700*

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	*Ribes sp.*	*Aster sp.*	*Agrostis stolonifera*
Populus tremuloides	*Rubus idaeus*	*Geranium richardsonii*	*Elymus canadensis*
		Helianthella uniflora	*Carex hoodii*
		Heracleum lanatum	
		Lathyrus pauciflorus	
		Mimulus guttatus	
		Ranunculus cymbalaria	
		Urtica dioica	

POOL ATTRIBUTES

% area in pools: *0*

% pool area made up of pools > 2' deep: *no*

AQUATIC VEGETATION

% streambed with filamentous algae: *no*

% stream margin with rooted aquatic: *yes*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°): *100 on right side in 2011; 0 in 2012.*

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

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

BANK CONDITION

% bank length vegetated, stable: *90 lt; 15 rt*

% bank length unvegetated, stable: *5 lt; 85 rt*

% bank length vegetated, unstable: *5 lt; 0 rt*

% bank length unvegetated, unstable: *0 lt; 0 rt*

NOTES:

1) New site in 2010
2) I considered all but 10 ft out from fallen tree as a riparian community.
3) The site was mostly *Elymus canadensis* which appeared a bit more mesic than wet.
4) The site was located just below a spring on the right.
5) Re-marked with GPS in 2011.
6) Evidence of flooding in year 2011
7) In 2012, there were cobble bars (9 ft on rt; 5 ft on lt) due to the flooding mentioned in 2011 (see photo).
8) The riparian zone on the left had water running through it in 2012.

DATA SUMMARY

WQ-39: Cover by community types in Winter Quarters Canyon (2012).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	3.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Elymus canadensis/Agrostis stolonifera	16.00
TOTAL COVER (Upland Species)	13.00
TOTAL COVER (Riparian Species)	16.00
ROCK (channel)	9.00
WATER (channel)	4.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	42.00

PHOTOGRAPHIC DOCUMENTATION

WQ-39

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-07 (eliminated in 2011 see Notes)*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,513 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Aspen/Conifer* Right: *Conifer*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

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

SUCCESSIONAL STATUS:

APPARENT FORAGE TREND:

ESTIMATED FORAGE PRODUCTION:

BEAVER ACTIVITY: *No*

PHOTOGRAPH TAKEN: *Yes (2011)*

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

SPECIES OBSERVED:

Trees	Shrubs	Forbs	Grasses (or grasslike)

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
% bank length vegetated, stable:
% bank length unvegetated, stable:
% bank length vegetated, unstable:
% bank length unvegetated, unstable:

NOTES:

1) In 2010 I could not find the old site; GPS coordinates went to an area with lots of fallen trees, so it may have been covered up. More trees had fallen here in 2011.
2) A new station was created, so previous data (pre-2010) cannot be compared to 2010 and later.
3) The left side riparian area was mostly level.
4) The right side had bank-influence moisture with only 2 ft influenced mostly from the stream.
5) This site was eliminated in 2011 because more trees had fallen and it now seems an illogical place to monitor.

DATA SUMMARY

WQ-07: Cover by community types in Winter Quarters Canyon (2011).

USDA Forest Service Protocol (1992)

UPLAND VEGETATION

RIPARIAN VEGETATION

Dominant Woody Species

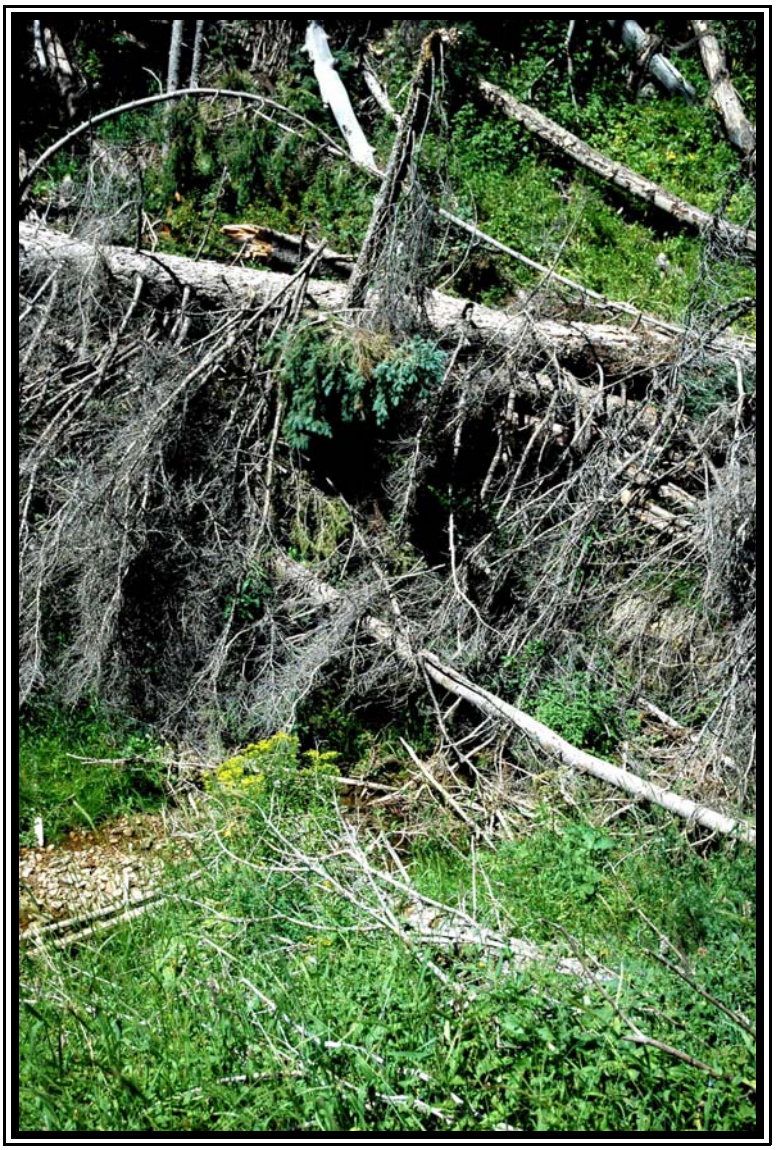
Dominant Herbaceous Species

Agrostis stolonifera/Ranunculus cymbalaria
Elymus canadensis/Carex hoodii

TOTAL COVER (Upland Species)
TOTAL COVER (Riparian Species)
ROCK (channel)
WATER (channel)
BAREGROUND (channel)
LITTER
MOSS

TOTAL COVER

PHOTOGRAPHIC DOCUMENTATION



WQ-07 (2011; transect line covered; site eliminated from sampling)

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-40 (New in 2010)*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *E*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,492 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Blue Spruce/Conifer* 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: *1,000 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)**
Picea pungens	*Ribes sp.*	*Achillea millefolium*	*Agrostis stolonifera*
		Mimulus guttatus	
		Potentilla sp.	
		Ranunculus cymbalaria	
		Urtica dioica	
		Viguiera multiflora	

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 (<90°): *0*

% bank length gently sloping (>135°): *100 lf; 50 rt*

% 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 community was present on the left side.
2) The right side had little riparian community.
3) This was a new site in 2010.
4) Site was located just upstream from the No Name trail head I marked.

DATA SUMMARY

WQ-40: Cover by community types in Winter Quarters Canyon (2012).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	10.00
	9.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Agrostis stolonifera/Ranunculus cymbalaria	20.00
TOTAL COVER (Upland Species)	19.00
TOTAL COVER (Riparian Species)	20.00
ROCK (channel)	1.00
WATER (channel)	6.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	46.00

PHOTOGRAPHIC DOCUMENTATION

WQ-40

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *Number WQ-09*

WATERBODY NAME: *Winter Quarters Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *ENE*

STREAM GRADIENT: *1-2* ^{o}

ELEVATION: *8,448 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *Conifer* 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: *1000*

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)
	Symphoricarpos oreophilus	*Helianthella uniflora*	*Agrostis stolonifera*
		Mimulus guttatus	*Carex hoodii*
		Geranium richardsonii	*Elymus canadensis*
		Ranunculus cymbalaria	*Poa secunda*
		Urtica dioica	

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: *0*

BANK TYPE & VEGETATION OVERHANG

% bank length undercut (<90°): *20% on right side (herb)*

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

% bank length with overhanging vegetation: *20 (herbaceous)*

BANK CONDITION

% bank length vegetated, stable: *95 (lf); 75 (rt)*

% bank length unvegetated, stable: *5 (lf); 15 (rt)*

% bank length vegetated, unstable: *0 (lf); (0 rt)*

% bank length unvegetated, unstable: *0 (lf); 10 (rt)*

NOTES:

1) Even though it was an old site, all stakes were located.

2) The coordinates were remarked on the GPS

3) In 2011, the left side riparian community seemed to have increased and no riparian on right side due to steep vegetated bank.

4) In 2012, riparian vegetation was beginning to establish on the right side.

DATA SUMMARY

WQ-09: Cover by community types in Winter Quarters Canyon (2012).
USDA Forest Service Protocol (1992)

UPLAND VEGETATION	
	6.00
	10.00
RIPARIAN VEGETATION	
Dominant Woody Species	
Dominant Herbaceous Species	
Carex hoodii	9.00
Ranunculus cymbalaria	2.00
TOTAL COVER (Upland Species)	16.00
TOTAL COVER (Riparian Species)	11.00
ROCK (channel)	0.00
WATER (channel)	6.00
BAREGROUND (channel)	0.00
LITTER	0.00
MOSS	0.00
TOTAL COVER	33.00

PHOTOGRAPHIC DOCUMENTATION

WQ-09

RIPARIAN COMPLEX DATA SHEET
2012

CLIENT: *Canyon Fuel Company, Skyline Mines*

COMPLEX: *N/A*

WATERBODY NAME: *Woods Canyon Creek*

LOCATION: *Wasatch Plateau, Utah*

DATE: *August 27 - August 31, 2012*

OBSERVER(S): *P. Collins, S. Vlietstra*

QUAD NAME: *Scofield, Utah*

GEOLOGIC PARENT MATERIAL: *Blackhawk Formation*

STEAM ASPECT: *ENE*

STREAM GRADIENT: *1-2 °*

ELEVATION: *8,480 ft*

SIZE OF COMPLEX: *(see quantitative data)*

ADJACENT UPLAND VEGETATION (looking downstream)

Left: *n/a (see Notes)* Right: *n/a (see Notes)*

VEGETATIVE DESCRIPTION (Dominance by Community Types)

Community Name	% of Complex

SUCCESSIONAL STATUS: *N/A (see Notes)*

APPARENT FORAGE TREND: *N/A*

ESTIMATED FORAGE PRODUCTION: *N/A*

BEAVER ACTIVITY *N/A*

PHOTOGRAPH TAKEN: *Yes*

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

SPECIES OBSERVED: n/a (see Notes)

Trees	**Shrubs**	**Forbs**	**Grasses (or grasslike)**

NOTES:

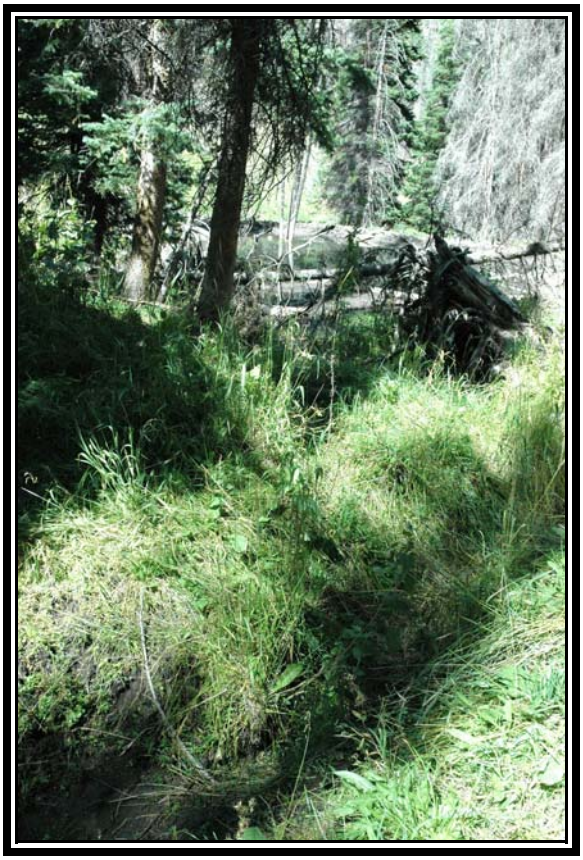
1) The areas for the 2012 study included those that could potentially subside for the 5-year period (2010-2014). When subsidence areas were mapped it included some of the tributaries of Woods Canyon, but not the main drainage channel (see Cumulative Subsidence map in the Results & Discussion section). This map drove the study plan for 2012, or which stations were to be sampled in 2012. Although none of the existing Woods Canyon sample stations were in the study area, there were 2 tributaries of the canyon feel within the subsidence zones for these years.

When the baseline data were recorded, it focused on those reaches where perennial streams were found. Although no sample stations were placed in these two tributaries, and after consulting with representatives (Gregg Galecki) from Canyon Fuel and a consulting hydro-geologist (Erik Petersen), they were included in the 2012 study as a precaution. The tributaries are shown on both maps included in this report.

Mr. Petersen reported to me that the east tributary on those maps did not have a perennial stream within it. He was unsure, however, about the west drainage, so this drainage was visited during the field study.

A spring was located in the west drainage (see photograph below). This spring is shown on the Cumulative Subsidence map. Springs do not have sample stations placed at them for the annual riparian monitoring study.

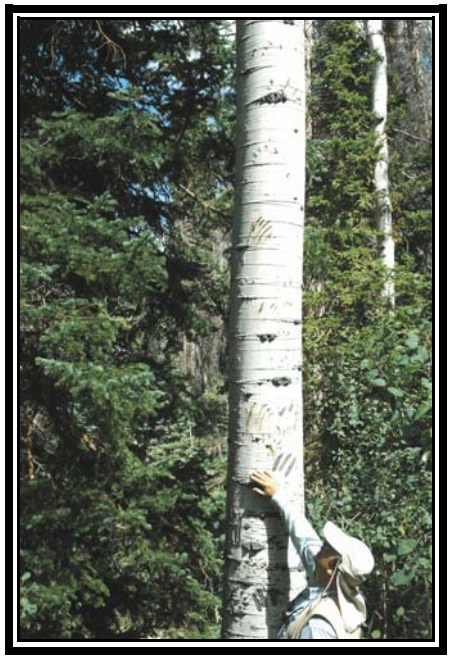
PHOTOGRAPHIC DOCUMENTATION



Woods west tributary spring area

Woods west tributary spring area

Woods west tributary drainage above spring area



Aspen in area with bear scratches

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

Date: 11/1/2012

CLIENT: Canyon Fuel Company, LLC.
Project: Skyline Utah#6
Lab Order: S1208457

CASE NARRATIVE

Report ID: S1208457001

Samples WR2012-1, WR2012-10, WR2012-11, WR2012-2, WR2012-3, WR2012-4, WR2012-5, WR2012-6, WR2012-7, WR2012-8, and WR2012-9 were received on August 21, 2012.

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

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: S1208457001

Project: Skyline Utah#6
Date Received: 8/21/2012

Date Reported: 11/1/2012
Work Order: S1208457

Lab ID	Sample ID	pH s.u.	Saturation %	Electrical Conductivity dS/m	Field Capacity %	Wilt Point %	PE Calcium meq/L	PE Magnesium meq/L	PE Potassium meq/L	PE Sodium meq/L	SAR
S1208457-001	WR2012-1	8.1	38.2	2.03	11.9	10.2	4.15	3.19	0.54	15.9	8.29
S1208457-002	WR2012-2	7.9	36.4	2.39	11.2	10.4	7.62	7.14	0.88	15.7	5.78
S1208457-003	WR2012-3	7.8	38.1	2.66	12.7	11.2	10.3	8.39	1.08	17.1	5.61
S1208457-004	WR2012-4	7.9	39.8	3.65	12.3	10.5	13.9	12.8	1.17	27.2	7.44
S1208457-005	WR2012-5	7.8	35.3	2.10	13.2	11.3	11.1	10.8	1.36	3.92	1.18
S1208457-006	WR2012-6	8.3	37.3	1.72	14.2	11.7	1.68	1.09	0.40	15.4	13.1
S1208457-007	WR2012-7	7.9	39.3	2.78	12.7	11.1	9.25	7.41	0.72	18.4	6.38
S1208457-008	WR2012-8	7.8	37.9	2.74	12.2	10.7	11.6	6.83	0.71	18.3	6.03
S1208457-009	WR2012-9	7.8	37.1	3.73	12.8	10.7	17.9	10.0	0.99	26.4	7.06
S1208457-010	WR2012-10	8.0	33.0	2.01	17.4	10.1	4.36	3.15	0.78	13.5	6.94
S1208457-011	WR2012-11	8.0	34.2	2.33	16.4	10.2	4.12	3.28	0.96	15.3	7.95

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

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: S1208457001

Project: Skyline Utah#6
Date Received: 8/21/2012

Date Reported: 11/1/2012
Work Order: S1208457

Lab ID	Sample ID	Sand %	Silt %	Clay %	Texture	Coarse Fragment %	Boron ppm	Nitrate (as N) ppm	Selenium ppm	TKN %
S1208457-001	WR2012-1	85.0	9.0	6.0	Loamy Sand	51.6	0.78	0.3	0.05	0.26
S1208457-002	WR2012-2	63.0	25.0	12.0	Sandy Loam	46.6	0.72	17.2	0.09	0.13
S1208457-003	WR2012-3	65.0	24.0	11.0	Sandy Loam	39.0	0.95	4.2	0.10	0.15
S1208457-004	WR2012-4	69.0	24.0	7.0	Sandy Loam	51.1	0.54	0.5	0.02	0.18
S1208457-005	WR2012-5	39.0	39.0	22.0	Loam	33.1	0.78	19.0	0.13	0.10
S1208457-006	WR2012-6	69.0	24.0	7.0	Sandy Loam	52.1	0.56	0.2	0.04	0.17
S1208457-007	WR2012-7	69.0	23.0	8.0	Sandy Loam	47.0	0.51	0.2	<0.02	0.13
S1208457-008	WR2012-8	75.0	17.0	8.0	Sandy Loam	57.4	0.97	0.3	0.04	0.38
S1208457-009	WR2012-9	72.0	22.0	6.0	Sandy Loam	60.0	0.72	0.2	0.06	0.23
S1208457-010	WR2012-10	48.0	35.0	17.0	Loam	58.8	0.61	54.2	0.07	0.06
S1208457-011	WR2012-11	44.0	37.0	19.0	Loam	56.0	0.94	72.3	0.08	0.06

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

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Soil Analysis Report

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

Report ID: S1208457001

Project: Skyline Utah#6
Date Received: 8/21/2012

Date Reported: 11/1/2012
Work Order: S1208457

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
S1208457-001	WR2012-1	1.61	1.01	49.4	48.6	0.56	17.4	63.9	46.5
S1208457-002	WR2012-2	1.22	0.65	20.1	19.1	0.34	10.5	86.0	75.5
S1208457-003	WR2012-3	1.36	0.70	36.0	35.1	0.48	15.1	71.1	56.0
S1208457-004	WR2012-4	2.66	1.58	44.1	42.9	0.82	25.5	99.9	74.4
S1208457-005	WR2012-5	0.34	0.20	13.8	12.8	0.18	5.59	85.3	79.7
S1208457-006	WR2012-6	2.17	1.60	48.3	47.2	0.66	20.6	92.6	72.0
S1208457-007	WR2012-7	1.83	1.11	41.5	40.2	0.67	21.0	109	88.0
S1208457-008	WR2012-8	1.47	0.78	47.9	47.1	0.50	15.5	67.8	52.2
S1208457-009	WR2012-9	2.08	1.10	42.5	41.5	0.52	16.4	80.1	63.7
S1208457-010	WR2012-10	1.10	0.66	2.1	1.2	0.09	2.94	72.8	69.8
S1208457-011	WR2012-11	1.41	0.89	3.3	2.5	0.17	5.33	69.5	64.2

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

Reviewed by: Karen A Secor
Karen Secor, Soil Lab Supervisor

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

Your Environmental Monitoring Partner

Date: 2/14/2013

CLIENT: Canyon Fuel Company, LLC.
Project: Skyline Utah#6
Lab Order: S1301135

CASE NARRATIVE

Report ID: S1301135001

Samples WR2012-12, WR2012-13, WR2012-14, WR2012-15, WR2012-16, and WR2012-17 were received on January 9, 2013.

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

Inter-Mountain Labs
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Your Environmental Monitoring Partner

Soil Analysis Report

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

Report ID: S1301135001

Project: Skyline Utah#6
Date Received: 1/9/2013

Date Reported: 2/14/2013
Work Order: S1301135

Lab ID	Sample ID	pH	Saturation	Electrical Conductivity	Field Capacity	Wilt Point	PE Calcium	PE Magnesium	PE Potassium	PE Sodium	SAR
		s.u.	%	dS/m	%	%	meq/L	meq/L	meq/L	meq/L	
S1301135-001	WR2012-12	8.5	35.1	1.79	17.0	10.6	1.53	0.76	0.50	14.1	13.2
S1301135-002	WR2012-13	9.1	33.4	1.83	16.3	9.8	1.64	0.77	0.48	14.2	12.9
S1301135-003	WR2012-14	9.2	28.9	1.90	15.2	8.6	1.07	0.59	0.36	14.4	15.7
S1301135-004	WR2012-15	8.3	31.5	2.39	10.5	5.4	1.10	0.65	0.48	18.3	19.5
S1301135-005	WR2012-16	8.5	27.6	2.10	10.0	5.6	0.91	0.49	0.43	16.6	19.8
S1301135-006	WR2012-17	8.5	28.3	1.42	14.5	10.7	0.96	0.46	0.29	12.8	15.2

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

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Your Environmental Monitoring Partner

Soil Analysis Report

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

Report ID: S1301135001

Project: Skyline Utah#6
Date Received: 1/9/2013

Date Reported: 2/14/2013
Work Order: S1301135

Lab ID	Sample ID	Sand %	Silt %	Clay %	Texture	Coarse Fragment %	Boron ppm	Nitrate (as N) ppm	Selenium ppm	TKN %
S1301135-001	WR2012-12	50.0	33.0	17.0	Loam	38.8	0.79	17.0	0.03	<0.01
S1301135-002	WR2012-13	52.0	32.0	16.0	Sandy Loam	26.1	1.03	23.2	0.03	<0.01
S1301135-003	WR2012-14	58.0	26.0	16.0	Sandy Loam	27.0	0.71	23.5	0.04	<0.01
S1301135-004	WR2012-15	84.0	8.0	8.0	Loamy Sand	32.0	0.36	14.7	<0.02	0.01
S1301135-005	WR2012-16	80.0	12.0	8.0	Loamy Sand	24.0	0.57	19.9	<0.02	<0.01
S1301135-006	WR2012-17	40.0	33.0	27.0	Clay Loam	26.1	1.25	9.9	0.03	<0.01

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

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: S1301135001

Project: Skyline Utah#6
Date Received: 1/9/2013

Date Reported: 2/14/2013
Work Order: S1301135

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
S1301135-001	WR2012-12	1.22	0.72	2.7	1.4	0.08	2.63	111	109
S1301135-002	WR2012-13	1.43	0.96	2.6	1.2	0.10	3.15	112	109
S1301135-003	WR2012-14	1.41	0.99	3.1	1.6	0.13	4.16	123	119
S1301135-004	WR2012-15	0.96	0.38	11.5	11.0	0.22	6.85	39.1	32.3
S1301135-005	WR2012-16	1.53	1.08	2.8	2.0	0.19	5.96	73.8	67.8
S1301135-006	WR2012-17	3.35	2.99	3.5	2.7	0.18	5.59	63.8	58.3

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: Karen A Secor
Karen Secor, Soil Lab Supervisor

RECEIVED
MAR 2 7 2013
DIV. OF OIL, GAS & MINING

LEGEND

- Area Approved for Mining Activities
- 2011 As Mined (Longwall)
- 2011 As Mined (Development)

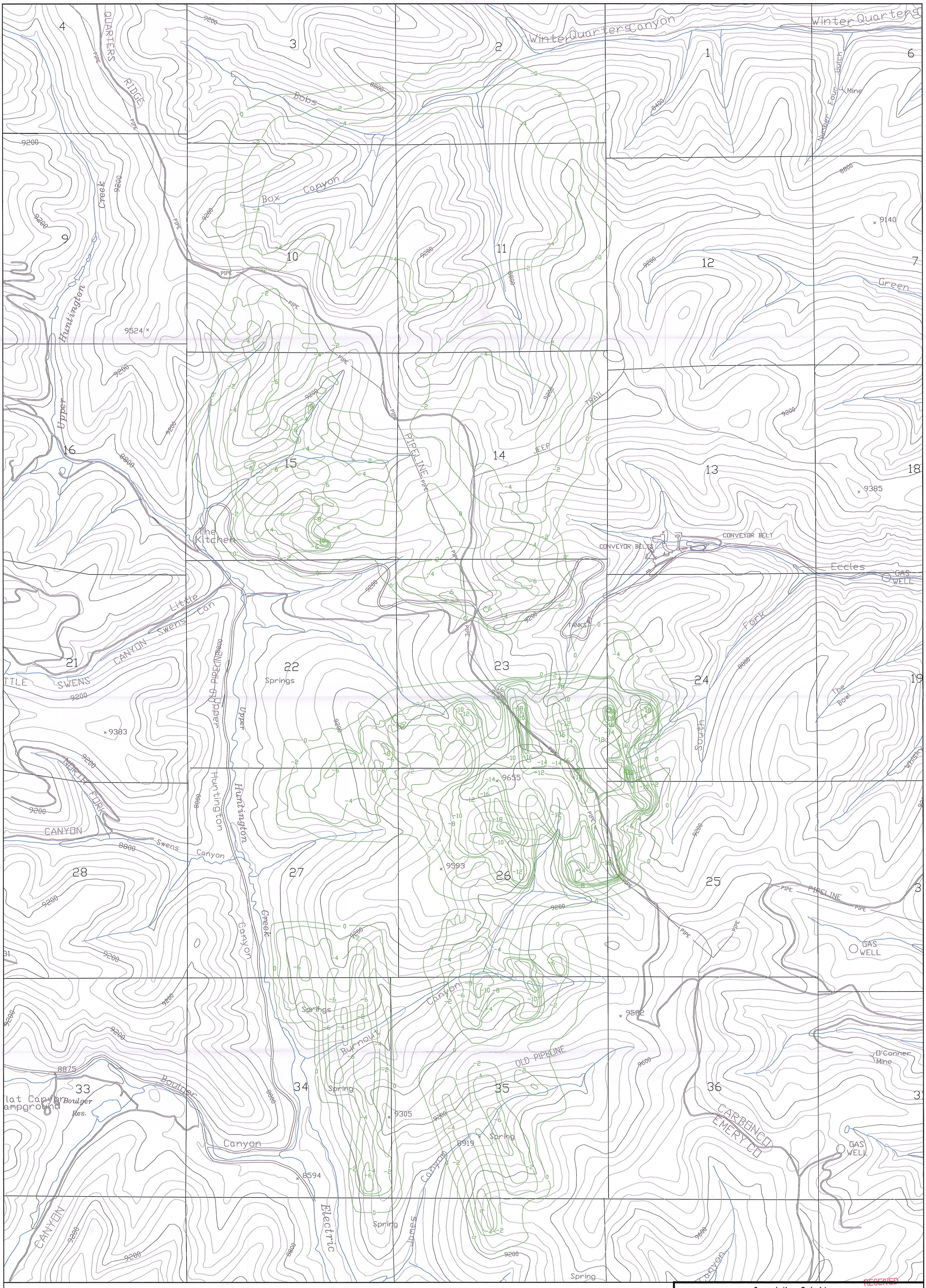
REGISTERED PROFESSIONAL ENGINEER
CARL W WINTERS
NO 22 157958-2202
STATE OF UTAH
3-26-13

1000' 0' 500' 1000'

Skyline Mine
Mine 3
As Mined 2012

Skyline Mine

HCR 35 BOX380, HELPER, UT, 84526 435-448-2632	DATE: 03/21/13	CK.BY:GAG	REVISION: 0
CAD FILE: As Mined 2012	SCALE: 1"=1000'	DR.BY:GAG	
DWG. NO.: As Mined 2012			



-2 SUBSIDENCE CONTOUR

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

1000' 500' 0' 500' 1000'

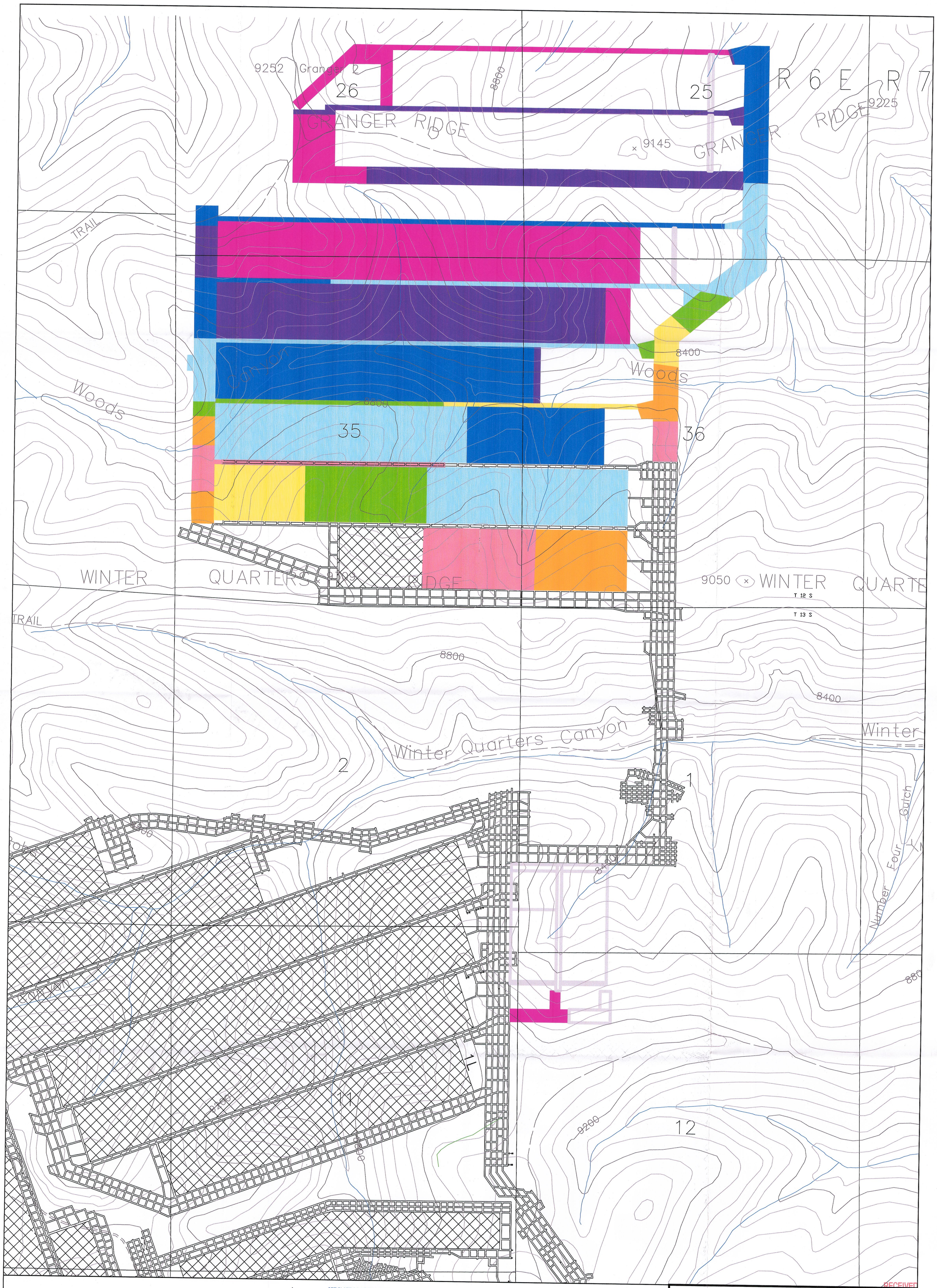
LICENSED PROFESSIONAL GEOLOGIST
GREGG GALECKI
5248584
3-26-13
STATE OF UTAH

Cumulative Subsidence
1982–2012

RECEIVED
MAR 27 2013
DIV. OF OIL, GAS & MINING

Skyline Mine

HCR 35 BOX380, HELPER, UT, 84526 435-448-2632	DATE: 3/18/13	CK.BY: GAG	REVISION: 0
CAD FILE: 2012 Subsidence_Final	SCALE: 1"/1000'	DR.BY: GAG	
DWG. NO.: Cumulative Subsidence 2012			



LEGEND

- 1st QUARTER 2013
- 2nd QUARTER 2013
- 3rd QUARTER 2013
- 4th QUARTER 2013
- 2014
- 2015
- 2016
- 2017
- AS MINED

SEE PLATE 1.6-3 FOR PERMIT AND ADJACENT AREAS

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.

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

REGISTERED PROFESSIONAL ENGINEER
CARL W WINTERS
NO 22 167958-2202
STATE OF UTAH
3-26-13

RECEIVED
MAR 2 7 2013
DIV. OF OIL, GAS & MINING

Skyline Mine
Mine 3 – Level 3
Projected Mining 2013–2017

Skyline Mine

HCR 35 BOX380, HELPER, UT, 84526 435-448-2632	DATE: 3/12/13	CK.BY: GAG	REVISION: 0
CAD FILE:	SCALE: 1"=600'	DR.BY: GAG	
DWG. NO.: Projected Mining			

2012 Technical Memo-Subsidence Area Surveys

To: Gregg A. Galecki
Environmental Engineer
Canyon Fuel Company, LLC
Skyline Mine
(435)448-2636

RE: 2012 Subsidence Area Raptor Nest Monitoring Program

The potential subsidence area in Winter Quarters Canyon was surveyed for nesting raptors in 2009, 2010, and 2011. The broadcast acoustical surveys were conducted following U.S. Department of Agriculture (USDA) Forest Service (USFS), 2006, Northern Goshawk Inventory and Monitoring Technical Guide pp.3.13-15 as directed in the Utah Regulatory Program document Raptor Survey Guidelines (UDOGM Guidelines). This is also in conformance with the UDOGM Guidelines pg 3, Subsidence section, subsections 1 and 2, and Appendix B- Species Specific Protocols. In 2011, the acoustical survey was expanded to include monitoring of two USFS documented nest sites within the subsidence area. The results of the nest monitoring can be found in the 2011 subsidence report.

Prior to initiating surveys in 2012 coordination with UDOGM wildlife biologist Ingrid Campbell and USFS wildlife biologist Jeff Jewkes was conducted. As a part of this coordination discussions included the masked nest locations received from the Utah Natural Heritage Program (UNHP) database requests. Ingrid indicated that she is working with UNHP to get more accurate, or unmasked, point location data for us in the future. Other items discussed included seasonal variations from the UDOGM Guideline recommendations to allow Skyline Mine to comply with USFS requirements and the USDA technical guide's seasonal recommendations. This also included a discussion about the second bulleted item in UDOGM's *2011 Annual Report Review Completion, Skyline Mine, C/007/0005, Task ID #4061* and reviewer comments regarding seasonal timing of surveys. It was agreed that in order to follow the USDA Technical Guide recommendations and the USFS Manti-La-Sal National Forest survey requirements that northern goshawk and other nesting raptor surveys would be conducted in June and July annually.

Due to the restricted access caused by the Seely wildlife, the location of the known nest sites within and near the area of potential subsidence, and data collected on previous inventories, it was agreed by all parties that monitoring of the known northern goshawk territories in Bob's Canyon, which extends into the area of potential subsidence, and Woods Canyon (i.e., north of the subsidence area) would be completed in lieu of the inventory protocol. The monitoring surveys were an extension of, and a result of the intensive surveys conducted 2009, 2010, and 2011 and the data collected during those surveys. The restricted access resulted in the initial monitoring surveys being conducted by USFS biologist Jeff Jewkes, who surveyed the Bob's Canyon and Woods Canyon territories around the first week in July (i.e., see attached conformation email dated July 07, 2012) and found to be unoccupied. All the nest sites were monitored again on July 26, 2012 by WLS biologists. Those monitoring surveys confirmed USFS monitoring results.

From: Jewkes, Jeff A -FS
To: Mace Crane;
Subject: RE: nests
Date: Saturday, July 07, 2012 10:07:41 AM
Attachments: Goshawk_Inventory_Protocols_ml.doc

Mace,

I just wanted to let you know that the Bob's Canyon and the Wood's Canyon Territories were checked this year and neither territory was occupied. I also wanted to let you know that your surveys are in compliance with Forest Service standards and follow our protocol. We stipulate that any contract surveys on Forest Service lands do not begin until June. I do not begin our known nest monitoring until June. As you know, goshawks are more vocal during the nestling stage and more easily detected mid-June. I have attached a copy of our regional protocol. Hope this helps.

Sincerely,

Jeff Jewkes

From: Mace Crane [mailto:mace.crane@westernls.com]
Sent: Saturday, July 07, 2012 9:21 AM
To: Jewkes, Jeff A -FS; Albrecht, Kevin -FS
Subject: RE: nests

Jeff and Kevin,
Could you send me nest location UTM's for all the nests in Bob's Canyon and Woods Canyon. As Skyline Mine continues northward we need to continue monitoring them as per UDOGM's guidelines. Also, now that the Seely Fire is a little more under control, we are going to complete the second year of NOGO surveys on the west side of Electric lake and the road. We will be using the same call stations as last year as shown on the attached maps. The difference between the two maps is the number of call stations. I've place a 0.5 mile buffer around the currently known nests. My plan is to check them first; if they are active we will give them a buffer as not to disturb them. The second map labeled 365 displays the survey area if all nest were active. If you'd prefer I could come over and meet with you. Give me a call on my cell phone 435-201-9828 when you get a minute and we can catch up.
Thanks

Mace Crane
Sr. Wildlife Biologist
(866) 896-5521

From: Jeff A Jewkes [mailto:jjewkes@fs.fed.us]
Sent: Thursday, July 28, 2011 1:45 PM
To: Mace Crane
Subject: nests

Mace,

I can't remember if you already told me about the Bob's Canyon and Wood's Canyon territories. I need to update the monitoring and need to know if they were checked. If not, I will check them.

Thanks,

Jeff

Jeff Jewkes Wildlife Biologist
Manti-La Sal National Forest Ferron District Office
Phone: 435-636-3592

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Mace Crane

From: Sarah Lindsey [sarahlindsey@utah.gov]
Sent: Thursday, July 12, 2012 11:24 AM
To: Mace Crane
Subject: Re: Skyline Mine Survey Data Request
Attachments: 4396_unhp_masked_pts.zip

Mace,

Attached is a shapefile (NAD 83, UTM Zone 12) in response to your request. Our data classifications under state law (GRAMA) prohibit us from releasing exact species locality data; therefore, the data attached contains locations masked to within one square mile of the actual location.

Please contact me if you have any questions.

Sincerely,
Sarah Lindsey

Utah Natural Heritage Program
Division of Wildlife Resources
1594 W. North Temple
Salt Lake City, UT 84116
(801) 538-4759

>>> Mace Crane <mace.crane@westernls.com> 7/7/2012 8:39 AM >>>
Sarah,

As per UDOGM's raptor survey guidelines, I am submitting a request for known raptor nests and any other special status species occurrence data within the following legal descriptions.

1. Township 13 S, Range 6 E, Sections 15, 16, 17, 20, 21, 22, 27, 28, 29, 31, 32, 33, 34, and 35; and
   Township 14 S, Range 6 E, Sections 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, and 16

2. Township 13 S, Range 6 E, Sections 2, 3, 4, 9, 10, and 11

Thank you,

[Crane,-Mace]